Electronics World

NOVEMBER, 1969
60 CENTS

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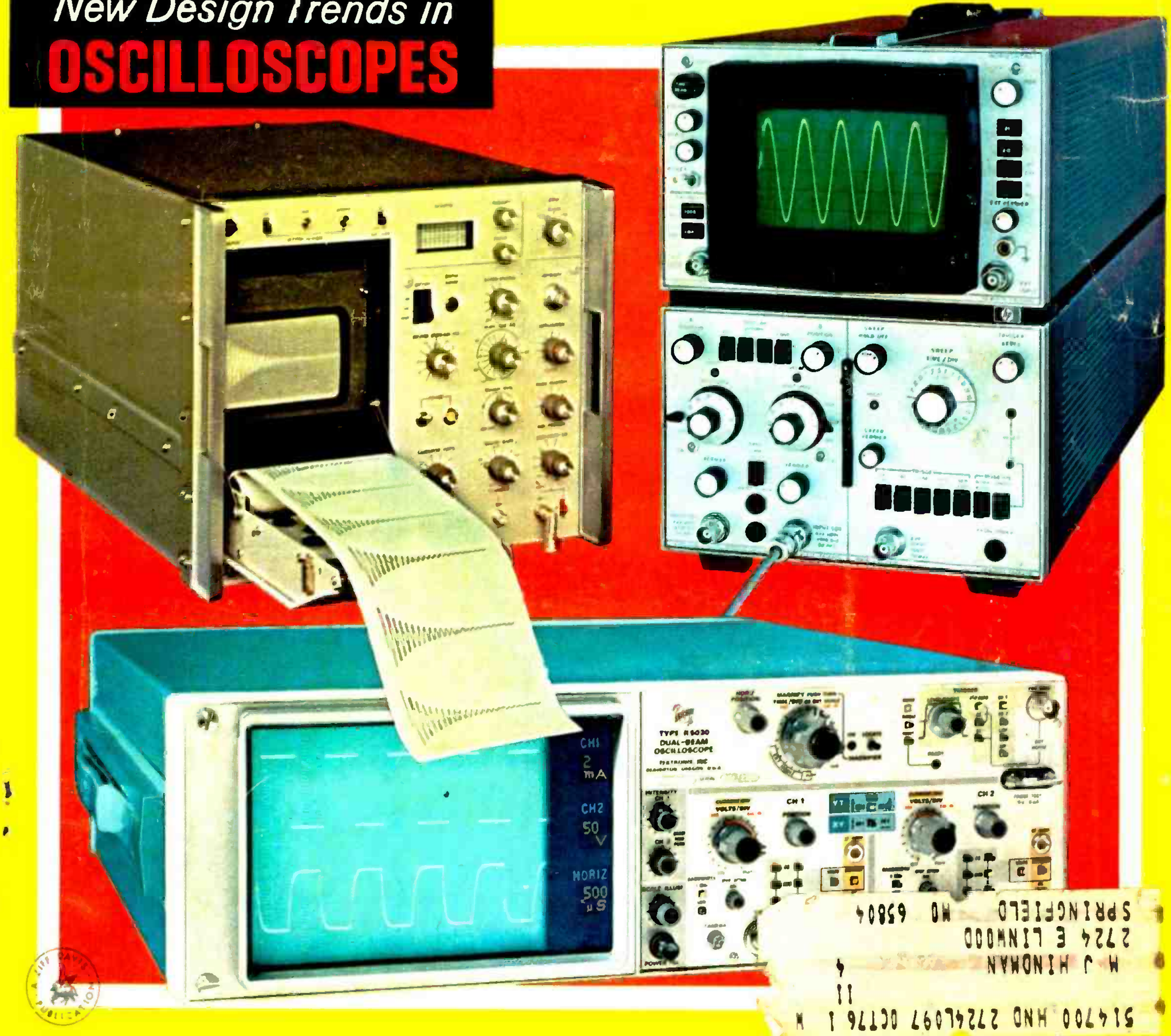

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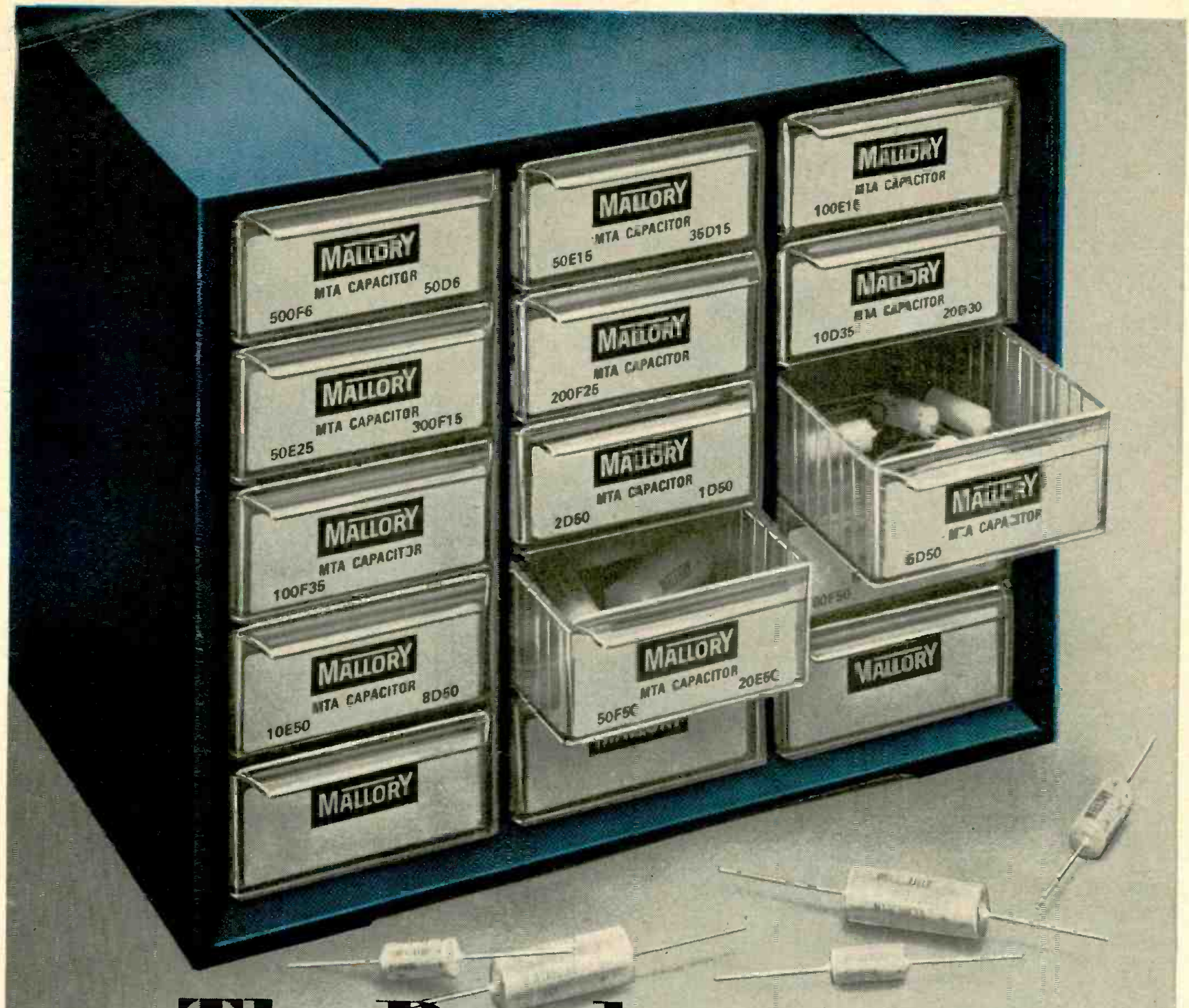

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THIS MONTH'S COVER shows three oscilloscopes discussed in this issue, representing some of the new design trends in the display instrument field today. At top left is Honeywell's 1806-A that combines display techniques of a scope with recording techniques of an oscillograph. The scope at top right is Hewlett-Packard's Model 183A plug-in unit that has a d. c. to 250-MHz response due to its CRT's unique distributive deflection system. This scope will maintain compatibility with both earlier plug-in units and any future ones having higher performance. Tektronix Model R5030 (bottom) is a non-plug-in unit with many of the features found in plug-in types. Photo: Dirone-Denner.

ZIFF-DAVIS PUBLISHING COMPANY

Electronics World

NOVEMBER 1969 VOL. 82, No. 5

CONTENTS

MONTHLY FEATURES

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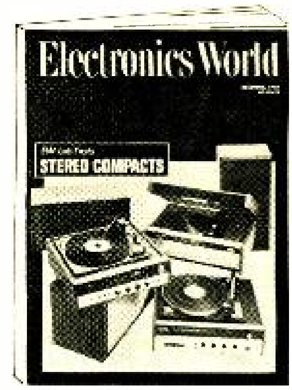
COMING NEXT MONTH



SPECIAL FEATURE ARTICLE:

STEREO COMPACTS

Don't miss this EW Lab Test report on compact stereo music systems. Growing in popularity by leaps and bounds, these component-quality units provide the answer to the problems of limited space and limited budgets. Hirsch-Houck Labs has tested a number of these systems—including Fisher, Harman-Kardon, Heath, Scott, and Sony, among others—and gives you a rundown on performance, features, and prices.

LARGE-SCALE INTEGRATION

Is this the beginning of the LSI era? David Heiserman discusses some of the problems encountered by semiconductor manufacturers in going to LSI and provides information on presently available LSI devices.

LOUDSPEAKERS FOR P.A. SYSTEMS

In this final article of the series, Abraham B. Cohen describes available p.a. speakers, provides comparative characteristics, and tells you how to make the best choice for a particular public-address system installation.

ELECTRONIC TYPE COMPOSITION

Edward Lacy brings you up-to-date on the new computer-driven CRT systems that are being used to compose type for newspapers, magazines, and books. A number of electronics firms are deeply involved in basic research and development in this field.

AUDIO EQUALIZATION CURVES UP-TO-DATE

Here is a summary of the curves now in use for FM broadcasting, disc and tape recording, and the latest standard for the popular tape cassette.

All these and many more interesting and informative articles will be yours in the December issue of ELECTRONICS WORLD . . . on sale November 18th.

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For the record

WM. A. STOCKLIN, EDITOR

TV SERVICING

INDEPENDENT radio and television service technicians from across the country gathered in Waterbury, Conn. for the annual convention of NEA (National Electronic Associations, Inc.). They came from as far as California, Oregon, and Texas to help solve industry problems and to release their pent-up emotions on the manufacturers. At times tempers flared, but the manufacturers' representatives—from such companies as *Philco-Ford, G-E, Motorola, Winegard, Sylvania, Panasonic, Sprague,* and *RCA*—answered the questions extremely well and, at times, quite cleverly.

This year for the first time—by special invitation from NEA—we participated in their convention, and we were impressed. The men who attended were personable, ambitious, intelligent—by any standards, good businessmen. They were independent technicians, yet very few, if any, were from a one-man shop. For the most part they were the owners and operators of larger service shops and some ran multi-shop operations.

Problems of serviceability, warranty, and replacement parts continue to plague the technician. They have ever since radio was invented and they probably will continue to forever. But continuing dialogue between service groups and manufacturers as at national conventions of this type will, in some way, reduce such headaches.

What was new, though, was a report by Dr. Robert Elder of the Public Health Service on the subject of x-ray radiation from color-TV sets. A law spelling out radiation limits goes into effect next January 1st and responsibility for seeing that color sets meet legal standards rests with the manufacturers. The limit is not a danger level but simply a guideline far below any level which could adversely affect the general viewing public. Actually, the x-rays produced by TV sets can not be compared to medical x-rays at all—they're so much weaker that they cannot be measured at normal viewing distances. Even if the radiation were twice the recommended standard, there still would be no danger to anyone under normal viewing conditions.

Another interesting point is that, starting next year, all color-TV sets will have to be registered, *i.e.*, the name and address of the owner must be recorded by either the dealer or the manufacturer.

The highlight of the meetings, in our opinion, was a speech by Bill Woodbury, president, *Sprague Products Co.* (A condensed version appears on page 13, don't miss it). In it, he made two main points:

1. A plea for unity. Actually there are two major national service associations, NEA and NATESA, working independently although for the same goals. It's a shame not only because of the wasted effort but because much more could be done with a unified national service association. Bill pinpointed the tremendous amount of electronic service business being lost to the independent. We had never given a thought to the amount of money involved and his figures came as somewhat of a surprise.

2. One point we particularly appreciated—since we've mentioned it in the past and will continue to do so in the future—is that the service industry is going to change. It has been changing for a number of years, but there are more drastic changes to come. With fully transistorized television we foresee the disappearance of the one-man shop. Normal attrition, in the sense that servicing solid-state equipment is much more involved than tube designs, will cause many old-timers, who just will not keep up, to fall by the wayside. Another change we foresee is the trend toward modular construction. *Motorola* started this several years ago and we feel that, in time, all sets will be modular. This will alter the entire concept of electronic servicing. It will create a situation wherein set owners will bring in various modules for checking and we will have PC-board repair stations in every major city.

CATV will bring about another important change: within 20 years all homes will be cable-connected. When this occurs CATV operators will have the inside track to all TV servicing. In fact, it's likely that many sets then in use will be rented and serviced directly by CATV operators. (These are only a few of the things we foresee for television, a subject which will be covered in depth in our upcoming January article, "Television: 20 Years From Now.")

The convention ran for four days and accomplished a lot. At least all of their present-day problems were discussed even if nothing was seriously considered about problems of the future. Well, that's another problem for another convention. ▲

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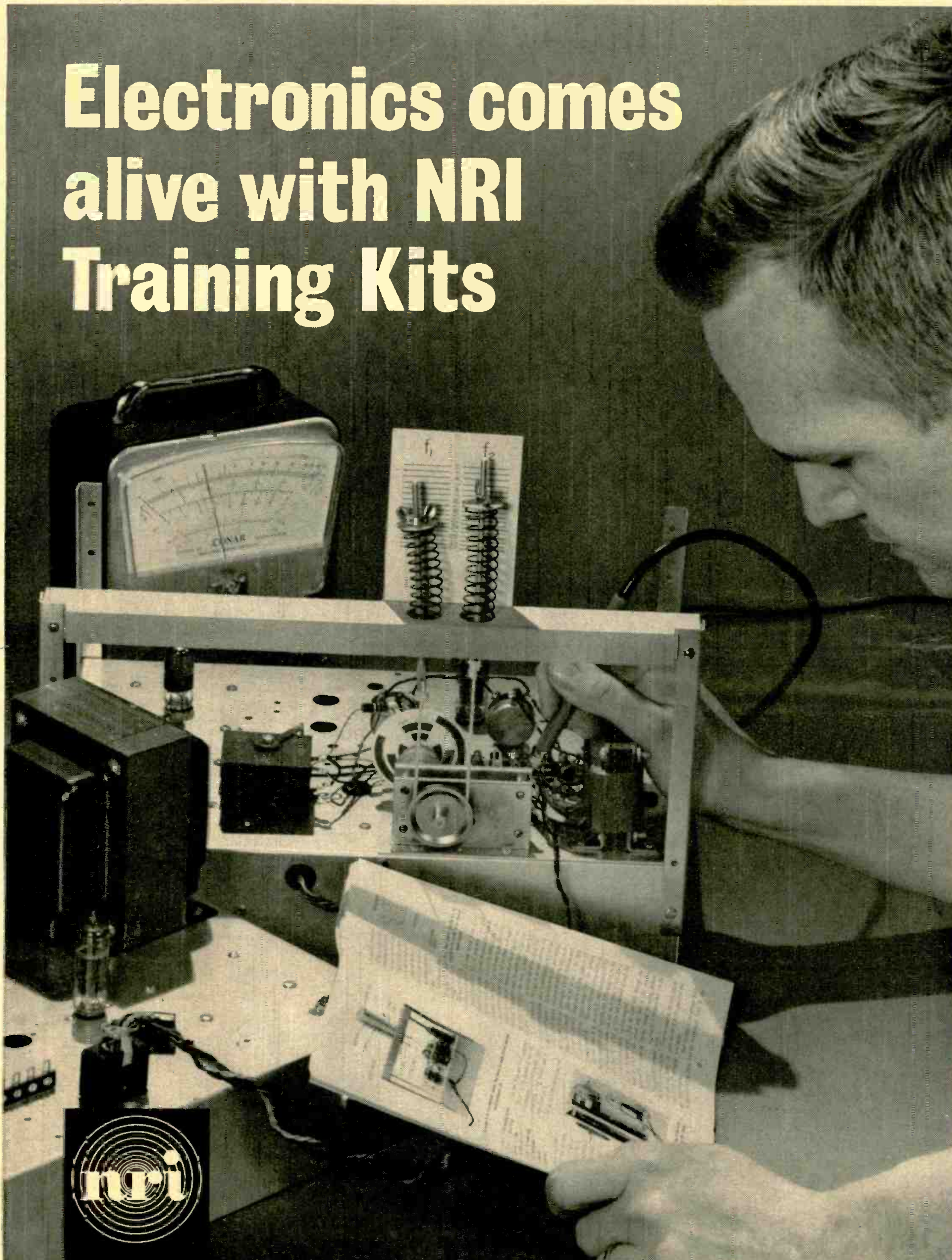
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Don't get the idea the hysteresis motor is all the Concord Mark II has to offer. It also has just about every other professional feature. Three high-quality heads: ferrite erase head; wide gap Hi-Mu laminated recording head for optimum recorded signal and signal-to-noise ratio, narrow gap Hi-Mu laminated playback head for optimum reproduced frequency response. No compromise combination heads. The three heads and four preamplifiers also make possible tape monitoring while recording.

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The hysteresis drive Mark IV, the top-of-the-line Concord deck offers all of the performance and conveniences of the Mark II and III including wide gap record, narrow gap playback heads, tape source monitoring, sound-on-sound, echo recording. Plus, a dual capstan tape transport mechanism with electronic automatic reverse, no metal foil or signal required on the tape. Superior recording performance plus the convenience of automatic reverse and continuous play. A superb instrument with the finest performance money can buy, and it's under $330. Audition the new Concord Mark series, the tape decks with the hysteresis synchronous drive motor. For "all the facts" brochure, write: Concord Electronics Corp., 1935 Armacost Ave., Los Angeles, Calif. 90025. (Subsidiary, Ehrenreich Photo-Optical Industries, Inc.) EPOI

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CIRCLE NO. 141 ON READER SERVICE CARD

GUEST EDITORIAL

A Plea For. . .

A United Service Association

By R. W. WOODBURY
President, Sprague Products Company

Highlights from speech presented by Bill Woodbury before NEA (National Electronic Assns.) National Convention held in Waterbury, Connecticut.

"THANK you for the opportunity to spend a few minutes with you this evening. As you know from our history, we at *Sprague Products Company* strive to maintain a very close relationship with all of you people in the electronic service industry. We devote a high percentage of our research and development activities towards providing you with exact replacement components. . . It is also our aim to supply you with replacement components of the highest possible quality level . . .

"Because my company, and I personally, are vitally interested in your organization, I am here today to give you my thoughts on a few things which I hope will contribute to your future.

"Your committee has assigned me a topic for my talk, the title of which would be something like 'What the parts manufacturer can do for the service technician.' So let me start out by changing the words around and ask you, 'What *can* the parts manufacturer do for the service technician?' I would—very seriously—like to hear from each of you on that subject . . .

"In the meantime—until I hear from you—I am going to strike out on my own, and give you some of my thoughts . . .

"You may not like to hear some of the things I am going to say—you may not agree with me—but because we *are* friends I am going to speak freely . . .

"Here's the first thing I am going to say that you may not like. The independent electronic service industry does not know how to work together in a trade association. I should perhaps soften that and say: Either you don't know or you *won't* work together. I am *not*, of course, talking about only fellows here in this meeting; I am talking about the *total independent electronic service industry*. It is obvious that most of you here in this group *do* know how to work together: Your committees make an excellent attempt in the job of organizing, planning, and association promotion. The handwriting is on the wall, however; these few cannot do everything that must be done—it will take every one of your members and even those who will join later.

"You have a tremendous task ahead of you. I understand there are 125,000 active electronic service technicians in this country, and 15 to 25 percent of this number belong to a trade association. Isn't that a pathetic batting average? So I say it is going to be a real accomplishment to get the majority of these 125,000 technicians to work together; some people say it is impossible, that it *never* can be done. I say it is *not* impossible, I say it can be done, and the nucleus of motive power needed to gain the necessary momentum is right here in this group. You fellows who care enough about your future . . . to take time away from your businesses to come here to contribute to that future, and that industry, are capable of successfully completing this job that absolutely *must* be done.

"Another very important point that I should make here, and one that disturbs all of us, is this: 15 to 25 percent who belong to a trade association belong to several *different* trade associations, each going off in its own independent direction, each having some small effect on the objectives you all are attempting to attain. Wouldn't it be an ideal situation if all of these electronic service businesses belonged to *one* nation-wide trade association . . .

"So, how do we turn these trade association membership percentages around? A minute ago I said *you* have a big job to do. I emphasize *you*, because nobody—there is nobody—can do it for you . . . I might add, also, that manufacturers, distributors, or the consuming public are not going to do it for you.

"This leaves you standing out there pretty much all alone.

"First you must have an objective. And here, your first objective should be to build a strong, large, effective, and *single* national trade association with a voice so loud as to be heard from coast to coast. NEA, it appears to me, has the vitality, the enthusiasm, the talent necessary to do the job.

"The first step involves the binding together of all the splinter service associations across the country. This can be accomplished with the help of the responsible individuals here tonight. These fellows can do the groundwork; they can negotiate the merging of these various associations through meetings with those leaders who see the wisdom of joining together in *one* association. . .

"There are so many benefits to be derived from a national trade association that the service industry actually cannot afford to continue on the route they are now following. It appears to me, as I am sure it must to others, that your existing trade associations spend so much time and effort fighting among themselves there can be little time left to make the necessary contributions to the industry . . . Think for a moment: One segment of this industry holding its national convention here in July, another doing the same next month in Chicago. Think how this looks to the world . . .

"I firmly believe that if you fellows had had a strong, influential, and well-financed national trade association, supported by every electronic service technician in the country, you would not have—in recent years—let millions, perhaps billions of dollars in electronic sales and service literally slip through your fingers. I refer to the electronically controlled garage door business, intercom, marine radio, mobile radio, hi-fi, electronic organ, Citizens Band business—and on and on—all slipping through your fingers. The fact that the service industry has virtually refused to sell and service these products has not helped your image.

"And now we are in an era where we find heavy electronic application in the medical profession and even heavier application in the computer industry. Consider the digital read-out manufacturers who are looking for warranty repair stations. How many of you are going to sit idly by and let these opportunities slip through your fingers?

"A strong, healthy, and properly functioning trade association could have supplied you with marketing trends and data that would have provided you with information with which to prepare yourselves for handling the business I have just outlined. This is an important function of a trade association.

"You now need the information with which to prepare yourselves for the shocking changes that will take place in this industry within the next ten years. What are you going to do when every new TV set is completely modularized, could possibly require very little service? You had better start preparations now, attend every 'Home' Show and Electronic Trade Show available to you to learn about the new electronic gadgets for the home that will be quite commonplace five or ten years from now. You must branch out into these other areas of electronic service. Somebody is going to do it. It had better be you.

"Every town and neighborhood in larger cities should *now* have an electronic service center, capable of repairing any electronic *and* electric gadget to be found in the American home. You notice I said 'electric' as well as electronic. Yes, I recommend that you gear yourself into this phase of service too. Through a *cooperative* effort you can do anything that must be done. The electrical industry is getting into your business; you had better get into theirs. It should be a part of your over-all 'survival' plan." ▲

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SR-202 REVERBERATION AMPLIFIER — The most dramatic new component in years! No matter what your system is, the SR-202 adds dimension and greater realism to your stereo sound than you can realize. The SR-202 increases the natural quality of your recordings and tapes. Reverberation can be added to an audio amplifier using one or two tape recorders, a record player, or a tuner. In fact, a total of 15 equipment combinations are possible. $95.00

These three Pioneer Outperformers are each housed in a handsome cabinet with brushed chrome facing and Brazilian rosewood end pieces. Hear them in action at your local Pioneer dealer.

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CIRCLE NO. 115 ON READER SERVICE CARD

Radio & Television news

By FOREST H. BELT /Contributing Editor

Triniton Makes It

After repeated new-set "announcements" over the past three years, *Sony* is finally getting its 12-inch color portable into the U.S. market. You'll be seeing ads—in full color, appropriately enough—telling how and why the "Trinitron" picture tube is "better" than shadow-mask tubes. The Trinitron, you may remember, is a one-gun color tube that produces three beams. The red, green, and blue phosphors are laid down in vertical stripes on the screen. They are masked by an aperture grille, a sheet of thin bars that make sure the deflected beams fall on the proper color phosphors. Ads claim greater brightness over shadow-mask tubes. American tube-makers may challenge that, since they have the new black-surround and new gadolinium phosphors on their super-bright color CRT's. Numbers of the small *Sony* sets are still limited. A larger-screen version has been introduced in Japan, and will probably make it to the U.S. some time in 1970.

X-Rays—Clean Bill of Health

The Bureau of Radiological Health, the new arm of the U.S. Department of Health, Education, and Welfare, now admits it has no evidence that television x-radiation has ever caused any illness or other harmful effect. This revelation came with BRH's final setting of reasonable standards for color-set radiation. The schedule looks something like this:

(1) By January 1970, all properly adjusted color sets coming off factory assembly lines must emit no more than 0.5 mR/hr of x-radiation; that's a sensible limit, far below any possible harmful dose, and much more practical than the 0.1 mR/hr which was to be demanded, according to earlier reports.

(2) By June 1970, color sets must include some means of limiting x-radiation to 0.5 mR/hr, even when badly misadjusted.

(3) By some time in 1971, chassis design must be such that radiation cannot exceed the limit, no matter what kind of breakdown occurs in the chassis.

This still may not be the end of news about x-rays in color sets. The subject has now become a matter of concern to the fraud divisions of many police departments. It seems a rash of gimmick-pushers are capitalizing on the public's lingering fear of the possibility of x-rays from color TV. Small do-it-yourself "x-ray measuring kits" are popping up, some at ridiculous prices. In the opinion of BRH, none of these gadgets—usually only a few pieces of film—is of any significant value in detecting excess radiation. Maybe this new angle is something the politicians who have been looking for windmills to tilt can get their lances into.

More Super-Bright Picture Tubes

After *RCA* and *Zenith* almost simultaneously announced their new extra-bright color picture tubes, with black masking around each phosphor dot to cut down wasted beam energy, other makers joined in. *Admiral* has one with the black-surround like *RCA's; General Electric* has one with new brighter gadolinium phosphors; *Motorola* has a bright-phosphor tube; *Sylvania* has a brighter version with "improved" phosphors; *Magnavox* will buy someone's version for its high-end models. Brighter screens mean higher prices, too. All sets using the new CRT's carry net prices higher than equivalent models without the bright tubes.

From the Top

It's no wonder consumers complain. A lot of them get raw treatment. Service people give them excuses why the set can't be fixed properly, promptly, or reasonably. Complaint managers turn a deaf ear or give an unknowing shrug to questions about warranty. Manufacturers can't come up with replacement parts, even for sets that are a year old. Is it any wonder consumer protectionists are having a field day?

What seems to annoy people most is the uncaring attitude that is so common these days. It's bad to generalize, but this serious problem is plaguing most of the country today. It is especially damaging to the already embattled service business. It's too easy to give a smart-aleck answer, to feign ignorance, to just shrug off responsibility to customers. Whatever happened to plain old-fashioned courtesy?

Something we've noticed. If you can't get satisfaction from a front-line employee, you're not likely to get any more satisfaction "on up the line." The fact is, employee attitudes reflect those "up the line." Over and over, you'll find that evasive, discourteous attitudes in the lower echelon of an organization have filtered down from above. If you feel the person you're dealing with doesn't really care that you have a problem with whatever you bought, you can safely bet the boss doesn't care either. Check it out some time.

Then turn around and apply it to your own relations with customers . . . or those of your employees. Do you consider your customers inconveniences, especially when something goes wrong with whatever you sold them? If you do, your employees will, too. Those are the kinds of attitudes that are justifying the new laws Congress is arming consumers with. When the worm turns, will it be on you? Have you been treating your customers, whoever they are, the way you want to be treated?

Television Satellite for Canada

The distinction of being first with satellite-beamed domestic television seems likely to go to our neighbor to the north. Telesat, as it is called, goes into a parking orbit early in 1972. It will hover over the equator and concentrate its directional antenna over the entire area of Canada. The beam will touch some of our northernmost states and Alaska. We're helping design the bird and our own NASA will launch it. But the project is strictly Canadian. We might get some use from it in Alaska, but no agreement to this effect has been signed.

The satellite will have six two-way TV-type channels. Two of them will be subdivided into hundreds of communications channels for telephone circuits to remote regions. One will be held in reserve in case another fails. Only three will carry television.

The Canadians, for the good of their outlying territories, overcame most of the thorny political problems that keep the U.S. from having domestic satellites; we might pick up some pointers from their way of getting it done.

Whose Fault?

Visiting in shops around the country, we sometimes get some eye-opening viewpoints about "what's wrong with the repair business." In a midwestern shop not long ago, it was obvious business was bad and getting worse. The owner had laid off his two men, although one helped out evenings on occasion. Inevitably, the talk got around to what makes the business "so bad."

This technician/owner insisted he is a victim of circumstances. We put the question, "What does the technician or the industry do wrong?"

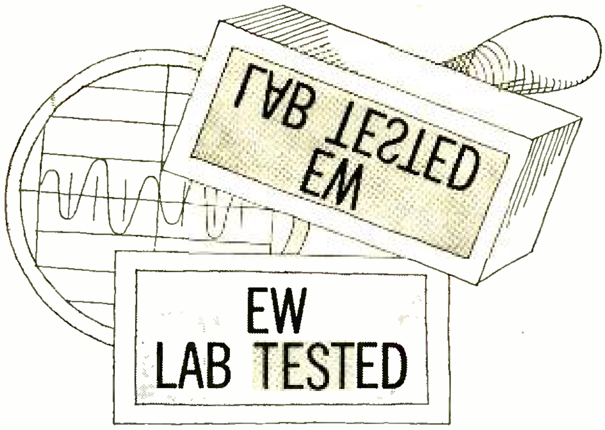
He answered, "Nothing. You can't blame the serviceman. It's just a rotten business. The customers give you hell for no reason at all. Nearly half my calls are to go back and fix some set that didn't stay fixed. And the customer wants it for free this time. It's not my fault the sets won't stay fixed. If the manufacturer only made the sets right, there wouldn't be any need for so much repair work. And the chiseling customers won't let you charge enough to make anything even when you fix it. No, it's just a lousy business. I'm gonna close up shop one of these days and get a decent job."

The windows were dirty. The floor hadn't been swept in weeks. The bench was cluttered. There were no shelves and the chassis were strewn around the floor. The owner wore dirty shirt and trousers. The newest piece of test equipment was about 12 years old, and a narrow-band scope was under the bench covered with dirt. There was one drawer with a few sheets of service literature. "I do my servicing mostly from memory," he told us.

For him it really is a rotten business. But we simply couldn't agree that he was doing everything right. This man isn't a victim of circumstances; they are his victim.

Flashes in the Big Picture

One complaint about inboard warranties is that manufacturer picks servicer; *Midland International Corp.* of Kansas City, lets customer choose own service company if warranty repairs become necessary.... New Chairman of FCC is Dean Burch, former Republican National Chairman; replaces Rosel H. Hyde.... Station manager and owner Robert Wells replaces James J. Wadsworth as FCC Commissioner; first time in long time Commission has had experienced broadcaster. . . . New booklet "How to Buy Color TV" produced by Electronic Industries Association and Better Business Bureau; quantities ($3 per 100) from National Better Business Bureau, 320 Park Avenue, New York, N.Y. 10017. . . . *Philco-Ford* supplied thousand transistor radios to help rescue agencies get word to Hurricane Camille victims. . . . Electric utility companies are helping dealers in their areas promote color-TV sales; example is *Cincinnati Gas & Electric*, with theme "Color Turns You On;" helps several hundred dealers. ▲



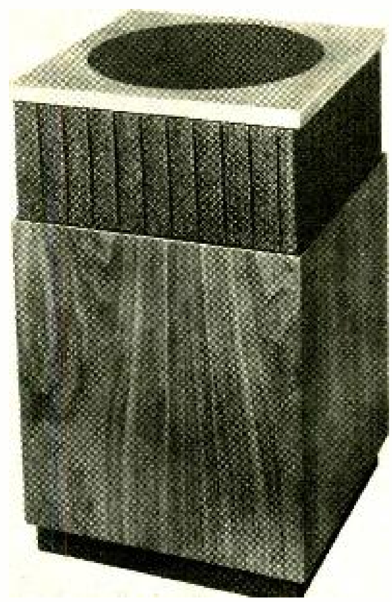
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Harman-Kardon HK50 Speaker System
Dual 1212 Automatic Turntable

Harman-Kardon HK50 Speaker System

For a copy of manufacturer's brochure, circle No. 34 on Reader Service Card.



ALTHOUGH the concept of omnidirectional speakers is far from new, it has seen little commercial application until recently. Theoretical arguments abound—both pro and con—and we are unlikely to see any general agreement in the foreseeable future.

The basic advantage of omnidirectional speakers, according to their proponents, is that they more closely simulate the reverberant sound environment existing in the concert hall. Most sound reaching the listener has been reflected one or more times and arrives from random directions.

The usual forward-facing speaker sprays a more-or-less directional beam of sound into the room. Even though much of what the listener eventually hears is reflected from the surfaces of the listening room, the concentration of high-frequency sound along the axis of the speaker is frequently painfully audible, especially when one sits close to the speaker. The better speaker designs attempt to achieve wide dispersion of sound at all frequencies—which is just another way of describing omnidirectionality.

If the speaker distributes all frequencies without directive beaming, almost all the sound will be reflected before reaching the listener. With no concentration of energy along any particular axis, one is free to sit anywhere without being overpowered by piercing highs. This, in essence, is the appeal of omnidirectional speakers. Their sound quality is quite uniform everywhere in the room, and (this must be experienced to be believed, but it is true) they sound little different in volume and timbre at a distance of one foot than they do across the room.

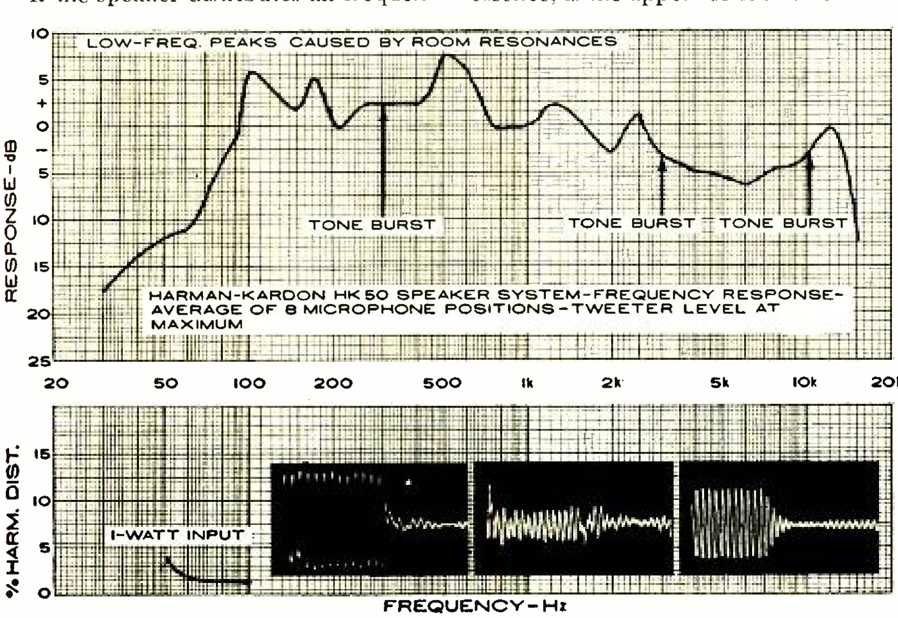
A few years ago, *Harman-Kardon* offered an omnidirectional speaker system, designed by Stuart Hegeman, in its Citation line. It was expensive and was not a commercial success. Now the company has introduced the Model HK50, a diminutive moderate-priced system that seems to be well-conceived and executed.

The HK50 is tiny—a floor-standing unit which can double as an end table or lamp support. It is 10¾" square, stands 18" high, and weighs about 20 pounds. Externally, one can see only four identical walnut sides and a top with a simulated slate insert. A black grille cloth surrounds the unit on all four sides for a distance of about 4" down from the top.

Within the HK50 is an upward facing woofer, about 8" in diameter and a small cone tweeter which also faces upward. A molded reflector disperses the sound from both drivers in all directions. The tweeter, being in one corner, is not fully omnidirectional, but the reflector is shaped for best dispersion. Under the speaker unit, in addition to the input terminals, is a tweeter level control.

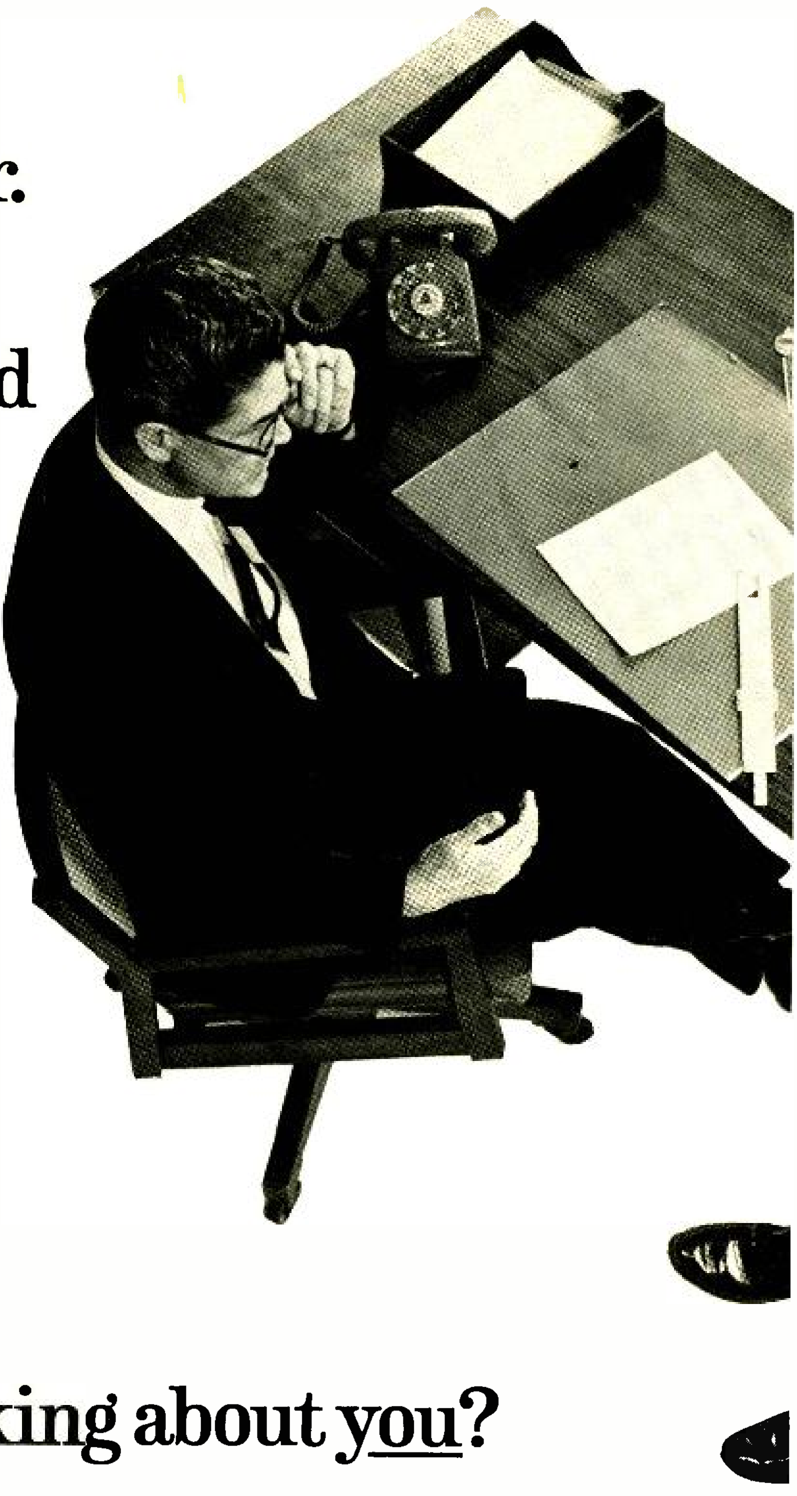
Our method of speaker testing, using the averaged output of several microphones in a "live" room, is well-suited to testing a speaker such as this one. In contrast, anechoic or free-field measurements are worthless since they measure only a tiny fraction of the speaker's total output along a single axis.

The average response curve, including all normal room resonances, was within ±7 dB from 75 Hz to 14,000 Hz. The smoothness of the response contour clearly showed that the total energy output of the HK50 was relatively uniform over the audible spectrum—a vital consideration for an omnidirectional speaker system. Many conventional speakers have fairly flat response along their major axis, but fall off badly elsewhere and



(*Continued on page 80*)

"He's a good worker. I'd promote him right now if he had more education in electronics."



Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

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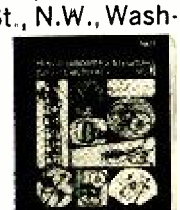

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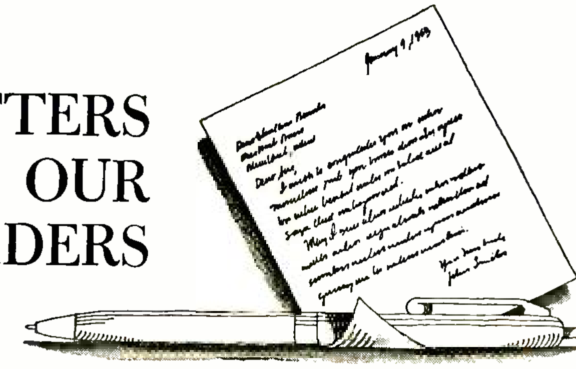
LETTERS FROM OUR READERS



STEREO VS CONCERT HALL

To the Editors:

In regard to the July letter on "Stereo verus the Concert Hall" and the comments on the ping-pong effect, I seem to remember having heard of a type of medieval musical performance in which two choirs, on opposite sides of a cathedral, sing alternate lines in a sort of statement-and-response pattern. If I've remembered correctly, the ping-pong effect is older than many people believe, and perhaps more respectable.

And I'd like to propose an experiment: In many recordings of live performances of popular and folk music, the audience reaction is very prominent in the form of applause, screaming, clapping in rhythm, etc. How about a stereo set-up in which an essentially mono performance (with some audience noise) is coming from a speaker directly in front of the listener while the second speaker, carrying only the audience noise, is direcently behind him?

THOMAS G. DIGBY
Los Angeles, Cal.

Four-channel stereo, which would do just what you have proposed, has been suggested by at least one recording company and by at least one tape deck manufacturer that we know of. We refer you to the item concerning Vanguard Records *in our September "Radio & Television News" column, and to the article "Four-Channel Stereo Adds Depth To Tapes" in our May, 1961 issue.—Editors*

* * *

TRUTH ABOUT FM

To the Editors:

For an article that was supposed to "clear up a few misconceptions about" FM broadcasting, Mr. Haskett, in "The Truth About FM" (August issue), managed to generate a few of his own misconception, notably, the misconception of the actual operation of pre-emphasized audio. Mr. Haskett states, "only the 15,000-Hz signals modulate the transmitter 100%." He makes reference to this "fact" several times in the article, and further deludes the reader into believing that frequencies less than 15 kHz will modulate the transmitter less than 100% due to pre-emphasis.

The *truth* of the matter is that pre-emphasis takes advantage of the fact that very little high-frequency energy exists in most program content, making it possible to apply high-frequency boost. In essence, the 100% modulation level for frequencies below 400 Hz is established, and frequencies above this require less level to attain 100% modulation. For example, whatever level of audio it takes at the transmitter input for 100% modulation for frequencies below 400 Hz, a signal 17 dB below that level at 15 kHz will modulate the transmitter 100%. Therefore, as the signal frequency increases above 400 Hz, it takes less and less level following the pre-emphasis curve shown in Fig. 2 to modulate the transmitter 100%.

The de-emphasis network in the receiver returns the various frequencies back to their original corresponding levels. For example, if a 15-kHz signal is fed into the transmitter at −17 dB, due to pre-emphasis, it will modulate the transmitter 100%. At the receiver, the de-emphasis network will reduce the 15-kHz signal back to −17 dB below the average program level with an attendant 17-dB reduction in noise at that frequency.

EDWARD B. BENCH, Chief Engineer
Radio Station KCFM
St. Louis, Mo.

Reader Bench is correct. Our author kept too close to the theory rather than the practice.—Editors

* * *

SCOPE & V.T.V.M. CALIBRATOR

To the Editors:

Reference is made to the July "Letters From Our Readers" column of your magazine where Mr. Neidich comments on the design practices used in my article "Low-Cost Precision Scope & V.T.V.M. Calibrator." Mr. Neidich apparently is trying to enhance stability of the circuit. While this is a desirable goal, it cannot be accomplished using his suggestions alone. The over-all voltage stability of the mercury cells is lower than that of the presently used type of resistors for *R8* and *R9*. The only reason for the use of ±1% precision resistors in the lower leg of the voltage divider is ease of calibration by one adjustment (*R9*) for all voltage ranges.

If Mr. Neidich wishes to obtain the benefits of his suggestions, the mercury cells would have to be replaced by a temperature-stabilized, precision-regulated power supply. Even the most rudimentary double zener-regulated, thermally stable supply would increase the cost of the project so as to disqualify the title "Low-Cost Precision Scope & V.T.V.M. Calibrator."

G. A. Lehmann
Tonawanda, N. Y.

* * *

FM STEREO OR STEREO FM

To the Editors:

Now that the word "monaural" is nearly completely eliminated from the audio vocabulary (only a few recalcitrant retailers and advertisers are still using this incorrect and obsolete word), it is time that the audio professionals and enthusiasts do something about the other piece of jargon, "FM stereo," that has become noticeable recently.

The term "FM stereo" is backwards. It should be "stereo FM." The contrast is between mono FM and stereo FM, monophonic frequency modulation and stereophonic frequency modulation, not "frequency modulated stereophony" as implied by "FM stereo." The complete phrase is "stereo multiplex FM radio receiver/tuner/broadcast;" any of these words can be used *in this same order*, as in "stereo multiplex," "stereo FM receiver," "multiplex FM," "multiplex FM tuner," and so on. Any other word order violates the normal word relationships, the order of modifiers and subordinates, of the English language.

Now is the time for the audio field to eliminate the jargon of "FM stereo."

Philip N. Bridges
Ashton, Md.

We do use the term "stereo FM," but since most manufacturers and broadcasters seem to prefer "FM stereo," we have frequently gone along with them when discussing a particular hi-fi product. Although we tend to agree with Reader Bridges, as does our sister publication Stereo Review, *there is some justification for the use of "FM stereo." For example, a broadcaster may want to describe stereo reproduction by FM broadcasting (using the multiplex technique) as opposed to the old stereo broadcasting using AM and FM, or stereo on tape or on discs. In which case, he could talk about "FM stereo," "AM/FM stereo," "tape stereo," or "disc stereo."—Editors*

* * *

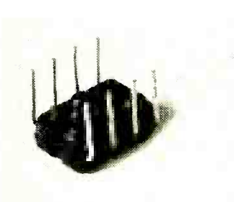
SONY/SUPERSCOPE ADDRESS

In our Japanese Trade-Name Directory," which appeared on p. 75 of the August issue, the New York address given for Sony Corp. of America *is to be used only for radios, TV's, and audio equipment. For tape recorders and magnetic tape, the proper address is* Superscope Inc., *8150 Vineland Ave., Sun Valley, Calif. 91352.* ▲

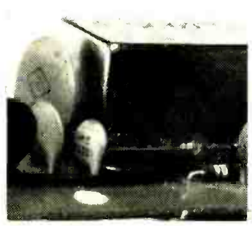
How man's conquest of the moon helped Scott develop the world's most advanced AM/FM Stereo Receiver

The billions of research dollars expended towards America's race to the moon helped foster the development of many entirely new electronic devices. Alert Scott engineers realized that the adaptation of some of these devices could result in significant advances in the performance of high fidelity components . . . a realization that inevitably led to the development of the 386 AM/FM stereo receiver.

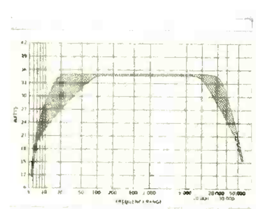
The 386 represents a level of sound quality and performance characteristics that is a giant-step ahead of any stereo component ever before available . . . utilizing entirely new features that help you control incoming signals with a degree of accuracy never before possible . . . incorporating new assembly techniques that guarantee superb performance over periods of time previously thought unattainable.



There are 7 ultra-reliable Integrated Circuits in the 386 . . . more than in any other receiver now on the market. These 7 circuits include a total of 91 transistors, 28 diodes, and 109 resistors!

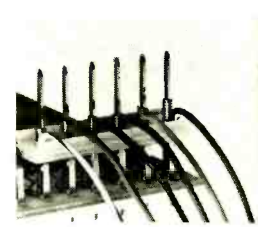


Quartz crystal lattice filter IF section, never before found in a receiver in this price class, ends the need of IF amplifier realignment, and gives very low distortion and high selectivity.



Higher power at lower distortion: The shaded area indicates where competitive receivers tend to rob you of full response in the extreme lows (organ, bass drum) and highs (flutes, triangles, etc.)

Perfectune, a computer logic module, decides when you've reached the point of perfect tuning *and* lowest distortion, then snaps on the "Perfectune" signal light.



Wire-wrap terminal connections and plug-in printed circuit module construction result in the kind of reliability usually associated with aerospace applications.

386 Specifications

Total power (± 1 dB) 170 Watts @ 4 Ohms. IHF Dynamic power, 67.5 Watts/channel @ 4 Ohms; Continuous power, both channels driven, 42 Watts/channel @ 4 Ohms, 35 Watts/channel @ 8 Ohms; Distortion < 0.5% at rated output; Frequency response (± 1 dB), 15-30 KHz; IHF power bandwidth, 15-25 KHz. FM usable sensitivity (IHF), 1.9 μV; FM selectivity, 42 dB. Price, $349.95.

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CIRCLE NO. 102 ON READER SERVICE CARD

The OSCILLOSCOPE EVOLUTION

By JAMES W. GRIFFIN/Tektronix, Inc.

Multiple plug-in capabilities, electronic character generation, bright CRT's, and permanent display recording are some of the exciting innovations that have opened up new application areas for this basic test instrument.

THE oscilloscope has indeed come a long way! Approximately 40 percent or some $200 million of the total instrument sales per year is captured by the scope. Today the oscilloscope is the most widely used instrument in the laboratory. At one time it was the most difficult to use and had limited capability; its name was not even the same. In the late 40's the single timebase, fixed-frequency oscilloscope with a triggered sweep and calibrated timebase was introduced by *Tektronix*. Because of its fixed frequency and sensitivity, however, there remained the need to buy a new scope for each new measurement requirement. The early 1950's saw the advent of the first plug-in oscilloscope and a new versatility in instrumentation. The user now had the option of employing the same equipment for dual-trace and differential measurements and could change the sensitivity and scope capability with the simple insertion of a plug-in unit.

As the years passed, measurement requirements changed and the oscilloscope rose to the occasion. Today it is capable of making measurements in many different domains.

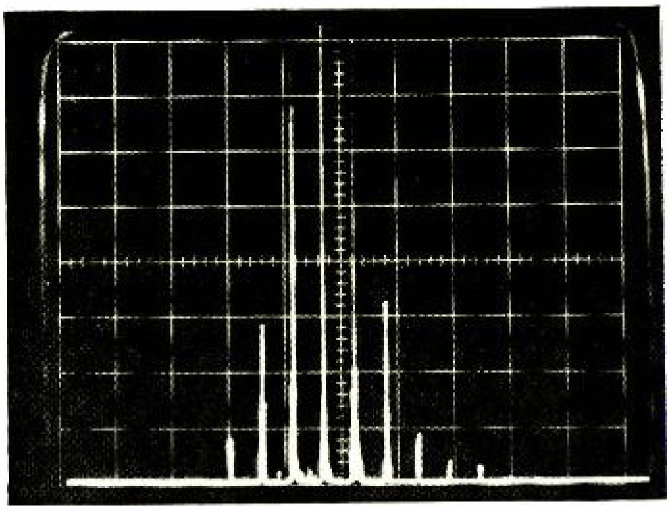
Microwave

In microwaves the scope finds use in two broad areas. First, as a sampling instrument where the signal is measured at many points in time. Its performance is similar to an ideal instantaneous voltmeter, which on command not only measures the instantaneous amplitude of a signal but remembers its value. The second important application is its use as a spectrum analyzer (Fig. 1) which measures frequency stability, amplitude modulation, frequency and pulse modulation, and makes ECM, time-domain, antenna pattern, video pulse spectra, and wide dispersion measurements. Add to this the oscilloscope's ability to store a CRT display so that it may be observed for any period of time, and the mind begins to envision how versatile the scope can be.

Television

The TV industry enjoys a new flexibility in waveform monitoring. Signal-level monitoring, bandwidth and differential gain measurements, sine², pulse and bar testing (Fig. 2), monitoring vertical interval test signals, transmitter percentage modulation measurements, YRGB displays and others are possible with the scope. Vectorscopes have been designed to measure luminance, hue, and saturation of the color-television signal (Fig. 3). Dual inputs permit time-shared displays for comparison of input-output phase and gain distortion. Phase shifts produced by unequal signal paths are easily canceled, leaving only phase and amplitude

Fig. 1. A display of an overmodulated AM signal as seen when the oscilloscope is functioning as a spectrum analyzer.



OSCILLOSCOPE KITS

By C. A. ROBERTSON / Heath Company

THE degree of sophistication obtainable in oscilloscopes offered in kit form is limited only by practical market considerations; there are no significant technical or actual assembly considerations. Because the savings and do-it-yourself aspect of kits appeal mostly to the hobbyist and part-time technician, the higher sales volumes are achieved in less sophisticated scope designs. Few hobbyists or service technicians need a d.c.- to 50-MHz scope with calibrated sweep delay and plug-in units. Those working in research or production facilities, requiring such an instrument, generally shun the time involved in assembling a kit. More sophisticated oscilloscope kits are further limited by the practical problem of obtaining alignment equipment which is good enough to insure the specified performance. Good scope calibrators are seldom found outside instrument maintenance and manufacturing plants.

As the preceding comments imply, the most popular oscilloscope kits are those for general-purpose use and television service. Typically, the basic bench instrument for every electronic hobbyist and technician is the 5-inch a.c.-coupled oscilloscope with a vertical amplifier frequency response of 5 MHz and a maximum horizontal sweep spread of 500 kHz. This scope, available in kit form for less than $100, has been constantly refined over the years. Even lower-cost 3-inch scopes are available in kit form, but they enjoy less widespread acceptance because of the smaller screen size.

What is currently considered a basic oscilloscope for development and industrial applications, roughly corresponding to the more sophisticated scopes, is now available in kit form. An example is the 5-inch d.c.- to 8-MHz vertical bandwidth scope with triggered sweep, calibrated vertical attenuator, calibrated time base, and vertical signal delay lines selling in the price range of $180 to $250. Despite the fact that alignment to full specifications after assembly of this more "advanced" kit oscilloscope taxes the capability of most calibrating equipment readily available to kit builders, its added features make it worthwhile for those seeking better performance and ease of operation.

While the practical market considerations outlined above will continue to limit the sophistication of oscilloscope kits in the foreseeable future, some advancements will occur, primarily in the area of vertical amplifier frequency response. Of greatest significance, however, will be the trend to solid-state circuitry in all oscilloscope kits with the benefits of better over-all performance, increased reliability and reduced size.

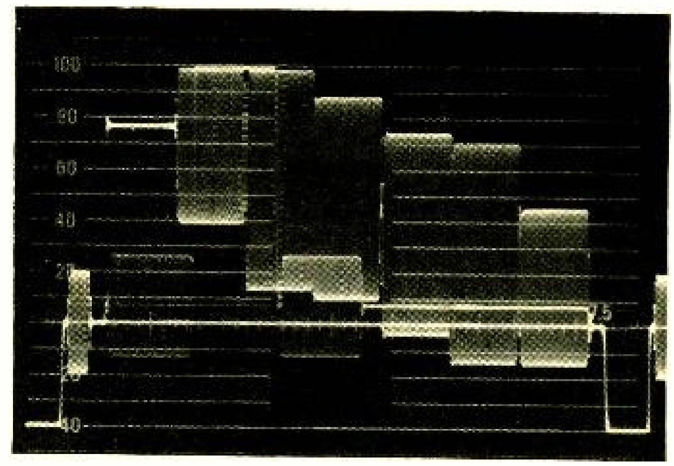


Fig. 2. A TV monitor display of split-field color bars.

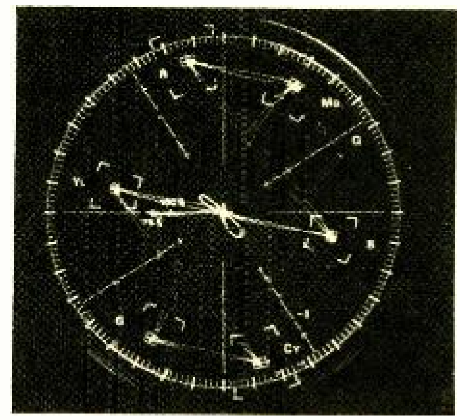


Fig. 3. A vector display of full-field color bars.

distortion caused by equipment deficiencies. Differential gain and phase measurement capabilities are provided with accuracies within 1 percent for gain and 0.2 percent for phase. Push-button controls offer new operating convenience and permit rapid selection of displays for quick analysis of TV-signal characteristics.

Medicine

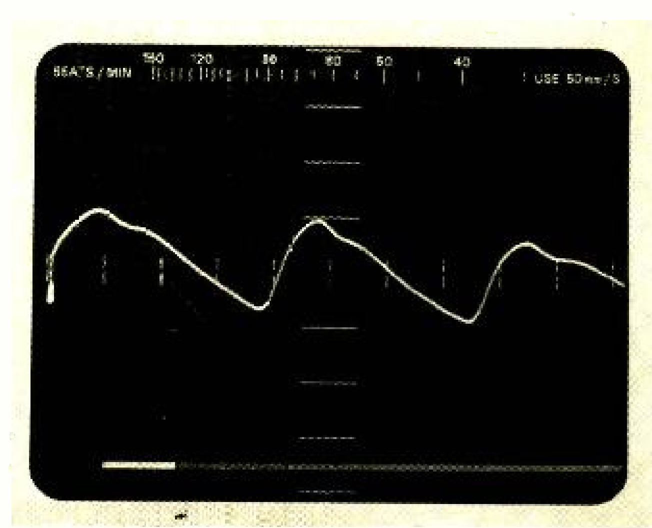
Outside the normal electronics industry the oscilloscope is found in such places as hospital operating rooms where portable self-powered physiological monitors are in use. One available solid-state physiological monitor features easy-to-read displays of ECG, EEG, and auxiliary inputs on a 5-inch screen. A heart-rate scale scribed along the top of the display permits direct reading of heart rate in beats per minute (Fig. 4) while an audible tone is provided for heart beat or pulse monitoring when viewing ECG input waveforms.

Mechanical Industry

The mechanical industry also benefits from the oscilloscope. An engine analyzer has been designed to eliminate the guesswork in locating possible failures in gas and diesel engines and compressors. The engine analyzer provides four simultaneous displays (Fig. 5) of engine pressure, ignition, vibration, and crankshaft rotational marks *versus* time or crankshaft rotation. When used in conjunction with a preventive maintenance program, the engine analyzer can reduce substantially maintenance cost and increase engine and compressor life and efficiency.

The engine analyzer detects and locates malfunctions such as faulty ignition, timing, faulty valves, blowby, and broken or frozen piston rings. Damaged bearings, low compression pressures and other failures that impair the performance of the engine are also indicated on the scope. With the use of a rotational function generator and pressure transducer, engine horsepower can be calculated. A *Tektronix* engine analyzer consists of a Type 561B oscilloscope with specially designed engine analyzer timebase and amplifier plug-ins.

Fig. 4. Pulse display showing approximately 75 heart beats/min.



RECORDING OSCILLOSCOPE

By A. H. SEIDMAN / Contributing Editor

Here is a versatile oscilloscope that has the ability to both measure and permanently record frequencies up to 1 MHz.

THE need for making permanent recordings of analog and digital data on paper or film is ever prevalent in the engineering and scientific communities. Commonly used instruments for this purpose are strip-chart and X-Y recorders. Because of their limited bandwidth, typically under 100 Hz, engineers and technicians find their use restricted to the recording of slowly varying phenomena, confined to two axes.

The recording oscilloscope, also referred to as an oscillograph, with its greater bandwidth opens up new possibilities in the recording of rapidly varying data. *Honeywell's* Model 1806A second-generation instrument, dubbed the Visicorder, features a fiber-optic CRT and has the ability to measure and record data at frequencies up to 1 MHz on four axes. The unit, selling in the $12,000 price range, is supposedly 100 times faster than any direct-write system on the market.

A block diagram showing the essential features of the 1806A recording scope is given in Fig. 1. The four recording axes are: X-axis (time base or horizontal), Y-axis (amplitude or vertical), Z-axis (spot intensity), and the Y′-axis (movement of recording medium). Four axes allow the recording of continuous and transient signals that previously required magnetic-tape or oscilloscope-camera techniques. Video pictures, one frame at a time, can be printed as a continuous series of 3″ × 5″ rasters on direct-record paper for immediate viewing. Reference grid lines in the horizontal and vertical directions are recorded by means of light from a flash tube. Several recording media can be used at different trace speeds. Trace velocities greater than 12 million in/s have been recorded on *Kodak* RAR-2490 paper; using *Kodak* Ektaline 12 paper, more than 40 million in/s can be recorded.

The phosphor on the faceplate of the CRT is selected to have a spectral output matching that of the recording medium, providing an efficient transfer of energy to the light-sensitive record. Light from the CRT is focused on the record by a fiber-optic faceplate on the CRT. The record is in intimate contact with the faceplate. As the paper, driven by a high-speed servo motor, emerges from the instrument it is developed by an ultraviolet light source. The process, called latensification, causes the latent image of the signal to appear within seconds as a permanent record.

Applications for the Model 1806A Visicorder are virtually unlimited. To cite a few of its uses, they include the recording of low- and high-speed facsimile records, high-speed PCM telemetry signals, and on-line spectrum analysis. It has been also used to record and measure such mechanical data as strain, force, vibration, and stress, and temperature and pressure. In medical applications, the transverse recording mode using intensity modulation is suitable for cardiovascular data. Because of its good high-frequency response, the instrument can record single-beat vectorcardiograms up to heart rates of 2000 per minute. The 1806A appears quite versatile and its potential for numerous other applications seems limited only by the user's imagination.

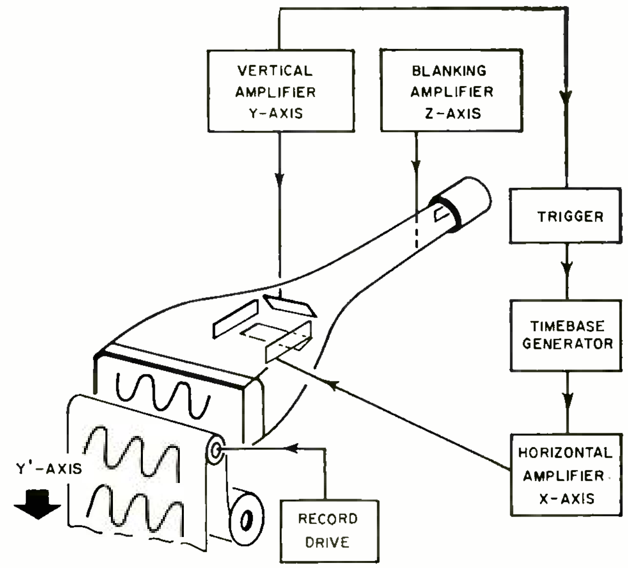


Fig. 1. Scope diagram showing the four recording axes. Data is recorded in both normal horizontal (X-axis) and transverse (Y-axis) modes, in addition to intensity modulation (Z-axis) and paper motion control (Y-axis) modes.

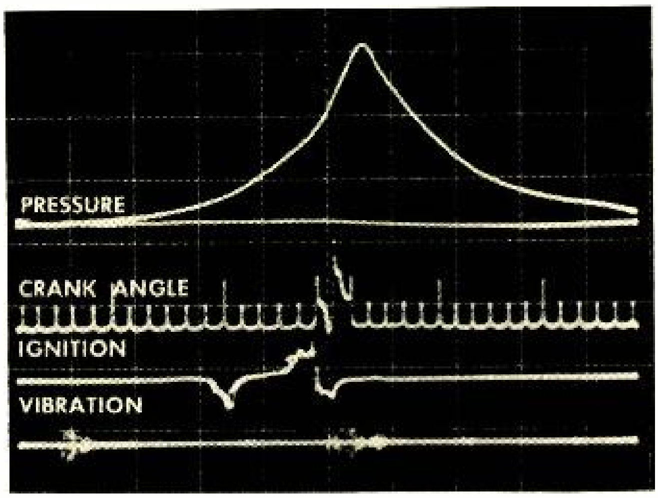
(Editor's Note: The fabulous growth of electronic automotive testing stations throughout the country in the last few years gives testimony to the effect that the oscilloscope has had upon the mechanical industry.)

Four Plug-In Scope

Over the years the plug-in oscilloscope has been improved upon and expanded in the areas of higher bandwidth, faster sweep rates, and improved CRT characteristics. We have now literally outgrown the present design approach. In the face of the increasing rate of technological change, a new oscilloscope series has been developed with an unprecedented degree of flexibility as insurance against obsolescence. The intent of this product line (7000 Series) is to establish a new base from which *Tektronix* can better provide for customer requirements of today and tomorrow.

The unprecedented flexibility is realized by the use of a four plug-in concept: two plug-ins for the vertical and two plug-ins for the horizontal deflection systems. Switching between the two vertical units is done in the mainframe as is switching between the two horizontal plug-ins. With a full complement of plug-ins, two amplifiers and two timebases, some possible displays are: (1) a single amplifier plug-in

Fig. 5. Simultaneous waveform display of four engine parameters. Reading waveforms from top to bottom: engine pressure; crank-angle markers in the center indicating the top dead center; engine ignition; engine vibration showing the valves opening and closing and some of the vibration due to combustion.



DISTRIBUTED PLATES IMPROVE CRT RESPONSE

By ARTHUR H. PETTIS / Technical Editor, Hewlett-Packard

A new CRT, featuring a novel distributed deflection system, permits oscilloscope to display signals as high as 250 MHz.

A SCOPE that can display signals as high as 250 MHz is the most recent addition to the *Hewlett-Packard* 180 oscilloscope family. A new cathode-ray tube using a novel distributed deflection system (Fig. 1) for the electron beam, with a cut-off frequency greater than 500 MHz, is the heart of the instrument. The 250-MHz response is limited only by the vertical amplifiers. The 183 mainframe, with the 1830 vertical amplifier and 1840 timebase plug-ins, sells for $3150.

In designing this product many factors had to be considered. It was necessary to ensure that plug-ins used in the 180-series family be compatible with the new system design. Another requirement was that the instrument not be limited by present state-of-the-art, permitting the customer future flexibility when new devices and techniques become available. Finally, the sweep circuits had to be fast enough to display present and future input signals.

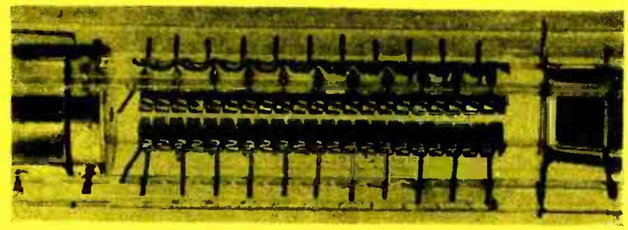


Fig. 1. Distributed deflection system used in 250-MHz scope.

A New CRT

The cathode-ray tube was the obvious source of the problem. A CRT capable of being driven with existing plug-ins must have a 3-V/cm deflection sensitivity with a risetime far less than can be considered state-of-the art. The risetime limitation of a cathode-ray tube is proportional to the length of the deflection plates divided by the velocity at which the electron beam travels between the plates. In other words, the time it takes for a single electron to pass from one end of the deflection plate to the other, referred to as transit time, determines the risetime or, since they are related, the frequency response of a CRT.

Consider a conventional cathode-ray tube with a pair of single-piece deflection plates. Assume that at some arbitrary time, $t1$, there are four electrons traveling between the plates. Just after the first electron leaves the plates at time $t2$, a switch is closed, making the top deflecting plate E-volts positive with respect to the bottom plate. Because the first electron was outside the deflection plates when the switch was closed, it proceeds to the phosphor screen undeflected. The other three electrons, however, are deflected by an amount that is proportional to voltage E and the time it takes to travel between the plates. Since E is constant, the deflection of the electron therefore becomes proportional to the time the electron finds itself between the plates. The fourth electron has to travel the entire length of the plates and is deflected by an angle $ø$; the third electron by an angle $2ø/3$; and the second electron by an angle $ø/3$. Consequently, instead of getting an output on the CRT approaching the ideal case, where the risetime is zero, a waveform is obtained with a risetime greater than zero, which can be quite appreciable in many applications.

By splitting the deflection plates into segments and introducing the delay (D) between segments, the structure, shown in simplified form in Fig. 2, is obtained. The delay between each segment matches the speed of the electrons in the beam. The electrons are deflected as they pass the first segment and are deflected again as they pass the next segment (shown by dashed circles). This occurs because the applied vertical deflection signal progresses from one segment to the next at the same speed as the electrons travel through the deflection region. As a result, a smaller risetime is obtained than is possible with a conventional CRT.

The delay between segments is inherent in the structure of the deflecting system. Each segment is in the form of a flattened helix that provides the inductance and capacitance for an equivalent parallel LC network. The CRT uses 20 segments and has an average characteristic impedance of 330 ohms.

Other Features

The existing plug-ins for the 180 scope were designed to drive a conventional CRT. This problem was solved with a switching network that shorts the elements of the distributed deflection system when the lower frequency 1800 series plug-ins are inserted into the mainframe. When using the new 1830 vertical plug-in the distributed deflection system in the CRT is utilized. Compatibility is therefore obtained while allowing the new distributed deflection system to be used in the same mainframe.

Another consideration was that the writing speed of the CRT be sufficiently high so as to be compatible with the advanced systems. The writing speed can be increased by raising the accelerating voltage, decreasing the spot size, or increasing the beam current. The standard method used in high-frequency oscilloscopes has been to increase the CRT potential. This was not acceptable because the beam has less time to be acted upon by the deflection system and violates a design requirement that the CRT be capable of being driven by existing plug-ins.

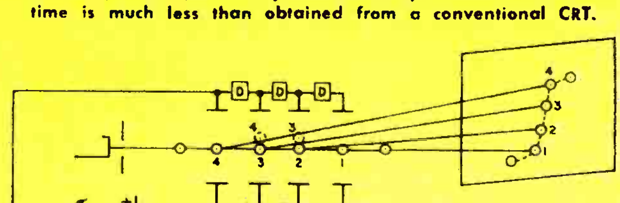
By using a divergent lens after the deflection structure one realizes both high deflection sensitivities and high accelerating potentials. Greater effectiveness is obtained if the divergent lens is a domed screen mesh. The divergent lens has the equivalent effect of shortening the physical length of the cathode-ray tube while maintaining the deflection sensitivity of a very long tube. An accelerating voltage of 20 kV is used and, with the aid of the divergent lens, both high deflection sensitivity and high writing speeds are provided within the same instrument.

Another feature is the flood gun, which consists of a separate heater-cathode structure inserted in the CRT. The flood gun scatters electrons over the CRT phosphor, illuminating the face of the tube and the graticule. This feature of the 183 scope is especially useful when photographing high-speed transients since the flooding increases the writing speed of the film.

Future Prospects

The 250-MHz scope bandwidth is limited by the vertical amplifier, a 5-stage array of monolithic IC's. It is not unlikely that the frequency response of these amplifiers will be extended in the future. If the frequency response of the vertical amplifiers is pushed up far enough, the scope will be limited only by the CRT, which has a frequency response in excess of 500 MHz. ▲

Fig. 2. Deflections of electrons in CRT using segmented deflection plates separated by inherent delay networks. The risetime is much less than obtained from a conventional CRT.



displayed on two separate timebases, (2) two amplifier plug-ins, each displayed on a separate timebase; this is a conventional dual-beam, dual-timebase display, and (3) two amplifier plug-ins, each displayed on two separate timebases, providing a four-trace display.

If the plug-ins are re-arranged, the possible number of displays expands. As an example, consider the amplifier-timebase-amplifier-timebase plug-ins, arranged from left to right in the mainframe. Possible displays using the mainframe vertical and horizontal mode switching are single-trace raster T-T, single-trace X-Y or Y-T, and dual-trace displays of either X-Y and Y-T, Y-Y and T-T, or Y-T and T-T. Couple to any of these a wideband d.c. Z-axis input, and the possibilities increase further. A list of the key specifications for both mainframes and major plug-ins are summarized in Tables 1 and 2.

VERTICAL AMPLIFIER PLUG-IN	BANDWIDTH		MINIMUM DEFLECTION FACTOR	IMPORTANT FEATURED PERFORMANCE
	7704	7504		
7A11 ($850)	150 MHz	90 MHz	5 mV/div	Low capacitance FET probe amplifier
7A12 ($700)	105 MHz	75 MHz	5 mV/div	Dual-channel amplifier
7A13 ($1100)	100 MHz	75 MHz	1 mV/div	Differential d.c. offset high freq. CMRR amplifier
7A14 ($575)	50 MHz 105 MHz	45 MHz 75 MHz	1 mA/div	Current probe amplifier (2 current probes)
7A16 ($600)	150 MHz	90 MHz	5 mV/div	Wide-bandwidth conventional input amplifier
7A22 ($500)	1 MHz		10 μV/div	D.C.-coupled high-gain differential amplifier

Table 1. Key specifications for plug-in amplifiers used with the Tektronix Series 7000 four-plug-in oscilloscopes.

MAINFRAME	TIMEBASE PLUG-IN	FUNCTIONAL DIFFERENCE	MAX. SWEEP RATE	TRIGGERING FREQ. RANGE
7704 (with readout—$2500) (without readout—$2100)	7B71 ($685) 7B70 ($600)	Delaying sweep Delayed sweep & external amp.	2 ns/div	d.c.—200 MHz
7504 (with readout—$2000) (without readout—$1600)	7B51 ($510) 7B50 ($450)	Delaying sweep Delayed sweep & external amp.	5 ns/div	d.c.—100 MHz

Table 2. Specifications for Tektronix Series 7000 scopes.

Character Generation

For the 7504 and 7704 mainframes it was decided to develop a fully integrated electronic character generating system, time sharing the CRT with the displayed waveforms. Scale factors are read out as set on the plug-ins. However, magnifiers, attenuations, and identification of probes, as well as the parameter label (*i.e.*, mA or mV) are taken into account. It is capable of generating a display of eight words of up to ten symbols per word from a font of 50 characters (Fig. 6) and can recognize and execute a relatively large variety of stored instructions.

The great flexibility of this system stems mainly from the data coding techniques. Instead of using the usual binary codes, a time-multiplexed, multi-level analog current code was adopted. The symbols are stored in a matrix of ten rows by ten columns. Decoding is accomplished on the readout board by integrated A-D converters which then address the matrix. The characters are generated by a new form of stroke generator incorporating several novel features. Each stroke may have virtually any length and angle, permitting high-quality symbols to be generated by a small number of coordinate pairs.

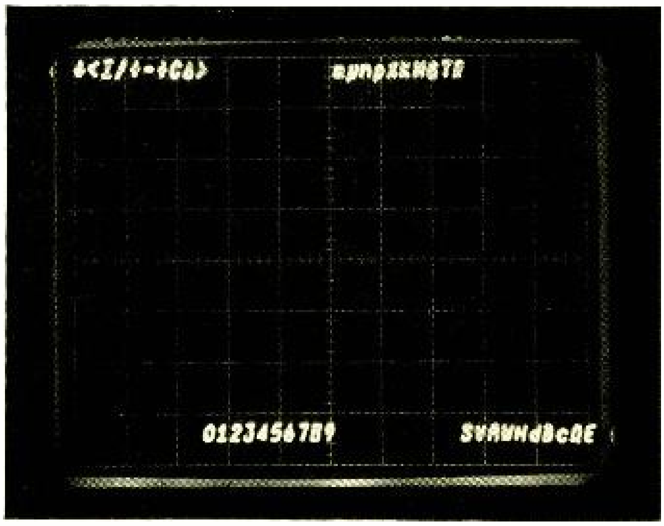
A ten-symbol set is stored on a 65-mil square IC chip. The outputs correspond to the scanned X and Y values of the complete symbol and require no further processing. Addressing is performed by a current on one line (the column select) and a voltage on another (the row select). The column select current is in the range of 0 to 1 mA and the character size is directly proportional to current. Thus, it is a simple matter to generate a display having mixed symbol sizes; electronic italicization is also possible.

Other Innovations

An innovation added to the trigger circuit is peak-to-peak auto. This function, located on each timebase, serves to normalize the trigger level control. The control maintains full sensitivity for all amplitudes of trigger signal that are within the trigger sensitivity limits and accomplishes this by peak detecting the trigger signal (Fig. 7), storing it in peak-to-peak memories, and then impressing the output across the trigger-level pot. With this function the operator would find it difficult, if not impossible, to obtain an untriggerable condition no matter where he positions the trigger level control. Slope selection is incorporated in the trigger-level control through a reduction gear. The triggering level point can be varied over 360° rotation of the control; the slope switches automatically at 0° and 180°.

Other innovations were made in the component area. Examples are small lighted push-buttons on the plug-ins, low-capacitance relays, low-torque cam switches, families of IC's, new CRT's, and a high-efficiency power supply. The power supply uses a 25-kHz transformer, high-efficiency d.c.-to-d.c. conversion regulation, small filter components,

Fig. 6. Display showing four sets of 10 symbols as written by the character generator and using the CRT for readout.



and exhibits low series-voltage loss in the series regulators. The line-to-oscilloscope circuit power conversion efficiency is 70.5 percent. Reregulated supplies are short-circuit protected by foldback current limiting and supplies not reregulated are fused within the instrument.

Many of the features of the plug-in line are found in the first of a new line of non-plug-in oscilloscopes (5000 Series). Front-panel color coding is carried over as is scale-factor readout, although in the case of the R5030 ($1850) the scale factors are read out *via* fiber optics immediately to the right of the CRT rather than time shared in the CRT. Since the user does not have the option of changing its characteristics through plug-ins, as much flexibility as possible was built into the R5030. High-gain, 10-µV sensitivity differential inputs were added to each of its two beams as was a current-probe input for each of the beams.

Leaving the laboratory environment, and considering the service industry, we find that *Telequipment*, a subsidiary of *Tektronix, Inc.*, has designed a line of oscilloscopes specifically for the service industry. A prominent member of this family, the S54 ($395), is a solid-state scope with a 6- × 10-cm viewing area. The bandwidth is d.c. to 10 MHz

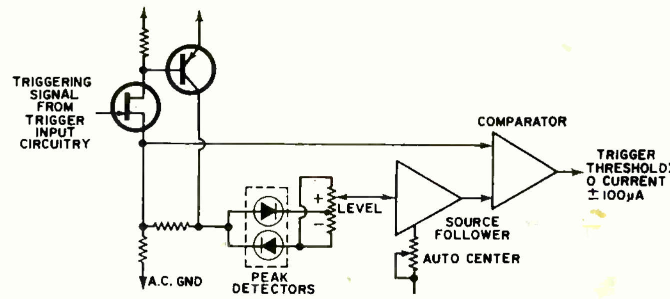


Fig. 7. Diagram of the peak-to-peak auto circuit. Located on each timebase, it serves to normalize trigger level control.

with a 35-ns risetime. It provides full triggering with automatic or level selective operation. The scope is capable of triggering on a TV frame or line for easy TV waveform triggering. Its basic sensitivity of 100 mV/cm can be increased to 10 mV/cm with a decrease in bandwidth to 4 MHz. The S54 oscilloscope, by virtue of its specifications and relatively light weight (17 lbs), should appeal to those who are actively engaged in the service industry. ▲

TRI-COLOR OSCILLOSCOPE

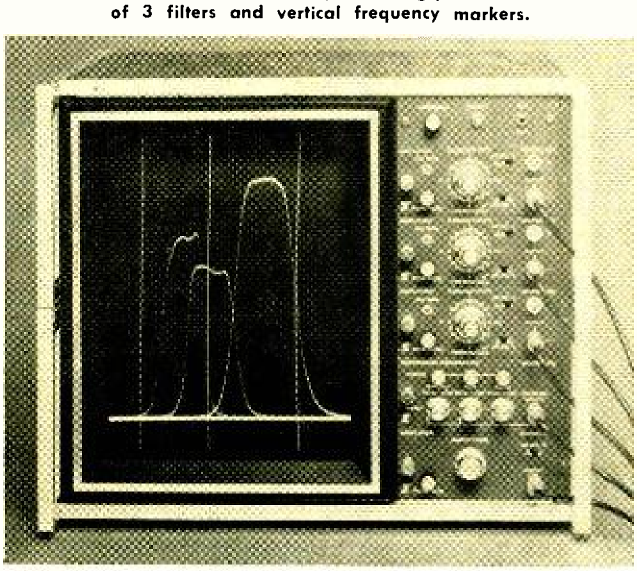
NOT to be outdone by the TV industry, a new cathode-ray tube display system featuring tri-color presentation has been introduced to the display instrumentation field by *Telonics Systems*, a division of *Telonic Industries, Inc.*

This instrument, designated the Model 201 multitrace, tri-color video display system, shown in the photo, uses a three-gun, 15″ rectangular, shadowmask CRT and accepts up to three input signals, displaying each in a different color—red, green, and blue. Since each of the input signals is identified by a specfic color, overlapping waveforms can be instantaneously identified, and the entire height of the CRT becomes available for all signals, thereby adding to the display system's excellent resolution.

Each input channel is provided with its own vertical deflection plug-in amplifier, which is available in two versions: a basic unit with a range of 100 mV/in to 10 V/in and a high-gain differential model with a range of 100 µV/in to 100 V/in. The latter unit assures maximum resolution regardless of input level. Horizontal deflection is obtained either by an external source, such as a sweep generator, or internally by an optional timebase generator plug-in unit. A calibrated control on the timebase generator permits the technician to obtain horizontal sweeps of 1 ms/in to 1 s/in.

One of the most prominent features of the Model 201 scope is another optional plug-in unit called the reference line

Telonic 201 tri-color scope showing passbands of 3 filters and vertical frequency markers.



generator. The reference line generator contains controls that permit the operator to display individually up to three vertical and/or horizontal lines on the CRT in red, green, and blue and provides an input for externally generated signals such as a time or frequency marker pulse. Consequently, since reference information is displayed in a separate mode rather than signal information, various reference lines, internal or external markers, or an electronic graticule may be generated without interference with the vertical input signal waveforms.

Operation of the display system is based on a power oscillator circuit, phase locked to the line frequency, that generates a sinusoidal current in the vertical deflection coil of the CRT. This current causes each of the electron beams to scan the entire face of the CRT at a continuous rate of 36.2 kHz. This sinusoidal current corresponds to the beam position and, by sampling the current waveform, generates a beam-position voltage that is fed, along with a reference voltage and an input signal from each vertical channel, to the corresponding voltage comparator module (red, green, and blue).

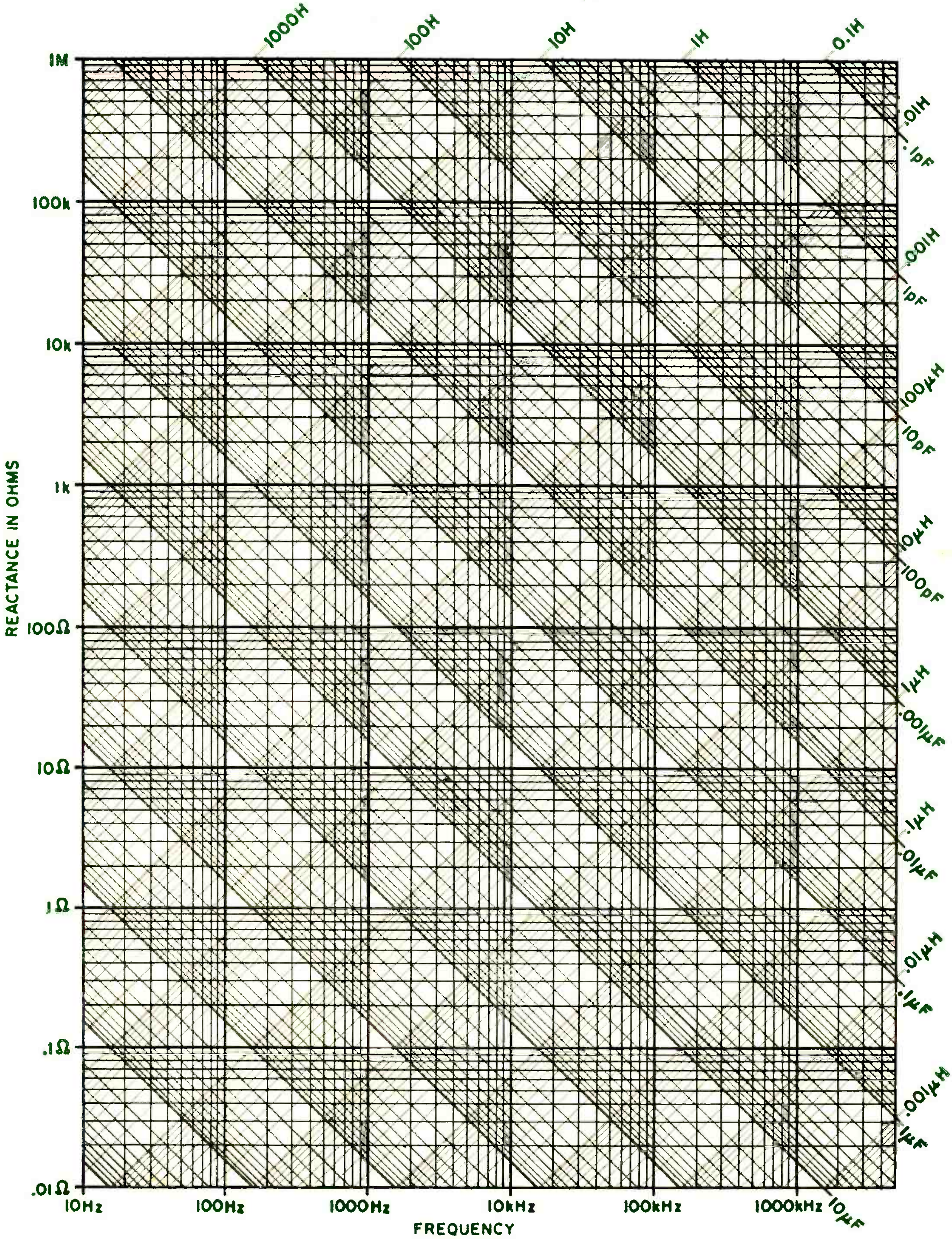
During downscan, the vertical input signal and beam-position voltages are compared and, when they are equal, a dot is generated on the face of the CRT. Likewise, during upscan, a dot is also generated on the CRT face when the comparator determines that the beam-position and reference voltages are equal. These dots, generated during vertical scan, are extended into waveforms by horizontal beam deflection. Horizontal deflection is accomplished by a feedback amplifier which forces current in the deflection coil to beam an exact replica of the horizontal channel voltage, thereby allowing up to six reference lines and three signal waveforms with up to 0.1 mV/in sensitivity to be displayed.

In *Telonic* Model 201 static and dynamic convergence corrections (convergence is basically the ability of electron beams to track each other over the CRT face) are applied to the CRT electron beams, causing the beams to track each other within one line width over the entire face of the CRT.

Power requirements for the CRT are approximately 20 kV at up to 500 microamps, furnished by a fully regulated supply integrally contained in the basic chassis. The regulation provided by this power supply eliminates voltage fluctuations which could cause unwanted modulation effects and beam-position fluctuations.

The high resolution, excellent sensitivity, and large display area (10.5″ × 7.9″) make the Model 201 an ideal instrument for use in electronics, medicine, and education. Prices for a complete Model 201 system range from $2400 to $3700, depending on the number of input channels and other plug-in modules required. ▲

REACTANCE CHART



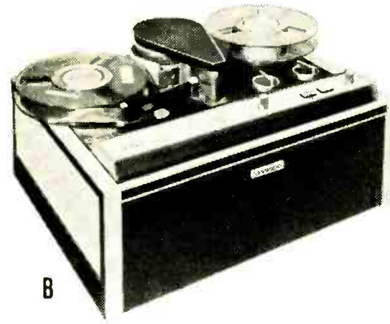
Directory of Most Popular, Low-Priced VIDEO TAPE RECORDERS

PHOTO	Model	Tape Width (in)	Tape Speed (in/sec)	Record Playback Time (min)	Cost/hr of Record Time ($)	No. of Video Heads	Est. Video Head Life (hrs)	VIDEO CHARACTERISTICS Horiz. Resolution (lines)	Bandwidth (MHz)	Signal-to-Noise Ratio (dB)	Number of Audio Tracks	MAIN AUDIO Bandwidth (Hz)	Signal-to-Noise Ratio (dB)
AMERICAN PHOTOCOPY EQUIPMENT CO., 2100 W. Dempster St., Evanston, Ill. 60204													
	VT-101	½	7.5	60	40	2	500	325	3.5	42	1	60-10,000	—
AMPEX CORP., 401 Broadway, Redwood City, Cal. 94063													
A	VR-660C	2	3.7	300	62	2	250	330	4.2	40	2	50-9000	45
B	VR-4900	1	9.6	60	60	1	1000	240	3.0	42	1	90-9000	39
	VR-7000	1	9.6	60	60	1	1000	280	3.5	42	1	50-12,000	46
	VR-7500	1	9.6	60	60	1	1000	350	4.2	45	2	50-12,000	45
	VR-7800	1	9.6	60	60	1	1000	350	4.2	42	2	50-15,000	50
BELL & HOWELL CO., 7235 N. Linder Ave., Skokie, Ill. 60076													
C	2966	½	7.5	60	40	2	1000	300	3.0	40	1	60-10,000	40
	2000	1	6.91	60	45	1	500	400	4.2	41	1	75-10,000	40
	2910	1	6.91	60	45	1	500	400	4.2	43	2	80-10,000	40
CONCORD ELECTRONICS CORP., 1935 Armacost Ave., Los Angeles, Cal. 90025													
	VTR-400	½	12	14	64	2	2000	260	—	40	1	80-10,000	40
	VTR-900	½	12	40	64	2	2000	250	—	40	1	50-12,000	42
	VTR-2000	1	8.57	67	60	2	1000	350	—	43	1	50-12,000	46
CRAIG CORP., 2302 East 15 St., Los Angeles, Cal. 90021													
	6401	½	9.5	63	48	2	1000	250	3.0	40	1	70-10,000	40
	6402	½	9.5	63	48	2	1000	275	3.0	40	1	70-10,000	40
	6403	1	7.5	96	60	2	1000	400	4.2	42	2	60-10,000	45
DIAMOND POWER SPECIALTY CORP., Box 415, Lancaster, Ohio 43131													
	DP-1	½	9.45	63	40	2	500	200	2.0	40	1	70-10,000	40
	DP-2	1	7.5	96	60	2	500	350	3.6	42	2	60-12,000	45
GENERAL ELECTRIC CO.—CCTV Business Section, 600 Old Liverpool Rd., Liverpool, N.Y. 13088													
	4TD-1-B2	½	7.5	64	40	2	1000	200	—	40	1	80-10,000	40
GPL TV SYSTEMS DIV.—Singer-General Precision, Inc. (Subsidiary of The Singer Co.), 63 Bedford Rd., Pleasantville, N.Y. 10570													
	VR-400	1	6.9	60	45	1	1000	400	3.5	43	2	75-10,000	40
INTERNATIONAL VIDEO CORP., 675 Almanor Ave., Sunnyvale, Cal. 94086													
	IVC-600	1	6.91	60	45	1	1000	400	4.2	43	1	75-10,000	40
D	IVC-800	1	6.91	60	45	1	1000	400	4.2	43	2	75-10,000	40
PANASONIC—Matsushita Electric Corp. of America, 200 Park Ave., New York, N.Y. 10017													
	NV-8100	½	12	40	64	2	—	220	2.0	40	1	80-10,000	40
	NV-8100AD	½	12	40	64	2	—	260	2.0	40	1	80-10,000	40
	NV-204C	1	8.57	67	60	2	—	350	3.0	43	1	50-12,000	46
PHILIPS BROADCAST EQUIPMENT CORP., 1 Philips Pky., Montvale, N.J. 07645													
	LDL-1000	½	7.9	40	42	2	500	200	2.0	42	1	120-10,000	40
	EL-3401A	1	9	60	60	1	500	230	2.5	40	1	120-12,000	50
E	EL-3403	1	7	60	60	1	500	325	3.8	40	1	120-10,000	40
RCA CORP.—Commercial Electronic Systems Div., Front & Cooper Sts., Camden, N.J. 08101													
	IVC-800	1	6.91	60	45	1	500	400	4.2	43	2	75-10,000	40
REVERE—Mincom Div./3M Co., 3M Center, St. Paul, Minn. 55101													
	VTR-150	½	7.5	60	40	1	2000	160	2.0	35	1	50-10,000	40
ROBERTS—Califone/Roberts Electronics Div., Rheem Mfg. Co., 5922 Bowcroft St., Los Angeles, Cal. 90016													
	1000-VTR	¼	11½	40	7	1	X	250	X	40	1	100-10,000	40
SHIBADEN CORP. OF AMERICA, 58-25 Brooklyn-Queens Expy., Woodside, N.Y. 11377													
F	SV-700U	½	7.5	60	40	2	500	300	3.5	42	1	60-10,000	40
	SV-800U	½	7.5	60	40	2	500	300	3.5	42	1	60-10,000	40
	SV-727	1	8	90	60	2	1000	360	4.5	42	2	50-10,000	46
SONY CORP. OF AMERICA, 47-47 Van Dam St., Long Island City, N.Y. 11101													
	CV-2100	½	7.5	60	40	2	—	220	—	40	1	80-10,000	40
	DVK/CVK-2400	½	7.5	20	40	1	—	220	—	40	1	100-8000	38
G	EV-310	1	7.8	60	60	2	500	300	—	40	2	50-12,000	50
VICTOR CO. OF JAPAN, LTD., 12, 3-Chome Moriyacho, Kanagawa, Yokohama 221, Japan													
H	KVC-8200	½	9.5	60	X	2	X	350	X	40	X	X	X

SPECIAL NOTES: All recorders operate with nominal video levels of 1 volt. input and output at 75 ohms impedance. unless otherwise stated. Tapes recorded on machines of one manufacturer are not normally reproducible on machines of other manufacturers unless specifically stated. **A.** Tapes recorded on Shibaden SV-700U. SV-800U, Bell & Howell 2966. and American Photocopy VT-101 are mutually interchangeable; **B.** Tapes recorded on GPL VR-400. RCA IVC-800. all Bell & Howell (except 2966) and all IVC recorders are mutually interchangeable; **C.** Records plays NTSC color; **D.** Records NTSC color. plays monochrome only; **E.** Color optional for additional $500; **F.** Color optional for additional $1000.

A

B

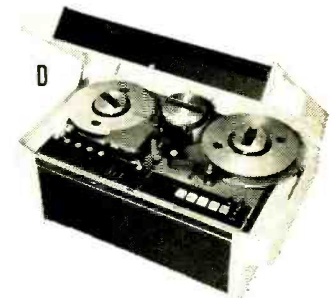


C

TRACK CHARACTERISTICS				PHYSICAL CHARACTERISTICS					
Micro Input Imp.	Line Input Imp.	Output Level	Output Imp. (ohms)	Dimensions (in) W	H	D	Weight (lbs)	Special Notes	Basic Cost ($)
Hi	Hi	−14 dBm	—	18 3/8	10 3/16	15 11/16	52.8	A, J	995
Hi	Lo	+ 8 dBm	600	30	17 3/8	14 5/8	100	—	8950
—	—	2 W	8	23 1/4	18 1/4	12 1/2	61	J, P	995
Lo/Hi	Hi	6 W	8	29	18	15	100	J. M	2500
Lo/Hi	Hi	6 W	8	29 3/4	20 1/2	13 3/4	100	E, J, L, M	4500
Hi	Hi	+ 8 dBm	600	34	19	15	140	G, L, M	9500
Hi	Hi	−14 dBm	2200	19	10.6	16.3	52	A	995
Lo	Lo	+ 4 dBm	600	25	10	14	47	B, D, E, M	1835
Lo	Lo	+ 4 dBm	600	23 5/8	13 1/2	11 3/8	65	B, D, E, M	4200
—	Hi	—	—	14 3/8	9 1/4	4 5/8	15	N, U	1250
Hi	—	− 2dBm	20 K	16 1/2	16 1/2	10	52	J, L, M, R, S	695
Lo	Lo	X	Lo	25 1/2	12	16 1/2	97	K	3750
Hi	Hi	0 dBm	2 K	21 3/4	13 3/4	17 3/4	65	H, J, M	850
Hi	Hi	−10 dBm	30 K	18 1/2	10 1/4	17 1/2	59	H, J, K, L, M	1200
Hi	Hi	+ 4 dBm	600	25	18 1/2	21	160	K	4000
Hi	Hi	0 dBm	2 K	20.8	11.6	17 1/2	66	—	995
Hi	Hi	+ 4 dBm	600	25	18 1/2	21	130	K	4450
Lo	Hi	0 dBm	10 K	16	8 3/4	14	35	V	595
Lo	Lo	+ 4 dBm	600	24	12	14	57	B, D, M	4200
Lo	Lo	+ 4 dBm	600	25	10	14	47	B, D, E, M	1835
Lo	Lo	+ 4 dBm	600	24	11 1/2	13 1/2	59	B, D, E, M	4200
Hi	Hi	0.1 V	600	17 1/4	10 5/8	17	53	R, M	950
Hi	Hi	0.1 V	600	17 1/4	10 5/8	17	63	K, M	1500
Lo	Hi	0 dBm	600	29 3/8	12 1/8	15 3/8	97	F, L, M	4250
Lo	Hi	1.0 V	2 K	16 1/2	7 3/4	13 3/8	26	—	650
Lo	Hi	1.0 V	20 K	24 3/4	15 1/4	16 1/2	100	J	995
Lo	Lo	2.0 V	600	19 1/4	9 7/8	15 1/4	48	L, M	2300
Lo	Lo	+ 4 dBm	600	24	11 1/2	13 1/2	78	B, E	6050
Hi	Hi	0.5 V	10 K	20	9 1/2	14	50	—	995
Lo	Lo/Hi	X	X	19	11 1/2	17 1/2	66	W	1095
Hi	Hi	−14 dBm	—	18 3/8	10 1/4	15 3/4	53	A, J	995
Hi	Hi	−14 dBm	—	30	11	17 1/2	75	A, J	1295
Lo	Lo	+ 4 dBm	600	22	22	15	132	—	5450
Lo	Hi	—	—	18 1/8	11 7/8	15 3/4	49	—	795
Lo	—	—	—	11 1/4	4 7/8	11 5/16	11	N, Q, T, U	1295
Lo	Hi	+ 4 dBm	600	18 3/4	10 1/2	19 1/4	70	C, K, L, M	3700
X	X	X	X	19	19	10 1/2	55	C	2000

G. Color optional for additional $4000; **H.** Audio bandwidth is ±10 dB; **J.** R.f. output provided for feeding direct to TV receiver antenna terminals; **K.** Includes editing; **L.** Includes slow-motion playback; **M.** Includes stop-motion playback; **N.** Record only; **P.** Play only; **Q.** Video input impedance 50 ohms; **R.** Available with electronic editing at $1050; **S.** Available with remote control as Concord VTR-700 at $1495; **T.** Battery powered, includes charger; **U.** Price includes camera, recorder, and microphone; **V.** Deck only; **W.** Stereo audio; **X.** New product, data not yet available.

D



E

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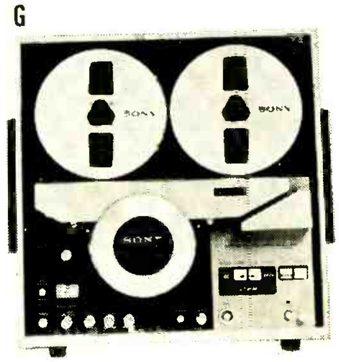
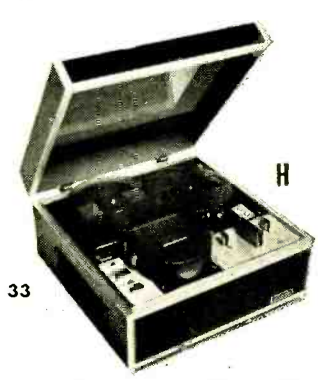
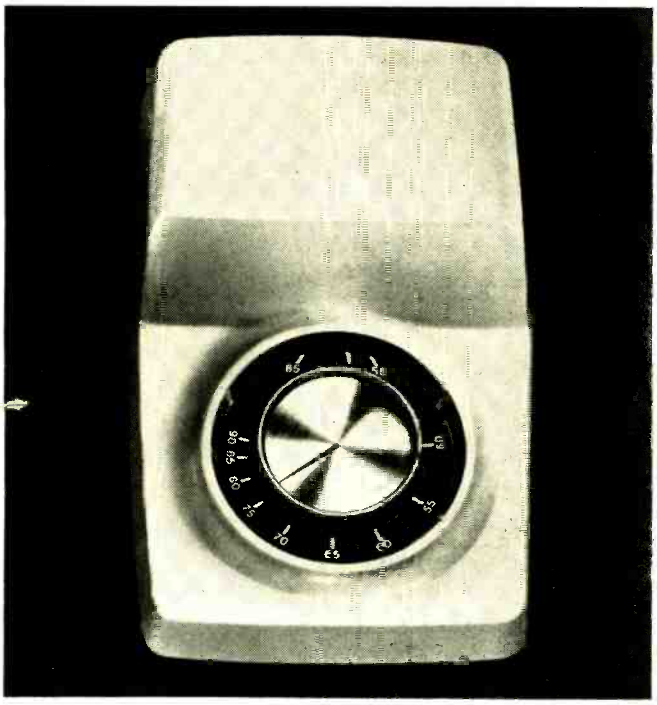
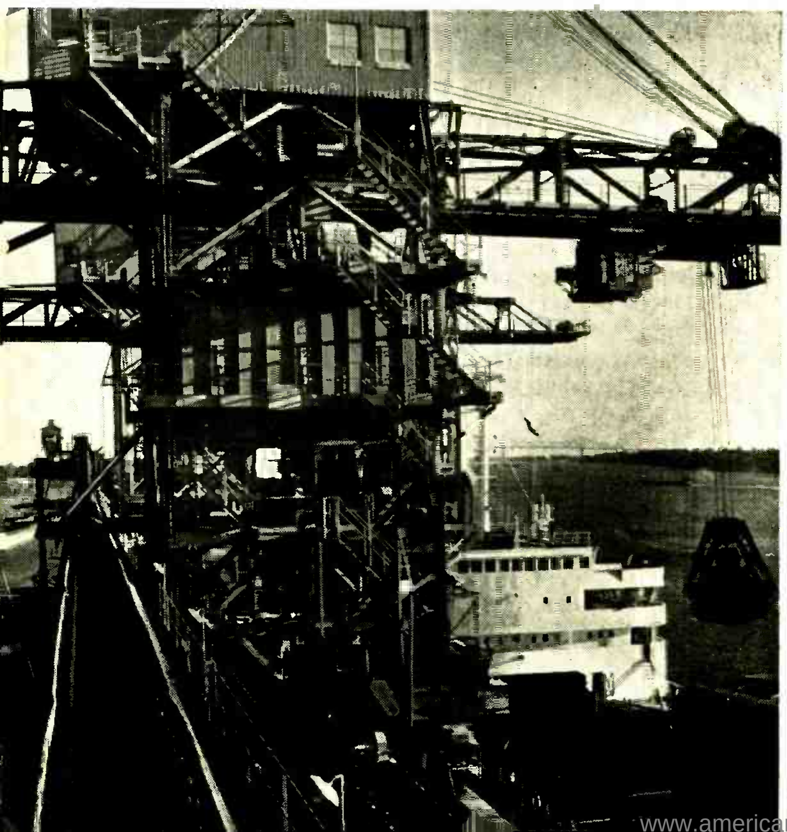
G



H







RECENT DEVELOPMENTS IN ELECTRONICS

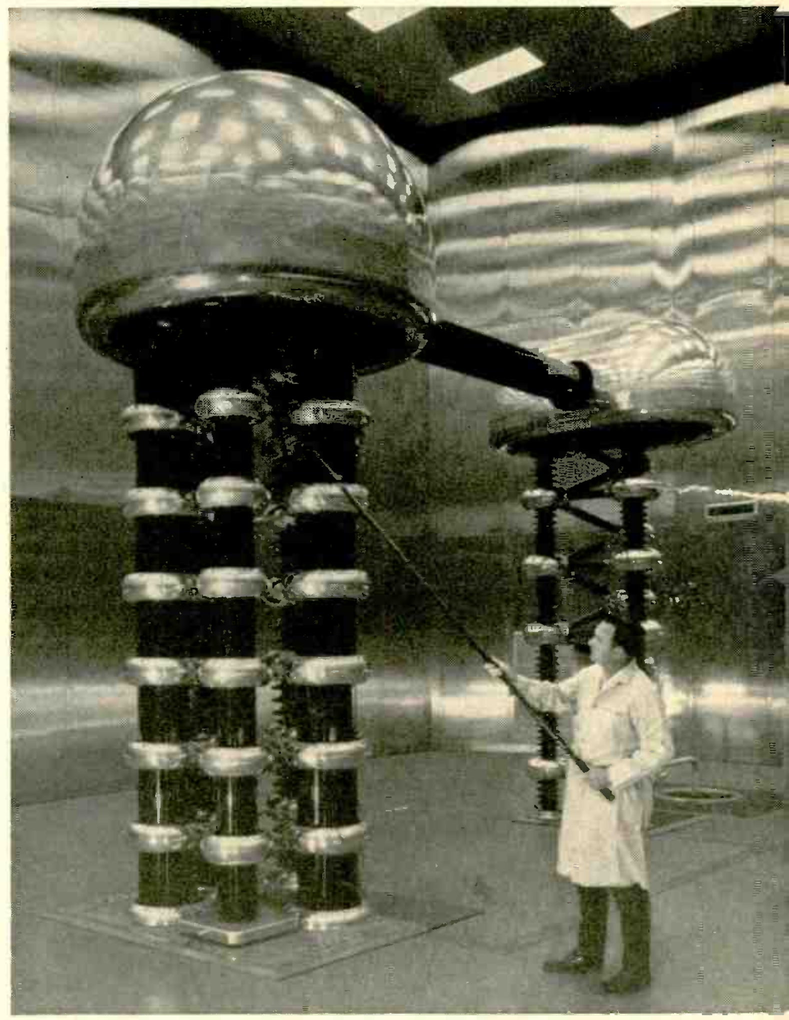
Calibrating Standard Recording Tape. (Top left) The National Bureau of Standards has available a half-inch wide reference standard magnetic tape, SRM 3200, to be used by industry to check their own computer tapes. The tape, when used with suitable instrumentation, permits the accurate performance calibration of computer tape. The standard is useful during production control and it can be employed to supplement the reference tapes maintained by individual manufacturers. To go along with the tape, NBS scientists have developed a signal amplitude measuring system to determine the average amplitude of a train of equispaced signal pulses. Complete information on the system and its use is supplied with the standard tape. Prior to this work by the Bureau, there were several different methods of evaluating computer tape. In some cases, average peak volts, average peak output, or average pulse amplitude were measured. As a result tape sometimes evaluated by one method and thought to meet its manufacturer's specs was found to perform marginally. By using the new standard, this situation will be avoided.

Portable Electronic Thermostat. (Center) Unlike the usual room thermostat that is permanently mounted on the wall and wired directly to the heating-system controls, the unit shown here is portable and wireless. The thermostat can be carried from room to room where it constantly monitors the furnace or air-conditioner by sending a periodic electronic signal to a responder unit at the furnace. All you need do is dial the temperature you want; a built-in thermometer indicates the current room temperature. The thermostat is battery-operated and is designed to run for 18 months before battery replacement is required. The responder unit is a.c.-operated and is connected to the furnace controls by means of two wires. There are no moving parts in the portable thermostat and, unlike a conventional thermostat with a mercury switch, can be operated in any position. An electronic differential adjustment is provided, with a range of 0 to 8 degrees. The system was designed by Kimco Laboratories.

Radio-Controlled Gantry Cranes. (Below left) These two huge gantry cranes, used for bulk-cargo handling, can move up to 2000 tons of materials an hour. Located half-way between Baton Rouge and New Orleans on the east bank of the Mississippi and surrounded for miles with lumbering antebellum mansions, the modern, radio-controlled transfer facility unloads all types of bulk cargoes from ship to rail, to barge, to stockpile, or any combination of the three. Prior to the installation of a sophisticated solid-state wireless radio remote-control system, the huge travelling gantry cranes had been plagued by electrical control failures due to an antiquated remote-control system. The new system, built by Telemotive Div. of Dynascan Corp., uses 200-400 kHz radio transmitters at the rear of the crane cabs. Signals are picked up by receivers in the metal bridge housing straddling each crane some 100 feet above the river. The receivers decode the signals for the 26 functions of each crane. Solid-state plug-in modules are used for ease of servicing and maintenance. Loop antennas are used for transmitting and receiving.

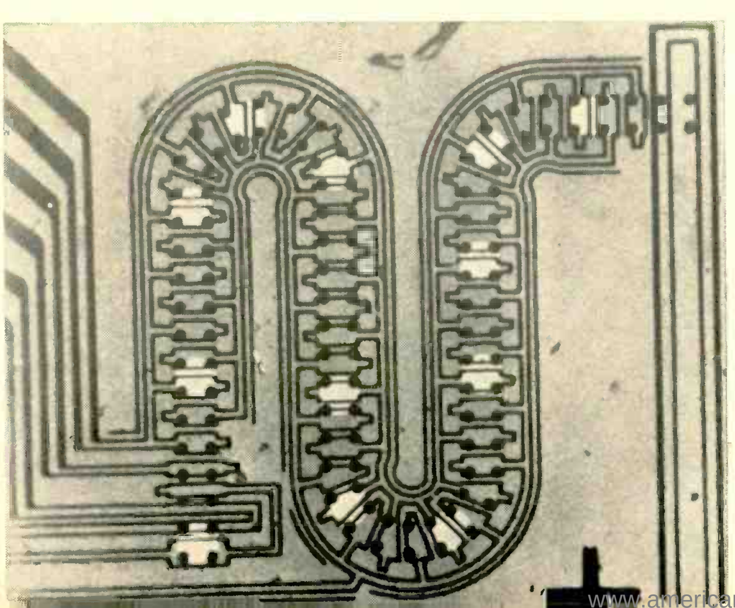
Ultrasonic Rail-Inspection Car. (Top right) A new ultrasonic rail-inspection car, shown being loaded for shipment to Australia, is believed to be the first mobile ultrasonic laboratory of its kind. Built by Automation Industries, the rail-inspection system is incorporated into an air-conditioned, diesel-powered transit bus equipped with retractable railroad guide wheels for on-rail use. As the vehicle moves over the rails, ultrasonic transducers in its search wheels radiate and receive signals that check for variations in rail size, distinguish differences between bolts, bond-pin holes, torch cutting, and a true defect. A continuous chart recorder and an alarm system are operated during the course of inspection.

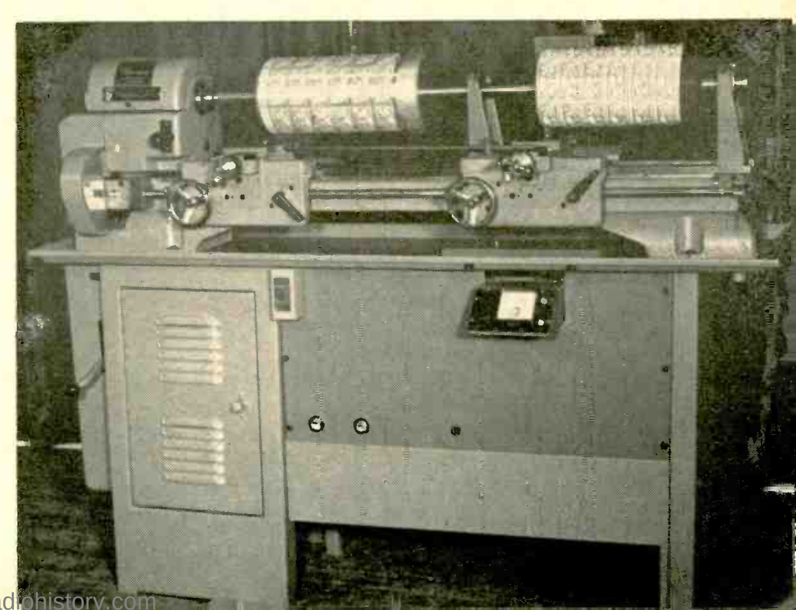
Accelerators for Electron Microscope. (Center) A technician is removing charge from the 17-ft high accelerators used to power a million-volt electron microscope. This instrument, the largest and most powerful in the Western Hemisphere, is at U.S. Steel's research center at Monroeville, Pa. It will be used in a cooperative study of samples of moon rock brought back to earth by our astronauts. Although the accelerating voltage is one-million volts, a precision voltage regulator keeps the d.c. voltage constant to within 0.0004 percent. A stream of electrons is fired through the magnetic lenses at 94 percent to speed of light. This gives the electrons a pentrating power of ten times that of beams in standard electron microscopes and permits viewing thicker specimens.

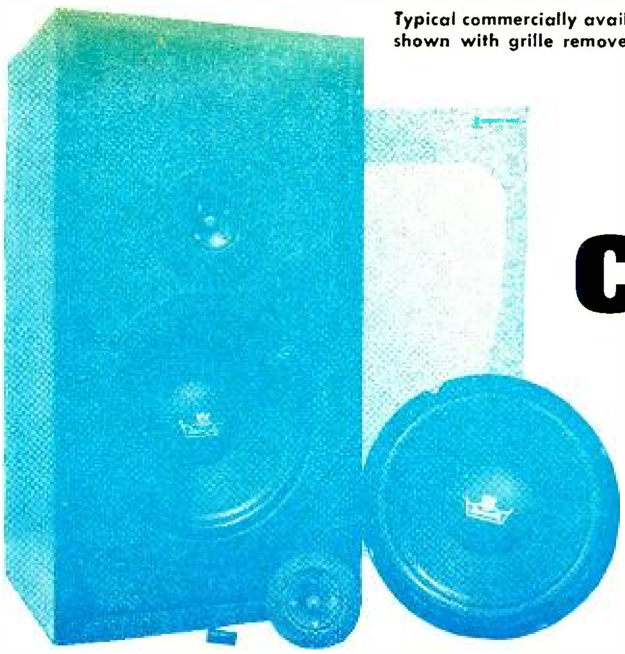


Magnetic "Bubbles" for Digital Counting. (Below left) Tiny computers and electronic telephone switching systems of the future may accomplish counting, switching, memory, and logic functions all within one solid magnetic material, using a new technique now being explored by Bell Labs. The circuit shown here consists of a photolithographic pattern on the surface of a sheet of rare earth iron oxide, in which magnetic "bubbles" (large white dots) can be moved. These are cylindrical magnetic domains that can be moved at high speeds and into precise positions under the influence of a surrounding magnetic field or as a result of current flow in the printed conductor.

PC Boards Made by Electronic Cutting. (Below right) This scanning machine makes PC boards directly from artwork by use of a tungsten-carbide stylus that cuts away the copper foil. The machine does away with the delays of photochemical etching and can be used with both rigid laminate or flexible film. A scanning rate of 325 passes per inch insures good resolution so that lines and spaces only 0.008-in thick can be reproduced. About an hour of machine time is required to make a small PC board. The machine is manufactured by Graphic Electronics and is sold for $3750, including installation and instructions.







Typical commercially available closed-box speaker system shown with grille removed. Unit is University Project M.

Closed-Box Speaker Systems

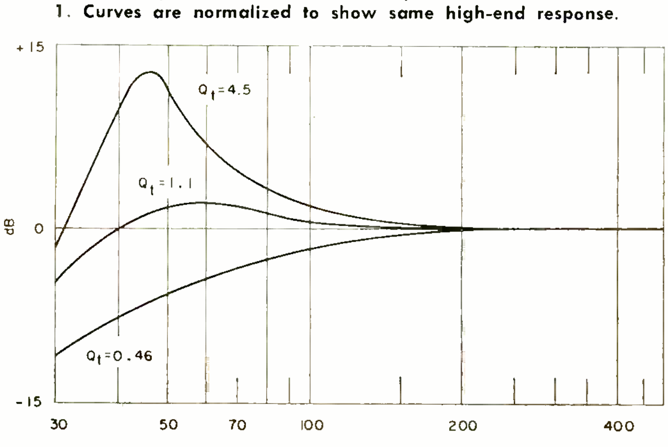
By HUGH G. MORGAN / Acoustical Section Head
University Sound (Div. of LTV Ling Altec, Inc.)

Here are complete details on building your own acoustic-suspension speaker system. All the factors that go into the design are covered along with practical information on cabinet structure and proportions.

Editor's Note: Many of our readers have requested information on the construction and design of the acoustic-suspension speaker system. This is among the most popular enclosures for stereo use since it provides good bass efficiency in a reasonably sized cabinet. Although the system appears simple, there are a good many factors that must be taken into account. Our author has described all these factors in the following article for those who want to take the time and effort required to design and build their own closed-box speaker system.

THE woofer and its marriage to its enclosure have been subject to almost as much research, contention, and misunderstanding as has marriage itself. Several types of woofer-enclosure marriages are currently practiced. Each type brings forth its special advocates who tend to fault other types. This is unfortunate, since each type offers a set of virtues not entirely encompassed by any other type; and further, each type embraces some limitation not common to others. Of the various types, one of the most popular and most honored is the closed box, or acoustic-suspension system, which employs an enclosure having no openings except those into which the speaker or speakers are mounted. The woofer is highly compliant and the "springiness" of the air within the speaker enclosure helps to a great extent to support or "suspend" the cone.

Fig. 1. Closed-box bass response as a function of Q_t. Large values of Q_t produce humped bass response, small values produce "tight" but rolled-off bass. Optimum value is around 1. Curves are normalized to show same high-end response.



Virtues of the closed box are: it may be very small in size; it never "unloads" the speaker even at very low frequencies; its penultimate bass response falls off at a slower rate than does that of other widely used types; and it can be extremely economical. However, every type achieves its virtues at the cost of some limitation. The limitation of the closed-box system is that it must operate at relatively low efficiency if it is to have flat response and good bass performance. This flat response, efficiency, and bass extension are controlled by Q_t (composite resonance magnification factor), which is graphed in Fig. 1.

Why Build Your Own?

But before we go further, perhaps we should consider a question which may be troubling you at this very moment: Why should you build your own system? After all, you can buy them complete and as designed by an expert. Undeniably, the practicing professional has access to a lore of acoustical know-how, as well as access to an industrial speaker design laboratory with very sophisticated facilities for analysis and test. But the hobbyist has access to other important factors: his own living room, his own taste, and his own ears. Also, even if he goes astray, the hobbyist generally has an out—a luxury seldom allowed the professional, for whom, if he makes

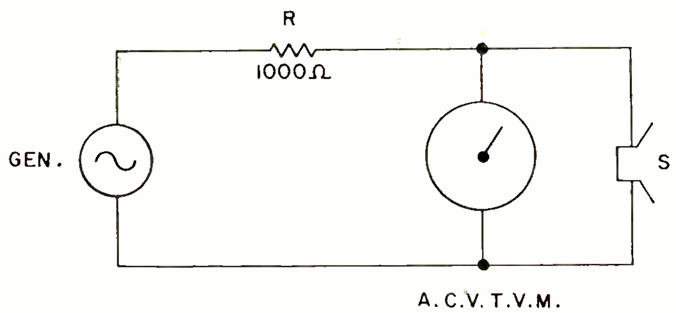


Fig. 2. Method of finding f_{os}. Woofer is suspended freely by a cord far from walls or other reflectors. As audio generator is tuned though its low-frequency range, a peak in meter reading will occur at the bass resonant frequency, f_{os}.

a mistake, it's back to the drawing board (or back to the farm).

To perform our speaker-enclosure marriage, we will require the purchase of one of its partners, the woofer. But we can get a much better feel for the requirements for this partner if we first lay out the requirements for our ceremony. Step-by-step, we must determine: (1) speaker bass resonant frequency, f_{os}; (2) speaker stiffness, S_s; (3) cabinet stiffness, S_c; (4) composite resonant frequency f_{oc}; and (5) composite resonance magnification factor, Q_t.

Speaker Resonance and Stiffness

First, then, we will find the speaker fundamental bass resonance, f_{os}. This is determined by the setup and method of Fig. 2.

Speaker stiffness, S_s, is determined by reference to Fig. 3. However, in order to use the graphs, we must find speaker moving mass m.

Having already determined speaker fundamental resonance f_{os}, we attach to the cone a known weight m' which should be non-magnetic and may take the convenient form of a roll of soft, sticky clay. For accurate measurement of weight, use a good balance, or make one by placing a round pencil across the center of an ordinary wood ruler, adjusting until the ruler balances exactly when laid pencil-side-down upon a smooth, level surface. The roll of clay is placed at one end of the ruler. Nickels and/or pennies are placed at the other end. The amount of clay in the roll or the size of the money pile is adjusted for exact balance. Nickels weigh 5 grams each, and pennies are 3 grams each. Thus the m' may be found with sufficient accuracy, its magnitude being unimportant as long as it is known.

The clay roll is then gently but firmly pressed onto the cone around the dust cap. A new resonant frequency of f_{o2} is then taken, again using the method of Fig. 2. Then the following is computed:

$$m_t = \frac{m' f_{o2}^2}{f_{os}^2 - f_{o2}^2}$$

where: m' = added weight in grams, f_{os} = initial resonant frequency in Hz as before, f_{o2} = new resonant frequency in Hz, and m_t = total moving mass including radiation reactance mass.

Then, $m = m_t - m_{xr}$, where $m_{xr} = (3.23 \times 10^{-3})\, a^3$ = radiation reactance mass, and a = radius of effective speaker piston in cm. (Take the width of one side of the surround, add to distance across the top of the cone, and divide by 2.)

Now we have speaker moving mass m and hence can estimate speaker stiffness from the curves of Fig. 3.

Cabinet Stiffness and Composite Resonance

When the speaker is cabineted, the cabinet-enclosed air stiffness will add to the speaker stiffness. We now find cabinet stiffness S_c from Fig. 4.

When the speaker is mounted into its cabinet, a composite speaker-enclosure resonance, f_{oc}, will occur. This is graphed

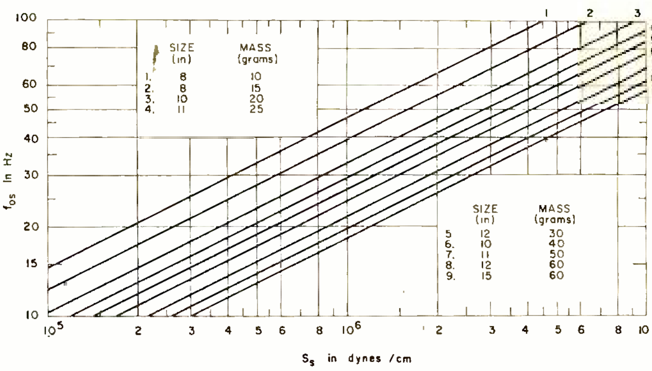


Fig. 3. Speaker stiffness, S_s, as a function of fundamental resonance, f_{os}, and speaker moving mass m. Curves are identified by numbers for various speaker sizes and mass.

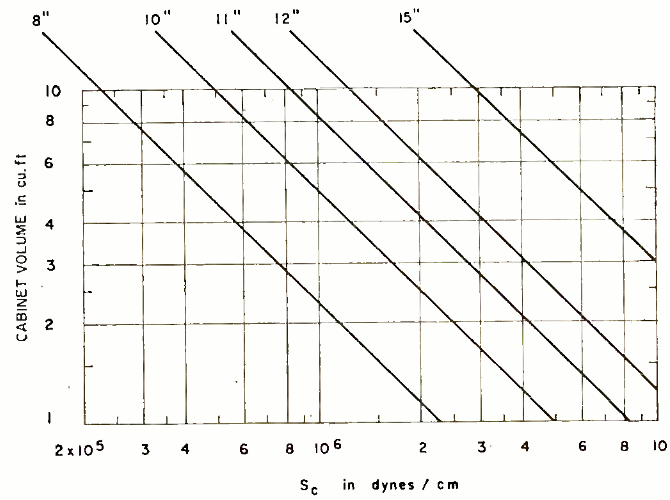


Fig. 4. Cabinet stiffness, S_c, for all the common speaker sizes for enclosures with internal values from 1-10 cu ft.

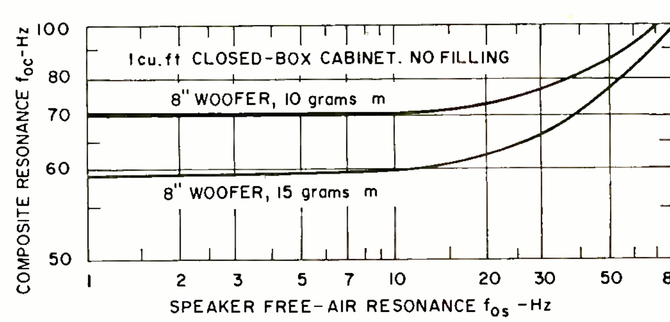
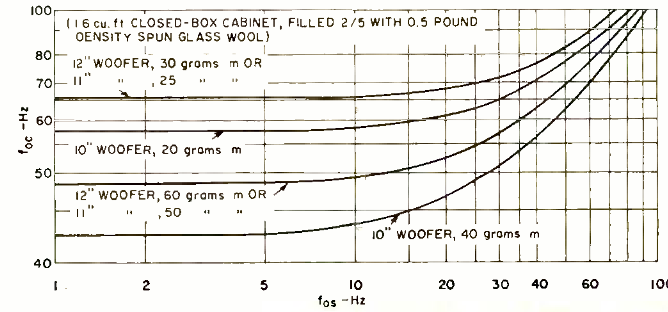


Fig. 5. Composite resonance as function of free-air-resonance and moving mass of 8-in woofers in 1-cu-ft closed box.

in Fig. 5 for 8-inch woofers in a one-cubic-foot box; in Fig. 6, for six different speakers in a 1.6-cubic-foot box; and in Fig. 7 for two different 12-inch woofers in boxes from 1 to 10 cubic feet.

Thus we see that f_{oc} may be set at will by changing cabinet

Fig. 6. Composite resonance of various 10, 11, and 12-inch woofers in a 1.6-cubic-foot closed box with damping material.



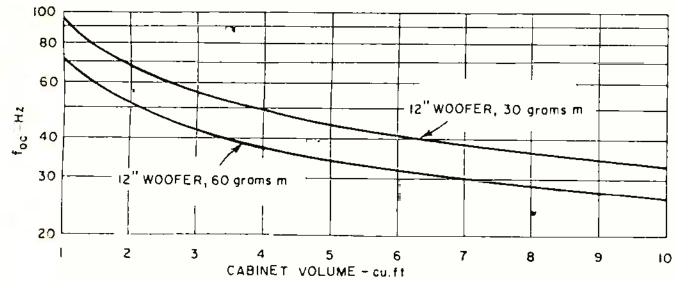


Fig. 7. Composite resonance for 12-inch woofers with free-air bass-resonant frequencies of 15 Hz in various cabinet volumes.

volume, speaker moving mass, and speaker size. This is of great significance, for f_{oc} determines bass cut-off; that is, f_{oc} determines the frequency below which bass will fall off rapidly.

Composite Resonance Magnification Factor

Looking again at Fig. 1, we see that, while cut-off is defined by f_{oc} (about 40 Hz in this case), that is by no means the whole story. The shape of response down to cut-off is determined mainly by Q_t. Since we are at the mercy of Q_t, as it determines what we are allowed to hear, its importance cannot be overstated. It is measured by the method of Fig. 8.

The value of Q_t is determined by the characteristics of the woofer used (resistance of voice coil, magnetic flux density, length of voice coil) as well as the mechanical and acoustic parameters of the speaker system. Since the hobbyist cannot change the design of the woofer he will use, the most he can do is to add mass to the speaker, alter enclosure size, and add damping material within the box.

Damping Material

Any fuzzy substance like a furry blanket, cotton, rock "wool," Tufflex wood-fiber "wool," or fiber glass can absorb sound. Fig. 9 shows a section of response of an experimental speaker: (A) with box lined with ½-inch Tufflex, and (B) with no lining. Notice notches in response in (B) due to sound reflections within box. This demonstrates absorption at the wall.

But damping material has another function—enclosure volume expansion. With the speaker cabinet completely filled with fuzz, the material acts as a heat sink and reduces the effective velocity of the sound; hence, the speaker "sees" an acoustic volume substantially larger than the volume measured by a ruler.

But we do not get something for nothing. The speaker drives energy into the box. The fuzz converts some amount of that energy into heat. That amount never returns to the speaker, never gets into the room, often shows up as overdamping of the low end of the woofer (energy lost), and can cause low-end distortion. Thus indiscriminate fuzz-stuffing has ruined many a system. If the woofer requires stuffing of its enclosure, by all means stuff. But try different amounts of stuffing—¼ full, ½ full, and so on. Measure Q_t and listen. Be sure to do both. When the bass begins to sound constricted or overdamped, remove some stuffing (regardless of Q_t). When the bass sounds ample and relaxed (but not sloppy), you have it.

Purchasing the Woofer

For closed-box operation, the woofer should have a very soft, compliant surround, preferably a half-round shape. As you examine a woofer, press in and out on the cone. It should move at least ¼ inch in both directions. Nothing should make a dragging, scraping, scratching sound. Indeed, when operated like this, the speaker should make no sound whatever. Then feel the cone. It should be fairly thick (perhaps 1/32 to 1/16 inch) and not too hard.

Sometimes, by experimenting with a beam from a small, bright flashlight, you can manage to see through the spider and observe the frontward extension of the voice coil. If the magnet is open in the back except for a cover or covers, you may be able to observe the rearward extension of the voice coil. If the end of the coil does not extend out of the pole pieces as you watch it and move the cone, that speaker is not for this application. The coil should overhang the magnetic gap by at least 3/16 inch. If you can, get the salesman to run an f_{os} for you or get this information from the manufacturer. The proper value should be from about 15 Hz to 25 Hz.

If you require a lower f_{oc} than you get initially, then you may try a bigger box. But take care, you can make it nice and big and wind up with a low f_{oc} but with a Q_t of 0.5 or less and *no* satisfactory bass.

Perhaps weighting the woofer will provide just the degree of trimming you need. Add some putty to the cone as you did before until you get the desired f_{oc}. Resist the temptation to go farther down in frequency than 50 Hz. And about 20 grams added weight is probably maximum, as too much added mass tends to decouple the main body of the cone from that section immediately adjacent to the coil. This produces a peak in response at or above the speaker high-end cut-off. A coil of rosin-core solder wire fitting the cone-dust-cap juncture can furnish the added mass. Affix into place with something like *Duco* cement. Let it dry overnight, and don't use epoxy as you might want to get the weight off. Start with 10-grams added weight and, if you need to, add another 10 grams.

Cabinet Structure and Proportions

As a piece of woodwork, a loudspeaker cabinet leads a very rough life. Sound power is continuously attacking it.

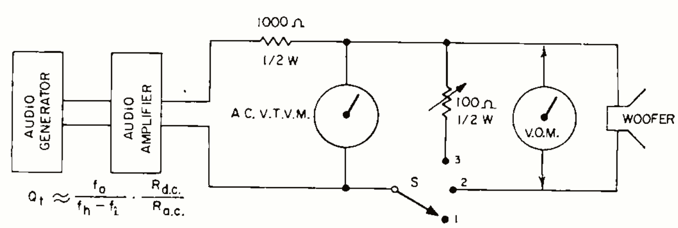
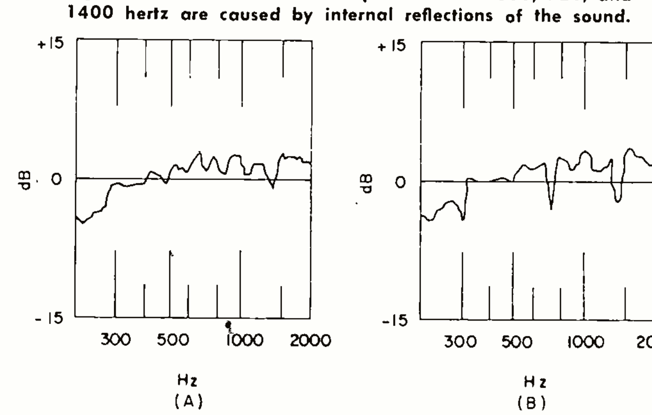
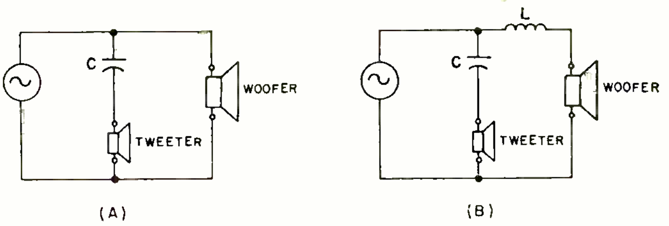


Fig. 8. Method of measuring Q_t of speaker enclosure. First place switch at 1 and measure resistance of woofer voice coil (R_{dc}) with v.o.m. Then, disconnect the v.o.m., set audio generator at 1000 Hz, and move switch to 2. Adjust amplifier gain for a reading of 10 volts on v.o.m. Sweep generator from about 20 to 100 Hz and note peak reading on v.t.v.m. This is f_o. Move switch between 2 and 3 and adjust variable resistor until there is no change in voltage. At this setting and with S at position 2, measure value of variable resistor with the v.o.m. This value is R_{ac}. Then, slowly increase frequency until voltage reads 0.707 of its peak value. Generator now indicates f_h. Finally, decrease generator frequency below the peak until the voltage again falls to 0.707 of the maximum. Generator is at f_l. Substitute in equation shown with diagram in order to obtain the value of Q_t.

Fig. 9. (A) Portion of response of experimental closed-box system with ½-in Tufflex lining. (B) Same but with lining removed. Notches in the response around 300, 720, and 1400 hertz are caused by internal reflections of the sound.





CROSSOVER FREQ. (Hz)	VALUES FOR NOMINAL 8Ω SPEAKERS	
	C (μF)	L (mH)
500	40.0	2.500
1,000	20.0	1.250
2,000	10.0	0.625
4,000	5.0	0.312
8,000	2.5	0.156

Fig. 10. Diagrams of simple crossover networks. If speaker impedance is 4 ohms, multiply C by 2 and divide L by 2. If speaker impedance is 16 ohms, divide C by 2 and multiply L by 2. Nonpolarized electrolytics can be used for capacitor, and air-core chokes for inductor. Values given are computed; final values depend on efficiencies and responses of speakers.

Even if its walls are very strong, they are flexed by changes in enclosed air pressure and this absorbs much more energy than it transmits to the outside air. Hence wall flexure should be minimized. This can be accomplished by use of thick, stiff walls.

Another problem is that of panel resonances—which can also be minimized by sturdy wall materials. Struts or braces are advisable where panels are wider than one foot. For six- and eight-inch woofer enclosures, panel material may be plywood or dense particle board of ½-inch thickness. For larger speakers, walls should be at least ¾-inch thick.

Small holes and cracks should be avoided. They make a hissing, puffing noise which robs the bass of measurable power. Therefore, good, tight, glued-and-screwed joints are a must. Even better are well-designed lock-joints such as those employed in some commercial closed-box systems. Such joints make cabinet assembly difficult and costly, but produce leak-proof, virtually destruct-proof cabinets.

Because it can be small in size, the closed-box speaker is particularly well-suited to shelf mounting. This suitability, in turn, tends to be enhanced by typical cabinet proportions, which generally present a front rather long and narrow and a depth seldom greater than a foot. Typical outside dimensions in inches are:

System Woofer Size	Length	Width	Depth
6	15	9½	6
8	19	10½	9½
10	23½	11½	10
11	24	13	12
12	25	14	13
15	30	19	16

Frequency-Dividing Networks and Tweeters

High-quality high-fidelity loudspeaker systems generally employ two or more separate speakers, each designed to handle a different band of frequencies; the division of energy is accomplished by a frequency-dividing or crossover network.

Two-way systems can sound excellent and present fewer problems to the home constructor than do more complex systems. Let us then limit the number of speakers to two, a woofer and a tweeter. Let us also limit the number of network components to a minimum, for recent research shows quality of sound deteriorates progressively with increase in the number of network components.

The simplest network is shown in Fig. 10A. The capacitor provides a low-impedance path for high frequencies to the tweeter and at the same time blocks low frequencies, forcing them to pass only through the woofer. A slightly more elaborate network (Fig. 10B) includes a series choke to keep the high frequencies out of the woofer.

As a speaker becomes smaller, its operation approaches that of a point source, uniformly distributing sound over the listening area. Conversely, as a speaker becomes larger, it "squirts out" more of its top frequencies in a narrow beam. So we want the smallest possible tweeter. But we would like the tweeter to go down far enough in frequency so that it can take over from the woofer at a low enough crossover to avoid the beaming of the woofer at its top speed. So we want the largest possible tweeter.

The best compromise is presently reached by using a long-throw, high-quality woofer of modest size, thus minimizing woofer top-end beaming, and the smallest possible, widest-range tweeter. One means of accomplishing the latter is to provide the tweeter cone with a series of strategically placed holes which allow the tweeter cone to operate at full size at at the bottom of its range, but which cause it to operate as a progressively smaller unit with rise in frequency. (Patent applied for by *University Sound*.) The tweeter is usually connected to the woofer in-phase so as to avoid cancellation around the crossover frequency.

Considering all factors, the optimum crossover point for a two-way system is about 1000 Hz.

If the network is to be minimized, its frequency-contouring function must be supplanted. That can be the contouring of the response of the speaker itself. Such contouring is difficult, but it can be done, as is shown in the shapes of the curve of the woofer top-end and of the tweeter bottom-end in Fig. 11 where only one capacitor is used as the network.

It is important to purchase speakers in matched sets from one manufacturer, and purchase the very best.

Speakers should be mounted from the front. Back mounting introduces unnecessary irregularities due to the "tunnel effect" of the speakers "looking through" the thickness of the cabinet front panel. Also the two speakers should be mounted as close together as possible. ▲

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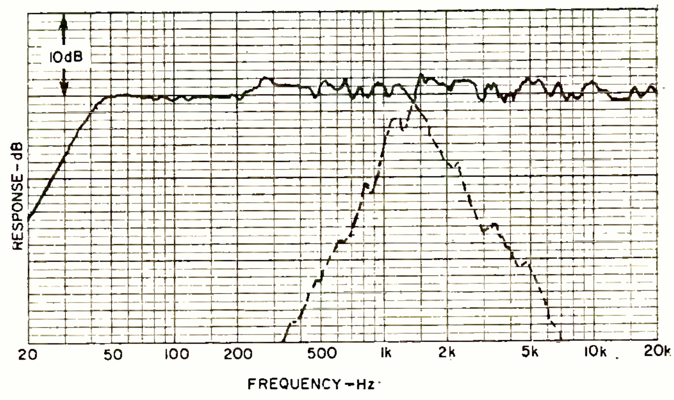
Fig. 11. Anechoic chambter on-axis pressure response of typical high-quality closed-box speaker system, University Sound's Project M. Dashed curves are outputs of speakers separately.



An adult music lab with seven pianos including one at left used by instructor.

The Electronic Piano

By EDWARD A. LACY

Wurlitzer, a leading manufacturer of these pianos, reports over 25,000 units in use and hundreds of classroom laboratory setups. Advantages include earphone or private operation plus portability.

Editor's Note: Although electronic pianos have quite a way to go before they can compete with the concert grand, these compact pianos have made an important place for themselves in dance bands, pop groups, and, more important, in many schools and music laboratories where they are being used for training purposes.

WHILE numerous patented improvements have been made in the piano within the past hundred years, the fact remains that there has been no substantial change or major improvement in piano construction during this time. Whereas other musical instruments, such as the guitar and the organ, have been revolutionized by the addition of electronics, only in the past ten years or so have electronic techniques been applied to pianos.

Now, however, electronic pianos are beginning to catch on. The total number of such pianos in use is not known, but *Wurlitzer*, a leading manufacturer of these pianos, reports that it has more than 25,000 units in use and hundreds of classroom laboratory setups in operation.

In addition, *M. Hohner, Inc., P.A. Starck, Rocky Mount Instruments, Inc.* (a subsidiary of the *Allen Organ Co.*), and the *Gulbransen Company* are now building various types; *N.V. Philips* has one under development, and the *Baldwin Co.* expects to market one this year.

No one is claiming that electronic pianos sound exactly like conventional pianos, but the sound is close enough so that musicians can ignore the differences in exchange for the electronic piano's two major advantages: *earphone or private operation and portability.*

Through the use of earphones, piano practice becomes unnoticeable or unobjectionable to others, a welcome feature for apartment dwellers and impatient parents. With this privacy feature, group instruction has become practical for the first time. With an electronic-piano music laboratory, for example, an instructor can listen to, speak over, or play for any individual student, or even arrange ensembles. He can give individual instruction in the midst of a group, correcting a student in private without embarrassing him.

Obviously, group instruction can save on the cost of teaching piano. According to classroom instructors, a more important advantage is the effect of group instruction on students—there's a friendly spirit of competition yet the pupil has a definite feeling of being part of the group. For youngsters in particular, there's no feeling of solitary confinement—their buddies may be right there with them.

Not surprisingly, such music laboratories have been put into use in classrooms throughout the country, from third grade through college—at such diverse places as the Canby, Minnesota elementary schools, the Allentown, Pa. high school, Ohio State University, and Eastman School of Music.

The second advantage—portability—is obtained by using steel reeds instead of piano strings, and an electronic amplifier and loudspeakers instead of a sounding board. Because of its construction, a portable model electronic piano may weigh only 56 pounds compared to 350 to 400 pounds for a conventional spinet-type instrument.

By using 64 notes or keys, instead of the usual 88, the size can be held down; one model with detachable legs is only 33 inches high × 40 inches wide × 18½ inches deep. While the keyboard is significantly shorter than the usual keyboard, the manufacturer believes it is more than satisfactory since approximately 90 percent of all music written can be played on the shorter keyboard, with its five-octave range instead of the normal seven-octave one.

With this size and weight reduction, it's easy to see how these instruments can be taken to places or to events where pianos may be rare—to weekend cottages at the beach or in the mountains, or even on small boats, if a.c. power is available. In Wichita, Kansas, the public school system puts 24 of these pianos in a van and trucks them around to the various schools. Because it is easy to carry, dance-band musicians have been using the electronic piano. Duke Ellington and the Harry James orchestra use them.

Depending on your viewpoint, the several thousand parts—levers, pins, pivots, springs, cushions, strings, etc.—in an ordinary piano constitute a mechanical marvel or a mechanical monstrosity. It would appear to be a prime example of an instrument that should have been modernized long ago through the use of electronics. Why this has taken so long and why it still is not perfected can best be explained by considering the construction of the conventional piano.

Conventional Piano Construction

In one sentence, a piano works like this: By pushing a key you throw a hammer at a string whose vibrations are subsequently carried to the air by means of a vibrating sound board. While this may sound simple, it is actually a very complicated process. *Story and Clark Piano Co.* has described this process in an excellent series of copyrighted monographs which are summarized below.

Through a system of levers and pivots, a pianist's down pressure on a key is converted to a forward motion of the hammer, a wooden head covered with a pad of wool felt. The hammer travels five times as far and approximately four times as fast as the front edge of the key, the key travel being about $\frac{3}{8}$ of an inch at its front edge. The hammer is not carried directly to the string but is literally thrown at the string, leaving the hammer free to rebound instantly. Because of the resiliency of the felt on the hammer, the time of actual contact between the hammer and the string is anywhere from 1/200th to 1/500th of a second. This quick getaway is important so that the hammer will not act as a damper and interfere with the free vibration of the string after it has been struck.

The 225 strings in a piano are not strings at all, of course, but high-grade Swedish steel wire with a tensile strength of 350,000 pounds per square inch and a diameter of 0.03 to 0.06 inch. When properly tuned, these strings exert a total tension of about 36,000 pounds. This load must be carried by a heavy cast-iron plate or stringing frame, which makes up a major part of the piano's weight.

There are three strings to each note in the treble and middle registers, two strings to a note in the upper bass, and one string for each note in the low bass. Multiple strings provide greater volume than a single string and produce a richer and more satisfying tone.

From the low note of 27.5 Hz to the high of 4186 Hz, each of the 88 notes has a different pitch, which is determined by the number of vibrations per second of the wire. This frequency depends on the "speaking length" of the wire, which is a function of the length of the string between the wooden bridge located at the bottom of the sounding board and the bearing point of the string on the iron plate at the top, the tension, and the degree of its loading by its overwrapping of copper wire in the bass section.

A string will vibrate at the same rate no matter if the blow is soft or hard. When a string is struck by the hammer, there is a succession of sounds which overlap each other and blend together in such a manner as to give the piano its characteristic tone.

The basic or lowest pitch of the string sounds first, producing the fundamental. This tone comes from the vibration of the whole speaking length of the string. Immediately after the whole length of the string has swung back and forth to produce the fundamental, it "divides" itself in the middle and each half vibrates separately, the fundamental having ceased.

Each of the halves vibrates twice as fast as the whole string did before, and because of this higher frequency the supplemental sound which these halves produce is one octave above the first, or fundamental, tone. This secondary sound is known as the second partial, since it is a partial of the first tone.

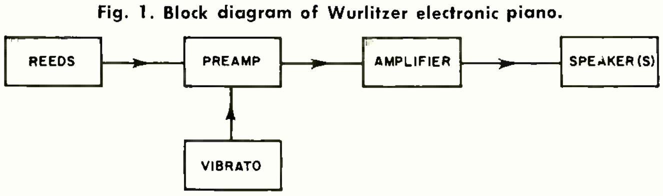
After the string has switched from one vibration section into two, it almost instantly divides itself again, breaking up this time into three sections, each of which starts vibrating at three times the original rate and producing a still higher tone, called the third partial. The partial tones produced by a piano, however, are not *exact* whole number multiples of the fundamental tone.

The generation of higher tones continues up to at least the eleventh partial, as far as significant piano tones are concerned. The lower partials are harmonious and pleasing to the ear, but the odd-numbered partials above the seventh are harsh, metallic, and unharmonious. The relative intensity of the partials contained in a tone determines its quality.

In the ideal tone, only the first seven partials would be used; fifty percent of the total intensity would be in the fundamental and the balance divided among the remaining six in decreasing proportions up to and including the seventh.

The tones generated by the strings are transmitted through the bridges to the sounding board where they are reflected, amplified, and projected into the air. The sounding board is a very thin wood panel, from $\frac{3}{16}$ to $\frac{3}{8}$ of an inch thick, which vibrates at the same rate as the strings.

Fig. 1. Block diagram of Wurlitzer electronic piano.



The Piano Goes Electronic

In his first attempts to build an electronic piano in the 1930's, Benjamin F. Miessner, who may very well be called the father of the electronic piano because of his many patents in this field, tried replacing the sounding board with electronic string-vibration pickups, amplifiers, and speakers. Tone quality was good but over-all the piano was not satisfactory because the tones did not decay fast enough in rapid passages.

After much experimenting, Miessner turned to reeds for tone generation because of their simplicity, ruggedness, ability to hold their tuning, and low cost. Reeds, of course, had been used in organs and accordions, but in an entirely different manner—in such instruments they vibrate continuously, not at all like their use in pianos. To adapt them for use in pianos, it was necessary to determine the precise point at which they were to be struck.

This method of tone generation is the basis for the *Wurlitzer* electronic piano.

In touch and response, the keyboard of a *Wurlitzer* electronic piano is essentially the same as that of a conventional instrument since it uses a modified grand-piano action. While it is an electronic piano, there are approximately 3200 wood, metal, and felt parts in the keyboard action. When a note is struck, a felt-covered hammer strikes a corresponding Sandvik steel reed which vibrates at a pre-set pitch.

Each of the 64 reeds is cut and weighted for the specific resonant frequency (from 55 to 2093 Hz) at which it will vibrate when set in motion. The reeds are mounted on two separate aluminum reed bars. Two pickup bars or plates are mounted on each reed bar, but are insulated from it. Slots are cut in the pickup bars so that the reeds can vibrate back and forth through the slots. A polarizing voltage of 170 volts is impressed across the pickup bars. As the reeds vibrate in this electric field, a capacitance change takes place at a rate corresponding to the reed's tuned frequency or pitch.

This capacitance change is used to produce a varying voltage across a load resistor and this voltage is then amplified and reproduced electronically (Fig. 1).

Earlier models used tubes but all of the company's present models use silicon transistors. The amplifiers have a frequency response from 20 to 20,000 Hz with 30 watts *peak* output power. A vibrator circuit in the amplifier modulates the signal by means of a light-dependent resistor. Since electronic amplification is involved, the volume can be set as desired without the pianist altering his playing technique.

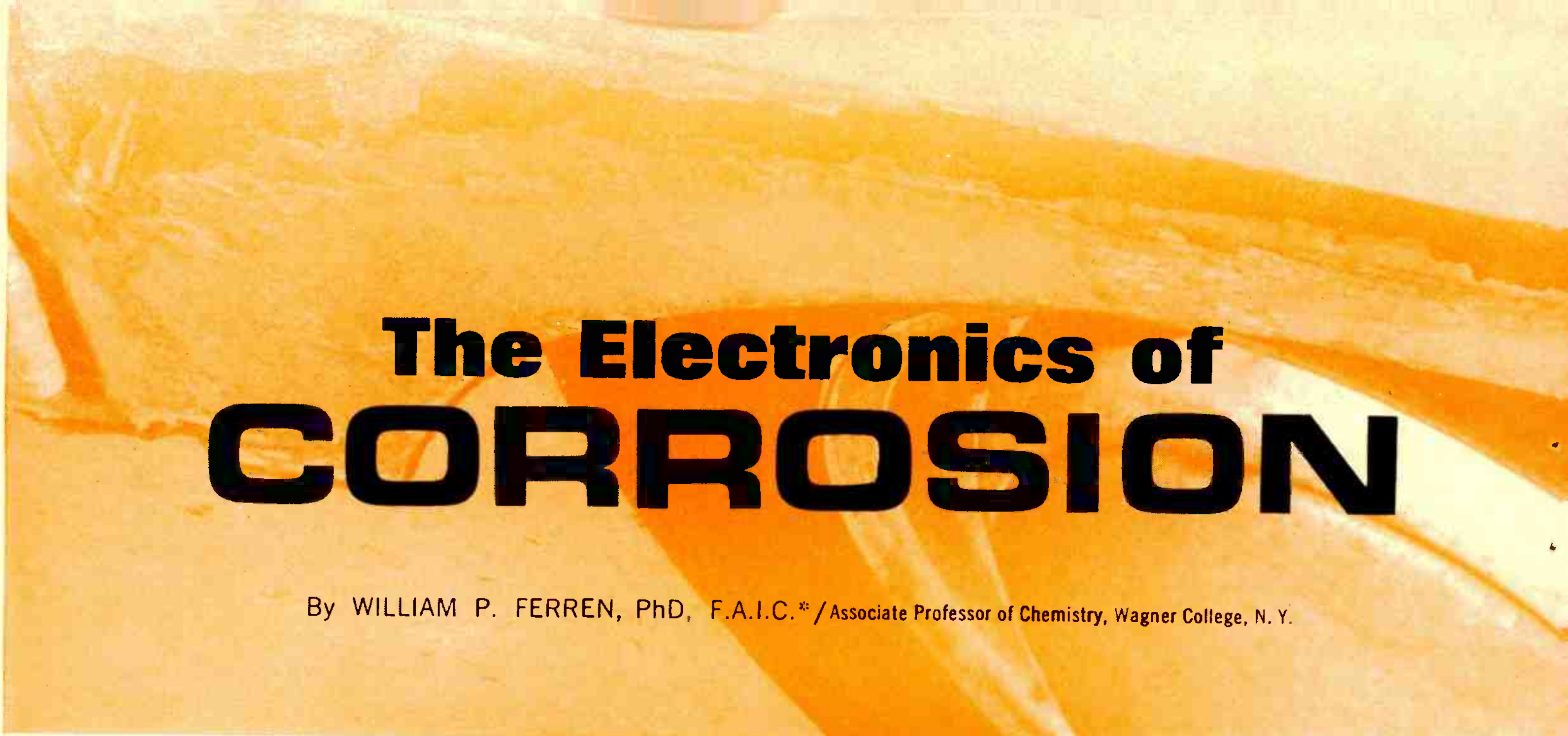
Two 4 × 8 inch oval speakers are mounted on the front of the piano. (High-fidelity earphones are optional.) The speaker at the bass end of the keyboard accents the bass notes and the speaker at the treble end stresses the highs, which makes the sound seem to move up and down the keyboard as the notes are played. In the console model, there are two additional speakers: these are 8-inch units mounted in the base.

An auxiliary output jack produces a low-level signal which can drive a guitar amplifier to full output or feed a high-fidelity amplifier through a tape-input jack.

Wurlitzer introduced its electronic piano in 1955. In 1964 the music laboratory was introduced, consisting of one instructor's console (with communications center), and six to 24 pianos for students. Optional aids for the instructor's console include a turntable with amplifier, tape recorder with amplifier, and a metronome. (*Continued on page* 75)

The Electronics of CORROSION

By WILLIAM P. FERREN, PhD, F.A.I.C.* / Associate Professor of Chemistry, Wagner College, N. Y.



The effect of local-cell corrosion on an automobile fender.

The role played by electronics in causing and/or minimizing corrosion, especially as related to marine environments, is explained. The various types of corrosion, as dependent on the environment (electrolyte) and the galvanic arrangement (dissimilar metals), are discussed by author.

THE fundamental action in corrosion is electronic in nature. This electro-chemical process holds true whether the corrosion takes place in an air environment, in the water, or in the interface between the two. Indeed, much of the terminology used by corrosion scientists and engineers reflects this. Such terms as anode, cathode, electrolyte, ionization, current, potential, voltage and e.m.f. are as familiar to the corrosion engineer as they are to the electronics technician.

Galvanic Corrosion

Similarly, the classical explanation of the phenomenon of corrosion is readily understandable by those in electronics. Any metal placed in a water solution will begin a process of dissolution. If we take two unlike metals such as zinc and copper, place them in water, and wire them together external to the water electrolyte, we have created conditions whereby corrosion can take place. It is from this simple galvanic cell that the particular type of corrosion that occurs when two dissimilar metals are exposed to a common electrolyte and are physically connected externally derives its name—galvanic corrosion. The zinc atoms in contact with the water lose electrons and enter the water as positively-charged zinc ions. The electrons released by the ionized zinc atoms will travel through the wire from the zinc anode to the copper cathode. In the electrolyte, the zinc ions will travel toward the copper cathode. But these zinc ions never reach the copper cathode because of a chemical reaction that has been taking place within the electrolyte.

The water atoms have also been ionizing; the hydrogen atoms in the H_2O combination become positively charged hydronium ions by giving up electrons, and negatively charged hydroxyl ions by gaining electrons. The positive hydronium ions seek to regain their lost electrons and take them from the copper cathode which by now has an abundance of the electrons released by the zinc atoms when they ionized. Thus, the hydronium ions become hydrogen molecules when they achieve balance. The negative hydroxyl ions share their excess electrons with the zinc ions and here, too, balance is achieved. If nothing further happened in this system, the galvanic corrosion process would cease for the hydrogen atoms clustered around the copper cathode in the form of hydrogen gas (polarization) would effectively shield it from the electrolyte. But oxygen becomes involved and combines with the hydrogen atoms to form water—H_2O—once more. This action exposes the copper cathode to the electrolyte, thereby re-establishing the electrical circuit, and permitting the corrosion process to continue.

Rating Galvanic Action

Traditionally, corrosion engineers and scientists while recognizing that an electrolyte, whether it be a water solution or highly humid air, is necessary for corrosion to occur, have tended to concern themselves more with the proper choice and treatment of metals existing in a system to impede or halt corrosion. The *base-noble* metal sequence in Table 1 is one of three common listings which have been compiled as an aid to choosing combinations of metals that will reduce the possibility of galvanic corrosion. The recommended practice is to either choose identical metals or metals close together in the base-noble series if they are to be in physical contact with each other while exposed to a common electrolyte. The farther apart two metals are from each other in this series, the higher the potential difference between the two and, therefore, the greater the possibility of corrosion. The same philosophy applies to both the activity and galvanic series (Table 1). In each of these three charts, the anodic metal—the one which will suffer the structural corrosion damage—is at the top, the cathodic metal—the one which will not be affected by the corrosive process—is at the bottom. The farther apart any two metals are in any of these series, the stronger the galvanic cell.

The galvanic series is probably the most used series in

The author is consultant to Marine Surveys Co., Inc., Stillwell & Gladding (an independent testing laboratory), and Marine Container Equipment Certification Corp. He recently hosted an industry conference on corrosion problems at Wagner College's Staten Island (N.Y.) campus.

considering the electronics of corrosion. This particular galvanic series was predicated on a sea-water electrolyte and using a silver/silver-chloride reference electrode. Just as in assessing antenna-gain figures, one must know exactly what the reference unit is. Readings based on a calomel electrode or a metal electrode would give entirely different readings than those listed for the galvanic series in Table 1. Fortunately, the silver/silver-chloride electrode is gradually becoming the standard. As mentioned above, the metal at the top of the scale will become the anode, the metal at the bottom the cathode. In the preceding zinc-copper explanation, for instance, the zinc was anodic, the copper cathodic. Similarly, copper would become the anode when coupled to nickel in a two-metal, electrolytic, physically connected system. Measurements performed by the author using the *Simpson* 313 v.o.m. with a silver/silver-chloride electrode yielded different values. The reason for the variance was that the author's sea-water samples came from the highly polluted New York port area while the readings for the galvanic series in Table 1 were based on relatively unpolluted sea water. In addition, the New York port area waters have a certain percentage of fresh water introduced by the Hudson River and other tributaries. The sea water used for the galvanic series in Table 1 is relatively unpolluted and has no meaningful fresh water content. Thus, we see that a difference in electrolyte will make a difference in the rate of corrosion. Indeed, the entire study of corrosion might be said to be a study in differences: differences in metal, in electrolyte, in—as we will see later—oxygen concentration in the electrolyte, even differences in size between the anode and cathode involved. In other words, the corrosion system is a differential system.

Corrosion vs Electrolyte pH

Just as there are instruments to read the differences in electronic concentration, *i.e.*, potential (the voltmeter) and to read the flow of electrons (ammeter), so also is there a meter to read the active concentration of ionized hydrogen atoms in a water solution. This is the pH meter and might be regarded as a high-impedance voltmeter used in conjuntion with a special permeable glass probe and a reference half cell. While the basic function of a pH meter is to determine the active acidity or alkalinity of a solution, most have an e.m.f. position to read voltages (instruments without the e.m.f. position may be used to read voltages by substituting 0.06 volt per pH unit). Probably the handiest pH meter for the electronics technician would be the unit made by *Analytical Measurements* (Chatham, New Jersey). This instrument (Fig. 1) is portable and battery-powered which permits it being taken "on the scene" which, in most cases, is a virtual necessity.

Fig. 1. A portable battery-operated pH meter that is used by electronics technicians who specialize in marine work.

The pH meter differs from the voltmeter or ammeter in that it reads "backwards." While the voltmeter will read higher on the scale when the voltage difference present is relatively higher, and the ammeter will give a higher indication when the current is high, the pH meter reads inversly, *i.e.*, the lower the ionized-hydrogen activity, the higher the pH reading; the higher the ionized-hydrogen activity,

Table 1. Listings of base-to-noble metal sequence, activity series, and galvanic series. Base metals at the top of the list function as the anode when used with metals lower in the series (more noble), and are subject to corrosion. The activity series, with hydrogen gas as the arbitrary reference, indicate the relative inertness of reactivity of metals. The reactive elements are above hydrogen while the inert elements are below. The galvanic series, the most used series in considering the electronics of corrosion, indicate voltage readings recorded between the indicated metal and a silver/silver-chloride reference electrode while immersed in a relatively unpolluted sea-water electrolyte.

BASE-NOBLE METAL SEQUENCE
BASE
↓
Magnesium
Zinc
Aluminum
Cadmium
Steel or Iron
Chromium-iron (active)
Lead-tin solders
Lead
Nickel (active)
Brasses
Copper
Bronzes
Copper-nickel alloys
Nickel-copper alloys
Silver solder
Nickel (passive)
Chromium-iron (passive)
Silver
Graphite
Gold
Platinum
↓
NOBLE

ACTIVITY SERIES
Magnesium
↓
Aluminum
Zinc
Chromium
Iron
Cadmium
Nickel
Tin
Lead
Hydrogen
Copper
Silver
Palladium
Platinum
↓
Gold

GALVANIC SERIES	
Material	Voltage
Magnesium	1.5
Zinc	1.03
Aluminum	0.75*
Cast iron & carbon steel	0.61
Stainless steel	0.55*
Bronze	0.4
Yellow brass	0.36
Copper	0.36
Red brass	0.33
Admiralty brass	0.29
Copper-nickel	0.27*
Nickel	0.2
Monel	0.075

*Represents an "average" reading taken of varying alloys of each of the respective metals.

SUBSTANCE	pH READING
Lemons	2.2-2.4
Apples	2.9-3.3
Wines	2.8-3.8
Sauerkraut	3.4-3.6
Strawberries	3.1-3.5
Beer	4.0-5.0
Spinach	5.1-5.7
Shrimp	6.8-7.0
Distilled Water (CO_2 expelled)	6.8-7.0
Crackers	7.0-8.5
Sea Water (Unpolluted)	8.0-8.4

Table 2. Representative pH readings of familiar substances.

the lower the pH reading. As mentioned above, the pH meter's basic function is the determination of the active acidity or alkalinity of a solution. Analytical chemists decided that the more acid a solution the lower the reading, the more alkaline the solution the higher the reading. The center point of the 0-14 scale—7—was assigned to carbon dioxide-free distilled water. Some representative pH readings of familiar substances are given in Table 2.

In practical terms, the electronics technician embarking on corrosion control will be concerned with only three electrolytes: sea-water, fresh-water, and high-humidity atmosphere. Comparatively, unpolluted sea water has a pH reading from 8.3 to 8.7 on the 0-14-pH scale. Polluted sea water, such as found in the New York port area, the Houston ship channel, and other areas in which industrial wastes abound, will read from 6.0 to 6.6 or sometimes lower. The conclusion: pollution is acid. It follows that the greater the pollution, whether in an air or water system or interface between the two, the higher the corrosion possibility. For example, a ship or pleasure boat with a galvanic arrangement (a metallic-differential system) of a bronze propeller and a steel rudder and moored or operating in the relatively alkaline environment of the open sea will not have anywhere the corrosion problem as the same ship moored in, say, Brooklyn's highly polluted Newtown Creek. In other words, a change in the electrolytic ecology in which the two dissimilar metals in the galvanic arrangement find themselves is far more insidious and influential than is usually realized.

This influence of pollution also holds true of corrosion in an air environment. Here, air with a relatively high percentage of humidity serves as the electrolyte. The damper climates such as experienced in the Gulf of Mexico and Florida areas, the Washington-Oregon area, certain portions of the Great Lakes, and, in fact, most seaboard areas will provide ideal surroundings for corrosion. Couple this ideal corrosion environment with air pollution and corrosion becomes a major economic factor. Indeed, some statistics state that one-fifth of the world's annual production of iron and steel is lost to corrosion. Table 3 lists the different types of corrosion; their characteristics and where generally found.

Electrolysis Corrosion

A close relative to galvanic corrosion is the so-called *electrolysis* corrosion or "stray-current" corrosion. This type arises when the voltage difference in a corrosion system is not self-generated but is impressed externally. With the advent of electronic equipment on boats, this kind of corrosion problem assumed increasing importance. There are two basic areas here and they are both electrical in nature: externally impressed voltages due to *voltage drops* in the boat's electrical system, and *cross grounding*. Owing to the increasing prevalence of grounding the negative side of the vessel's electrical system, this latter type is not encountered too often except in older commercial vessels. The author has several case histories in which propellers and other underwater metal boat parts have been destroyed in a matter of weeks due to cross grounding.

It is in this area of electrolysis corrosion that the electronics technician is most usually involved ("I didn't have this corrosion until you installed the radio!") and generally the villain of the piece is a voltage drop. Nine times out of ten, a voltage-drop condition can be eliminated by using the largest practicable size wire for power leads and by bonding all metal parts of the boat to a common ground strap. This could be a length of strip copper laid along the keelson with heavy wire or braid going from it to the various metals on the boat. One common voltage-drop condition involving the marinephone ground-plate is seen in Fig. 2. The best instrument for detecting voltage drops is one of the new breed of high-impedance input, battery-operated v.o.m.'s with extra-long clip leads. The check is made from each metal part to every other metal part and comparing the power-on with the power-off reading. On land, another pair of leads—even longer—with 12" to 18" spikes as the probes can be used for determining voltage drops on buried pipe systems. Gas company officials claim severe corrosion damage to their natural gas pipelines in the vicinity of electric train tracks despite the use of high-efficiency magnesium sacrificial anodes.

Local-Cell Corrosion

The two types of corrosion so far discussed have been based on physically obvious electrical circuits: two metals, a common electrolyte, a complete circuit. But what causes the corrosion in, say, a metal post with absolutely no connection or relationship to any other mass of metal? This kind of damage is due to *local-cell* action. Just as local action in a lead-acid storage cell, because of impurities in the electrodes, can cause sulphation of the plates or the same local cell action can cause the disintegration of the zinc casing of a dry cell, so also does this phenomenon cause the corrosion damage in seemingly independent metal structures. One of the most familiar samples of local cell corrosion is seen by the average person on automobile body parts such as that shown in the photo on page 42.

There are many reasons why these small local cells are formed on the surface of a piece of metal: impurities in the metal itself, orientation of the grains in the metal structure, imperfections on the surface, stresses placed upon the metal when it is used in construction, imperfect homogeneity in the manufacturing process and others. But in examining local-cell corrosion we find the identical action taking place that occurred in galvanic corrosion; there will be many minute anodic and cathodic areas. Each anode and cathode will, obviously, be physically connected and will also be exposed to a common electrolyte.

Oxygen-Differential Corrosion

In local-cell corrosion, however, the appearance of the damage is different from that caused by galvanic or electrolysis (externally impressed voltage) corrosion. It has a characteristically pitted appearance. This pitting process can, however, multiply and progress until the entire surface is corroded. This is seen in the familiar "rust" on iron and steel. It is in the area of pitting corrosion that often there is a merging into yet another form of corrosion: the oxygen-differential system or the creation of a galvanic cell composed of the same metal in physical contact but exposed to two different—but connected—electrolytes. The differences in the electrolytes will be a difference in oxygen concentration.

The oxygen-differential system can be found where one part of a metal structure is shielded or protected from the air or water while other parts of the same metal are exposed to the electrolyte. Painting part of a structure and leaving part unpainted is an invitation to corrosion. Barnacles on boat underwater metal parts will create a situation where the metal directly underneath the barnacle will be exposed to an electrolyte having less oxygen than the electrolyte in contact with the adjacent metal. A simple thing such as the buildup of sand around the base of a metal piling or post or even sand drifting onto part of a metallic structure can give rise to the oxygen-differential corrosion system. One very unfortunate and, one might say "treacherous," example of this type of corrosion may possibly take place under the zinc sacrificial anodes installed to *prevent* corrosion. As the zinc corrodes in its protective action, it will gradually leave a space between itself and the metal to which it is attached. The electrolyte (water) in this space will have less oxygen present than water in contact with the adjacent "protected" metal and oxygen-differential corrosion may take place. This condition may merge into one in which the zinc anode eventually becomes insulated from the metal part which it is supposed to protect and galvanic corrosion can then take place between the no-longer-protected metal and some other metal which is cathodic to it.

Oxygen, then, is another prerequisite to the corrosion process and as can be expected, we find massive corrosion damage in the so-called "splash zone" or interface between the air and water environments. The electrical activity of a corrosion system will be at its highest where wetting and drying, *i.e.*, alternate exposure to the electrolyte and to the increased oxygen in the air takes place. If we add chloride (the basic element that differentiates sea water from fresh water) to this system, we find extensive corrosion damage. The emergent containership industry is haunted by just this type of a problem. Containers, or rather more precisely, the fittings that are used for moving these containers, may fail long before their projected life expectancy. An inspection of metal structures along the waterfront of a port city such as New York will also bear this out. Fig. 3 is a photograph of Buchler's "Chloridometer," an instrument that can be used for determining the possibility of corrosion by measuring the amount of chloride present in the water sample.

Anti-Corrosion Techniques

Probably the most common way to combat the ravages of the corrosion process is by using sacrificial anodes. These are usually of zinc or zinc alloy and are interposed between the anode and cathode of the galvanic corrosion arrangement and connected to the anode. In effect, we are substituting a more efficient "battery" component—the zinc anode—having a higher anodic capability which will dominate the prior anode and thus protect it.

The true electronic means of protection, however, is the *impressed-current* approach. This might be viewed as making an asset of a liability. We have seen that corrosion can result from impressing an external current on the system (stray-current corrosion). If we were to use the same concept, but reverse the polarity of the voltage generated by a galvanic arrangement, we would find that the corrosion process would be effectively halted. If, for instance, there were a 0.3-volt difference between a bronze propeller and a steel rudder and these two metals were connected externally by metallic continuity or, as is often the case, through bilge water we would have the ideal arrangement for corrosion damage to the anodic rudder (the bronze propeller being the cathode). A 0.3 voltage of the opposite polarity impressed across the steel-bronze system (the physical external connection would first have to be broken) should effectively prevent corrosion damage to the rudder. The next logical step would be to bond all the vessel's underwater metal parts together to form a common cathode and then introduce a balance voltage of sufficient strength *via* an independent electrical anode so that the galvanic action would be effectively balanced out. In effect, this system weakens the anode-cathode relationship to a degree and can be done during the construction of the boat by using identical metals or metals close to each other in the galvanic series. This is the basic theory behind the im- (*Continued on page* 60)

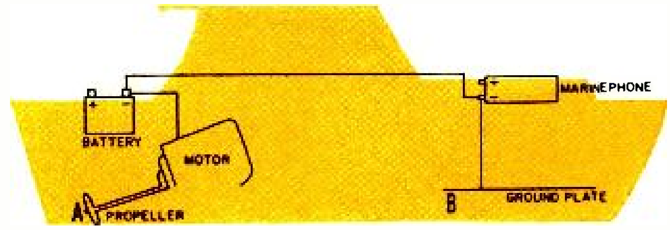


Fig. 2. A frequent cause of electrolysis corrosion in boats is the voltage-drop condition that exists between the propeller (A) and the ground plate (B) due to the long wire run from the negative terminal of the battery to marinephone.

Table 3. Characteristics of different types of corrosion.

TYPE	APPEARANCE	WHERE FOUND
General corrosion	Uniform eating away of metal	Bridges, flag poles, lighting standards, buildings, boats.
Pitting corrosion*	Characteristic pits or holes	Underground pipe, stainless steel, generally prevalent in crevices and cracks.
Corrosion-erosion	Quite similar to pitting corrosion	Wherever there is a flow of fluid or where the metal involved is in motion in a fluid. Boat propellers, pump impellers, tubing.
Dezincification	Massive damage	In alloys containing zinc.
Intergranular corrosion	Lacelike	Usually in improperly heat-treated metals.
Galvanic corrosion	Large damage to large area	Anywhere there is a "differential system"; two dissimilar metals, two dissimilar electrolytes in confluence, generally the most common.
Stress corrosion	Cracks formed in metal	Usually found in conjunction with galvanic, pitting and/or intergranular corrosion. Splash zones, heat exchangers and evaporators.

*An especially good treatment of pitting corrosion is found in the National Bureau of Standards circular #579

Electronics in Weighing Systems

By IRWIN MATH
Electronics Consultant

New electronic techniques make it possible to measure 250-pound loads to within ±.25 ounce—an accuracy of ±.0063%. Strain gages and linear variable differential transformers are used with beam- and spring-balance scales to do the weighing.

Extremely accurate electro-hydraulic beam-balancing scale used extensively by the medical profession when the exact weight of a patient must be calculated. See Fig. 6 for a diagram showing the measuring circuits and weighing platform.

IN many of the medical and industrial processes of today's highly complex technological world, the accurate measurement of weight is often of prime importance. Semiconductor materials are mixed by weight, as are certain drugs. Massive trucks have their loads checked this way, and even doctors who have patients recovering from exotic transplant surgery rely on extremely accurate scales to monitor various phases of their patient's rate of recovery. To perform such measurements, a group of highly accurate weight transducers and weighing systems have been developed to the point where it is now possible to measure a load of 250 pounds to an accuracy of ±0.0063% (±0.25 ounce), or 25 pounds to an accuracy of ±0.0075% (±0.03 ounce) with one instrument.

In weight-measuring systems there are basically two methods that can be used; the beam-balance method, as used in the familiar analytical laboratory scale, and the spring-balance method, as in the common bathroom scale. Weight transducers can use either of these methods. Fig. 1 shows a typical weight transducer of the spring-balance type using a strain gage. The movable piston is connected externally to the weight to be measured and internally to a "C"-shaped steel spring. Between the arms of the spring is a fixture holding a variable resistance strain gage. As the weight on the piston increases, the strain gage is stressed, with its resistance varying in direct proportion to the amount of stress. The steel spring acts as a "calibrated mechanical resistance" for the piston. By varying the size and composition of the spring, various weight ranges can be accommodated.

Strain Gage vs Load Cell

Advantages of the spring-balance type of transducer are simplicity of construction and relatively few mechanical alignment problems. Difficulties arise, however, when large ranges of weights must be measured. The linearity of the strain gage is maintained only over small movements and as

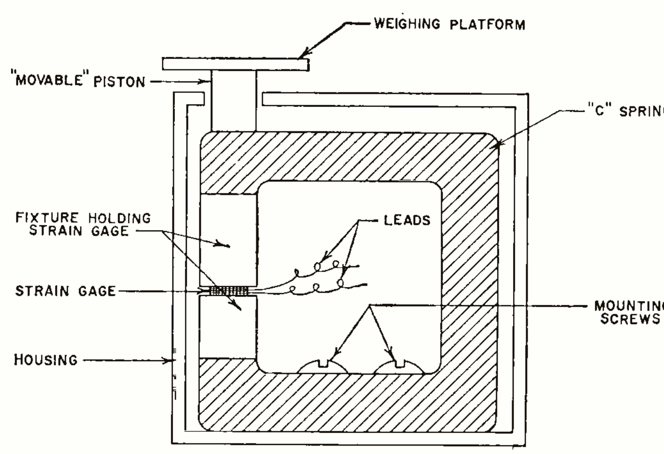
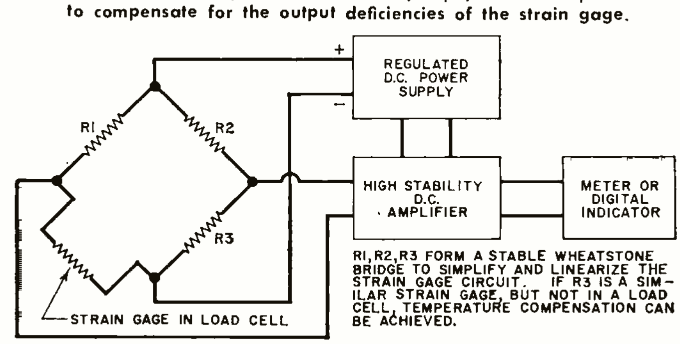


Fig. 1. Typical spring-balance scale using a variable resistance strain gage. Different weight ranges can be accommodated by varying size and composition of the "C" steel spring.

Fig. 2. Block diagram of simple strain-gage weighing system. Expensive and sophisticated auxiliary equipment is required to compensate for the output deficiencies of the strain gage.



a result, when changing ranges, the entire transducer must be changed. Also, since the output resistance change of a strain gage is quite small, auxiliary equipment such as sophisticated amplifiers, power supplies, and readout devices (which can be quite costly) must be used to compensate for this deficiency. Fig. 2 is a block diagram of a simple strain-gage weighing system.

Replacing the strain gage with linear variable differential transformer (l.v.d.t.) in a load cell eliminates many of the difficulties of the strain-gage unit. Fig. 3 shows such a load cell. The steel spring is still used, but this time the core of an l.v.d.t. is fastened to the spring. When a load is applied to the top of the cell, it causes the spring to deflect, which then moves the core of the l.v.d.t. Fig. 4 shows the auxiliary equipment required for this type of transducer. A low-cost oscillator drives the primary of the l.v.d.t. Secondary windings are connected in series-opposing on either side of the primary winding. Therefore, when the core of the l.v.d.t. has not been displaced (no load applied), the signal induced in each secondary is equal, and the output is zero. Any slight deviation from the exact center (or null) position of the core results in an output signal. This signal is measured and used to indicate the weight of the object on the cell.

Long-term stabilities of l.v.d.t. load cells are usually 5 to 10 times better than equivalent strain-gage systems, and their cost can be as much as 50% less. L.v.d.t. load cells are also more rugged and can be subjected to much greater overloads without damage. Also, since the core of an l.v.d.t. can be moved over displacements as great as ±0.1 inch (compared to thousandths for a strain gage), wider weighing ranges can be accommodated by the same load cell.

Beam-Balance Method of Weighing

In the beam-balance method of weighing, a rigid beam or bar is supported and balanced on a knife edge. The object to be weighed is placed on the weighing platform and, by gradually placing known weights on the other end of the beam, a point is reached where balance is obtained. The weight of the unknown object can then be determined by examining the known weights that have been added to achieve the balanced condition. The beam assembly of the familiar "doctor's" scale, in Fig. 5, clearly shows this. The weight on the weighing platform tends to pull the end of the beam "up." The movable weight is slid along the beam until a balanced condition is obtained, and the weight is read directly from the scale position of the movable weight.

The advantages of the beam-balance system over the load cells are its potential wide range and high accuracy. As long as the beam and knife edge can take the stress, almost any amount can be weighed from a few pounds to many hundreds and even thousands of pounds—and on the same scale. In addition, the longer the beam is made, the greater the resolution of the reading. Since the beam is only used to obtain balance, the over-all accuracy of a balance scale lies in the accuracy of the known weights.

Fig. 6 shows an extremely accurate electro-hydraulic beam-balancing scale for the medical profession. It is used primarily for research in metabolic diseases and for special treatments where the exact weight of a patient must be known. With this scale, a load of from 1 to 250 pounds can be weighed with an over-all accuracy of 0.0063%—something a single load-cell scale could never do. The force produced by the weight of the object or person being weighed is transferred to one end of a beam by means of a special hydraulic pressure system. The other end of the beam has some movable weights for balancing and the core of an l.v.d.t. on the extreme end. The output of the l.v.d.t. is processed and fed to a zero-center meter. The slightest deviation from exact balance causes the linear variable differential transformer to produce a signal which is displayed on the meter. A strip-chart recorder is connected in parallel with the meter and thus continuously records small changes in weight.

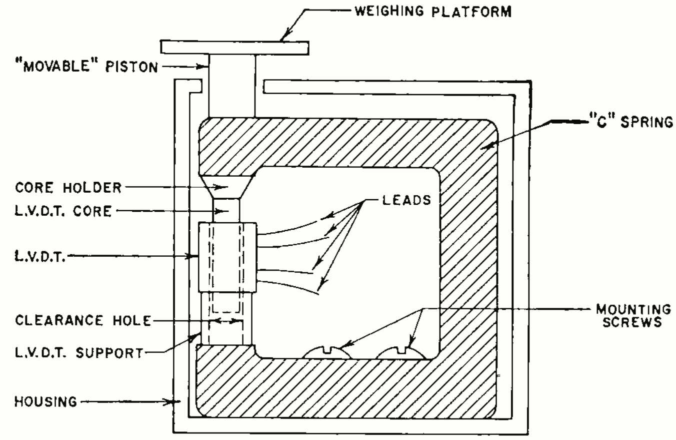


Fig. 3. Spring-balance scale using a linear variable differential transformer (l.v.d.t.) in a load cell. Use of l.v.d.t. eliminates the difficulties inherent in the strain-gage unit.

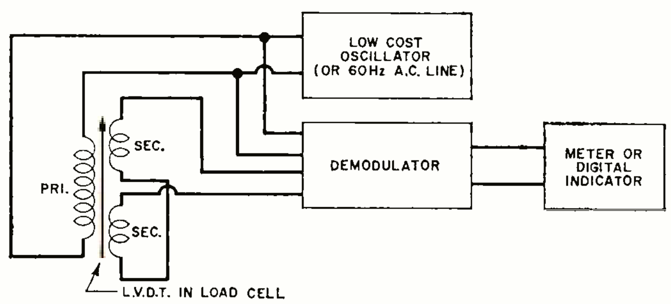


Fig. 4. Block diagram of an l.v.d.t. weighing system showing the auxiliary equipment required to measure the output signal from the load cell to determine weight of an object.

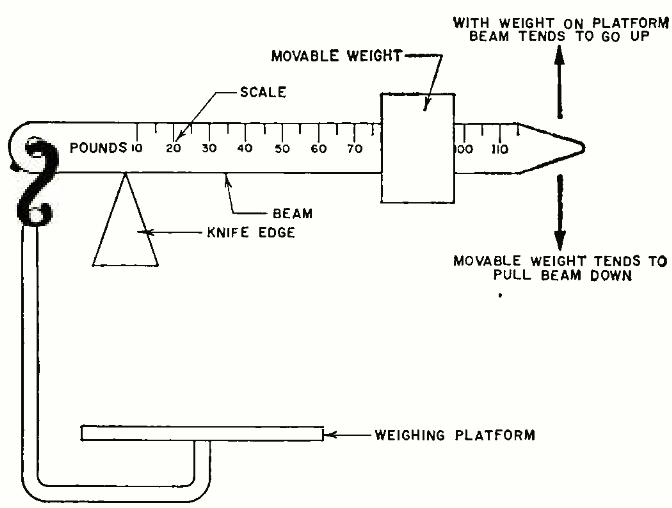


Fig. 5. "Doctor's" beam-balance scale demonstrating use of a movable weight in determining the weight of an object.

Fig. 7 is a simplified diagram of another beam-type scale—a fully automatic servo amplifier operated one. The movable weight travels on a threaded rod which is, in turn, driven by a servomotor. The signal to the servomotor is produced by an l.v.d.t. on the end of the beam. Whenever the beam is unbalanced, the servomotor turns, moving the weight in the proper direction to achieve balance. At balance, the l.v.d.t. output is zero, and the motor stops. Since the number of threads on the rod is known, the position of the movable weight and subsequent weight of the unknown object are directly proportional to the rotation of this rod. A flexible shaft attached to this rod and connected to a mechanical counter gives a direct reading of weight. The flexible shaft can be replaced by a synchro transmitter/receiver system with the resulting action being the same.

Typically, this scale has an ac- (*Continued on page* 98)

Reading Aid for the Blind

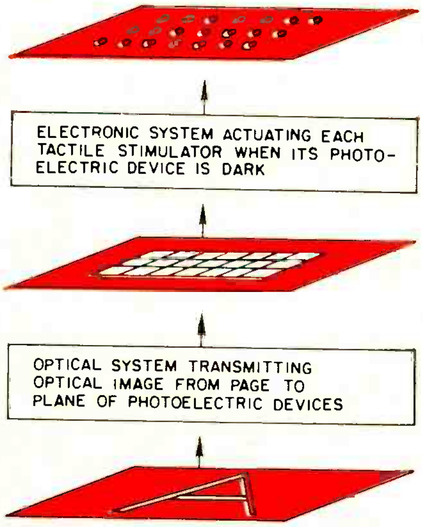
By J. S. BRUGLER and W. T. YOUNG
Dept. of Electrical Engineering, Stanford University

A system that permits the blind to "feel" ordinary printed matter and read it using his sense of touch. Phototransistors and piezoelectric reeds are used in system.

Reading aid showing operator scanning printed material with sensing probe containing optics and phototransistors while the index finger of left hand is used to feel changing letter pattern on the tactile output stimulator.

IN the dark world of the blind, the only communicating link with the world of literature has been through the auditory and tactile sensory processes. In the case of the auditory process, the blind must have the assistance of a sighted reader or use pre-recorded tapes. In the past, the tactile process has been implemented by the well-known Braille method in which the blind person uses his sense of touch to translate the printed material in coded form *via* the fingertips. Thus, with either the Braille system or "talking-book" tapes an intermediate translation step is necessary. Consequently, numerous reading materials of the sighted are not readily accessible to the blind because of the cost involved. This article reports on the development and progress of a system (first conceived by Professor J. G. Linvill at Stanford University), that provides the blind direct access to ordinary printed materials for the sighted.

Fig. 1. Direct-translation principle used in reading machine to convert printed image to tactile image. The letter "A" is presented to blind operator as a vibrating tactile facsimile.



Background

A number of reading machines for the blind have been developed in the past few decades, but none has been widely accepted because of limited performance. The advent of integrated circuits, giving low costs and small size per circuit function, has considerably improved the outlook. A high degree of electronic sophistication can now be achieved in a small, personal electronic reading aid. This, of course, is only one facet of the inevitable proliferation of sophisticated electronics in the home.

Reading aids for the blind have been classified into four categories. In the order of increasing complexity these are: (1) Simple optical probe, (2) direct translation, (3) intermediate, and (4) recognition. The simple optical probe merely provides the reader an indication of whether a small area of the reading material is light or dark, so has limited usefulness. The direct-translation machine employs a number of elements to provide a one-to-one transformation of the reading material to an audible or tactile display accessible to the blind. The latter two types of reading aid, in contrast to the others, incorporate electronic processing and decision-making circuitry. In other words, some sort of intelligence is built which recognizes the various printed characters for the blind user. The intermediate machine differs from the full-recognition machine by employing both the human and electronic brains, while the full-recognition machine relies on the electronics to accomplish most of the "thinking." All of these devices can use either an auditory or tactile output.

Our machine falls in the direct-translation category, since this approach appears to offer the best combination of simplicity and performance. A tactile output was chosen since it provides a parallel processing capability most suited for straightforward image translation. A difficulty with previous direct-translation devices, which we believe we have overcome, has been insufficient resolution, *i.e.*, the fine structure of each letter was not preserved in the image perceived by the blind reader. Without this fine structure, many similar-appearing letters, such as "e" and "c," cannot always be distinguished. We have not pursued the recognition approach thus far, preferring to rely on the built-in human pattern-recognition capabilities, for two reasons: (1) The limits of the direct-translation approach have yet to be established with results thus far indicating useful reading rates are attainable, and (2) the prohibitive cost and complexity of recognition devices (*e.g.*, address-recognizing machines of the Post Office) preclude personal ownership at this time. We do envisage our simple machine perhaps linked in the future *via* phone lines to a powerful time-shared central computer that provides automatic pattern-recognition capability.

Principles of Operation

The direct-translation principle, as employed in the reading aid, is shown in Fig. 1. The letter "A" on the bottom plane, representing a portion of the material to be read, is focused on a planar array of phototransistors. Each phototransistor is connected, by means of a threshold-detecting circuit, to a piezoelectric reed. A small pin is attached to the end of each piezoelectric reed and all of the pins arranged to comprise the planar array of tactile stimulators. If a phototransistor is dark, its output is below threshold, and its corresponding stimulator is driven. Conversely, when a phototransistor is lighted, its output exceeds the threshold, and its stimulator does not vibrate. By this process, a vibrating tactile facsimile (in this case a vibrating "A") is presented to the reader. Six columns, each having 24 rows, comprise the array, giving a total of 144 phototransistors and 144 stimulators. The stimulators are closely spaced (0.05″ × 0.1″) so that the entire tactile image can be felt by a single finger.

The lead photograph shows the reading aid in operation. The tactile image is felt by the index finger of the left hand of the operator, while the right hand scans the printed material with the sensing probe containing the optics and phototransistors. As the operator scans, the tactile letter pattern moves correspondingly. In this fashion the letters are felt in succession by the operator. The mechanical tracking aid shown in the photograph helps the operator easily scan horizontally across a line of print. A locking mechanism can be released by the thumb of the right hand to move the probe vertically. The system electronics is located beneath the tracking aid. Also shown is the light box display, which contains a 24 × 6 matrix of neon bulbs that provide a visual output of the letters. This visual output is solely for monitoring of performance by a sighted observer.

The present design has evolved from initial studies conducted at the Stanford Research Institute by Professor J. C. Bliss. In a sense, the system represents a return to earlier methods since embossed letters were used by the blind before the invention of the Braille system in the 19th Century. The feasibility studies indicated that computer-generated embossed letters could be read by the blind at useful rates. Experience with the present reading-aid hardware has confirmed this prediction.

Technical Features

The lead photo shows three primary system components: (1) The hand-held probe, (2) the control electronics, and (3) the tactile stimulator array. A number of technical innovations were required to develop these units. A few of these technical highlights deserve mention at this point.

The "eye" of the system is a monolithic silicon phototransistor array "retina" developed in the integrated-circuit laboratory at Stanford University. Such arrays are under development at a number of laboratories, with the reading aid being one of the first practical applications. Fig. 2 is a photograph of the silicon array mounted in a 40-lead flat pack. All 144 transistors, each 6 × 12 mils, are fabricated simultaneously by means of integrated-circuit photolithographic techniques. Such an array gives the advantages of all-solid-state imaging—small size, weight, and power consumption. In addition, the geometrical structure is precise, in contrast to the photo-cathode of imaging tubes. In the future, such arrays should become available with many more elements, eventually making possible an all-solid-state TV camera.

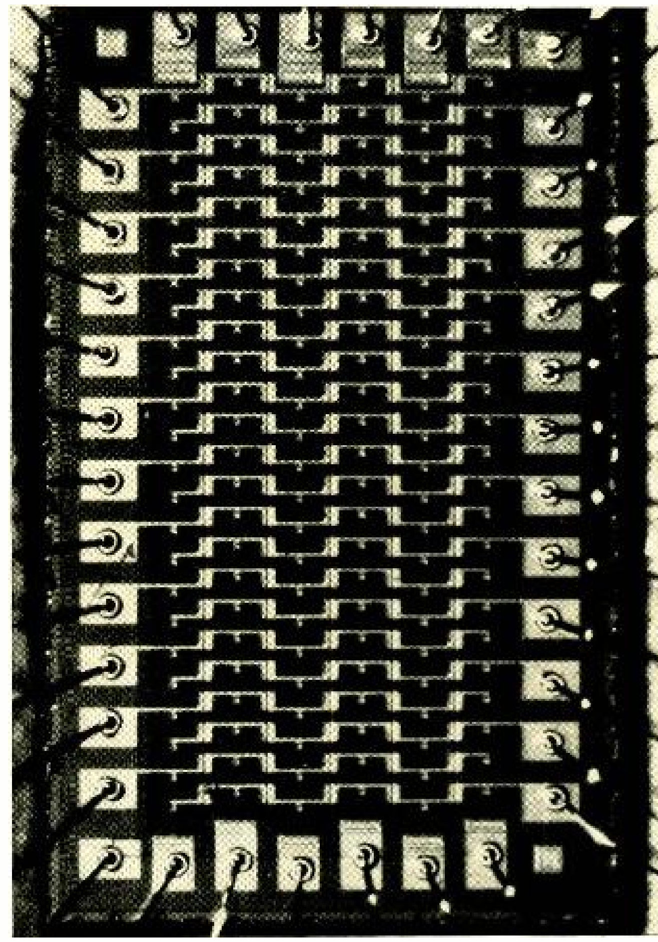
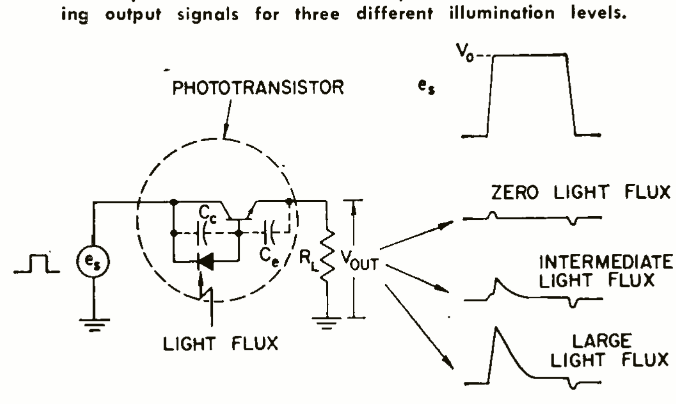


Fig. 2. Photomicrograph of sensor silicon array mounted in 40-lead flat pack and containing 144 6 × 12-mil transistors.

A key feature of the sensing array is phototransistor operation in the charge-storage or integration mode. This mode

Fig. 3. The charge-storage mode of phototransistor showing (A) circuit configuration using an equivalent representation of the phototransistor and (B) the pulse source and resulting output signals for three different illumination levels.



increases the peak phototransistor output by integrating the photocurrent of a phototransistor for a relatively long time, and then extracting the output signal during a short sample time. The charge-storage mode is depicted in Fig. 3. A voltage pulse is applied to the series combination of the phototransistors and a load resistor. The phototransistor base is floating, and charge is primarily generated at the collector-base junction by the impinging light flux. A photodiode from

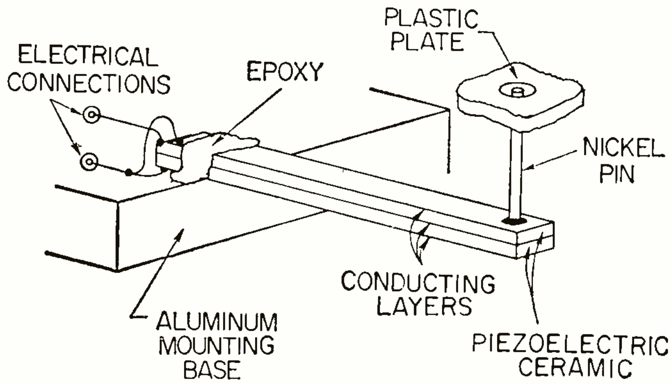


Fig. 4. Individual output stimulator consisting of two slabs of piezoelectric material sandwiched between conducting electrodes. When a voltage is applied, one slab expands while other contracts, causing attached pin to contact finger.

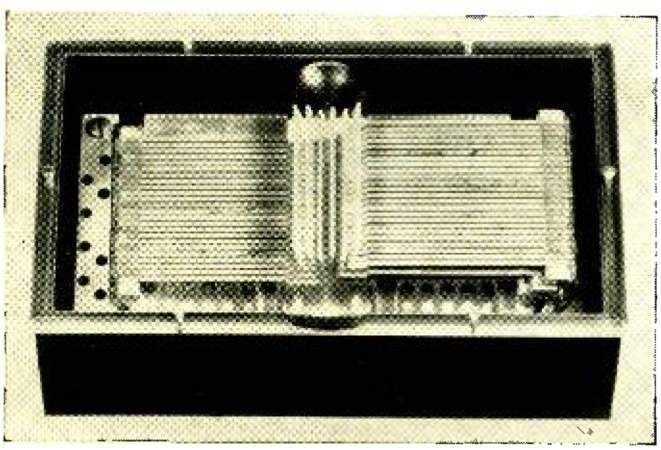
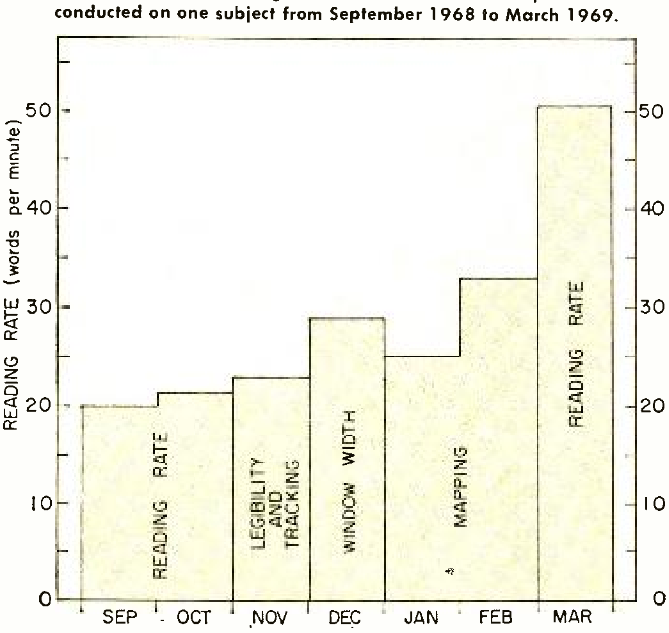


Fig. 5. Assembled tactile stimulator array, with perforated plastic sensing plate removed, showing pins (center) and the top tier of three tiers of piezoelectric slabs (left and right).

Fig. 6. Graph of reading rate measurements and experiments conducted on one subject from September 1968 to March 1969.



collector-to-base depicts this. When the pulse, e_s, is applied, the collector-base capacitance is charged approximately to its amplitude, V_0. After the short pulse returns to zero, the collector-base capacitance is discharged by photocurrent. When the next pulse comes along, an output pulse is generated having amplitude proportional to the change in collector-base voltage between sampling times. Since this pulse can be relatively large (volts), storage-mode operation is very useful.

Storage-mode phototransistor operation also meshes conveniently with multiplex electronics. For this reason, a 24-stage shift register is used to interrogate the photo-array, one row at a time. Six parallel-signal channels are extracted from the array columns and fed to six voltage comparators that decide whether a transistor is lighted or dark. If a particular transistor is dark, the comparator output is then gated to excite the appropriate stimulator. Important features of the processing electronics are: (1) Use of low-power electronics to enable battery-powered operation, and (2) automatic electronic compensation to account for varying page illumination and reflectivity.

The output stimulator array is an important and unique system component. Other schemes are possible, such as electrical stimulation, but experience thus far has indicated that mechanical vibration is the most satisfactory. The piezoelectric "Bimorphs" (*Clevite Corp.*) employed are commonly used as phonograph pickups to translate mechanical motion to an electrical signal. We use them in the opposite fashion as electrical-to-mechanical transducers in the cantilever configuration shown in Fig. 4. The Bimorph consists of two slabs of piezoelectric material sandwiched between conducting electrodes. When a voltage is applied, one slab expands and the other contracts, so the cantilevered Bimorph bends (much like the bimetallic strip used in thermostats). A pin is attached to the end of the Bimorph which protrudes through a small hole and contacts the finger. When an a.c. voltage is applied at the resonant frequency of the structure, the pin vibrates against the finger, creating a tingling sensation. Fig. 5 is a photograph of an assembled 24 × 6 stimulator array unit. The three left-hand columns of pins are driven by three tiers of 24 Bimorphs, assembled as previously described. The three right-hand columns are similarly driven in a symmetrical manner. Only the top tiers which drive the outside columns are easily seen in the photo. The perforated plastic sensing plate is tailored to fit the curvature of the finger.

Reading Performance

A comprehensive study of reading performance with existing hardware is under way at Stanford Research Institute. In addition, fundamental studies of the reading process are in progress in order to optimize reading-aid parameters. For example, the best number of array columns to use is still uncertain. Efforts are also under way to increase the field of view to enable "word-at-a-time" rather than "letter-at-a-time" reading.

Results using the present system have been quite encouraging. Fig. 6 shows the reading rates achieved by the Institute's most-experienced subject. Some fluctuation is present due to varying experimental conditions; however, continuous improvement is evident, and no limiting plateau has been reached. After about 160 hours of practice, 50-word-per-minute rates have been attained. Such rates, although slower than good Braille reading (approximately 150 w/min) are quite useful. In fact, much slower rates are satisfactory for many everyday purposes, for example, reading letters, bills, checks, etc.

Considerable training will naturally be required in the use of the machine; we are presently considering the problem. The tactile sense must be developed and the letter shapes learned. One fact that is clearly obvious is that early training in life is most desirable. (*Continued on page* 91)

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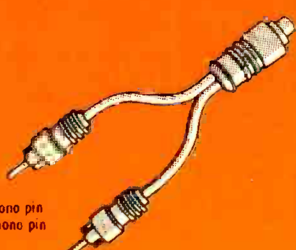

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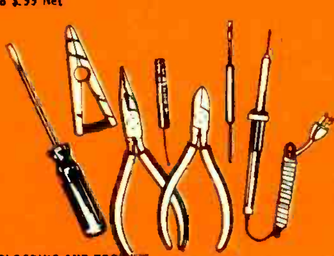

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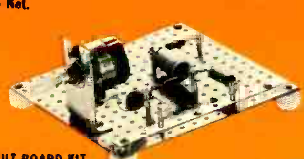

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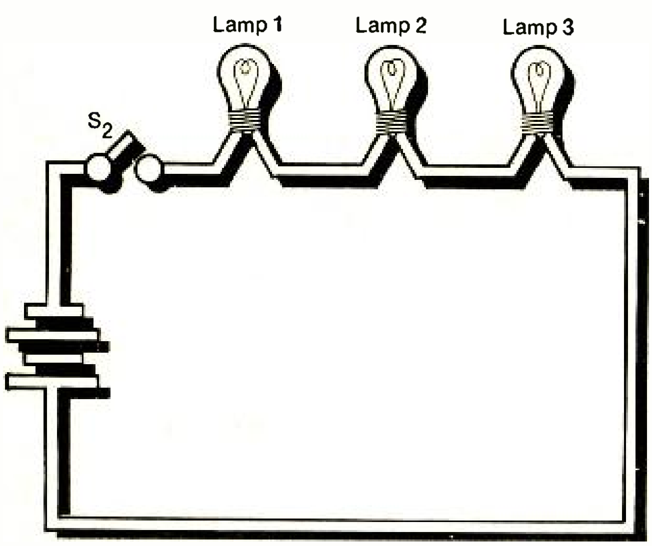
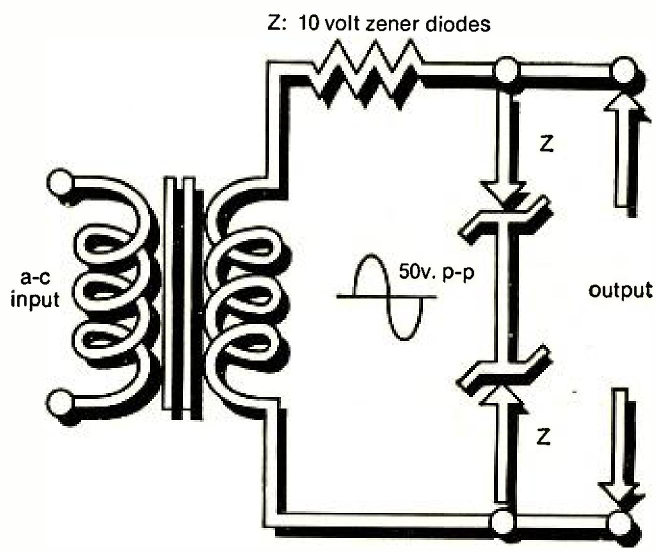
CIRCLE NO. 132 ON READER SERVICE CARD

Can you solve these two basic problems in electronics?





This one is relatively simple:

When Switch S_2 is closed, which lamp bulbs light up?

Note: If you had completed only the first lesson of any of the RCA Institutes Home Study programs, you could have solved this problem.

This one's a little more difficult:

What is the output voltage (p–p)?

Note: If you had completed the first lesson in the new courses in Solid State Electronics, you could have easily solved this problem.

These new courses include the latest findings and techniques in this field. *Information you must have if you are to service today's expanding multitude of solid state instruments and devices used in Television, Digital, and Communications Equipment.*

If you had completed an entire RCA Institutes Home Study Course in Semiconductor Electronics, Digital Electronics, or Solid State Electronics, you should now be qualified for a good paying position in the field you choose. Send for complete information. Take that first essential step now by mailing the attached card.

ANSWERS: Problem 1—they all light up
Problem 2—20 Volts (p–p)

RCA Institutes Autotext learning method makes problem-solving easier... gets you started faster towards a good-paying career in electronics

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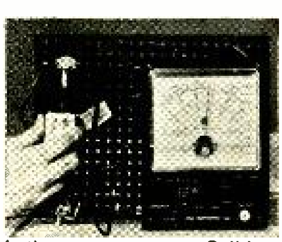
Electronics Drafting



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JOHN FRYE

Customers are finally threatening serious revolt against poor merchandise, worthless guarantees, slovenly service.

THE CUSTOMER REVOLT

"MAC," Barney said to his employer working beside him at the service bench, "have you been following the hearings being held by the Senate Commerce subcommittee, headed by Senator Moss of Utah, on the problems of shoddy merchandise and the shabby treatment of customers?"

"I certainly have," Mac replied, "and I think this is another straw in the wind of a gathering storm of consumer revolt. People are sick and tired of paying inflated prices for things that are poorly made and do not function properly; of having to write reams of letters and wait weeks for a manufacturer to make good on his warranty—if he ever does; and having a repairman make two or three calls before he does the job that should have been done on the first call. The consumers have been long suffering, but now they are in a mood to do something about it, and all of us in the manufacturing or construction or repair business would do well to pay attention to what they are saying."

"It strikes me as a little odd that customers should have to take this kind of action," Barney remarked. "What ever happened to that old saw about 'The customer is always right'? In the free-enterprise system, I thought competition was supposed to make the customer king."

"It was and it pretty much did up until the Second World War," Mac explained, "but then the demands of the war machine gobbled up raw materials and drastically reduced the production of consumer goods. All at once if you wanted a new car, typewriter, refrigerator, set of tires, slide rule, or anything else in short supply—and most things were!—you had to stand in line, fill out forms, and often wait months to get what you wanted. Unfortunately, there was another way: the black market. The dealer who had scarce items to sell was a most important and popular person. He didn't need to do any selling because there were many more customers than he had goods. Instead of his having to please his customers, the would-be customers wooed him with everything from flattery to outright bribery.

"It was the same way with service. Since so few new radios, refrigerators, washing machines, or automobiles were being produced, the old ones had to be kept running. Doing this was especially difficult because replacement parts, including vacuum tubes, were also in short supply and were doled out very sparingly to discourage hoarding. The service technician had as much work as he could possibly do, and more. He fell into the habit of thinking that he was doing his customer a favor in repairing his car or refrigerator or radio receiver, even though he was well paid for the job."

"I can see how this happened, but I'd think everything would have returned to normal after the war ended and factories started turning out consumer goods again," Barney commented.

"Well, it didn't work out that way," Mac said. "The thing that kept the sellers in the saddle was a booming inflation. Defense-plant workers made good wages during the war, with lots of overtime, and there was not much to spend it on while the war lasted. When the war was over and goods started appearing on the market, these well-heeled consumers were bidding against each other for these goods. Price was not much of an object, and there was still more demand than goods. Then along came the Korean War and after that the involvement in Vietnam to keep things off balance.

"The upshot of all this is that we have had more than a quarter of a century of a seller's market in this country. Anyone who has something to market, be that a durable item or a service, has little trouble in selling it. There are so many customers that little value is placed on the good will of the individual customer. If one is lost, there are plenty more to take his place. Competition, instead of concentrating on quality, takes the form of seeing who can turn out the most marketable items in the least amount of time, for in the back of the manufacturers' minds is the urgent conviction that they had better make hay while the sun shines because this is too good to last forever. Money spent on extravagant advertising pays off better than money spent on quality control, for if you just get the item into the hands of a dealer someone will buy it. Barnum was a wise old bird, and didn't he say, 'There's a sucker born every minute'?"

"Yeah, and labor has capitalized on his urgency," Barney chimed in. "They have demanded more and more wages for turning out the products and for building the factories in which to make them. Manufacturers have acceded to these demands with very little real resistance because they simply tacked the extra cost onto the selling price of their products. This, of course, fans the flames of inflation even higher."

"All true," Mac agreed, "but there are many signs these halcyon days for the sellers are about over. The complaint files of that Senate subcommittee you mentioned are becoming the most massive in Washington. A *UPI* story says people seem to be complaining to their congressmen more about shoddy merchandise than about taxes, the draft, ABM, or even the war in Vietnam. The subcommittee staff has drafted a bill on consumer warranty protection which is being considered. The thinking is clear and to the point: the way to force manufacturers to improve quality is to make it costly to produce shoddy products; and the way to make it costly is to demand clear and meaningful warranties backed by laws that say if a manufacturer guarantees his product and if it doesn't work as it is supposed to, he must repair or replace it."

"But the little guy can't afford to go to law to force a manufacturer to honor his warranty, especially on a low-cost item," Barney objected.

"The subcommittee realizes that, and they're exploring legislation to establish a federal consumer counsel office and an industry-wide system of ombudsmen to arbitrate consumer complaints. A consumer who felt he was getting the run-around from a manufacturer could either go to court or carry his complaint to one of these impartial arbitrators.

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CIRCLE NO. 126 ON READER SERVICE CARD

If the ombudsman decided the complaint had merit, the manufacturer would have to give the consumer satisfaction. An ombudsman system along these lines is already in operation in the dry-cleaning industry of New York City, where Bess Myerson Grant, Commissioner of City Consumer Affairs warns: 'Prime consumer difficulties arise from the sellers taking unfair advantage of the buyer's lack of expertise . . . the buyer will always be at the mercy of the seller. The answer: Wise up! Assert your rights!' "

"Dade County, Florida, has a kind of ombudsman system of its own," Barney said. "The Trade Standards Division maintains a 'consumer hot line' for the filing of complaints by consumers who feel they have been gypped and want something done about it. That red telephone on the division's desk is backed by what is called the toughest consumer protection code in the nation, a 28-page ordinance written into the county's municipal statutes. It has real teeth. Violators may be fined up to $500 and jailed for 60 days. In the first ten months of operation, more than 4000 complaints have been filed *via* the hot line. Oddly enough, only seventeen court cases have been filed against alleged violators, but hundreds of other grievances have been solved by a quick phone call. Very few gyp artists want to tangle with that tough law."

"Growing consumer anger is making itself felt in both high and low places," Mac agreed. "You remember a couple of months ago the President ordered government construction cut by 75% as an anti-inflation measure, and he made it clear that excessive demands by many of those in the building trades had much to do with his decision to issue the order.

"A single experience of my own recently," he went on, "helps me understand the growing impatience of consumers. When the wife was sick and we had to employ a housekeeper for a couple of months, she clobbered our faithful old coffee maker by repeatedly pulling the cord from the appliance instead of from the wall socket as should be done. The resulting arcing heated the appliance contact prongs and destroyed the block on which they were mounted. But nobody was going to tell that housekeeper how to run a kitchen, even if he was supposed to be a hotshot electronics man!

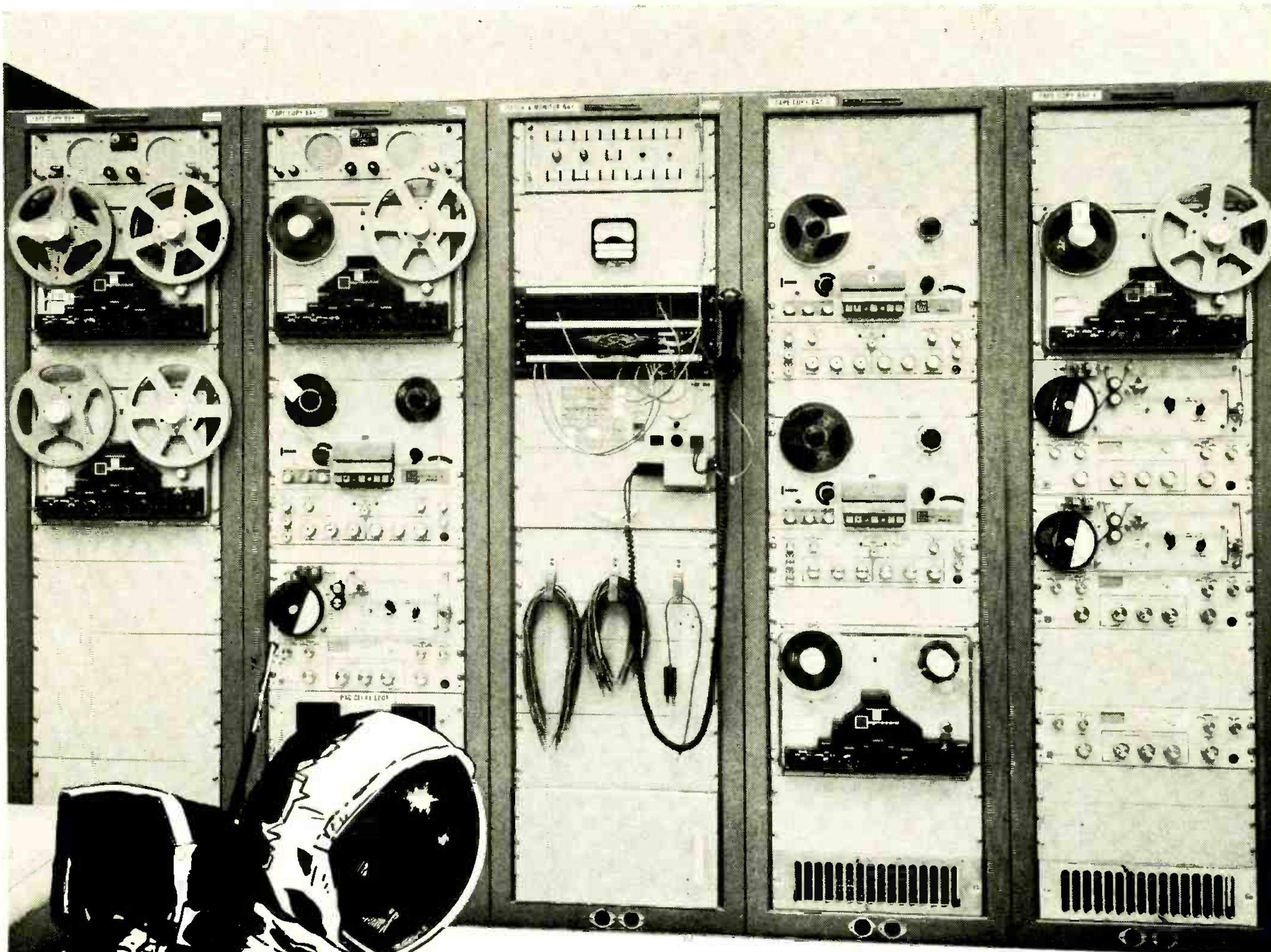
"I bought a new coffee maker from the dealer for one of the most respected names in the appliance business—according to the advertising. After we had used this a few days, the wife pointed out a spot about the size of a half-dollar on the inside that had never been plated. I suppose a spot of grease or something similar had prevented the plating from sticking to the raw brass. When I showed this to the dealer, he admitted it was a defect but said he would have to send it to the repair depot at Indianapolis. After three weeks I called to ask about my coffee pot. The dealer said Indianapolis was not equipped for plating, and the appliance had been forwarded to a factory on the East Coast. Finally, many weeks later, the dealer called to say my coffee maker was back. But actually it wasn't. It had been replaced with a new unit. Now why couldn't the dealer have been authorized to make this exchange in the first place and return the defective unit to the factory? That way the company would have retained my good will. Now I'll never buy another product manufactured by that company because I don't like the way they handle their warranty."

"Did you drink tea all this while?" Barney asked curiously.

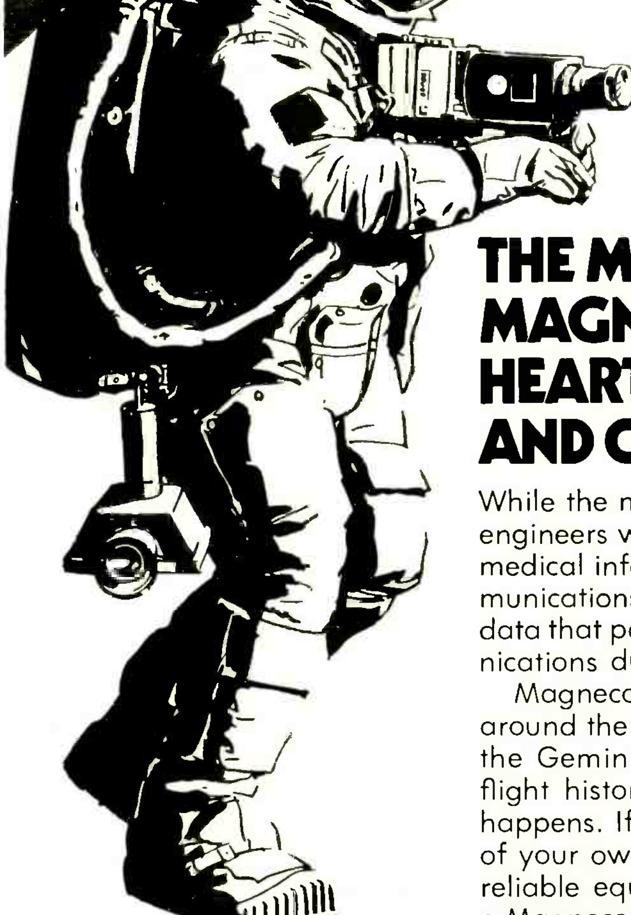
"Nope. I got busy and made a whole new terminal block for the old faithful," Mac said; "and it still, after fifteen years of use, makes better coffee than the new job."

"We come right back to the fact that what is basically wrong is that the manufacturer or the service person does not really care much what an individual customer thinks of his product or his work," Barney suggested. "There are too many customers with money burning their pockets to worry about the ill will of a few. Most people in manufacturing or doing service work today have no memory of how things were back in the '30's when I am told a customer was an important someone whose good will was to be won and retained at all costs."

"You were told right," Mac said, "and I'm afraid those days are coming back faster than many manufacturers, professional people, or service technicians realize. More and more people are beginning to feel they are being pushed around and exploited. They resent it and are starting to demand an end to this sort of thing. No longer do they listen to some intellectuals who say inflation is really good for the economy, that we can continue leapfrogging wages and living costs without concern, and that it really isn't necessary to balance the national budget. We might do well to remember the warning of Alfred North Whitehead, the British scholar: 'Wait for the back streets; when they move, the intellectuals are swept aside.' When we see the boycotts against soaring food prices, the threats to withhold taxes, and the stiffening resistance of consumers toward shoddy merchandise and service, there can be little doubt the back streets are starting to move. Now is a fine time for every business man to put King Customer back on his throne where he belongs!" ▲



NASA Manned Spacecraft Center, Houston, Texas



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CIRCLE NO. 95 ON READER SERVICE CARD

Electronics of Corrosion

(*Continued from page* 45)

pressed-current or "cathodic" protection systems.

It must be stressed that this form of electronic protection will not apply when stray-current corrosion (voltage drops or cross groundings) or the so-called *cavitation* or water-flow corrosion are involved. It is also of doubtful value in oxygen-differential or area-differential corrosion systems. Even its *forte*, the halting of galvanic corrosion, can sometimes be useless because of the difficulty of applying it. In a case where steel nails are used to install aluminum siding, and there exists the galvanic reaction between the steel and the aluminum (intense corrosion would be seen in the aluminum in the vicinity of the nails), there would be no advantage in attempting impressed current protection methods. The proper practice, of course, would be to use aluminum nails as a first choice with galvanized-steel nails as a second. Similarly—although impressed-current philosophy *could* be made to work—the corrosion potential between an aluminum lightning rod and a copper grounding wire would most sensibly be eliminated by using a copper lightning rod or aluminum grounding wire. In marine work, a like case is seen in marine antennas constructed of aluminum tubing being fed by a copper transmission line. The new fiber glass whips with imbedded copper-wire elements have done much to eliminate this common corrosion problem.

This is not to say that the impressed-current systems are not good. Far from it. Besides their obvious use in the marine area (oil tankships with this system can be constructed with lighter scantlings—on the order of 5-10%—which means construction costs are less), the protection of pipeline systems can be accomplished by connecting the pipe to a negative d.c. source and the positive d.c. to electrodes buried at proper intervals in the ground. The current flow in such a system is from 0.3 to 0.5 milliampere per square foot of pipe, and the voltage will range from 1.5 to 30 volts depending on the resistance of the system.

The impressed-current systems used on boats and ships are all basically the same. They consist of three elements: a reference electrode, a control unit, and the anode which introduces the proper current and voltage against the underwater metal parts to be protected. The reference electrode monitors the amount of protection given to the boat's underwater metal parts (bonded together to form a common cathode) and in turn the control unit compares this reference voltage produced by the reference electrode to the pre-set voltage of the control unit. The output of the controller is applied to the anode. Since the corrective current is externally applied and because deterioration of this anode would serve no useful purpose, it is usually made of one of the metals of the platinum family. Care must be taken that the anode voltage is not set too high as this may be of doubtful benefit and, in fact, may cause damage.

In summary, we have progressed from the electronic action which is the basis for corrosion to an electronic solution to combat this damaging process. Even the few digressions, such as the discussion of pH, were related to the electro-chemical phenomenon which is corrosion. Knowledge of such things as pH, chloride content, and so-on are, of course, valuable to the marine electronics technician. Too often, for instance, one will find that the malfunction of a transmitter or receiver or depth-sounder isn't due to something wrong with the unit itself, but to such things as improper supply voltage, r.f. interference, poor antenna placement, etc. The same applies to ascertaining the reasons for corrosion. The technician must be prepared (and this dictates proper instrumentation) to investigate the ecology which surrounds the vessel on which he has installed or is maintaining electronic equipment. When he knows the facts of the marine environment, then he'll have intelligent, helpful answers for the man who says:

"I didn't have this corrosion problem until you installed the radio . . .!" ▲

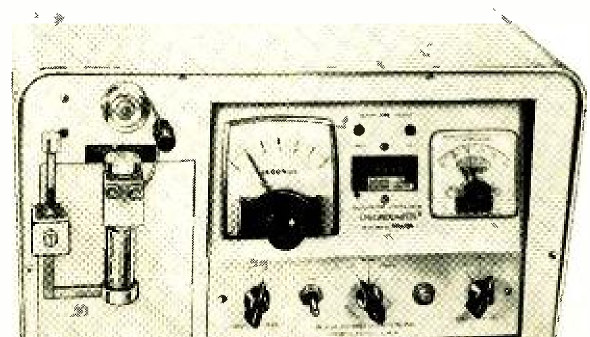

Fig. 3. Buchler's Chloridometer, an instrument that can be used for determining the possibility of corrosion by measuring the amount of chloride present in water.

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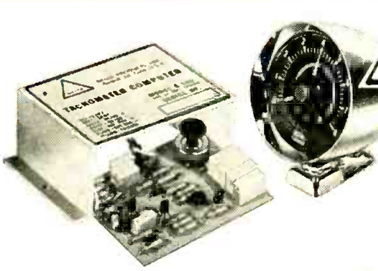

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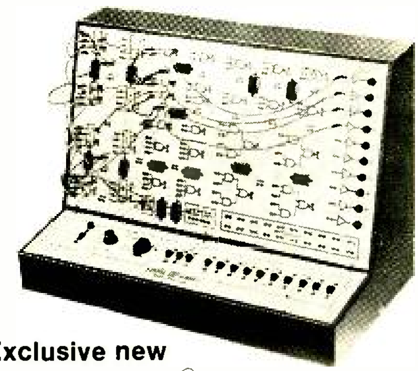

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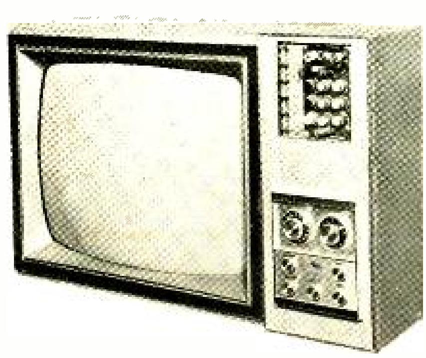

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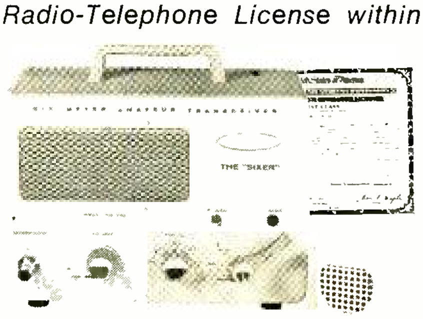

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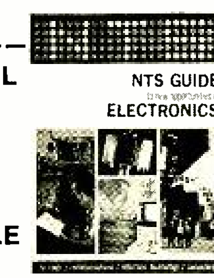

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TV Channel Assignments

Channel No.	Frequency Range (MHz)	½ Wave-length* (inches)	Picture Carrier (MHz)	Color Subcarrier (MHz)	Sound Carrier (MHz)
V. H. F. LOW-BAND CHANNELS					
2	54-60	103.8	55.25	58.83	59.75
3	60-66	93.8	61.25	64.83	65.75
4	66-72	85.7	67.25	70.83	71.75
5	76-82	74.8	77.25	80.83	81.75
6	82-88	69.5	83.25	86.83	87.75
FM	88-108	60.3	—	—	—
V. H. F. HIGH-BAND CHANNELS					
7	174-180	33.4	175.25	178.83	179.75
8	180-186	32.3	181.25	184.83	185.75
9	186-192	31.3	187.25	190.83	191.75
10	192-198	30.3	193.25	196.83	197.75
11	198-204	29.4	199.25	202.83	203.75
12	204-210	28.5	205.25	208.83	209.75
13	210-216	27.7	211.25	214.83	215.75
U. H. F. CHANNELS					
14	470-476	12.5	471.25	474.83	475.75
15	476-482	12.4	477.25	480.83	481.75
16	482-488	12.2	483.25	486.83	487.75
17	488-494	12.0	489.25	492.83	493.75
18	494-500	11.9	495.25	498.83	499.75
19	500-506	11.8	501.25	504.83	505.75
20	506-512	11.6	507.25	510.83	511.75
21	512-518	11.5	513.25	516.83	517.75
22	518-524	11.3	519.25	522.83	523.75
23	524-530	11.2	525.25	528.83	529.75
24	530-536	11.1	531.25	534.83	535.75
25	536-542	11.0	537.25	540.83	541.75
26	542-548	10.8	543.25	546.83	547.75
27	548-554	10.7	549.25	552.83	553.75
28	554-560	10.6	555.25	558.83	559.75
29	560-566	10.5	561.25	564.83	565.75
30	566-572	10.4	567.25	570.83	571.75
31	572-578	10.3	573.25	576.83	577.75
32	578-584	10.2	579.25	582.83	583.75
33	584-590	10.1	585.25	588.83	589.75
34	590-596	10.0	591.25	594.83	595.75
35	596-602	9.9	597.25	600.83	601.75
36	602-608	9.8	603.25	606.83	607.75
37	608-614	9.7	609.25	612.83	613.75
38	614-620	9.6	615.25	618.83	619.75
39	620-626	9.5	621.25	624.83	625.75
40	626-632	9.4	627.25	630.83	631.75
41	632-638	9.3	633.25	636.83	637.75
42	638-644	9.2	639.25	642.83	643.75
43	644-650	9.2	645.25	648.83	649.75
44	650-656	9.1	651.25	654.83	655.75
45	656-662	9.0	657.25	660.83	661.75
46	662-668	8.9	663.25	666.83	667.75
47	668-674	8.8	669.25	672.83	673.75
48	674-680	8.7	675.25	678.83	679.75
49	680-686	8.7	681.25	684.83	685.75
50	686-692	8.6	687.25	690.83	691.75
51	692-698	8.5	693.25	696.83	697.75
52	698-704	8.4	699.25	702.83	703.75
53	704-710	8.4	705.25	708.83	709.75
54	710-716	8.3	711.25	714.83	715.75
55	716-722	8.2	717.25	720.83	721.75
56	722-728	8.1	723.25	726.83	727.75
57	728-734	8.0	729.25	732.83	733.75
58	734-740	8.0	735.25	738.83	739.75
59	740-746	7.9	741.25	744.83	745.75
60	746-752	7.8	747.25	750.83	751.75
61	752-758	7.8	753.25	756.83	757.75

V.h.f. and u.h.f. TV channel assignments, including video, audio, and the color-subcarrier frequencies.

Channel No.	Frequency Range (MHz)	½ Wave-length* (inches)	Picture Carrier (MHz)	Color Subcarrier (MHz)	Sound Carrier (MHz)
62	758-764	7.7	759.25	762.83	763.75
63	764-770	7.7	765.25	768.83	769.75
64	770-776	7.6	771.25	774.83	775.75
65	776-782	7.5	777.25	780.83	781.75
66	782-788	7.5	783.25	786.83	787.75
67	788-794	7.4	789.25	792.83	793.75
68	794-800	7.4	795.25	798.83	799.75
69	800-806	7.3	801.25	804.83	805.75
70	806-812	7.3	807.25	810.83	811.75
U. H. F. TRANSLATOR CHANNELS					
71	812-818	7.2	813.25	816.83	817.75
72	818-824	7.2	819.25	822.83	823.75
73	824-830	7.1	825.25	828.83	829.75
74	830-836	7.0	831.25	834.83	835.75
75	836-842	7.0	837.25	840.83	841.75
76	842-848	6.9	843.25	846.83	847.75
77	848-854	6.9	849.25	852.83	853.75
78	854-860	6.8	855.25	858.83	859.75
79	860-866	6.8	861.25	864.83	865.75
80	866-872	6.8	867.25	870.83	871.75
81	872-878	6.7	873.25	876.83	877.75
82	878-884	6.7	879.25	882.83	883.75
83	884-890	6.7	885.25	888.83	889.75

*Free-space half wavelength. For antenna length, use 95% of these values; for twinlead use 82%; for coax use 66%.

ELECTRONIC CROSSWORDS

By JAMES R. KIMSEY

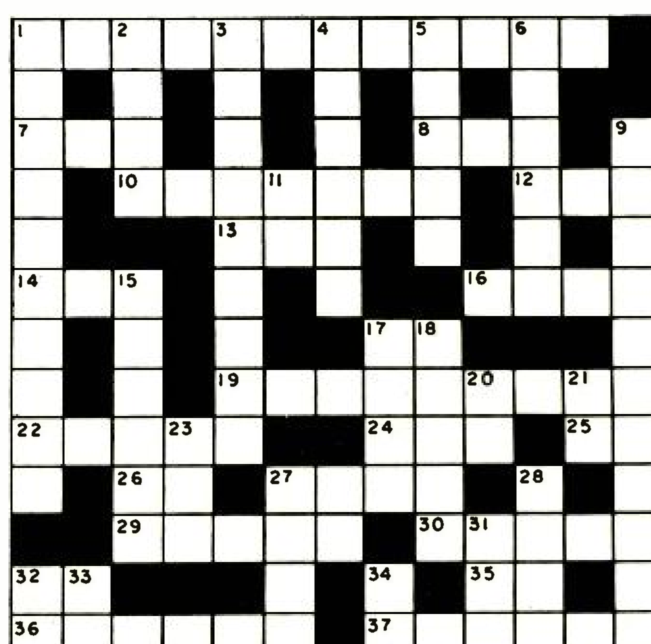
(*Answer on page* 104)

ACROSS

1. This is also called a surge-voltage recorder.
7. A system of components.
8. Title of respect.
10. One of two or more forms of the same element having the same atomic number but a different atomic weight.
12. A luminous discharge of electricity.
13. Attenuator.
14. A low-pitched droning noise.
16. A nuclear reactor.
17. Addition to a letter (abbr.).
19. A nine-pin glass base for a miniature electron tube (2 words).
22. ______plate. A storage battery plate consisting of a conductive lead grid filled with active paste material.
24. Distance from side to side (abbr.).
25. An electronic antenna switch (abbr.).
26. A large Western city (colloq.).
27. A type of capacitance bridge circuit for measuring dielectric losses.
29. A hypothetical medium that pervades all space.
30. The progressive rotation of the cross-section of a waveguide about the longitudinal axis.
32. Symbol for plate current of a vacuum tube.
35. Exists.
36. An oscillation introduced for the purpose of overcoming the effects of friction, hysteresis, or clogging.
37. In disc recording, a mold electroformed from the master.

DOWN

1. ______Laws. The current flowing to a given point in a circuit is equal to the current flowing away from that point.
2. Kind of antenna.
3. A photoelectric device that converts light energy into sound energy.
4. An eight-electrode electron tube.
5. Restore a storage device to a prescribed state.
6. A bolometric vacuum gage for measuring pressure.
9. A device for imparting a very high velocity to charged particles such as electrons or protons.
11. A hard ductile metallic element (abbr.).
15. A combination of components which are contained in one package or common to one mounting and provide a complete function.
17. Deficient in color or intensity of color.
18. ______range. In radar, the line-of-sight distance from the measuring point to the target.
20. ______-cut crystals. Most extensively used crystals in radio-frequency transmitters from 4500 to 10,000 kHz.
21. City division (abbr.).
23. Rodent.
27. Deteriorate by use.
28. A parabola-shaped microwave antenna.
31. Humor.
32. Ego.
33. 3.1416.
34. A radio band (abbr.).



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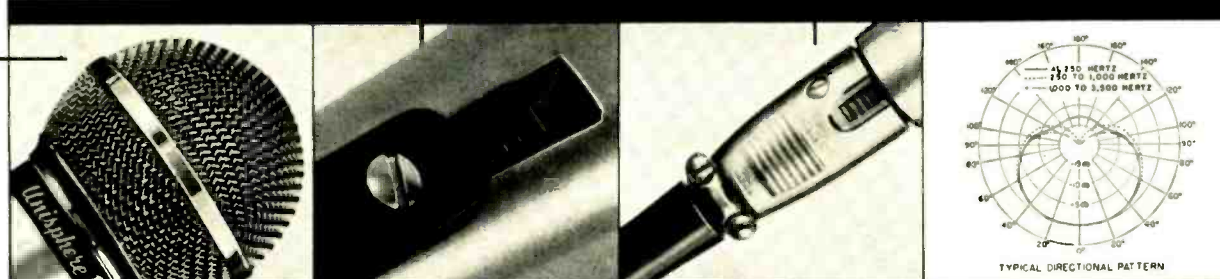

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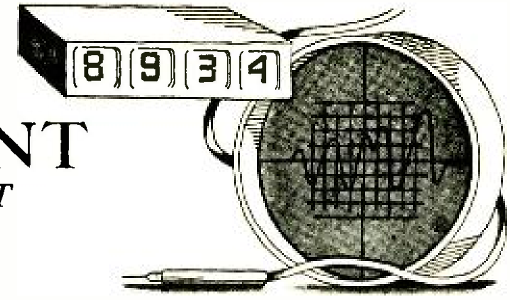
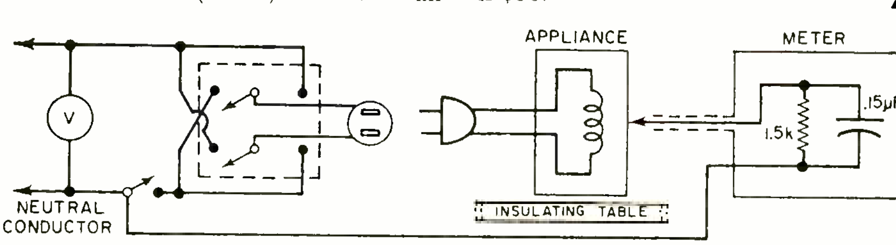


Simpson Model 229 A.C. Leakage-Current Tester
For a copy of manufacturer's brochure, circle No. 36 on Reader Service Card.

EARLY this year a new Standard for Leakage Current for Appliances (C101.1), sponsored by *Underwriters' Laboratories*, was published for trial and study. The proposed standard is for 120-volt appliances, including radios and TV's, that are connected by 2-wire flexible cords to the a.c. power line. When measured in accordance with the setup shown in the diagram below, the maximum a.c. leakage current is not to exceed 0.5 mA (r.m.s.) between all exposed conductive surfaces of the appliances to the neutral or grounded side of the power line. The measurement is to be made across a meter terminal impedance consisting of 1500-ohm resistor shunted by a 0.15-μF capacitor. This *RC* circuit simulates the impedance of the human body under such potentially dangerous conditions as when one's fingers are wet. With a leakage current of 0.5 mA flowing through 1500 ohms, the a.c. voltage drop amounts to 0.75 volt. Measurements are taken with the appliance turned on and with the a.c. line applied first one way and then with the a.c. power line reversed.

Simpson has performed a real service in coming out with a new tester that will measure the leakage current in accordance with the newly proposed standard. Its Model 229 has four leakage-current ranges: 0.3, 1, 3, and 10 mA. Currents as low as 5 microamps can be measured on the lowest range scale. In addition there is an a.c. voltage range (150 V), a setting for measuring the appliances for shorts (we assume this is a simple ohmmeter function), and a setting for checking the meter's internal battery. Accuracy of the meter is within ±2 percent of full scale.

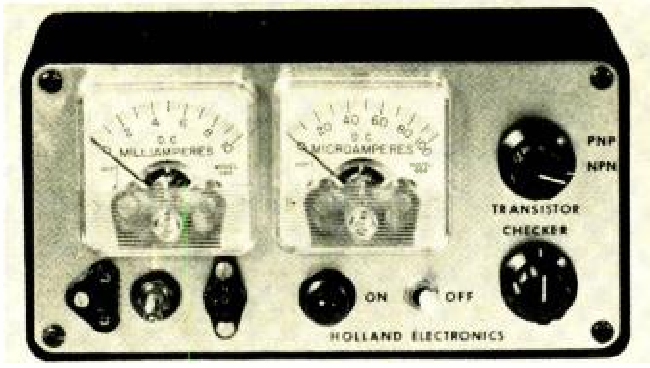
The instrument and circuits are fully protected against overloads of up to 150 V on all ranges. Also, all the internal components and circuitry are completely potted in epoxy. Price of the Model 229 is $90. ▲



Holland Electronics Model TT-285 Transistor Tester
For a copy of manufacturer's brochure, circle No. 37 on Reader Service Card.

THIS new, compact, very easy-to-use transistor tester is made by a manufacturer that specializes in TV studio equipment, *Holland Electronics*. As a matter of fact, the tester is an outgrowth of a product designed for a TV network to check the transistors used in some of their studio equipment. The Model TT-285 can also be used by testers for incoming inspection and testing of transistors, and by technicians and engineers for checking new or replacement transistors.

To use the tester, a transistor is simply

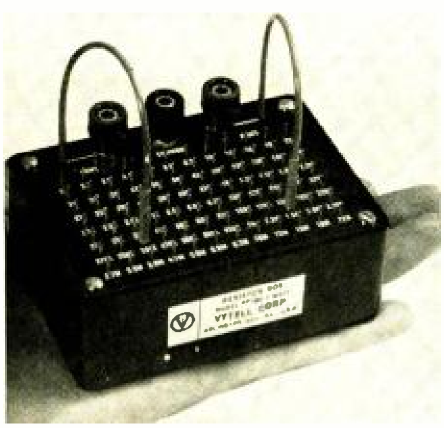


plugged in and a pot is rotated while the user observes the two current meters on the front panel. The pot is part of a voltage-divider circuit that applies current to the base circuit of the transistor under test. The meter at the left is a 10-mA unit which monitors collector current, while the meter at the center monitors base current up to 100 μA. By watching the tracking of the meters, quite a bit of information can be determined about the transistor being checked. If a short or open exists, the tester will show either no collector current or will indicate a constant, high value. For gain readings, the values of collector and base current are taken at various settings and gain is calculated.

The tester is small, measuring only 2½" x 5⅞" x 3⅛" deep and is battery-powered, using two penlight cells. The unit is self-contained in its plastic case, and no lead wires or clips are used. It can be easily carried in a portfolio, brief-case, tool kit, or service caddy. The price of the Model TT-285 is $65. ▲

Vytell Model RP-1001 Resistor Box

For a copy of manufacturer's brochure, circle No. 38 on Reader Service Card.



HERE is a new, small resistor substitution box that provides all 84 EIA standard resistor values in about one-third the size of other such boxes. In place of the usual control-knob switches for resistor selection, the *Vytell* RP-1001 uses a pair of push-on leads connected to binding posts. All the resistors, with their values clearly marked on the key-board-like front-panel matrix, terminate in vertical pins on which the connectors are pushed. One lead from each of the resistors is connected to the "Common" binding post. The various resistors can be connected in series and parallel to obtain over 3400 non-standard resistance values. With additional leads, an almost limitless number of discrete resistance values can be obtained. The resistors used are all ten-percent types, with resistances from 2.7 ohms to 22 megohms.

The resistor box is useful in bread-boarding circuits or in making resistor substitutions during servicing of electronic equipment.

The unit is furnished in a molded phenolic case, measuring 3" x 4" x 2¼" deep. The cover is readily removable so that resistors may be replaced if any of them is damaged due to excessive voltage or current during use. The resistors are all one-watt standard types with maximum voltage rating of 500 volts. Price of the resistor box is $16.95. ▲

1968 U.S. ELECTRONIC EXPORTS HIT NEW HIGH

FOREIGN trade in communications and electronics products reached new highs of $1.8 billion in exports and $1.2 billion in imports, according to figures released by the U.S. Dept. of Commerce.

Communications and electronics exports were up 15.4% over 1967 while communications and electronics imports soared 40.3% over the previous year.

Nearly 30% of the total U.S. exports were commercial, military, and industrial products and showed a 16% increase, rising from $442 million in 1967 to $513 million in 1968.

Exports of consumer products increased 21%, from $93 million to $115 million. With increased sales to Canada and Mexico, TV receiver and chassis shipments—which accounted for 37% of the consumer product exports—increased 22%. Components also showed a healthy 18% increase from the previous year. Semiconductor devices increased by 35% with the largest gain in IC exports—up 37%.

Principal buyers of U.S. exports were Canada, Mexico, and the European Economic Community. Large orders were also placed by the United Kingdom, Japan, Switzerland, and Sweden. ▲

Piezoelectric Igniter Generates Instant Flames

By DON MARKESON/Product Manager
Piezoelectric Division, Clevite Corp.

By using piezoelectricity, a device has been developed that can deliver instant flame by a simple lever action.

A device that uses piezoelectricity to produce sparks for igniting any type of gas-fired appliance is now commercially available.

Cognizant engineers realized piezoelectricity had the potential to provide a simple, completely dependable, long-lasting high-voltage charge across a gap to form sparks, and knew that its nature to convert mechanical energy into electrical energy made it ideal for this purpose. The trick, however, was in developing a piezoelectric ceramic with the necessary qualities for an igniter. Such a material would have to be mechanically strong, have a high dielectric constant, low leakage, and a high voltage output coefficient, with retention of these properties over a wide range of pressures and temperatures.

Pioneering work by *Clevite* for this precise material resulted in the development, in 1950, of lead-zirconate-titanate, now sold under the trademark PZT. This opened the door for practical consideration of a working igniter.

PZT ceramics used in the igniters are made up in disc and cylinder form, coated with conducting electrodes on flat surfaces. Mechanical strain induced by pressure or tension applied between these surfaces produces a charge across the electrodes that is directly proportional to the strain. As a whole, it can be considered a self-charging capacitor, with the ceramic acting as charger and low-loss dielectric.

Simply, this is what happens: exterior mechanical pressure produces movement within the structure of the ceramic crystals. This causes a flow of electrons in such a way that one electrode is given a positive charge and the other a negative charge. This charge is released when the voltage has risen to a level sufficient to overcome the particular spark gap between the electrodes. The structure is then once more in equilibrium. Continuing pressure in this direction will result in a repetition of the entire process. Similar charges, but of opposite polarity, occur with release of the pressure.

When the piezoelectric material in the igniter, shown in the photo, is squeezed (by lever action) multiple sparks with more than five times the energy necessary to ignite LP or natural gas, are produced at the end of the wire. In addition, a second series of sparks of equal strength is produced when the piezoelectric material is released (the lever is allowed to swing back).

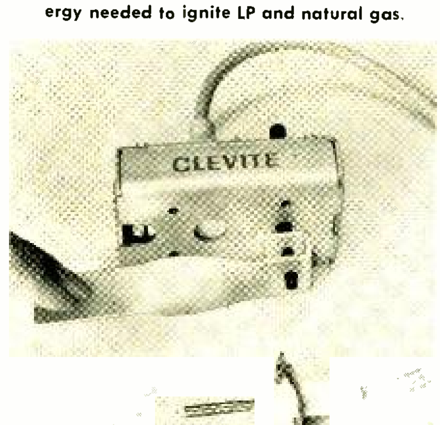
Applications

Applications vary. As a pilot lighter for gas-fired appliances, it has been incorporated in through-wall heaters, pool heaters, home furnaces, assorted portable heaters, ranges, hot-water heaters, and infrared heaters. The igniter has also been used to light outdoor grills, camp lanterns, camp stoves, welding torches, and residential lawn lanterns. No one can be sure at this time of its future potential.

Early development efforts resulted in a rather bulky assembly that took up quite a bit of space. But the igniter has been refined to the extent that it can now be offered in a package smaller than a pack of cigarettes. Hopefully, a much smaller version will be available in the near future.

Because the igniter is self-contained and generates its own energy, it truly may be termed "solid state." And because of the nature of piezoelectricity, it may also be described as a direct "energy converter." ▲

The Clevite igniter, which requires no wires, batteries, or other energy sources, instantly produces a series of sparks at the end of the wire when the lever is depressed and again upon its release. The sparks are more than five times the energy needed to ignite LP and natural gas.



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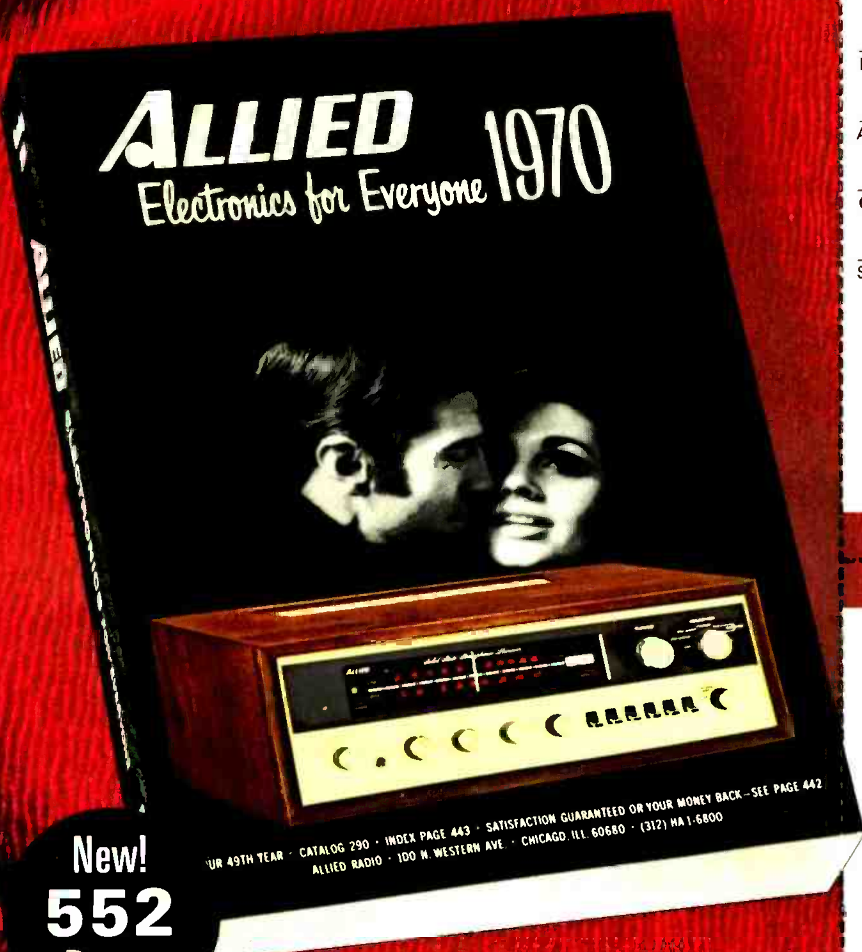

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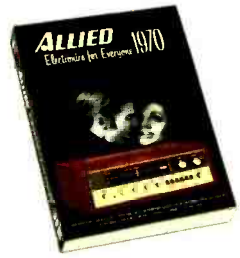

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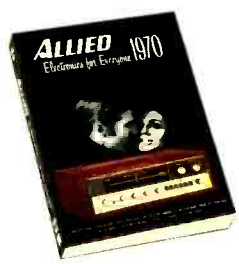

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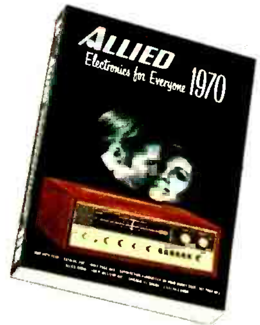

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The new Heathkit GR-681 is the world's most advanced Color TV with more built-in features than any other set on the market. Automatic Fine Tuning on all 83 channels . . . power push button VHF channel selection, built-in cable-type remote control . . . or you can add the optional GRA-681-6 Wireless Remote Control any time . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's. Other features include high & low AC taps to insure that the picture transmitted exactly fits the "681" screen, automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs, top quality American brand color tube with 2-year warranty. With optional new RCA Matrix picture tube that doubles the brightness, **Model GR-681MX only $535.00.**

GRA-295-4, Mediterranean Cabinet shown **$124.95***

Heathkit "295" Color TV

With Optional RCA Matrix Tube . . . with the same high performance features and built-in servicing facilities as GR-681 above . . . less AFT, VHF power tuning and built-in cable-type remote control. You can add the optional GRA-295-6 Wireless Remote Control at any time. New optional RCA Matrix tube doubles the brightness, **Model GR-295MX, $485.00.**

GRA-295-1, Contemporary Walnut Cabinet shown **$64.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown Early American style at $109.95*

NEW Deluxe Heathkit "581" Color TV With AFT

The new Heathkit GR-581 will add a new dimension to your TV viewing. Brings you color pictures so beautiful, so natural, so real . . . puts professional motion picture quality right into your living room. Has the same high performance features and exclusive self-servicing facilities as the GR-681, except with 227 sq. inch viewing area, and without power VHF tuning or built-in cable-type remote control. The optional GRA-227-6 Wireless Remote Control can be added any time you wish. And like all Heathkit Color TV's you have a choice of different installations . . . mount it in a wall, your own custom cabinet, your favorite B&W TV cabinet, or any one of the Heath factory assembled cabinets.

GRA-227-2, Mediterranean Oak Cabinet shown **$109.95***

Heathkit "227" Color TV

Same as the GR-581 above, but without Automatic Fine Tuning . . . same superlative performance, same remarkable color picture quality, same built-in servicing aids. Like all Heathkit Color TV's you can add optional Wireless Remote Control at any time (GRA-227-6). And the new Table Model TV Cabinet and roll around Cart is an economical way to house your "227" . . . just roll it anywhere, its rich appearance will enhance any room decor.

GRS-227-5, New Cart and Cabinet combo shown. **$54.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets; not shown, Contemporary cabinet $64.95*

NEW Heathkit Deluxe "481" Color TV With AFT

The new Heathkit GR-481 has all the same high performance features and exclusive self-servicing aids as the new GR-581, but with a smaller tube size . . . 180 sq. inches. And like all Heathkit Color TV's it's easy to assemble . . . no experience needed. The famous Heathkit Color TV Manual guides you every step of the way with simple to understand instructions, giant fold-out pictorials . . . even lets you do your own servicing for savings of over $200 throughout the life of your set. If you want a deluxe color TV at a budget price the new Heathkit GR-481 is for you.

GRA-180-1, Contemporary Walnut Cabinet shown. **$49.95***

Heathkit "180" Color TV

Feature for feature the Heathkit "180" is your best buy in color TV viewing . . . has all the superlative performance characteristics of the GR-481, but less Automatic Fine Tuning. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart. Get the value-packed GR-180 today.

GRS-180-5, Table Model Cabinet & Cart combo **$42.50***

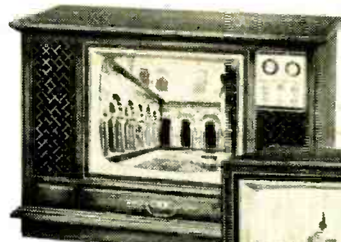
Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets; GRA-180-2, Early American Cabinet $94.95*.

Add the Comfort And Convenience Of Full Color Wireless Remote Control To Any Rectangular Tube Heathkit Color TV . . . New Or Old!

Kit GRA-681-6, for Heathkit GR-681 Color TV's. **$64.95***
Kit GRA-295-6, for Heathkit GR-295 & GR-25 TV's. **$69.95***
Kit GRA-227-6, for Heathkit GR-581; GR-481 & GR-180 Color TV's **$69.95***

Now There Are 6 Heathkit® Color TV's To Choose From

2 Models In 295 Sq. Inch Size



NEW
Kit GR-681
With AFT
$499.95*
(less cabinet)

Kit GR-295
$449.95*
(less cabinet)

2 Models In 227 Sq. Inch Size

NEW
Kit GR-581
with AFT
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(less cabinet)

Kit GR-227
NOW ONLY
$379.95*
(less cabinet & cart)

2 Models In 180 Sq. Inch Size

NEW
Kit GR-481
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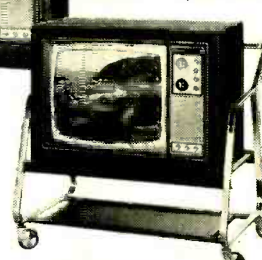
(less cabinet)



Kit GR-180
NOW ONLY
$329.95*
(less cabinet & cart)

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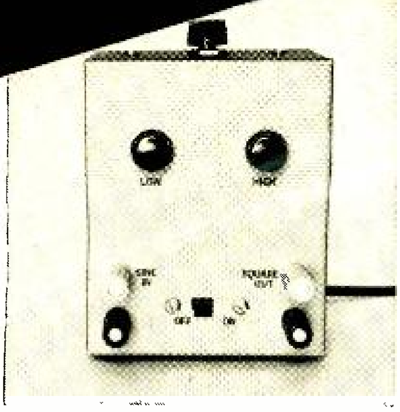
*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. CL-368

CIRCLE NO. 128 ON READER SERVICE CARD



IC Sine-Wave Clipper

By FRANK H. TOOKER

This easy-to-construct clipper produces clean, symmetrical square waves from 20 to 100,000 Hz.

A SINGLE test with a square-wave input signal can tell as much about an audio-frequency amplifier's performance characteristics as several tests made by other means. For this reason, a good variable-frequency square-wave source is a valuable tool and no service technician or engineer should be without one.

Several methods are used to obtain square waves. One method—that employed in the instrument described—is to amplify and severely clip a sine wave. The greater the amplification and the more severe the clipping, the shorter the rise time of the resulting square waveform. A distinct advantage of this circuit is that if the sine-wave input signal is free from distortion, the output waveform of the clipper can be symmetrical over the entire audio-frequency range. The same is not necessarily true of all square-wave sources.

The clipper shown in the photo was designed for use with the *Heath* IG-72 precision sine-wave audio-signal generator, which has an advertised distortion of less than 0.1% over the range of 20 to 20,000 Hz. In general, however, any sine-wave signal generator suitable for audio testing can be used with the clipper.

A unique feature of this sine-wave clipper is that it uses a *Fairchild* μA703 integrated circuit (*IC*1 in the schematic), a component specifically designed for amplifying and clipping (or limiting) in the intermediate-frequency portion of an FM receiver. Its value as a clipper in such service lies in the fact that it limits without having its transistors driven into saturation. Furthermore, its input and output electrodes are well isolated by internal circuitry. Thus, when it is properly adjusted, the possibility of "ringing" within the clipper itself is reduced considerably. Ringing is a tendency toward regeneration or oscillation at a particular frequency, as though the amplifier contained a tuned circuit and positive feedback.

A clean, symmetrical square wave is produced by this instrument over the range of 20-100,000 Hz. In checking out the clipper at frequencies near 100,000 Hz, make certain your oscilloscope can reproduce a square wave accurately over the entire frequency range. Some scopes will show frequency distortion at certain settings of the vertical attenuator.

Field-effect transistor *Q*1 provides the clipper with a high input resistance, while transistor *Q*2 provides an effective low output resistance to drive the input of the IC. *Q*2's low output resistance is assured by the negative feedback obtained by feeding a portion of the signal at *Q*2's collector to the source electrode of *Q*1 *via* resistors *R*3 and *R*4. This same network of resistors affords d.c. stabilization for the *Q*1-*Q*2 amplifier.

Potentiometer *R*5 supplies both the signal and d.c. bias to pin 3, the input electrode of the IC. Proper adjustment of *R*5 sets the d.c. level at pin 3 equal to the d.c. level at pin 5. In more conventional use of the IC, pin 5 supplies bias to pin 3 through the secondary winding of the i.f. transformer.

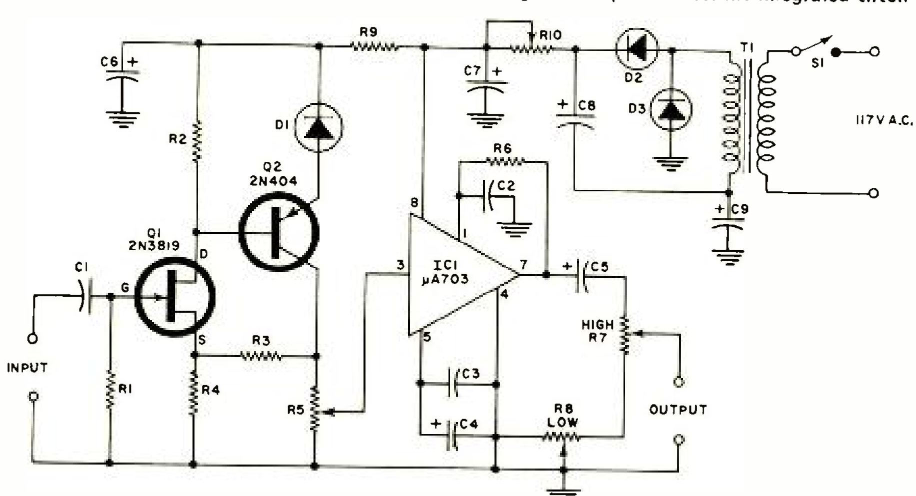
The output from the IC (taken at pin 7) is fed through capacitor *C*5 to the two output attenuators, potentiometers *R*7 and *R*8. Potentiometer *R*7 is used when high-output-signal levels are required. Low-output signals, with easy control of the level, are obtained by setting *R*7 at minimum output and then controlling the level by adjusting *R*8. *R*8 also serves as a vernier for *R*7. Maximum output from the clipper is about 8 volts over-all swing.

The clipper utilizes a built-in voltage-doubler-type a.c. power supply having a fairly high internal resistance. This provides a measure of protection for the clipper circuit each time the instrument is turned on, inasmuch as it allows the electrolytics to charge at a reasonably slow rate. This is especially desirable for *C*4, which is charged through an internal resistance in the IC.

Adjustment

Initial adjustment of the clipper consists of setting the d.c. levels. To do this, set *R*5 at midposition and *R*10 at *max-*

Complete schematic diagram and parts list for the integrated-circuit sine-wave clipper.



R1—1 megohm, ½ W res.
R2—5600 ohm, ½ W res.
R3—3300 ohm, ½ W res. (see text)
R4—2700 ohm, ½ W res.
R5—1000 ohm wirewound pot
R6—3900 ohm, ½ W res.
R7—10,000 ohm linear-taper pot
R8—1500 ohm linear-taper pot
R9—220 ohm, ½ W res.
R10—1500 ohm wirewound pot
C1—0.15 μF, 100 V Mylar capacitor
C2,C3—0.005 μF disc ceramic capacitor
C4—100 μF, 3 V elec. capacitor
C5—30 μF, 15 V elec. capacitor
C6—100 μF, 15 V elec. capacitor
C7,C8,C9—175 μF, 25 V elec. capacitor
S1—S.p.s.t. switch
T1—12 V at 10 mA miniature power transformer
D1—2.7 V, 1-watt zener diode
D2,D3—1N4002 diode
IC1—Integrated circuit (Fairchild μA703)
Q1—2N3819 FET
Q2—2N404 transistor

imum resistance in the circuit. Connect a sensitive d.c. v.t.v.m. between pins 3 and 5 of the IC, and switch S1 to "on." Adjust $R5$ for zero on the v.t.v.m.

Next, using the v.t.v.m., check the voltage drop across resistor $R6$, and the voltage between pin 7 of the IC and ground. Adjust pot $R10$ to equalize these two voltage readings. Do not advance $R10$ too far, since the d.c. potential applied to the IC must always be less than 20 volts. Operating voltage of the prototype is about 12 volts, operating current about 10 milliamps, with the setup properly adjusted. Of this, 7 milliamps flow through the IC.

After setting $R10$, recheck the setting of $R5$ in the manner previously described. With this done, connect an oscilloscope to the clipper's output terminals and a low-distortion audio signal generator at the input terminals. Set pots $R7$ and $R8$ for maximum output. Feed a low-level signal (about 30 millivolts r.m.s.) at 1000 Hz into the clipper's input terminals. At this low input level, the output signal from the clipper should be a sine wave. Increase the input level until distortion due to overdriving the IC begins to appear in the scope trace. Re-adjust $R5$ slightly, if necessary, to make the distortion equal on the positive- and negative-going excursions of the waveform. In the instrument shown in the photo, $R5$ is located on the top of the cabinet.

For a square-wave output the input signal level is about 1.0 volt r.m.s. Run the input up to this level and carefully inspect the trace on the scope screen. It should be a clean, sharp, symmetrical square wave. If the trace does not show this, make certain the fault is actually in the clipper before attempting to correct it. The scope's vertical amplifier or input attenuator could be the culprit.

Gain of the clipper's amplifier, before limiting, is 60. The ratio of output to input signal voltage for square-wave operation is 4:1.4 or about 3. Therefore, the output signal contains only 3/60 = 0.05 or 5% of the input sine wave; 95% is sheared off by clipping. This accounts for the steep sides of the output.

When $R5$ is properly adjusted, the slider of this control should be at a position that is 50 to 60% of its rotation in the direction of $Q2$'s collector. If the setting is lower than this, decrease the value of $R3$ in about 5% steps until the preferred setting is obtained. On the other hand, if the setting of $R5$ is too high, increase the value of $R3$ in a similar manner.

The preceding adjustments, if needed, are best done during an initial check of the assembly before it is mounted in a cabinet. To reduce the possibility of multiple ground paths, insulate $R5$ from the metal cabinet even if the shaft of this pot is already insulated from its slider. ▲

Electronics in Weighing

(*Continued from page 47*)

curacy of ±0.03% and can weigh a load from 1 to 250 pounds. Because its operation is controlled almost entirely by electronics, all kinds of modifications are available to incorporate the scale into complex industrial systems. This scale is, in fact, one of the main components of several automatic mixing and batching machines, and also finds use on an automatic production line for quickly checking the weight of bags as they are filled.

Although there are undoubtedly other ways to measure

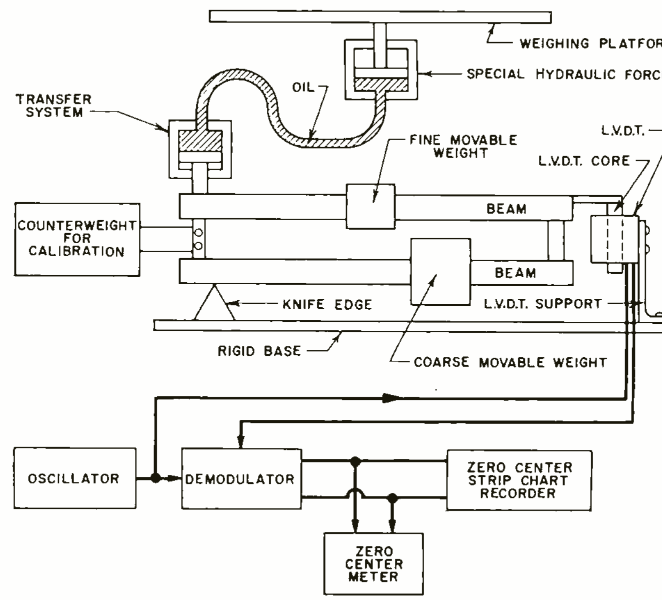


Fig. 6. Extremely accurate electro-hydraulic beam-balancing scale used primarily in medical research. Weighs a load of from 1 to 250 pounds with an over-all accuracy of 0.0063%.

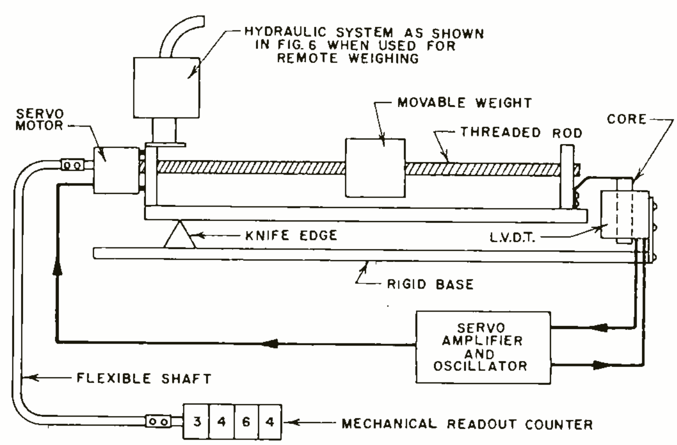


Fig. 7. Fully automatic servo amplifier-operated beam-type scale can weigh a load from 1 to 250 pounds with an accuracy of ±0.03%. Because of its electronic operation, this scale can be readily incorporated into complex industrial systems.

weight, any system is certain to be an outgrowth of either a spring balance or a beam balance. By becoming familiar with these methods, one can usually figure out the intricacies of more sophisticated types of devices.

The author would like to thank the *Brookline Instrument Co.* of White Plains, N.Y. for assistance in preparing this article. ▲

(*Editor's Note: Readers who have access to back issues will find an article on the characteristics of a strain gage in the March 1969 issue, under the title "Strain Gages Come of Age" by Joseph Tusinski.*)

LCR CIRCUITS QUIZ

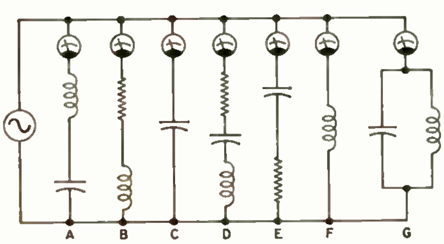
By ROBERT P. BALIN

THE seven circuits shown below are frequency sensitive: as the frequency of the input voltage changes, the a.c. current indicated on each ammeter not only changes in value, but its cycles may lead or lag those of the input voltage.

To test your knowledge of a.c. circuit behavior, try to match the seven circuits (A-G) with the descriptive statements (1-20) given below. One or two circuits may fit each statement.

1. At the resonant frequency, the current drops to its minimum value.
2. As the frequency increases, the current always decreases.
3. Below the resonant frequency, the current leads the input voltage.
4. As the frequency is increased, the leading power factor increases.
5. Above the resonant frequency, the current lags the input voltage.
6. As the frequency decreases, the current always increases.
7. At the resonant frequency, this circuit is purely resistive.
8. The current always leads the input voltage by 90 degrees.
9. At the resonant frequency, this circuit behaves like a short circuit.
10. As the frequency is decreased, the lagging power factor increases.
11. Below the resonant frequency, the current lags the input voltage.
12. As the frequency decreases, the current always decreases.
13. At the resonant frequency, the current is in-phase with the input voltage.
14. As the frequency is decreased, the leading power factor decreases.
15. Above the resonant frequency, the current leads the input voltage.
16. As the frequency increases, the current always increases.
17. At the resonant frequency, the current reaches its maximum value.
18. The current always lags the input voltage by 90 degrees.
19. As the frequency is increased, the lagging power factor decreases.
20. At the resonant frequency, this circuit behaves like an open circuit.

(Answers on page 104)



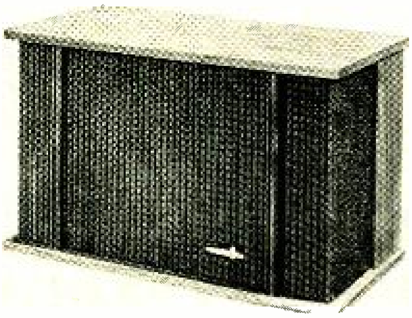
NEW PRODUCTS & LITERATURE

For additional information on items identified by a code number, simply fill in coupon on Reader Service Card. In those cases where code numbers are not given, may we suggest you write direct to the manufacturer.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

STEREO SPEAKER SYSTEM

The new "Stereo 1" provides true stereo reproduction in a single speaker cabinet. Designed for installations where space is at a premium, the new system features a unique "Acousti-Matrix System" whereby precisely metered sum-



and-difference sound outputs are fed to carefully directed arrays. According to the company, this provides completely realistic projection of the total sound coming from many points, rather than sound reflection or wall bounce.

Each system is balanced at the factory so that it will be balanced for any room in which it is used.

Inside each enclosure is an array of full-range, high-compliance, heavy-duty "Flexair" speaker units. Frequency range is 30-20,000 Hz and power rating is 35 watts per channel, integrated program material. Impedance is 8 ohms. Terminals are located at the rear of the cabinet for right- and left-channel inputs. The speaker measures 13" high x 21¾" wide x 11 9/16" deep. Jensen

Circle No. 1 on Reader Service Card

DIRECTION FINDER/RADIO

An all-solid-state, 5-range portable radio receiver, the "Sea Air," has been designed for boat owners, hunters, fliers, fishermen, or SWL's. The Model CR-50 covers 30 bands and provides AM reception of standard broadcast stations, reception of FAA and Canadian weather-navigation stations, marine and aviation radio beacons on the 185-400 kHz long-wave range, ship-to-ship, ship-to-shore, time signals, marine calling and distress, marine weather stations, hams and other services in the 2-5.2 MHz range.

The 8-pound, battery-operated unit has a top-mounted 360° rose bearing compass indicator for small-boat navigation or as a standby for larger boats and aircraft. The direction finder works on long-wave, standard AM, and marine 2.0-5.2 MHz. The unit measures 7½" x 12" x 4". Hallicrafters

Circle No. 2 on Reader Service Card

MINIATURE TRANSFORMERS

Relcom, 2329 Charleston Road, Mountain View, California 94040 has available a new line of miniature transformers. They feature an extremely wide frequency range of 0.1 MHz to 700 MHz and have an insertion loss of less than 0.5 dB. Impedance transformations include 50 ohms to 12.5, 25, 50, 100, 200, and 800 ohms. Six transformers are balanced with both the amplitude and phase balance specified. Four transformers are single-ended. Some models have d.c. isolation.

Each transformer is packaged in either a high-temperature epoxy container or a hermetically sealed TO-5 package. Weight is less than 0.1 ounce. Specifications are guaranteed over a temperature range of −54° to +100°C.

Jim Cochrane, Marketing Manager of the firm, will supply additional details to those writing him at the above address on their business letterheads.

POWER TRANSISTORS

The Transistor Division of Solitron Devices, Inc., Riviera Beach, Florida 33404 has expanded its line of fast-switching power transistors with a 10-amp device with turn-on time less than 10 nanoseconds. Identified as the SDT6110-SDT-6113 Series, these 10-amp devices are packaged in the TO-60 case.

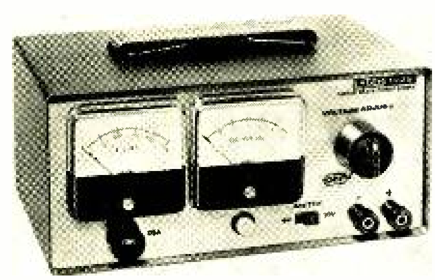
The new devices have total switching time less than 80 nanoseconds and rise time less than 10 nanoseconds. They feature planar construction and are typically f_T = 500 MHz.

For additional information and prices, write on your business letterhead to the firm at 1177 Blue Heron Blvd., Riviera Beach.

VARIABLE POWER SUPPLY

The Model 1025 power supply is an all-transistor power source with built-in meters to provide continuous monitoring of both output current and voltage.

Output voltage is continuously variable from 0 to 30 volts. Maximum continuous load cur-



rent is 150 mA in the 0-12 volt range, 200 mA from 12 to 24 volts, and 300 mA from 24 to 30 volts. Maximum ripple at full load is only 0.005%.

The power supply is fuse-protected against shorts. When the fuse blows, the pilot light remains on but the voltmeter reads zero. The unit is available in either kit or factory wired versions. Eico

Circle No. 3 on Reader Service Card

HALF-INCH VIDEO TAPE

A ½-inch professional video tape mounted on a 4⅝" reel is now available as the #182-5. Designed to fit all battery-operated portable video recorders, including Sony and Shibaden, the reel is also designed for use on larger ½-inch machines. The tape is 845 feet long. Irish

Circle No. 4 on Reader Service Card

DESOLDERING "TOOL"

A tool for desoldering electrical connections to make the reworking or salvaging of expensive circuitry practical, is now available as "Dri-Wick."

The product is woven of ultra-fine copper, un-nickled, each strand coated with water white rosin, and wound on self-closing spools. To use, the operator lays Dri-Wick on the joint, applies the tip of a 30- or 40-watt soldering iron to the top of the tool then lifts the iron and

tool simultaneously. Solder is absorbed into the Dri-Wick. The product is available in four widths for desoldering different size connections. American Beauty

Circle No. 5 on Reader Service Card

RELAY SERVICING TOOL KIT

A new, 15-piece relay servicing tool kit contains a carefully selected group of tools for use in the electronics and telecommunications industries. Tools necessary for adjusting, servicing, and calibrating all types of relays are provided. All tools are of carbon steel, with heavy chrome plating. Dielectric tools permit adjusting or repairing live equipment without interrupting operation.

The tools are supplied in a zippered leather case which measures 11" long x 6" wide and weighs two pounds with tools. Jonard Industries

Circle No. 6 on Reader Service Card

VARIABLE VOLTAGE SUPPLY

The Model PS-30 is a regulated integrated-circuit power supply that provides a highly regulated (0.01%) continuously adjustable output covering the range from 0 to 30 volts at currents from 0 to 1 A. Ripple level is below 1 millivolt. Output voltage and current are monitored by a front-panel meter and are isolated so that either terminal may be grounded. Short-circuit protection and provision for remote sensing and programming are included.

The PS-30 measures 3½" high x 5¼" wide x 9" deep and weighs 4½ pounds. It is sized for one-third rack mount. AUL

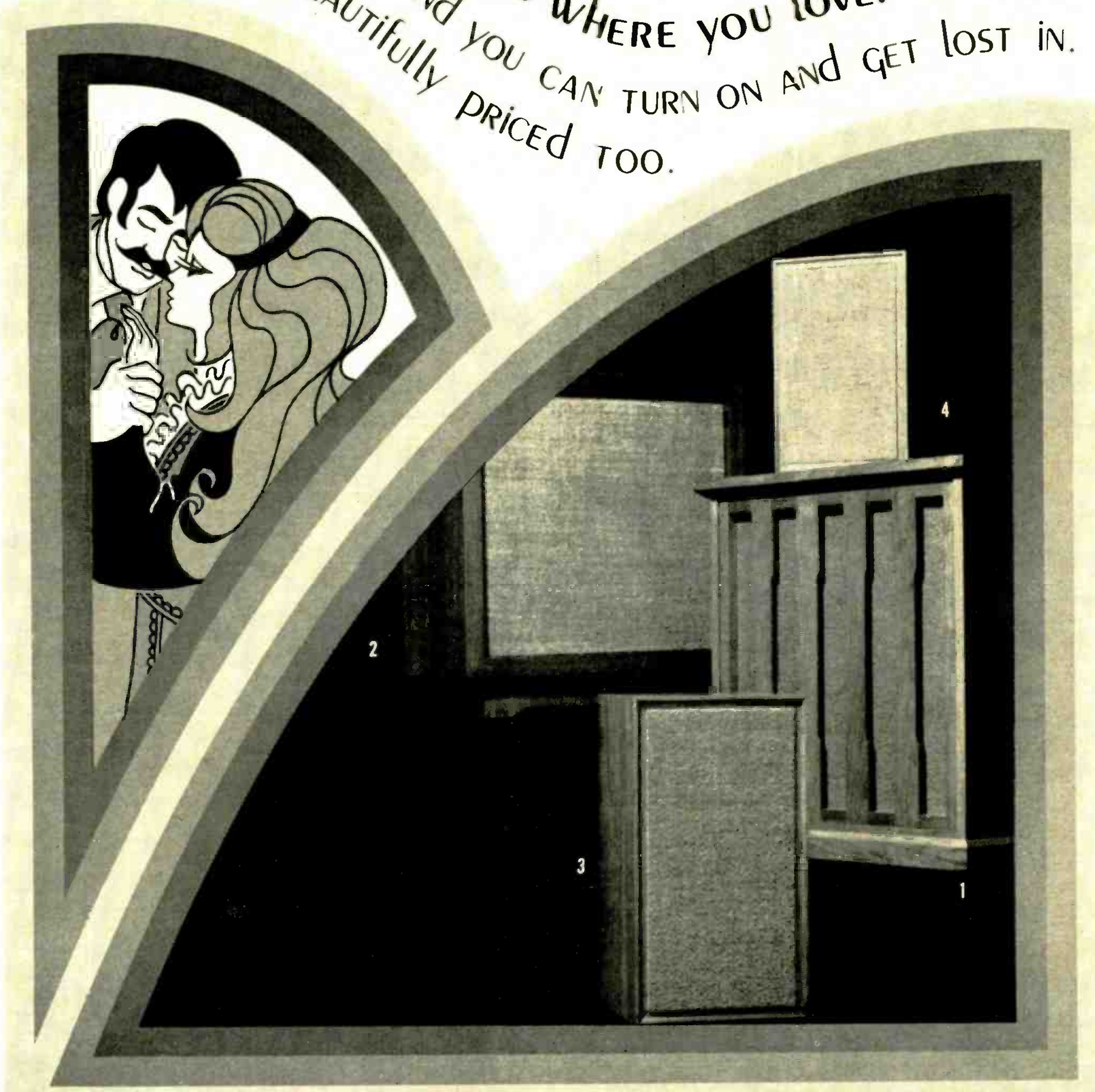
Circle No. 7 on Reader Service Card

VIDEO TAPE RECORDERS

Two new video tape recorders, the LDL-1000 and 3403, are now available for distribution. The LDL-1000 is a lightweight unit which uses one-half inch Crolyn recording tape. Simplicity of operation makes it suited for on-site recording in all types of training, educational, industrial, and business applications. This fully transistorized VTR has a playing time per reel

LISTEN TO THE HEART LINE

Four brand-new speaker systems that hit you where you love. The Heart line...personal, living sound you can turn on and get lost in. Beautiful! And beautifully priced too.



1) The President 2) The Vegas 3) El Paso 4) El Dorado
For some lovely specs, plus more detailed information about this fine new group of speaker systems, see your University dealer or write Heart Line, 9500 West Reno, Oklahoma City, Oklahoma 73126.

CIRCLE NO. 92 ON READER SERVICE CARD

of 40 minutes and a rewind time of 3 minutes. Audio frequency response is 120-10,000 Hz with video frequency response of 0-2.0 MHz and minimum horizontal resolution of 200 lines.

The 3403 is a semi-professional unit intended for universal applications. It can record and play back video signals with or without associated audio signals. It is suitable for use in scientific research, sales promotion and market research, education and training, advertising, and dramatic arts.

Information on either or both of these new VTR's is available on request. Philips Broadcast

Circle No. 8 on Reader Service Card

COMPACT STEREO SYSTEM

The new Model 2506 is a compact stereo system combining a solid-state AM/stereo-FM receiver, a Garrard automatic turntable, and any one of three different speaker systems.

The receiver section incorporates "Perfectune" automatic tuning circuitry, integrated circuits,

and new full complementary output circuitry which virtually eliminates distortion at low levels, according to the manufacturer. Impedance is both 8 and 4 ohms for applications where extra speakers are desired.

Power is 110 watts ± 1 dB (IHF) at 0.8% distortion with both channels driven, frequency response is 20-20,000 Hz ± 1 dB, and IM distortion is less than 0.3% up to rated power. FM usable sensitivity is 1.9 μV, selectivity is 40 dB, and tuner stereo separation is 40 dB. Phono sensitivity is 3 mV. H.H. Scott

Circle No. 9 on Reader Service Card

CONVERTER/CHARGER

A special power cord along with a low-cost, wall-mounted a.c./d.c. converter/charger permits continuous operation of battery-powered electronic flash units even when the batteries are deeply discharged, completely dead, or without batteries. The power plug recharges normally discharged batteries automatically without removing them from the strobe light case.

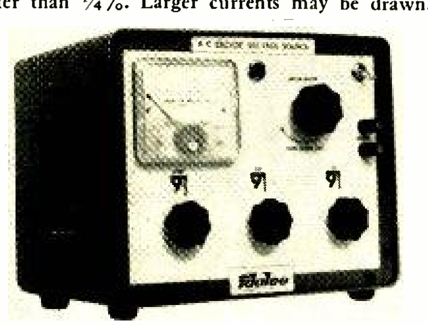
Slightly larger than an ordinary a.c. line cord, the power cord plugs into any household outlet and converts 120-volt current to low d.c. power at the wall outlet.

A technical brochure outlining various applications for the unit is available on request. Dynamic Instrument

Circle No. 10 on Reader Service Card

DECADE VOLTAGE SOURCE

Idalee Electronics Corp., 891 Fulton Street, Valley Stream, N.Y. 11580 is now offering a multi-tapped transformer which is dialable from 1 to 999 volts in 1-volt steps. Output is shown numerically in three large windows. Accuracy at 10 mA is a guaranteed ½% and is normally better than ¼%. Larger currents may be drawn.



The input can be set to a single reference point on a highly accurate expanded meter scale. The input voltage range is 105-125 volts and input frequency range is 50-1000 Hz.

For full details on this unit, write on your business letterhead to the company at the above address.

THERMISTOR KITS

Victory Engineering Corporation, Victory Road, Springfield, N.J. 07081 is now marketing two "Thinistor" kits to acquaint engineers, designers, and researchers with the latest advances in thermistor technology: thin-film thermistors. These kits consist of two basic types, free-standing and substrate-backed.

Kit KFN101 contains four different free-standing units while the KFN101 infrared kit has two infrared detector pairs matched within 1%. One of each pair has special black infrared absorbent coating. Each kit includes pertinent technical data with performance curves and characteristics.

Write the company on your business letterhead for complete details.

INTERCOM SYSTEM

The "Mastercom M30" is a fully transistorized intercom system with push-button operation. The flexible, expandable system can handle up to 30 stations, freeing the regular telephone system for outside calls. The system features simplified, one-cable installation that eliminates costly and complex wiring.

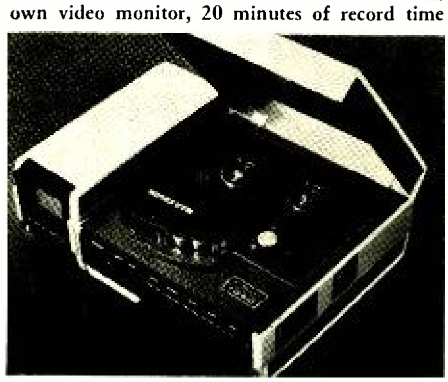
Each station measures just 8" x 9" x 4½" and is housed in an ebony and silver high-impact polystyrene case. The central control unit measures 24" x 14" x 4".

A four-page brochure listing all of the features of the new system is available on request. Norelco

Circle No. 11 on Reader Service Card

PORTABLE VIDEO TAPE UNIT

A portable, battery-operated video tape recorder which uses ¼-inch tape has just been introduced as the Model 1050. It features its own video monitor, 20 minutes of record time



on a 5" reel, better than 250 lines resolution, and is a.c. adaptable. The complete system, including camera, recorder, and monitor weighs under 20 pounds. Roberts

Circle No. 12 on Reader Service Card

ANTENNA TRIPODS

Three new gold tripods in 2-, 3-, and 5-foot sizes have just been introduced. Each is available in a gold baked-enamel finish and is supplied with six lag screws and three tar patches for sealing and mounting holes.

The 3- and 5-foot towers have heavy-duty 1¼" diameter legs and a tilt-up feature to facilitate antenna installation. GC Electronics

Circle No. 13 on Reader Service Card

HAND-HELD CB TRANSCEIVER

A 23-channel, hand-held CB transceiver has been put on the market as the "Fanfare 23."

The completely portable unit has full 5-watt power with an effective inland range of 10 miles, depending on terrain. Over-the-water operation increases the range substantially, according to the manufacturer.

The all-solid-state unit weighs less than 5 pounds but provides good voice reproduction through a 2¾" PM dynamic speaker. Crystals are included for transmission and reception on all 23 CB channels. Fanon

Circle No. 14 on Reader Service Card

STEREO RECEIVER

An all-silicon AM/stereo-FM receiver, housed in an oiled walnut cabinet with an all-black front panel, has been put on the market as the Model SX-770.

Output is 70 watts (IHF) at 4 ohms, which is sufficient to power any speaker or combination of speakers currently available.

An FET front-end is used for optimum sensi-

tivity, while the i.f. section contains two IC's. IHF usable sensitivity is 1.8 μV, image rejection is 60 dB at 98 MHz, and signal-to-noise ratio is 70 dB. The multiplex section uses a time-switching demodulator.

In addition to functioning as a receiver, the SX-770 can also be used as the control center for a hi-fi system since it has input terminals for magnetic and ceramic phonos, tape monitor, microphone, or auxiliary inputs. There are output terminals and jacks for speakers, stereo headphones, tape recording/playback, and a simultaneous tape recording jack equipped with a tape monitor switch. Pioneer

Circle No. 15 on Reader Service Card

RFI/EMI FILTERS

RtroN Corp., P.O. Box 743, Skokie, Illinois 60076 has introduced a new line of tubular, bulkhead-mounting-type RFI/EMI filters that meet the requirements of MIL-15733. The line includes a wide range of combinations of voltage, current, and insertion loss characteristics.

All units are conservatively rated as to current and voltage; temperature rating on all filters is $-55°$ to $-85°$C. Insulation resistance exceeds 1000 megohms/microfarad at 25°C. Maximum case temperature rise, when operated at rated current and voltage, does not exceed 25°C. Maximum voltage drop at rated current is 1% of rated voltage.

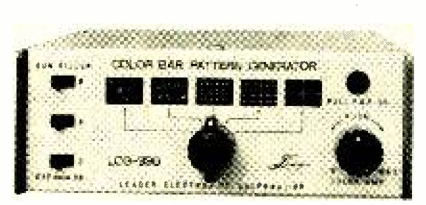
The company will forward a copy of Catalogue RNC-1 covering these filters to those making a letterhead request.

COLOR-BAR GENERATOR

The Model LCG-390 color-bar generator is a compact, solid-state instrument with binary counters and gates in the logic circuitry. The patterns generated by this unit remain completely stationary and show no signs of flicker regardless of temperature extremes, line-voltage conditions, or transmitter signals, according to the company.

The instrument is designed for convergence and sync adjustments in color and monochrome TV receivers. It may also be used for linearity checks on TV monitors.

Five basic patterns are displayed: gated rainbow; R-Y and $-$(R-Y) color bars; dots; square crosshatch; and single cross centered on raster. Gun killers are provided for convergence adjustments.



The generator measures 2⅛" high x 5⅞" wide x 7¾" deep and weighs 2.9 pounds. It operates from 105-125 volts, 50/60 Hz. Leader
Circle No. 16 on Reader Service Card

SOUND-LEVEL METER

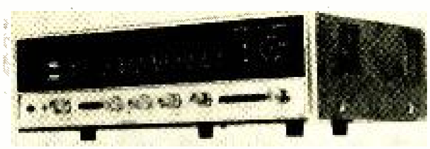
A compact, self-contained sound-level meter, the SLM-3, is now available for distribution. When maximum noise levels allowed in working areas were established by Section 50-204.10 of the Walsh-Healy Act earlier this year a need for an instrument to measure such levels arose.

The new instrument is designed specifically for measuring noise levels and eliminates the costly networks required with more complex instruments. The SLM-3 can be operated by non-technical personnel. It has a range of 50 to 130 dB and its scale is based on the A weighted curve. Each instrument is individually calibrated and comes with its own matched microphones. Its accuracy meets the requirements of International Standard IEC-123. Trans Atlantic Electronics
Circle No. 17 on Reader Service Card

160-WATT STEREO RECEIVER

The Model 4000 is a 160-watt AM/stereo-FM receiver of all-solid-state design, featuring four IC's in the i.f. section plus an FET FM front-end.

The receiver provides 160 watts of IHF music power, with 65 watts per channel continuous power at 4 ohms. The FM tuner sensitivity is



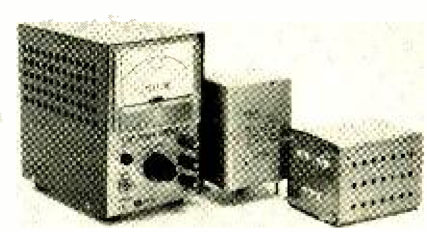
1.8 μV (IHF) and selectivity is better than 40 dB at 98 MHz. Stereo separation is better than 35 dB.

The amplifier section provides a flat frequency response from 10 to 50,000 Hz. The preamplifier, multiplex, and two driver sections are of "snap-out" modular design for easy checking and replacement.

Complete specifications and additional information on the Model 4000 will be forwarded on request. Sansui
Circle No. 18 on Reader Service Card

REGULATED D.C. SUPPLY

An all-silicon transistorized power supply designed for general-purpose laboratory applications is now available. The d.c. output voltage



is adjustable from 1 to 28 volts for loads up to 500 mA. A dual-range meter provides full-scale indication of voltage or current output.

The output is floating and has an impedance of less than 0.1 ohm. Full protection against accidental overloads and short circuits is provided. Rosemount
Circle No. 19 on Reader Service Card

ONE-WATT AUDIO IC

A 1-watt linear monolithic IC audio amplifier which provides high sensitivity, low distortion, and high efficiency, according to its maker, has been introduced as the TAA300.

This microminiature device in a 10-lead, TO-5 envelope measures less than 0.025 cubic inch. It is intended for use in battery-powered portable equipment such as phonograph amplifiers, radio and TV audio systems, portable audio and speech amplifiers, tape cassette systems, and miniature hi-fi sets. Sensitivity is 10 mV for 1 watt output, including feedback of 20 dB. Input impedance is more than 10,000 ohms. Total harmonic distortion at the 1-watt level is 10% and noise figure is typically less than 6 dB from 30 to 15,000 Hz.

Detailed specifications and application data for the TAA300 are available on request. Amperex
Circle No. 20 on Reader Service Card

100-WATT CONTROL CONSOLE

A 100-watt portable control console designed to meet the needs of the professional entertainer is now available as the Model 1210A.

The new amplifier is rated at 100 watts r.m.s.

continuous power (248 watts peak music power), has seven input channels for large groups or those experimenting with multi-channel sonic techniques, and four two-position feedback filters.

Other features include hi-lo gain inputs to protect against overloading and distortion, built-in reverb and reverb switching on each of the six microphone channels, reverb timbre control, and an input for external reverb or tape echo devices. The deluxe carrying case has a locking lid that protects the reverb when the console is closed. Altec Lansing
Circle No. 21 on Reader Service Card

WIREWOUND RESISTORS

Nytronics, Inc., Berkeley Heights, New Jersey 07922 has designed a new line of wirewound power resistors to meet the needs of circuit designers for closer tolerance components. Standard total resistance tolerance is 1% with the new WP line.

The resistors are stocked in nine sizes and styles ranging from a miniature 0.078" diameter x 0.250' length to 0.375" diameter x 1.780" length in ratings from 0.4 to 11 watts. All standard values are available off-the-shelf; non-standard values are available on request. Maximum resistance ratings are available from 3500 to 200,000 ohms.

Upon letterhead request, the company will supply complete engineering details on the WP line.

SINGLE-FREQUENCY RECEIVER

A low-priced, crystal-controlled, solid-state pocket receiver which is being offered with or without squelch is now on the market. The receiver measures approximately 2½" x 4¼" x 1½" and comes complete with a removable 18" telescoping v.h.f. antenna, crystal, earphone, battery, and carrying case.

The receiver can be ordered to receive any single frequency between 30-54 MHz or 108-174 MHz. It can also be ordered to receive U.S. Weather Bureau forecasts at 162.55 MHz. JMD
Circle No. 22 on Reader Service Card

WIRELESS MICROPHONE

The "Piezo WX-127" wireless microphone is now available for various applications ranging from professional entertainment and p.a., through communications, to remote-control babysitting.

The wireless microphone, which permits communications through an FM radio located up to 200 feet away, conforms to all FCC requirements. It is static-free and will not drift. The unit measures 4¾" x 1" x 1" and weighs only 3½ ounces. It is powered by two mercury cells. Mura
Circle No. 23 on Reader Service Card

WEATHER REPORTS

The "Weatheradio" is a completely self-contained single-channel FM radio receiver housed in a rosewood and plastic cube cabinet, 3 inches on a side, with a pull-out antenna. A wide touch bar turns it on and off.

The radio is designed to receive only 162.55 MHz, the U.S. channel for continuous area weather forecasts. New a.f.c. circuitry eliminates any possible effects of nearby metal objects upon tuning. The base-mounted vernier tuning and volume controls are preset once and need not be reset until the receiver is moved to a new location. Radio Shack
Circle No. 24 on Reader Service Card

WIRELESS HEADSET

A transmitting adapter and headset receiver have been developed to permit personal listening at distances up to 30 feet from a radio, tape recorder, or TV set.

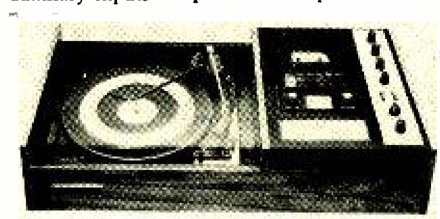
The transmitting adapter is plugged into any TV, radio, or tape recorder that has an earphone jack. It then "broadcasts" to the receiver built into the companion headset. The headset has an adjustable, padded top band and a built-in "on/off" switch and volume control. Total weight is just a little over one pound. The transmitting adapter weighs 3½ ounces.

The units are powered by a total of four penlight cells, two in the headset and two in the transmitting adapter. Hitachi
Circle No. 25 on Reader Service Card

COMPACT MUSIC CENTER

The Model 1450 music center features a 55-watt solid-state amplifier, an AM/stereo-FM tuner, a record player, and a mono/stereo tape cassette player.

The amplifier has separate bass and treble controls, a stereo/mono switch, and loudness control. Mike inputs and a stereo headphone jack are located behind a hinged panel and tape and auxiliary inputs are provided. Output at 4 ohms



is 55 watts ± 1 dB, 45 watts IHF, and 17.6 watts /channel r.m.s. Frequency response is 20-30,000 Hz ±1 dB. Impedance is 4-16 ohms. The tuner has an FET front end and uses all-silicon transistors.

The four-speed automatic turntable has a magnetic stereo cartridge with diamond stylus, low-mass arm, anti-skate control, cueing and pause control, and separate spindles for automatic and manual play.

The unit measures 8¾" high x 26¾" wide x 14¼" deep. Companion speakers are available to match the control unit. Allied Radio
Circle No. 26 on Reader Service Card

ONE-INCH-DIAMETER SWITCH

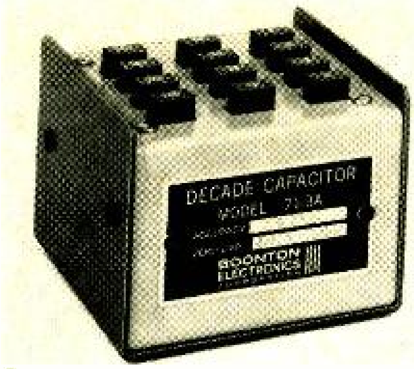
A compact, long-life selector switch for instrumentation, industrial, and military controls has been announced by CTS Electronics, Inc., 1010 Sycamore Ave., South Pasadena, California 91107.

The Series 223 one-inch-diameter switch provides 0.812-inch strut screw spacing. A style SR05 switch (MIL-S-3786C), the new design has a double-ball detent with 30° indexing from 2 to 12 positions. The detent rotational life is rated a 100,000 cycles through 12 positions and return at 10 cycles per minute.

Those wishing shaft and bushing material options, delivery data, and prices on the Series 223 should address their letterhead requests to Jack Bell, Sales Manager, at the above address.

DECADE CAPACITOR

Boonton Electronics Corporation, Route 287 at Smith Road, Parsippany, N.J. 07054 has just introduced a three-terminal decade capacitor, the 71-3A. The unit has a selectable range of 1 pF



through 1221 pF in 1-pF increments with an accuracy of ±0.25% for any value. Useful frequency range is from 5 kHz to 1 MHz.

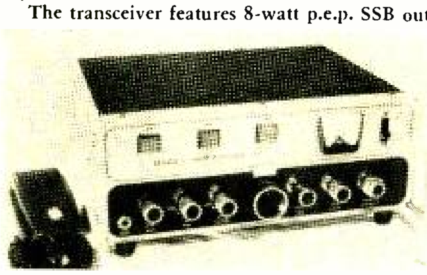
The device has a zero or calibrated residual capacitance of only 3 pF ±0.01 pF which may be zeroed out on many capacitance bridges or meters. Temperature coefficient is typically better than 100 ppm/°C. The unit comes with two BNC connectors.

Write the manufacturer on your business letterhead for additional details.

SSB/AM CB TRANSCEIVER

The "Sidewinder-46" is a single-sideband/AM Citizens Band transceiver featuring 23-channel AM, upper and lower SSB in an instrument-styled enclosure.

The transceiver features 8-watt p.e.p. SSB out-



put (3.5 watts AM) and rugged illuminated panel indicators identify operating model. The "S" unit/output meter and channel select dial are also illuminated. Mark Products

Circle No. 27 on Reader Service Card

PORTABLE STEREO SYSTEM

The F-600 portable entertainment system incorporates a 35-watt AM/FM/stereo-FM receiver, a built-in stereo cassette tape deck, microphone, and a pair of detachable speaker systems, all housed in a compact carrying case. The system operates from 117-volt, 60-Hz a.c.

The system includes separate bass and treble controls; microphone, ceramic phono, tape recorder inputs; speakers, headphone, line out outputs; built-in AM and FM antennas; and automatic stereo muting. Frequency response of the receiver is 20-25,000 Hz ±3 dB while that of the tape deck is 50-12,000 Hz ±3 dB.

The system measures 9" high x 18¼" wide x 12½" deep. It weighs 30 pounds. Concord

Circle No. 28 on Reader Service Card

MANUFACTURERS' LITERATURE

VIDEO EQUIPMENT DATA

Two data sheets on new video equipment have been published. One describes the Model EV-320 color and monochrome video tape recording system. A special feature is capstan-servo electronic editing, which permits sequences from a variety of sources to be inserted into a pre-recorded tape with perfect synchronization. This sheet includes complete specifications, standard and optional accessories, and a listing of equipment applications.

The other sheet covers the Model SEG-1 special-effects generator which provides for such effects as switching, fading, superimposing, or wiping two video signals. Sony Corp.

Circle No. 29 on Reader Service Card

COMPACT STEREO GUIDE

A fully illustrated brochure which is designed to help the buyer select the compact stereo system which best meets his individual requirements, is now ready for distribution.

Featured are complete descriptions of all systems and options, including clearly worded reasons for choosing one particular model over another. Complete specifications and retail prices are also included. H.H. Scott

Circle No. 30 on Reader Service Card

MICROPHONE CATALOGUE

A 20-page catalogue covering an extensive line of microphones is off the press. Five pages are devoted to the company's new Series 810 ultracardioids, Series 820 omnidirectional probes, and Series 840 lavaliers.

Illustrations, descriptions, and specifications are also given on some 50 models in the line, including microphones for ham, industrial, mobile, communications, p.a., paging, recording, and broadcast applications. A microphone selector guide is included and the catalogue also carries information on replacement microphone cartridges and accessories.

Copies of Catalogue M-69 will be supplied on request. Astatic

Circle No. 31 on Reader Service Card

STANDARDS CATALOGUE

The USA Standards Institute, 10 East 40th Street, New York, N.Y. 10016 has just published its 1969 catalogue of USA Standards and international recommendations. Some 600 U.S. and 300 international recommendations have been added to the new 112-page edition, which lists 3600 U.S. standards approved by the Institute and 1350 international recommendations.

Included is an index to the titles of all standards. A special symbol is used to identify publications available on microfiche.

For a copy of this catalogue, address your letterhead request direct to the Institute at the above address.

MODULE SCOPE DATA

James Millen Manufacturing Company, Inc., 150 Exchange Street, Malden, Mass. 02148 has issued a 24-page bulletin describing its line of module oscilloscopes, magnetic shields, and bezels.

The module scopes are intended to be built into the customer's equipment much like a meter. A line of accessories such as module plug-in high-voltage power supplies, deflection amplifiers, and deflection sweep generators, are also covered.

In the section on magnetic shields there is a complete listing of CRT's, photomultiplier tubes, charge storage tubes, etc., cross-referenced to the magnetic shield designed specifically for use with that tube.

Those wishing a copy of this bulletin should make a letterhead request direct to the company.

SEMICONDUCTOR DATA BOOK

The Fourth Edition of the Motorola Semiconductor Data Book is now available from the company's distributors or the Technical Information Center, Motorola Semiconductor Products Inc., Box 20924, Phoenix, Arizona 85036 for $4.95 a copy.

The 2160-page book includes specifications for all discrete semiconductors registered by EIA at publication time, as well as many house-numbered types. A new arrangement of data makes it easier than ever for the designer, component engineer, or purchasing agent to find information on semiconductors. A major feature is its numerical listing of important parameters of all semiconductors registered by the EIA (1N-, 2N, or 3N-prefixes). This 185-page section provides the information needed to identify and characterize any registered device and find recommended replacements for obsolete, hard-to-obtain, or nonpreferred devices.

VIDEO TAPE RECORDERS

A new 4-page brochure, covering the Series VTR-620 video tape recorders with electronic editing, is now available for distribution.

The publication also covers the Model VTR-620A recorder with a.g.c. This feature ensures perfect recordings by automatically compensating for audio or video level changes while recording. Also included is application data, special features, and technical specs on the two recorders. Concord Communications

Circle No. 32 on Reader Service Card

MATV PRODUCT GUIDE

A new 16-page guide to master antenna TV system products is now available. Included are antennas, preamplifiers, amplifiers, a.g.c. units, filters, mixers, tap-offs, matching transformers, splitters, FM converters, traps, coaxial cable, connectors, and terminators. JFD

Circle No. 33 on Reader Service Card

Answers to LCR Circuits Quiz appearing on page 99

1. G	7. D	13. A,D
2. B,F	8. C	14. D,E
3. A,D	9. A	15. G
4. D,E	10. B,D	16. C,E
5. A,D	11. G	17. A,D
6. B,F	12. C,E	18. F
19. B,D	20. G	

Answer to Puzzle on page 68

K	L	Y	D	O	N	O	G	R	A	P	H	
I		A		P		C		E		I		
R	I	G		T		T		S	I	R		A
C		I	S	O	T	O	P	E		A	R	C
H				P	A	D		T		N		C
H	U	M		H		E			P	I	L	E
O		O		O			P	S				L
F		D		N	O	V	A	L	B	A	S	E
F	A	U	R	E			L	A	T		T	R
S		L	A		W	I	E	N		D		A
		E	T	H	E	R		T	W	I	S	T
I	P				A		F		I	S		O
D	I	T	H	E	R		M	O	T	H	E	R

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ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 85¢ per word (including name and address). Minimum order $8.50. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 50¢ per word (including name and address). No minimum! Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issue closes January 1st). **Send order and remittance to:** Hal Cymes, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016.

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 4040 North Nashville Avenue, Chicago, Ill. 60634.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

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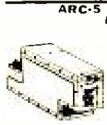
SCR-274-N, ARC-5 COMMAND SET HQ!

Freq. Range	Type	Exc. Used	Like New	BRAND NEW
RECEIVERS, Complete with Tubes				
190-550 Kc.	BC-453	$16.95	$23.50	$27.50
3-6 Mc.	BC-454	$16.50	$19.50	$22 50
6-9 1 Mc.	BC-455	$14.95	$17.95	$21.50
1.5-3 Mc.	R-25	—	$19.50	$21.50
TRANSMITTERS, Complete with Tubes				
4-5.3 Mc.	BC-457	$ 6.95	$ 8.95	$11.95
5.3-7 Mc.	BC-458	$ 6.95	$ 8.95	$12.95
7-9.1 Mc.	BC-459	$17.95	$19.50	$23.50
2.1-3 Mc.	T-18	—	$ 9.95	$11.95
3-4 Mc.	T-19	—	$12.50	$16.95

ARC-5 VHF RECEIVER, TRANSMITTER, MODULATOR 100-156 Mc.



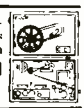
R-28 Receiver, with tubes and crystal, exc. Used Cond. **$24.50**

T-23 Transmitter with tubes and crystals. Brand New in original carton **$23.50**

T-23 Used, less tubes **$4.95**

MD-7 Modulator, with tubes, exc. used **$12.50**

AN/APR-4Y FM & AM RECEIVER "FB" FOR SATELLITE TRACKING!
High precision lab instrument, for monitoring and measuring frequency and relative signal strength. 38 to 4000 Mc, in 5 tuning ranges. For 110 V 60 cycle AC. Built-in power supply. Original circuit diagram included. Checked out, perfect, **LIKE NEW** **$88.50**
All Tuning Units Available for Above



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Code practice tapes for above P.U.R.

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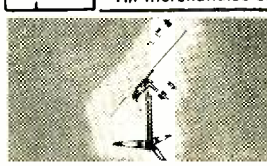

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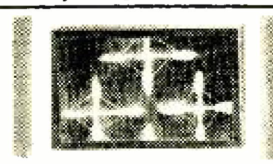

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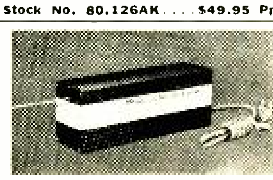

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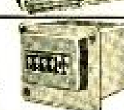

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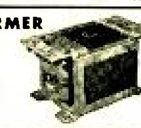

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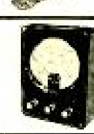

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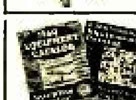

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ELECTRONICS WORLD NOVEMBER 1969

ADVERTISERS INDEX

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The Electronic Piano

(Continued from page 41)

The popularity of such music laboratories has increased rapidly as more and more adults take up the instrument they shunned as children.

Other Manufacturers

P.A. Starck's Pianotron uses piano strings struck by wool felt hammers but has no sounding board. It has a 74-note keyboard and electronic amplification and can be used with earphones and a teaching programmer.

Hohner's Clavinet also uses strings and electronic amplification. However, the firm's Pianet N uses reeds in a manner very similar to the *Wurlitzer*.

Gulbransen's electronic piano is said to have electronic tone generation instead of amplified reed or fork sources, and has variable attack and decay characteristics.

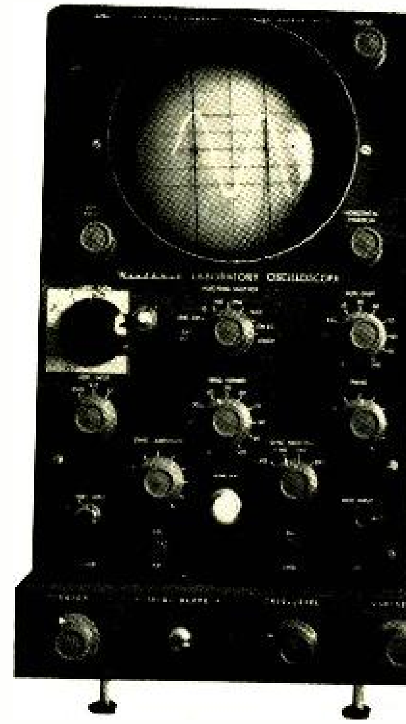
Rocky Mount Instruments, Inc.'s Electra-Piano and Harpsichord uses no strings or bars but has 61 separate tone generators, one for each note on the 61-note keyboard. It has harpsichord and lute sounds in addition to piano sound.

Baldwin is reported to be developing two models of Electropianos—64 note and 88-note models—plus an Electropiano instruction laboratory which will allow up to 24 units to be connected to a single teaching unit.

At the 35th Convention of the Audio Engineering Society, *N.V. Philips Co.* engineers described a research model of an electronic piano they had developed. This piano uses pulse generators, envelope filters, oscillators, frequency dividers, modulators, and amplitude-dependent filters in addition to the conventional amplifier and loudspeaker. ▲

A child can practice in privacy by using headphones, leaving family in peace.

This is one of several scopes that the author owns with which the outboard sweep generator (shown below) has been employed.



TRIGGERED SWEEP FOR ANY SCOPE

By IMRE GORGENYI

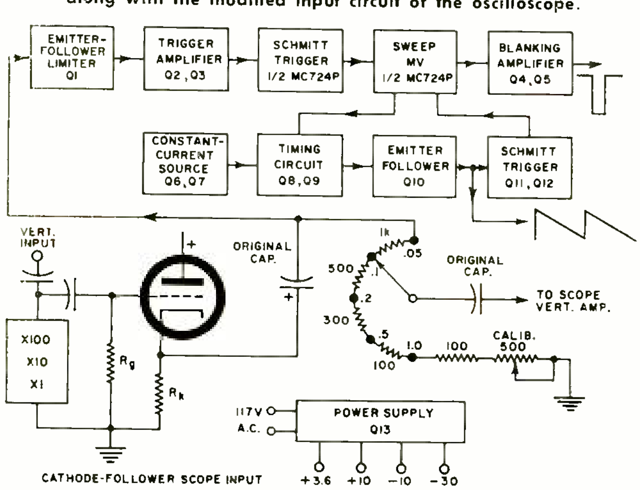
An add-on circuit that converts a low-cost general-purpose or service scope into an instrument with a triggered sweep circuit.

UNTIL the last decade, oscilloscopes were luxury items. Today, there are thousands of scopes in use and on the market, but many still own low-cost scopes designed in the 1940's. The trouble is, of course, not that these older scopes were cheap, but that the newer "good" scopes are expensive. We are not referring to laboratory scopes costing thousands of dollars. But even the most modest "good" scopes have a price tag of $250 and many of these are in kit form.

Our definition of a "good" scope is one with 5" CRT, d.c. coupling, triggered sweep, calibrated vertical input, and calibrated sweep. We could compromise on a 3-in screen, a.c. coupling, and a modest frequency response but we should still have to have a calibrated vertical amplifier and a triggered sweep. The a.c.-coupled scope kits are plentiful and their modification to calibrated vertical input and triggered sweep is not really such a big job. However, if you take your only scope apart for modification, how can you check out your work? This is the reason why so many scope-modification articles have been written for a *particular* model and so few modifications have been made.

The simple circuit presented here, thanks to IC's and transistors, represents the entire triggered sweep circuit. It can be built and checked out with a *Heath* O-10 or similar scope and, after a few connections, can be used, just by the flip of the switch, as a normal, or triggered sweep. The outboard circuit is connected to the scope and gives stable patterns in the triggered-sweep mode when the horizontal-deflection switch is in the "External" position. In other switch positions the scope works just as before. The circuit works with any scope, any size, any make or model; it has its own power supply, needs only 50-mV peak-to-peak signal to trigger it, and works up to 1 MHz. Price of the components is around $40.00. A kit containing all semiconductors and a glass-epoxy printed-circuit board with holes drilled is available. With this, the assembly time is cut a third. If you know what a triggered-sweep scope will do, you know that the investment is well worth it.

Fig. 1. Block diagram of triggered-sweep circuits shown along with the modified input circuit of the oscilloscope.



Circuit Operation

Basically, the outboard circuit provides a saw-tooth for the horizontal-deflection amplifier of the scope (Fig. 1). The start of the sweep, the saw-tooth, is initiated by the trigger amplifier. If the amplified input signal reaches a preset level, the Schmitt trigger changes the state of the sweep multivibrator, which in turn opens a gate, and starts to charge the timing capacitor. The capacitor charges linearly to a preset voltage, producing a saw-tooth. On reaching this point, the capacitor voltage triggers the flip-flop (the sweep multivibrator), which goes back to its previous state, closing the gate and discharging the timing capacitor. To provide a linear sweep, the saw-tooth has to be linear, therefore, we charge the capacitor with constant current.

We need a large negative-going pulse for the blanking. For the trigger level control, a d.c.-coupled amplifier is used. The power supply has to be stable in order to get uniform signal outputs. As can be seen, we need lots of circuitry if we want reasonable performance. With transistors and an integrated circuit it is easy, but it would be a complicated task with tubes.

Now let's go through the schematic shown in Fig. 2. The power supply is straightforward. The output voltages are nominal, depending on the zener diodes. They are not critical and could be +20, −10% as long as they are stable and the a.c. ripple does not exceed 15 mV (p-p). For Q13 any *n-p-n* transistor can be used, provided it has a minimum *beta* of 50 and can stand the voltage and power (300 mW).

Don't forget the heatsink. The MDA-920-1 bridge rectifier can be replaced too; four separate silicon rectifiers will do the job.

The input, coming from the scope's vertical cathode follower, is fed to the base of Q1. This connection will be explained later. The emitter-follower has two functions; it feeds the differential amplifier (Q2-Q3, gain about 20) through a d.p.d.t. switch (S2 Slope) and serves as limiter if the input signal exceeds 10 volts. The amplified signal triggers the Schmitt trigger, composed of two gates in the integrated circuit MC724P.

The positive-going output (pin 5) is differentiated and fed to pin 13 of the next gate pair which form a flip-flop. This pulse makes the multivibrator change its state; pin 3 goes positive, carrying the base of Q9 with it. Q9 goes into saturation, cutting off Q8. With Q8 cut off, the timing capacitor which is parallel with it can begin to charge from the constant-current source made up of Q6 and Q7. The timing capacitor starts to go negative, taking the base and the emitter of Q10 (emitter-follower) with it. From the emitter we take the saw-tooth signal and feed it to the scope's horizontal amplifier.

The same point is connected through a 4.7k-ohm resistor to a Schmitt trigger (Q11-Q12) which, referenced on D6, triggers the IC multivibrator, resetting it to its original state. Now, the multivibrator is ready for the next trigger pulse, which would start the next sweep.

The trigger pulse starts the sweep, the duration of which is determined solely by the timing capacitor. As the sweep ends, it automatically resets and is ready to go again. Only after reset can the next trigger pulse flip the sweep multivibrator. So it is assured that the sweep starts with the trigger pulse. With the slope control we can determine on which slope of a waveform the sweep starts.

There are only four timing capacitors provided, because the 2500-ohm variable control has a fairly wide range, about 1 to 10. The lowest sweep rate with the arrangement shown is about 10 Hz, the highest around 100 kHz. This means you can lock in one cycle of these frequencies on the scope's screen while the variable frequency control pot is in the minimum-resistance position. Turning the pot up, more and more cycles will appear on the screen. This simple arrangement is, of course, somewhat frequency-limited. However, the horizontal amplifiers in the scopes we have modified are in the 200-kHz range and our sweep generator will work up to about 1 MHz.

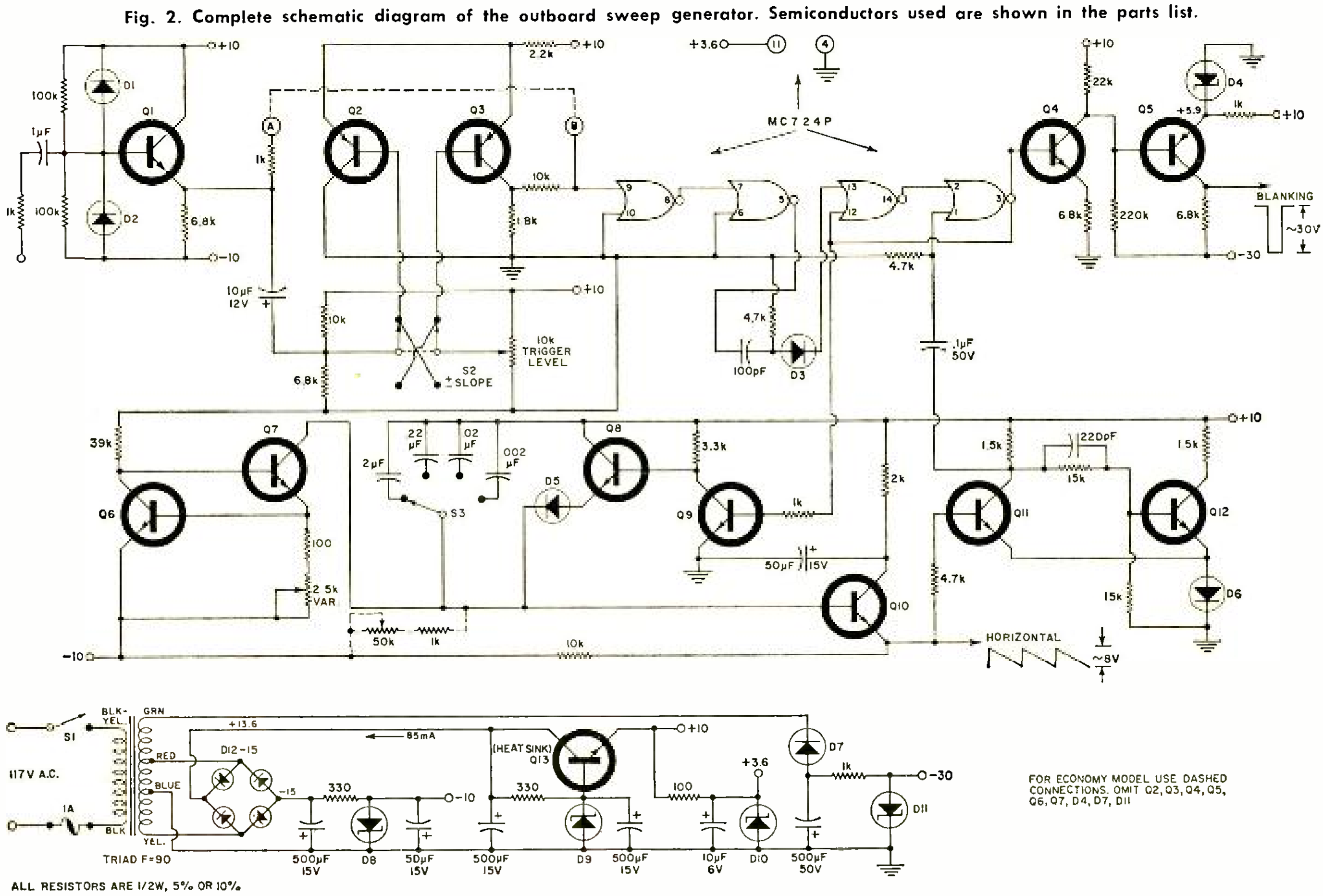
Q4 and Q5 form a d.c.-coupled amplifier, producing a negative-going blanking pulse. When the sweep multivibrator is waiting for a trigger pulse, the output of Q5 is −30 V, cutting off the CRT. During this time the beam is blanked out and does not appear on the scope. This is a peculiar property of the trigger-sweep scope; no input, no beam.

Simplified Version

If you are not using the printed-circuit board, we would recommend a small-hole *Vector* board, with pins. The layout is not critical, but have the leads short. If you want economy there are a couple of parts you can omit and still get satisfactory performance. You can omit Q2-Q3 and associated parts if you don't need the trigger level and slope controls. In this case, connect point *A* directly to point *B*.

If the retrace is not blanked, you will still have a pretty

Fig. 2. Complete schematic diagram of the outboard sweep generator. Semiconductors used are shown in the parts list.



Q1, Q4, Q6, Q7, Q8, Q9, Q10, Q11, Q12—MPS6512, MPS3394, MPS2711 (or HEP729)
Q2, Q3, Q5—MPS6516 (or HEP52)
Q13—MJE520, MPS6552 (or HEP245)
D1, D2, D6, D7—1N4001
D3, D5—1N34 (or equiv.)
D4—6.2 V zener diode (1N4734 or 1N5235A)
D8, D9—11 V zener diode (MZ500-17, 1N4741, or 1N5241A)
D10—3.6 V zener diode (MZ500-5, 1N4728, or 1N5227A)
D11—30 V zener diode (MZ500-27, 1N4751, or 1N5256A)
D12, D13, D14, D15—MDA-920-1 bridge rectifier (or HEP175)
Integrated Circuit—MC724P (or HEP570)

These semiconductor components can be ordered as a kit from PrinTrac, P.O. Box 3306, Scottsdale, Arizona 85257 for $35.00. The PC board alone is $5.00.

clean picture, so you can omit the blanking amplifier consisting of Q4 and Q5. By so doing you not only save two transistors, the zener diode, and five resistors, but also the power-supply parts (diode, zener, resistor, and capacitor) for generating the −30 volts. Furthermore, the extra winding on the power transformer is not needed either. You can also substitute the dashed resistors for the constant-current source (Q6, Q7).

We found, however, that it is worth building the entire circuit so we incorporated everything on the printed-circuit board for the kit.

Circuit Check-Out

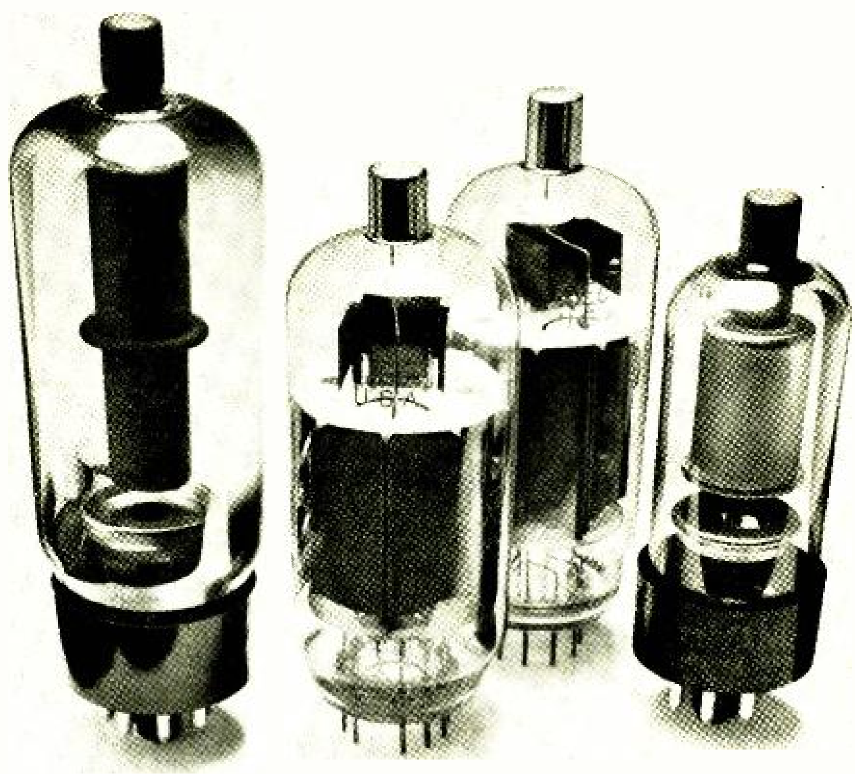
After the board is wired and the power-supply outputs have been checked, connect the board to the power. Check the voltages again. The plus and minus 10-volt lines should be between 10-12 volts under load. The 3.6 volts for the IC must not exceed 4.0 V. After applying a 1-volt signal (say 1 kHz) to the input, take your scope probe and verify the operation of the different stages. Keep in mind that you get an output (saw-tooth) with an input signal only with the trigger level control in the correct position. Put your probe at the 1800-ohm resistor in the Q3 collector circuit and turn the level pot. There will be about 4-V peak-to-peak signal if the pot is the middle of its range. On pin 5 of the MC724P you will see a square wave, and on pin 3 the same.

After the circuit is working properly, connect the output to the scope's horizontal input (marked "Ext"), place the Horizontal switch in External position, the blanking pulse to the Z-axis terminal (on the rear of some scopes), and the input to the first vertical cathode follower, or the top of the vertical gain control.

Here we recommend a modification, the only one on the inside of the scope that has nothing to do with the sweep, namely, the addition of a vertical calibrator switch. The advantages of the calibrated vertical input are obvious; peak or peak-to-peak voltages of any signal may be read directly from the oscilloscope.

The amplitude calibrator is a 5-position switch, replacing the "Vertical Amplitude" or "Vertical Gain" potentiometer on the front of the scope. Refer back to Fig. 1 for the modification circuit. Now the signal needed for the sweep trigger is taken directly from the 1000-ohm resistor on this switch. We are using five horizontal lines about 1-cm apart as a graticule on the center of a 5" CRT. The amplitude calibration is easily accomplished with the aid of an audio generator and a.c. voltmeter.

The horizontal sweep can be calibrated too. It requires good stable capacitors in the timing circuit and some sort of frequency-calibrated generator. ▲



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Well, we've given it special patented radiator fins that first absorb the heat and then radiate it out of the tube.

Now it runs cooler and lasts longer.

Same for our 6JS6C.

Or take our 6BK4C/6EL4A. That's the shunt regulator that eliminates runaway high voltage. We gave this one a whole new anode and shield design to improve heat transfer and stability.

Now it also runs cooler and lasts longer.

Or take our 3A3B high voltage rectifier. This one's got leaded glass for added protection. And it lasts longer too.

So next time you have to replace any of the hot ones, just cool it. You'll both last longer.

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

CIRCLE NO. 96 ON READER SERVICE CARD

EW Lab Tested

(Continued from page 17)

would not be suitable for this type of service.

This measurement was made with the tweeter level control at maximum, which also gave the best results in listening tests. The low-frequency response fell off sharply below 90 Hz. Harmonic distortion was very low, only about 1% down to 80 Hz, and rising to 4% at 50 Hz. Below that frequency, the output fell off so rapidly that we could not measure the distortion.

Tone-burst response was generally excellent—in fact, it could be termed superior except for a single anomaly at 3 kHz, where there was a sustained ringing. Although the specifications do not list the crossover frequency, it may well be at or around 3 kHz.

The most important consideration is, of course, how the speaker sounds. We can best describe it as extremely easy, smooth, and pleasant. *Harman-Kardon* describes it as "neither brilliant nor deep-throated," and we agree with this appraisal. Its sound is well-balanced and one is not normally aware of any lack of extreme highs or lows. Tone controls with the correct characteristics can be used with great effect to modify the speaker's basic sound. It simply would not "spit," "screech," or "boom," no matter how much boost we applied.

Like any good omnidirectional speaker system, the HK50 is difficult to localize by ear. Usually, one simply cannot tell where the sound is coming from. If conventional speakers are also visible in the same area, almost everyone assumes that they are producing the sound.

Beyond these comments, we would not attempt to further describe or define the sound of the HK50 speakers. They must be heard (this applies to any speaker, of course) to be evaluated. We consider them to be a very successful omnidirectional design, esthetically as well as sonically, at a moderate price. Incidentally, *Harman-Kardon* supplies a pair of HK50's as part of its top-of-the-line compact music system.

The HK50 sells for $99.95. ▲

Dual 1212 Automatic Turntable

For a copy of manufacturer's brochure, circle No. 35 on Reader Service Card.

FOR many audio fans, spending upward of $100 on a record player is out of the question. A budget music system, like any other, should emphasize the loudspeakers and while there are excellent low-priced speakers, there is a lower limit below which quality suffers noticeably. Caught in this price squeeze, many people have chosen to sacrifice quality in the record player, putting up with wow, rumble, and the indignities that low-priced changers sometimes impose on records and listeners.

When we heard of a *Dual* changer selling for less than $75, yet embodying most of the features of the more expensive models, we were both curious and skeptical. What had been sacrificed in the price-cutting process? Having now tested and used the new *Dual* 1212, we can affirm that little, if anything, has been done that could affect the user's enjoyment of his records, and the end result is an unqualified success.

The *Dual* 1212 is a three-speed changer, with interchangeable automatic and manual-play spindles. Up to six records can be stacked for automatic play. Like the other *Dual* players, the 1212 has a cueing lever with silicone damping for a gentle lowering of the cartridge to the record. The balanced arm has a direct-reading stylus-force adjustment that proved to be accurate within 0.15 gram at all settings. The arm is a very light aluminum beam with a "T" cross-section for rigidity.

The 1212 has a vernier speed adjustment of nominally ±3 percent about the

selected speed. Its high-torque motor does not change speed significantly over a wide range of line voltages. A unique feature of the changer is the automatic linking of the anti-skating force adjustment with the tracking-force adjustment. It really works, as we verified by observing that the cartridge output waveform on high-velocity records was clipped symmetrically on both channels. The arm friction is low enough to allow operation at a 1-gram tracking force, which is as low as we would recommend operating any cartridge we have used.

The changer has a 3¾-pound laminated platter. The finish is relatively spartan, basically flat black with silver accents. Light metal stampings are used for trim and covers, but the basic structure is solid and rigid.

The plug-in cartridge holder is released by simply pushing back the finger lift. Slots in the holder enable the cartridge to be positioned for optimum overhang and minimum tracking error, with the aid of a plastic jig supplied with the changer. A wedge may be installed under the cartridge to set it at a 15-degree vertical tracking angle when playing single records, if this is to be the usual mode of operation.

Obviously, practically all the advanced features of the manufacturer's 1009 and 1010 have been incorporated in the 1212. What about its performance? We measured the rumble as −39 dB in the lateral plane and −35 dB including vertical components. These are well below rumble figures we have obtained on other comparably priced record changers. Flutter was 0.025 percent and wow was 0.07 percent (0.09 percent at 78 r/min). The arm tracking error was less than 0.67 degree per inch of radius. These figures show the *Dual* 1212 to be compatible with the finest amplifiers and speakers, as well as the most compliant cartridges available today (some of which cost as much as the entire 1212, incidentally).

The *Dual* 1212 was easy-to-use, free from idiosyncrasies, smooth in its record handling, and very quiet, both acoustically and in its rumble output. The automatic turntable, priced at $74.50 (base and cartridge extra), is a truly fine value and should bring the best in record-playing capability to modest-priced home music systems. ▲

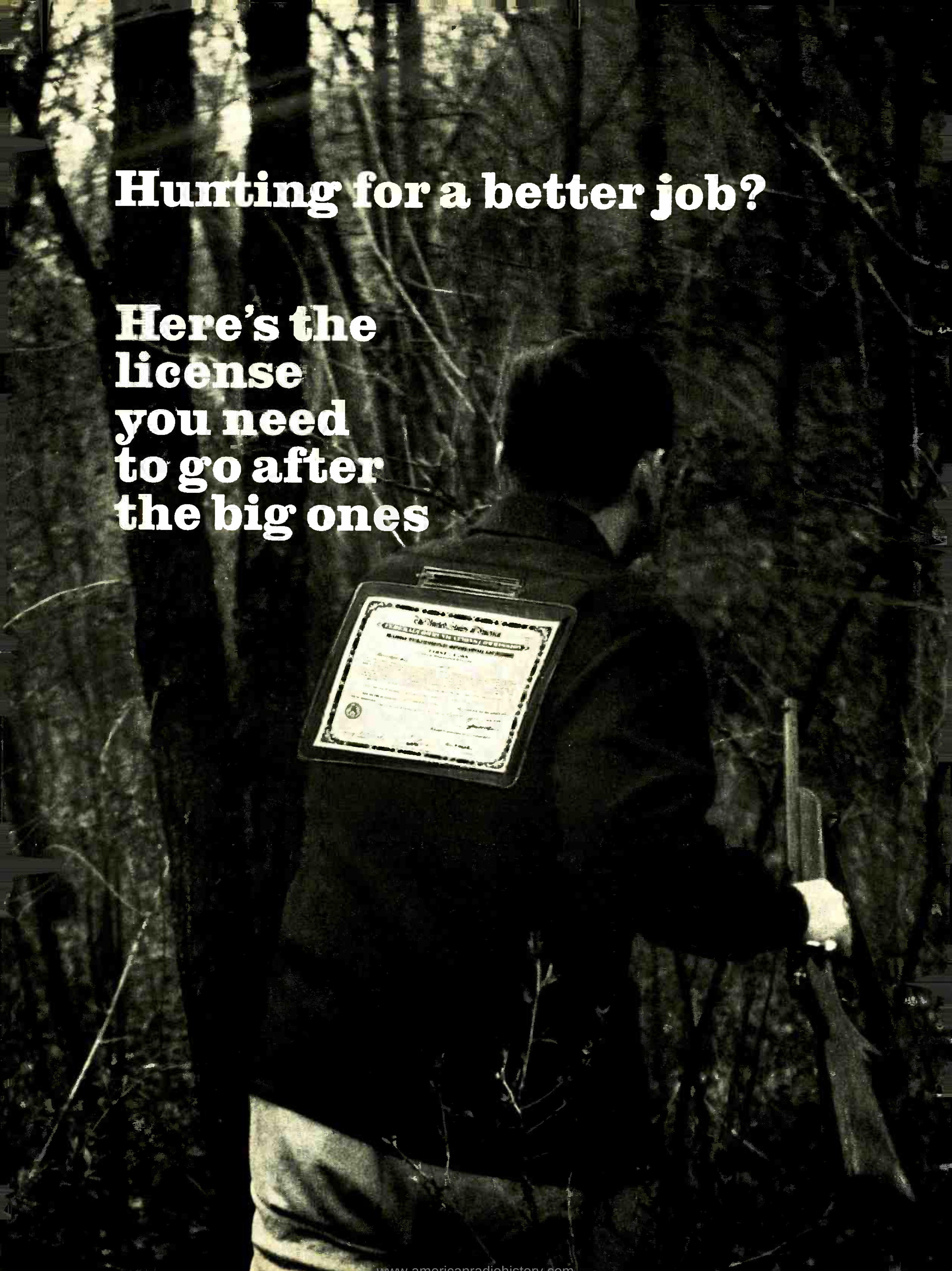
NEA TRAINING PROGRAM

THE NEA (National Electronic Associations) Apprenticeship & Training Program has had a twofold purpose—upgrading existing technicians and developing new ones. This program has had moderate success to date. The CET (Certified Electronics Technician) examination has been given to 3000 men, with about 1250 of these successfully acquiring the status of CET's. What has been learned from those who have failed the test is that there are four basic educational programs needed: TV alignment; the logical order of troubleshooting; solid-state circuits and systems; and the use of test equipment.

In order to enhance the existing program of upgrading technicians, NEA is now encouraging all their local organizations to work more closely with the vocational and technical schools in their area. It is their hope that they will develop a better understanding on the part of instructors of the industry needs for qualified radio-TV technicians.

Three facilities are needed to have a successful technician development program—a teaching site, a training site, and an indenture agency. The teaching site could by any local vocational/technical school in a given area. The training site could be any local electronics service shop. The indenturing agency (the local bureau of apprenticeship and training) is a branch of the U.S. Department of Labor that is located within each community.

For further information about the NEA program, or help along these lines, contact Charles Cave, CET, NEA Director of Apprenticeship & Training, 7902 Bardstown Rd., Louisville, Ky. 40291 (phone: 502/239-3718). ▲


Hunting for a better job?
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A Government FCC License can help you bring home up to $10,000, $12,000, and more a year. Read how you can prepare for the license exam at home in your spare time—with a passing grade assured or your money back.

IF YOU'RE OUT TO BAG A BETTER JOB in Electronics, you'd better have a Government FCC License. For you'll need it to track down the choicest, best-paying jobs that this booming field has to offer.

Right now there are 80,000 new openings every year for electronics specialists—jobs paying up to $5, $6, even $7 an hour... $200, $225, $250, a week... $10,000, $12,000, and up a year! You don't need a college education to make this kind of money in Electronics, or even a high school diploma.

But you *do* need knowledge, knowledge of electronics fundamentals. And there is only one nationally accepted method of measuring this knowledge... the licensing program of the FCC (Federal Communications Commission).

Why a license is important

An FCC License is a legal requirement if you want to become a Broadcast Engineer, or get into servicing any other kind of transmitting equipment—two-way mobile radios, microwave relay links, radar, etc. And even when it's not legally required, a license proves to the world that you understand the principles involved in *any* electronic device. Thus, an FCC "ticket" can open the doors to thousands of exciting, high-paying jobs in communications, radio and broadcasting, the aerospace program, industrial automation, and many other areas.

So why doesn't everyone who wants a good job in Electronics get an FCC License and start cleaning up?

The answer: it's not that simple. The government's licensing exam is tough. In fact, an average of two out of every three men who take the FCC exam fail.

There is one way, however, of being pretty certain that you will pass the FCC exam. And that is to take one of the FCC home study courses offered by Cleveland Institute of Electronics.

CIE courses are so effective that better than 9 out of 10 CIE graduates who take the exam pass it. That's why we can back our courses with this iron-clad Warranty: Upon completing one of our FCC courses, you must be able to pass the FCC exam and get your license—or you'll get your money back!

They got their licenses and went on to better jobs

The value of CIE training has been demonstrated time and again by the achievements of our thousands of successful students and graduates.

Ed Dulaney, Scottsbluff, Nebraska, for example, passed his 1st Class FCC License exam soon after completing his CIE training... and today is the proud owner of his own mobile radio sales and service business. "Now I manufacture my own two-way equipment," he writes, "with dealers who sell it in seven different states, and have seven full-time employees on my payroll."

Daniel J. Smithwick started his CIE training while in the service, and passed his 2nd Class exam soon after his discharge. Four months later, he reports, "I was promoted to manager of Bell Telephone at La Moure, N.D. This was a very fast promotion and a great deal of the credit goes to CIE."

Eugene Frost, Columbus, Ohio, was stuck in low-paying TV repair work before enrolling with CIE and earning his FCC License. Today, he's an inspector of major electronics systems for North American Aviation. "I'm working 8 hours a week less," says Mr. Frost, "and earning $228 a month more."

Send for FREE book

If you'd like to succeed like these men, send for our FREE 24-page book "How To Get A Commercial FCC License." It tells you all about the FCC License ... requirements for getting one... types of licenses available... how the exams are organized and what kinds of questions are asked... where and when the exams are held, and more.

With it you will also receive a second FREE book, "How To Succeed In Electronics," To get both books without cost or obligation, just mail the attached postpaid card. Or, if the card is missing, just mail the coupon below.

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CIRCLE NO. 142 ON READER SERVICE CARD

Resistivity: Some Definitions

By JOSEPH TUSINSKI/Chief Technical Instructor, Old Dominion College

Often when defining technical terms or using them in an equation, many technical men confuse them and unknowingly employ wrong expression.

ENGINEERS as well as technicians some time have difficulty defining resistivity. Resistivity and resistance are both related to the ability of a substance to impede the drift of electronic charges. However, in specifically defining one or the other, dimensions used in formulating each term are either disregarded or not even considered.

Resistance has dimensions of mass, length, time, and charge. Hence it is defined in terms of volts per ampere. The unit of resistance is the ohm and its symbol is capital *omega* (Ω). For example, when 100Ω is expressed, what is implied is 100 volts per ampere. Resistivity, on the other hand, is given in terms of resistance per volume and its symbol is *rho* (ρ). Thus a problem normally involves *resistivity* when it appears in a formula and the wrong dimensions are used, or it would be more appropriate to say *not used*. Care should be exercised in using tables of resistivities because, in many cases, identical substances may have different numerical values of resistivity.

Resistivity appears subscripted in a number of ways. Some are:

$\rho_{specific}$, ρ_{volume}, $\rho_{relative}$, $\rho_{surface}$, ρ_{square}, ρ_{bulk}, ρ_{sheet}, $\rho_{lattice}$, and $\rho_{imperfection}$.

Lattice and imperfection resistivity deal with lattice vibrations and imperfections of a crystallographic structure. Hence technicians familiar with how semiconductors and thin-films are made will encounter these terms as well as sheet resistivity. Sheet resistivity may be encountered in a number of fields such as thin-film technology or microwaves.

It should be mentioned here that all discussion about resistivity in this article refers to a homogeneous material. A heterogeneous material may be physically attainable or it may be obtained by virtue of frequency effects, such as skin-effect (see the author's article "What is Skin Effect?", June 1963 issue of this magazine).

Fig. 1A shows that for very thin films, resistivity varies logarithmically and that for thicker materials, the resistivity curve flattens out.

A four-point probe method (Fig. 1B) is used to measure sheet resistivity of semiconductor crystals. If the thickness of the crystal is more than twice the probe spacing, the resistivity of the material can be expressed by the equation: $\rho_s = (2\pi Vs)/I$ where s = probe spacing, V = voltage measured with a zero-current voltmeter, I = constant current source, and $2\pi = 6.2832$.

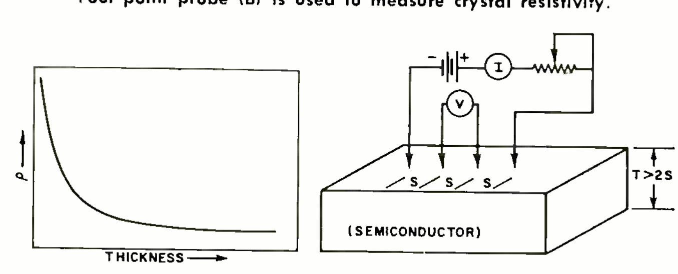
Bulk resistivity, ρ_∞, is another term used to describe the resistivity or the impurity concentration of a semiconductor. Ordinarily, when the resistivity of a material is measured, a known current is forced through the material and the resulting voltage drop is measured. Thus by Ohm's Law ($R = E/I$) the resistance is determined and related to resistivity in ohms/cm^3. Very often the term is shortened to ohm-cm, the cube being implied. However, in bulk resistivity measurements, the resistance of the ohmic contacts must not be included in calculations. Thus a method somewhat similar to the four-point probe method is used (Fig. 2).

Square resistivity is perhaps the most misunderstood of all. Technicians usually ask, "Square what?" or they assume that a square centimeter is implied. The implication of square resistivity is that the length of the sample is equal to the width, *i.e.*, is square. Resistivities are given in ohms/square. For example, assume a sample of material having a resistivity of R ohms/square. Thus if four of the basic units are combined, the length doubles, hence the resistance doubles ($2R$); however, the width also doubles, which is the same as paralleling two resistors having values of $2R$ each. The total resistance of the combination is: $(2R) \times (2R)/(2R + 2R) = R$.

A simile can be derived by increasing the length three times and the width three times, *i.e.*, square. The total resistance is: $1/(1/3R + 1/3R + 1/3R) = R$.

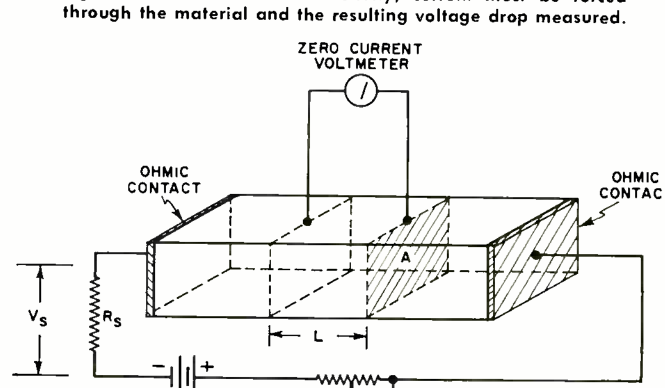
For example, suppose it is desired to achieve a resistance of 15 kΩ with a material having a resistivity of 300Ω/square. Let us assume that the resistor must have a minimum width of 20 mils: determine the length of the resistor. From $R = \rho_{square}(L/W)$, $L = WR/\rho_{square}$, then $L = (0.02 \times 15{,}000)/300$, or 1 inch. This equation states that to determine the resistance of a specimen, the square re-

Fig. 1. (A) In thin films, resistivity varies logarithmically. Four-point probe (B) is used to measure crystal resistivity.



(A) (B)

Fig. 2. To measure bulk resistivity, current must be forced through the material and the resulting voltage drop measured.



$\gamma = \frac{L \; V_S}{A \; R_S \; V}$ AND, $\rho = \frac{1}{\gamma}$ (ohm-cm)

γ = CONDUCTIVITY mhos-cm

R_S = PRECISION RESISTOR FOR DETERMINING THE CIRCUIT CURRENT

sistivity is multiplied by the ratio of the length to the width.

The use of specific, volume, and relative resistivities is normally relegated to metals. These are perhaps the most popular tables of resistivity available, and yet erroneous conclusions arise from their use.

In electronics, copper wire has been the most popular material used to interconnect components. For this reason, many tables list the various characteristics of copper. However, the characteristics of copper may be altered by various means (alloying or annealing). Therefore a certain type of copper is used as a standard in evaluating the conductivities of materials ($\gamma = 1/\rho$).

The standard, which represents 100 percent conductance, is annealed copper at a temperature of 20° C. The resistance of a one-meter-long section having a uniform cross-section of 1 mm^2 is equal to 0.01724 ohm. Other methods were tried dealing with the weight of copper; however these were not too fruitful, and the measurement of length and area became the popular way to standardize.

The conductivity of aluminum may vary by as much as 35 percent depending upon its composition. Pure aluminum (99.97 percent) has a conductivity of 64.6 percent of standard copper. Thus if standard copper is considered to be unity, aluminum has a relative resistivity of $1/0.646 = 1.54$ or a specific resistance 1.54 times that of standard copper. Thus values derived from a table consisting of relative resistivities must be multiplied by the resistivity of copper to determine their actual or specific resistance.

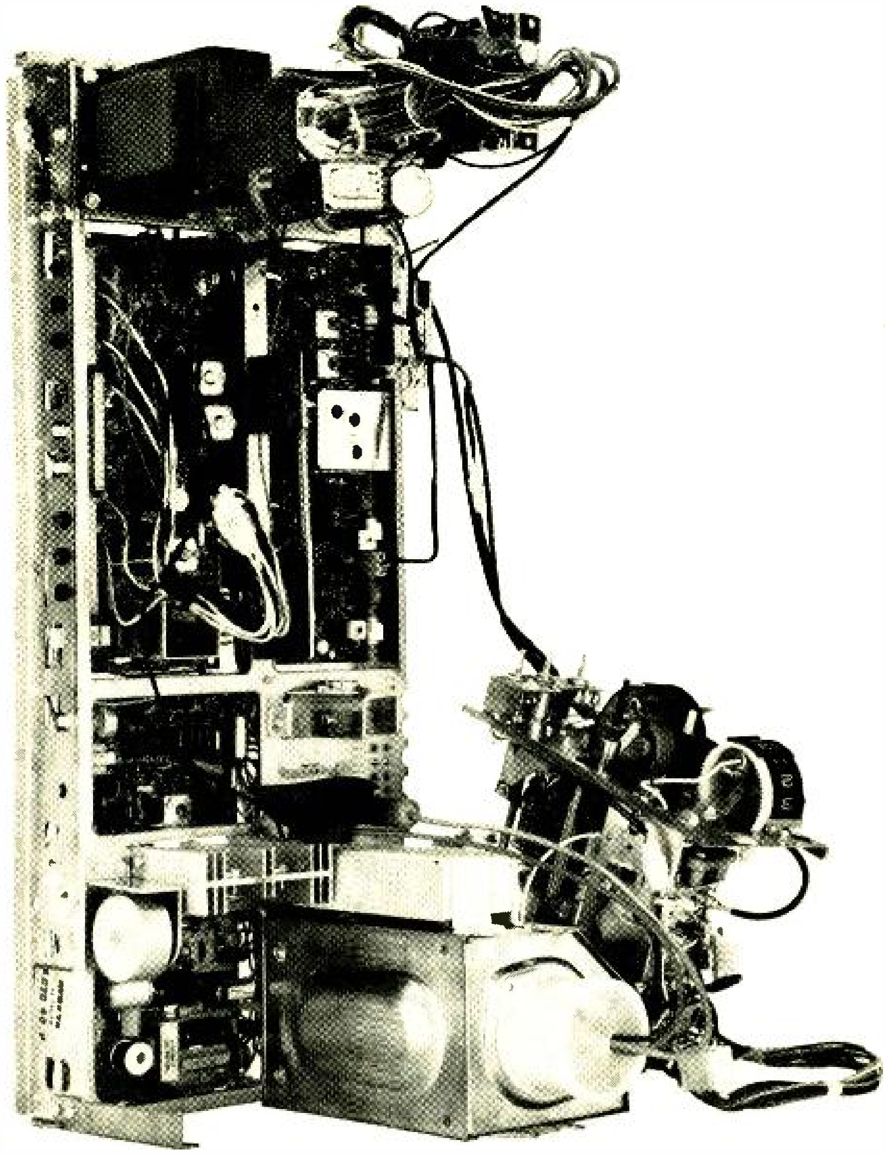
Tables relating the resistivity of a round copper wire were quickly formulated so that most of the arithmetic could be simplified. From these, a table of specific resistivities evolved. The popular dimensions chosen were the one-mil diameter and one-foot length. (The mil-inch was adopted in England.) Thus they yield the specific resistance of a material one-mil by one-foot, normally classified as Ω/mil-foot. For example, annealed copper would have a specific resistivity of 10.36Ω/mil-foot.

Volume resistivities relate the resistance of a cubic structure. They are specified as follows: 1. Ω/cm-cube (preferred), 2. Ω-cm, and 3. microhm-centimeters.

All three designations refer to a cubic specimen having square faces of one centimeter. The resistance is to be measured between flat plates making contact with opposing faces. Standard copper has a volume resistivity of 1.7241×10^{-6}Ω/cm-cube or 1.7241 microhm-cm. When ρ_{sp} and ρ_v of copper are compared (1.7241 microhm-cm compared to 10.36Ω/mil-foot) and dimensions disregarded, serious mathematical errors result. A simple example will help to illustrate this point. The resistance of any uniform homogeneous material is given as $R = \rho\ L/A$ (ohms). It is obvious that if $\rho = 1.64$, or $\rho = 2.83 \times 10^{-6}$, or $\rho = 16.9$ is used in the equation, different results would be obtained. However, all of these resistivities (relative, volume, and specific) are given for the same material. Thus in order for the calculated resistance to be meaningful, the units of L and A must be converted to correspond to the method used in determining the resistivity of the material.

Another factor should be mentioned about determining resistivities of insulators. For example, the surface resistivity of an insulator is measured from the opposite edges of a square specimen. The bulk resistance of the body, which is parallel to the surface, must be many times greater than the surface resistance. The volume resistivity of an insulator must be determined using sophisticated guarding procedures, so that surface charges will not mask uniform conduction through the sample.

All of the resistivities discussed are by no means all of the various forms of resistivity that the technician or engineer will encounter. The intent is to bring about a respect for a numerical value of resistivity and to be concise in specifying the dimensions, method used, or theory involved in determining a value of *rho*. ▲



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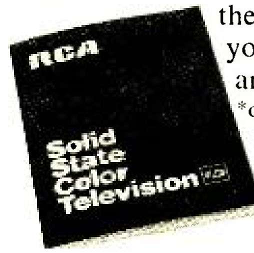
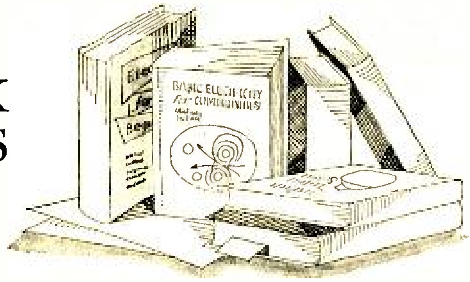
*one tube rectifier



RCA

BOOK REVIEWS



"HOW TO USE GRID-DIP OSCILLATORS" by Rufus P. Turner. Published by *Hayden Book Company, Inc.*, 116 W. 14th St., New York 10011. 108 pages. Price $2.95 soft cover.

This is a revised and updated version of the author's 1960 text and places heavy emphasis on the practical applications of the grid-dip oscillator in radio, television, and electronic work.

Lavishly illustrated, this book can be used as a study text or as a practical "how-to" handbook for the technician, engineer, or hobbyist. The author explains how to check *LC* circuits, linear and coaxial tanks, how to convert a signal generator or r.f. test oscillator into a GDO or a GDO into a conventional or marker generator, signal injector, or c.w. oscillator.

There are step-by-step instructions on how to measure inductance; test and align TV, radio, and FM receivers; how to get more out of a transmitter; and how to find the resonant frequency of an antenna or check for antenna matching.

As is the case with all of Mr. Turner's books, the exposition is clear, concise, and easy to understand.

* * *

"INTRODUCTION TO LARGE-SCALE INTEGRATION" by Adi J. Khambata. Published by *John Wiley & Sons, Inc.*, New York. 190 pages. Price $9.95.

The author has addressed this volume to the user's point of view and is intended to give management, marketing, field service, and technical personnel a basic look at LSI.

The book is divided into four main sections so the reader can select the material of most interest to him. Section one deals with device and technology considerations, section two covers systems considerations, section three explores application considerations, while the fourth section takes up miscellaneous topics such as the computer's role in LSI, reliability, testing, and price projections.

The appendices provide data sheet information on various commercially available items from eleven firms. An extensive bibliography is also included for those wishing to pursue a particular topic in greater depth.

* * *

"ELECTRONIC POWER SUPPLIES" by Joseph Grabinski. Published by *Holt, Rinehart and Winston, Inc.*, New York. 216 pages. Price $3.95. Soft cover.

This is another volume in this publisher's series of handbooks designed for use in technical institutes as well as junior and community colleges. It can also be used in industrial training programs for upgrading technicians or as a self-instruction text. The student should have had a course in a.c. and d.c. circuits, understand the basic operation of solid-state and vacuum diodes, and have a working knowledge of algebra, trigonometry, and elementary calculus before tackling this book.

The six chapters cover single-phase rectifier circuits, polyphase rectifiers, magnetic amplifiers, gaseous tube circuits, controlled rectifiers, and regulators. The text is well illustrated and the presentation is straightforward and concise.

* * *

"RTL COOKBOOK" by Donald E. Lancaster. Published by *Howard W. Sams & Co., Inc.*, Indianapolis, Ind. 233 pages. Price $5.50. Soft cover.

Our readers are, of course, familiar with the writings of Mr. Lancaster and will undoubtedly welcome this discussion of RTL's and their applications. His emphasis on a single type of digital IC's is based on their relatively low price and the ease with which they can be interfaced with conventional transistor circuitry.

After the discussion of basics, the rest of this volume covers logic and switching circuits, multivibrators, linear circuits and techniques, counting flip-flops, scaling and divide-by-*n* counting, decimal counting, and digital instruments and other RTL applications. The material is practical and the treatment is thorough. Those interested in working with these readily available, relatively inexpensive components will find this "cookbook" invaluable.

* * *

"104 SIMPLE ONE-TUBE PROJECTS" by Robert M. Brown. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 192 pages. Price $6.95 hard cover, $3.95 soft cover.

This is a book for the inveterate "build-it-yourselfer" who is never happy without an electronic project on the bench. No matter what type of project the builder has in mind, chances are he can find instructions here for building a simple, inexpensive gadget.

The projects range from test instruments and ham gadgets to wireless microphones, tube rejuvenators, electronic games, and audio devices. None of the circuits requires more than a single tube and in most cases the components can be salvaged from the "junk box." Even if purchased new, the cost per project has been limited to an easy-to-take $5.00 or less. Students with science-fair projects on their schedule should look over the assortment Mr. Brown has provided for ideas and construction assistance.

* * *

"ELECTRICAL FUNDAMENTALS FOR TECHNICIANS" by Robert L. Shrader. Published by *McGraw-Hill Book Company*, New York. 459 pages. Price $10.95.

This book represents a new and interesting approach to the problem of teaching basic electricity to prospective technicians of varied backgrounds and educational achievement.

The first seventeen chapters provide a largely nonmathematical coverage of the fundamentals of electricity. The balance of the book is a recap or "second look" at the subjects with emphasis on complete comprehension. The author even tells the student how to tackle the subject to avoid discouragement and, finally, defeat.

This volume can be used in formal classes in technical institutes, vocational schools, or junior college electronics courses or can be used by the student working on his own. There are "check-up" questions scattered throughout the text whereby the student can verify his comprehension of the material and then quizzes at the end of each chapter for further verification.

The text is informally written, well illustrated, and the subject matter logically presented—all of which contribute to its usefulness.

* * *

"SEMICONDUCTOR CIRCUITS LABORATORY MANUAL" by David J. Comer. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 122 pages. Price $7.35. Soft cover.

This manual is designed to be used in the second year curriculum of most technical institutes or in the third year of electrical engineering courses. Emphasis is on design, with special attention being given to design procedures.

The basic theory of diode and transistor operation is covered in the introductory section. With this material and the new theory introduced in each experiment, the student has enough information to understand circuit basics.

Experiments on each phase (diodes and transistors, power stages, high-frequency and special-purpose stages, switching and logic circuits, and power supplies) can be performed using standard and easily available parts. Each experiment is preceded by a listing of objectives, the equipment required, the theory involved, the procedure to be followed, and topics for discussion. ▲

Reading Aid for Blind

(Continued from page 50)

The feasibility of a direct-translation reading aid, based on the principle outlined, has clearly been established. With Office of Education support, three aids have been fabricated, and improved models are in the offing. Although the device is still in the early experimental stages, it shows promise of wide usefulness among the blind.

We gratefully acknowledge the encouragement and advice of Dr. J.G. Linvill, the valuable suggestions of Dr. J.C. Bliss and Dr. J.D. Meindl, and the assistance of the other team members of the blind reading-aid project. Further recognition is extended to J. Baer and J. Gill of the Stanford Research Institute, who designed and fabricated the stimulator array and most of the probe hardware. Finally, our gratitude to the *SEL Instrument Lab* for their assistance in the fabrication of the blind reading-aid units. ▲

(The work presented or reported herein was performed pursuant to a grant from the U.S. Office of Education, Department of Health, Education, and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S. Office of Education, and no official endorsement by the U.S. Office of Education should be inferred.)

$25-BILLION SALES IN 1969?

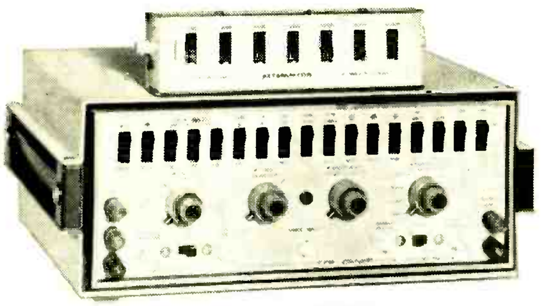
ACCORDING to Mark Shepherd, Jr., President of the EIA and President and Chief Executive Officer of Texas Instruments, 1969 is beginning to shape up as a banner year for the electronics industry.

After rising by 4.4% to reach $24.2 billion during 1968, total U.S. factory sales of electronics are expected to climb another 3.1% during this year, to reach nearly $25 billion.

It is anticipated that the major equipment markets will show a mixture of moderate expansions and leveling activities during the rest of this year. Sales of industrial electronics are expected to rise some 6.8% to reach nearly $7.2 billion. U.S. factory sales of consumer electronics are expected to increase 1.1% to reach $4.8 billion or more. Replacement component sales, estimated at $690 million, are up 2.2% from their over-all 1968 sales level.

The conservative sales gains anticipated for electronic products during this year reflect a somewhat slower growth rate for the over-all U.S. economy. Although there was relatively little immediate impact of the income surtax, some downward pressure on consumer buying may develop late this year and continue into 1970 as a result of tight money and the fact that discretionary income will be smaller as prices for basic needs soar. ▲

Exciting New Kits For Home & Hobby

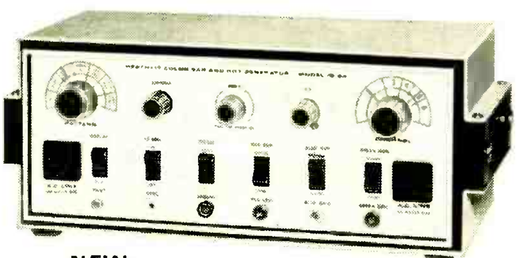


NEW Kit IG-57A

$135.00*

NEW, Improved Heathkit IG-57A Solid-State Post Marker/ Sweep Generator... Now With Built-In Video Sweep Modulator

Now align virtually every color and B&W TV set on the market with the new Heathkit IG-57A. New built-in Video Sweep Modulation eliminates the need for external equipment—the IG-57A and a scope are all you need to check the overall frequency response from the antenna terminals thru the tuner, IF strip, video detector to the color bandpass amplifier outputs. And you don't have to worry about video detector diode load. Another new feature is the addition of two individually adjustable 15 volt bias supplies with switchable polarity. Additional features: 15 crystal-controlled markers for color bandpass, TV sound, IF frequencies between 39.75 & 47.25 MHz and picture & sound carriers for channels 4 & 10 . . . switchable retrace blanking . . . adjustable phase control . . . trace reverse function for proper display . . . built-in switchable 400 Hz modulator . . . Zener regulated power supply . . . external attenuator for 1, 3, 6, 10 & 20 dB steps up to 70 dB . . . complete with all test leads, cables, connectors & plugs. Put complete servicing facilities on your bench now, with the new Heathkit IG-57A. 14 lbs.

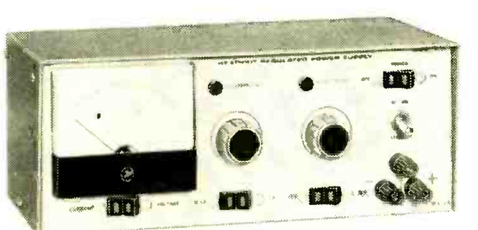


NEW Kit IG-28

$79.95*

NEW Heathkit Color Bar-Dot Generator... Advanced Integrated Circuitry Produces 12 Patterns Plus Clear Raster, Eliminates Divider Chain Instability Forever

The new IG-28 is the signal source for all color and B&W TV servicing. No other instrument at any price will give as much stable, versatile TV servicing capability. Its solid-state circuitry produces dots, cross hatch, vertical and horizontal bars, color bars, and shading bars in the familiar 9x9 display . . . plus exclusive Heath 3x3 display of all these patterns . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustment. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments. And for time-saving convenience the IG-28 has variable front panel tuning for channels 2 through 6. Plus & minus going video signals at the turn of a front panel control . . . for sync, in-circuit video or chroma problems, use the front panel sync output. Two front panel AC outlets for test gear, TV set, etc. Built-in gun shorting circuits and grid jacks too. Add any service-type scope with horizontal input and you have vectorscope display capability as well. Fast, enjoyable circuit board-wiring harness construction. You can't beat the Heathkit IG-28 for versatility or value . . . put it on your bench now. 8 lbs.



NEW Kit IP-28

$47.50*

NEW Heathkit 1-30 VDC Solid-State Regulated Power Supply

The new modestly priced IP-28 is an excellent power supply for anyone working with transistors. Compact Heathkit instrument styling with large, easy-to-read meter . . . two voltage ranges — 10 V., 30 V. . . . two current ranges — 100 mA, 1 A. External sensing permits regulation of load voltage rather than terminal voltage. Adjustable current limiting prevents supply overloads and excessive load current. Convenient standby switch. Fast, easy assembly with one circuit board and wiring harness. Order yours today! 9 lbs.

NEW Kit GR-78

$129.95*

NEW Heathkit GR-78 Solid-State General Coverage Receiver... Tunes 190 kHz To 30 MHz In Six Bands

The new GR-78 combines wide coverage, superior performance and portability with sharp styling to provide a remarkable value in general coverage receivers. Tunes AM, CW & SSB signals from 190 kHz to 30 MHz in six switch-selected bands. The all solid-state circuit employs modern FET's in the RF section and 4 ceramic filters in the IF to deliver maximum sensitivity and sharp selectivity. Bandspread Tuning is built-in, and can be calibrated for either Shortwave Broadcast or Amateur Bands. Completely portable . . . comes with a nickel-cadmium rechargeable battery pack and built-in charger that operates from 120 or 240 VAC and 12 VDC. Many built-in features . . . 500 kHz crystal calibrator . . . switchable Automatic Noise Limiter . . . switchable Automatic Volume Control . . . Receiver Muting . . . Headphone Jack and many more. Order yours today. 14 lbs.

NEW Kit GD-209A

$149.95*

NEW Heathkit Deluxe Radio-Controlled Screw-Drive Garage Door Opener Semi-Kit

The next best thing to a personal doorman. The "wireless" factory assembled transmitter operates up to 150 feet away. Just push the button and your garage door opens and the light turns on . . . and stays on until you're safely inside your home. The giant 7 ft. screw mechanism coupled with the ¼ HP motor mean real power and reliability and the adjustable spring-tension clutch automatically reverses the door when it meets any obstruction . . . extra safety for kids, pets, bikes, even car tops. Assembles completely without soldering in just one evening. Easy, fast installation on any 7' overhead track (and jamb & pivot doors with accessory adapter). Order yours now. 66 lbs.

Adapter arm for jamb & pivot doors, Model GDA-209-2, $7.95*

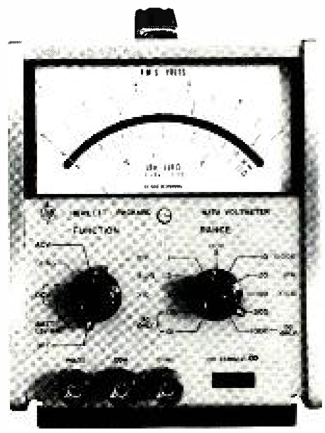
Why do these instruments cost so much?

Here are five solid-state research/industrial-quality instruments that offer high performance specifications—and that meet and even exceed those specs. They perform reliably over long periods of time, and you operate them with controls that are easy to understand, easy to use. They're instruments that give you measurements you can trust. And they're backed up with the extra advantage of local service on a nationwide basis. These are the reasons they cost a little more. Aren't your measurements worth it?

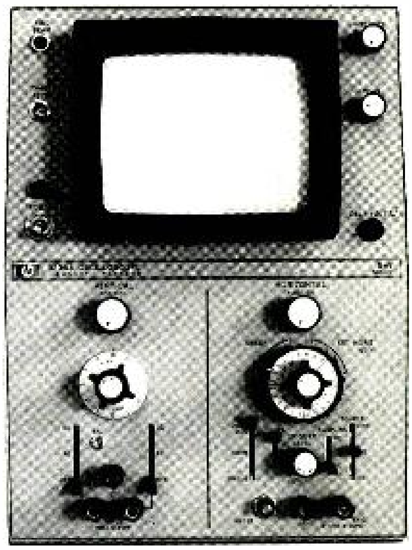
Power Our solid-state 6217A DC Power Supply is short-circuit proof and provides an extremely well regulated metered output of 0-50 V dc voltage, 0-200 mA dc current. Use the coupon for your copy of our Power Supply Selection Guide. Price, Model 6217A, $90.

Use the coupon for the information you want.

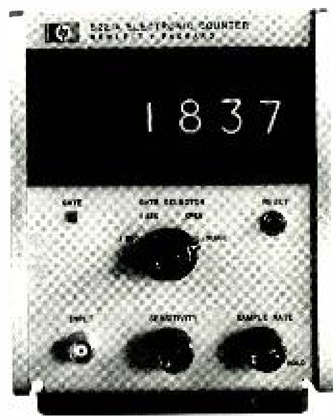
Signal Source The 3310A Function Generator furnishes sine, square, triangular and sawtooth waves, as well as pulse output. Solid state and reliable, it has a frequency range from 2.3 cycles per hour all the way up to 5 MHz in ten decade ranges. The output spans a 70 dB range, from a high of 15 volts peak-to-peak into 50 ohms. The output frequency can be controlled by an external voltage. A four-page technical data sheet gives all the information on the 3310A, $575.



Measure The solid-state 427A Multi-Meter measures dc voltages from 100 mV to 1 kV full scale, ac voltages from 10 mV to 300 V full scale at frequencies up to 1 MHz, and resistance from 10 Ω to 10 M Ω center scale. Battery operated—use it anywhere. Ask for a data sheet on the 427A, priced at $225.



Display The 1206A is a rugged solid state 500 kHz single-channel oscilloscope featuring sensitivity from 5 mV/div to 50 V/div with vernier. Sweep ranges from 1 μsec/div, with vernier extending slowest sweep to at least 12.5 sec/div. Automatic triggering, beam finder, human oriented controls. You can trust the measurement you see. Send for a copy of our 12-page brochure on the 1200 Series Low-Frequency Oscilloscopes. Model 1206A, $715.



Count The 5221A Solid-State Electronic Counter presents frequency and time interval measurements on an easy-to-read 4-digit display, counts to 10 MHz. Zero blanking, readout storage and sample rate control, adjustable from 100 msec to 5 sec, are just a few of the advantages of this low-priced counter. Ask for a technical data sheet on the 5221A, which is priced at $425.

Hewlett-Packard
Palo Alto, California 94304
Please send me more information on ☐ 6217A, ☐ 3310A, ☐ 427A, ☐ 1206A, ☐ 5221A.

Name__________ Company__________

Job title__________

Company address__________

City/State/Zip__________

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Why do service technicians specify RCA color picture tubes more often than any other brand?

Back in the early days of color, you had no choice. Now that you have a choice, it's still RCA by a wide preference. Why? Primarily because of experience.

And hand-in-glove with experience goes performance. Outstanding overall performance... down through the years...with a wide variety of tube sizes.

Put them together and they add up to confidence...for the service technician who installs the tube...for the set owner who has to pay the bill.

RCA puts its reputation on the line with every picture tube it makes. Whether it's the RCA HI-LITE built to OEM specs all the way...or a quality rebuilt RCA Colorama...you can rely on RCA picture tubes to protect your hard earned service reputation. They're designed to protect the biggest reputation in the COLOR TV industry.

RCA Electronic Components, Harrison, N.J.

RCA