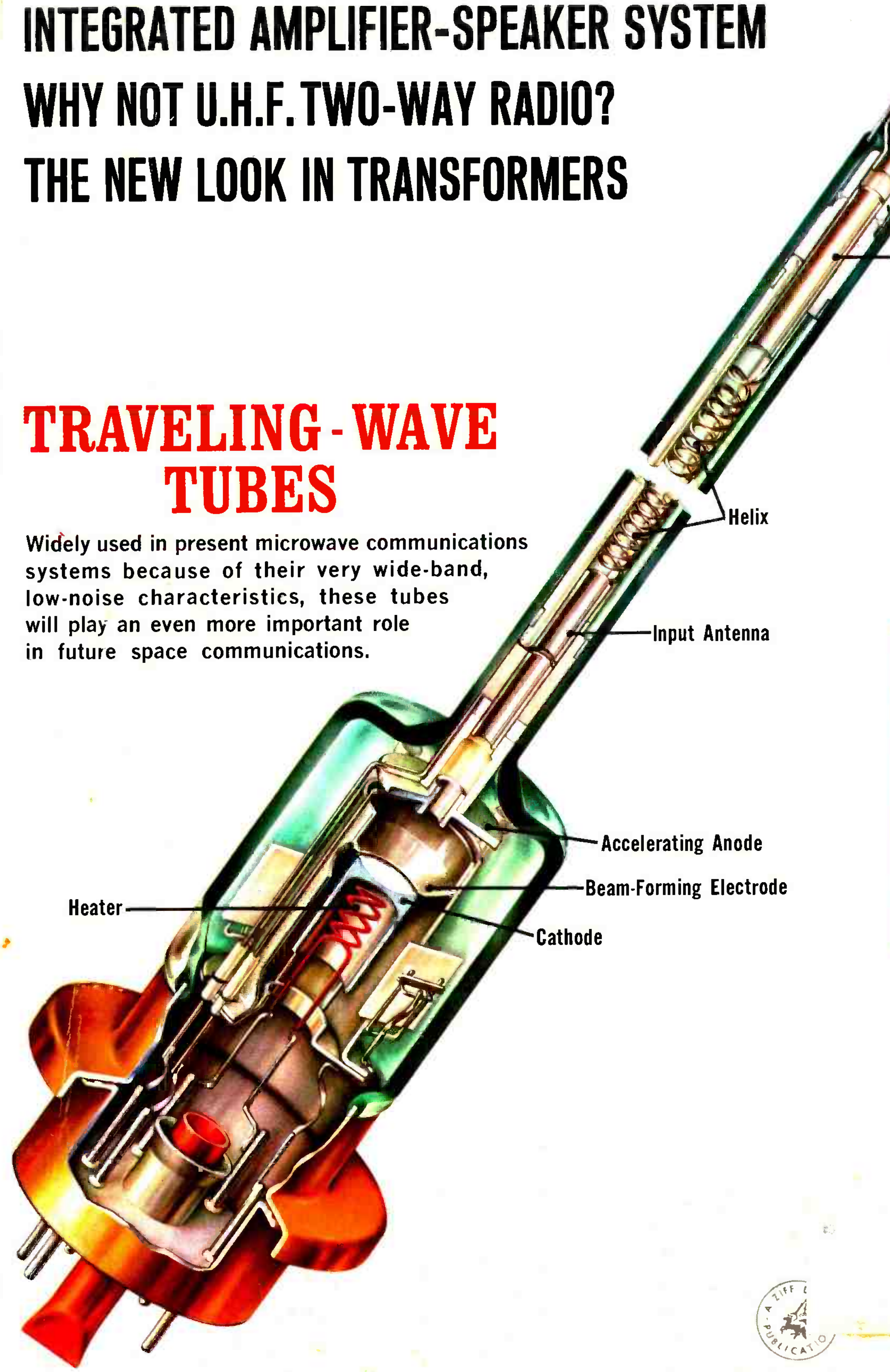
Electronics World

MARCH, 1964 50 CENTS

1964 TV DESIGNS ■ TRANSISTORS FOR MUSIC
INTEGRATED AMPLIFIER-SPEAKER SYSTEM
WHY NOT U.H.F. TWO-WAY RADIO?
THE NEW LOOK IN TRANSFORMERS

TRAVELING-WAVE TUBES

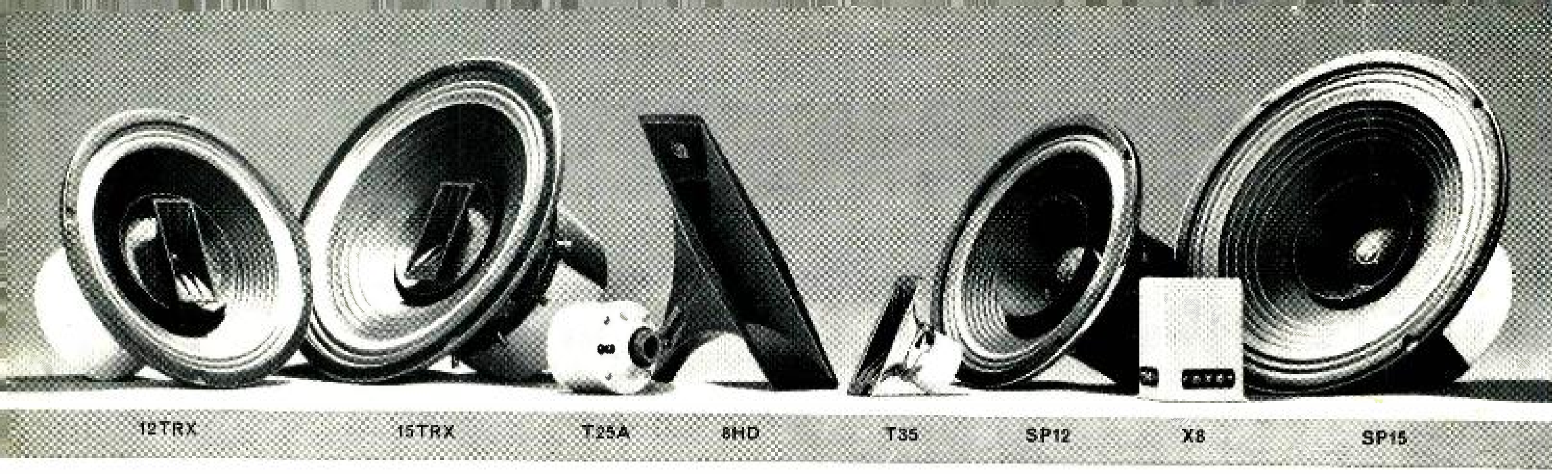
Widely used in present microwave communications systems because of their very wide-band, low-noise characteristics, these tubes will play an even more important role in future space communications.



Microwave Radio Relay

Satellite Communications

Missile Guidance & Tracking



A Return to the Fundamental Concept of High Fidelity: SOUND OF UNCOMPROMISING QUALITY!

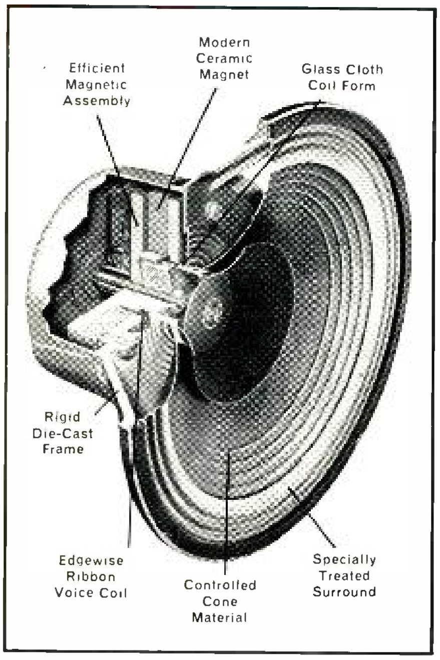
Before you make the final choice of speakers for your high fidelity system, take a moment to review your goals. What comes first—size, cost, or performance? If performance is of prime importance, then you owe it to yourself to look at—and listen to—Electro-Voice Deluxe component speakers. Granted, they are not the smallest or the least expensive speakers you can buy, but their design is predicated on the need for quality reproduction above all other considerations.

Your ear is the final arbiter of speaker system quality, but it may help you to know what's behind the unequalled popularity of E-V in the component speaker field. It begins with the finest engineering laboratory in the industry, finest not only in equipment, but also in the size of its staff and in its creative approach to electro-acoustics.

The basic design for E-V Deluxe components was laid down over a decade ago, and, despite numerous detail improvements, this approach is just as valid today. It begins on a firm foundation: the rigid die-cast frame that provides a stable basis on which this precision instrument can be assembled. It is this frame that assures that each E-V Deluxe speaker will forever maintain its high standard of performance by maintaining perfect alignment of all moving parts.

Added to this is a magnetic assembly of generous proportions that provides the "muscle" needed for effortless reproduction of every range at every sound level. In the case of the SP15, for example, four pounds, ten ounces of modern ceramic magnet (mounted in an efficient magnetic assembly weighing even more) provides the force needed for perfect damping of the 15-inch cone.

Within the gap of this magnetic system rides the unique E-V machine-wound



edgewise-ribbon voice coil. This unusual structure adds up to 18% more sensitivity than conventional designs. Production tolerances on this coil and gap are held to ±.001 inch! The voice coil is wound on a form of polyester-impregnated glass cloth, chosen because it will not fatigue like aluminum and will not dry out (or pick up excess moisture) like paper. In addition, the entire voice coil assembly can be made unusually light and rigid for extended high frequency response.

In like manner, the cone material for E-V Deluxe components is chosen carefully, and every specification rigidly maintained with a battery of quality control tests from raw material to finished speaker. A specially-treated "surround" supports the moving system accurately for predictably low resonance, year after year, without danger of eventual fatigue. There's no breaking-in or breaking down!

Now listen—not to the speaker, but to the music—as you put an E-V Deluxe component speaker through its paces. Note that bass notes are neither mushy nor missing. They are heard full strength, yet in proper perspective, because of the optimum damping inherent in the E-V heavy-magnet design.

And whether listening to 12-inch or 15-inch, full-range or three-way models, you'll hear mid-range and high frequency response exactly matched to outstanding bass characteristics. In short, the sound of every E-V Deluxe component speaker is uniquely musical in character.

The full potential of E-V Deluxe component speakers can be realized within remarkably small enclosure dimensions due to their low-resonance design. With ingenuity almost any wall or closet can become a likely spot to mount an E-V Deluxe speaker. Unused space such as a stairwell can be converted to an ideal enclosure. Or you may create custom cabinetry that makes a unique contribution to your decor while housing these remarkable instruments. The point is, the choice is up to you.

With E-V Deluxe component speakers you can fit superlative sound to available space, while still observing reasonable budget limits. For example, a full-range speaker such as the 12-inch SP12 can be the initial investment in a system that eventually includes a T25A/8HD mid-range assembly, and a T35 very-high-frequency driver. Thus the cost can range from $70.00 up to $220.00, as you prefer—and every cent goes for pure performance!

Write today for your free Electro-Voice high fidelity catalog and list of the E-V audio specialists nearest you. They will be happy to show you how E-V Deluxe component speakers fulfill the fundamental concept of high fidelity with sound of uncompromising quality!

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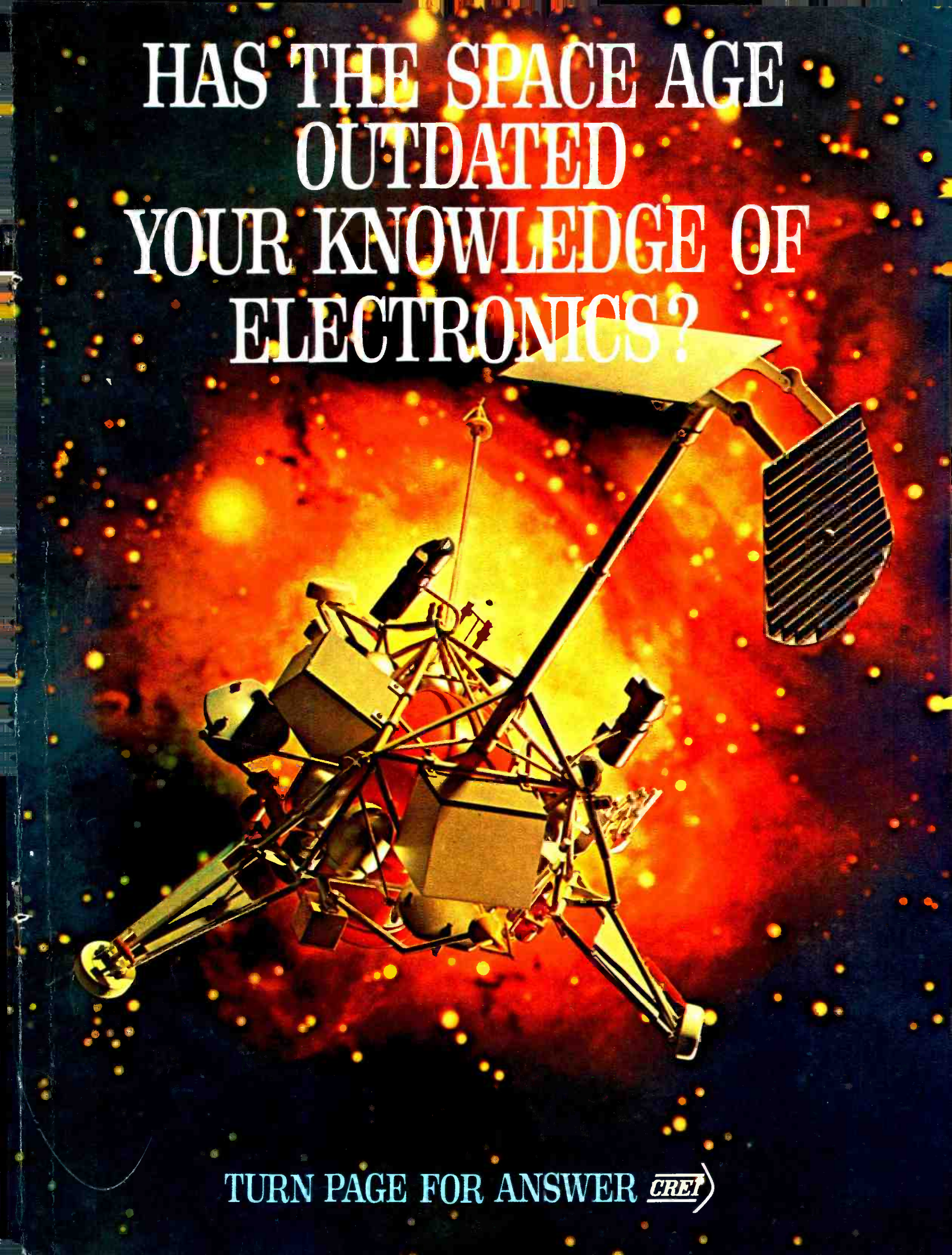
HAS THE SPACE AGE OUTDATED YOUR KNOWLEDGE OF ELECTRONICS?
TURN PAGE FOR ANSWER
CREI

WHAT HAPPENS TO TRANSISTORS IN THE VAN ALLEN BELT? HOW ARE VACUUM TUBES USED IN SPACE? WHY CAN'T REGULAR LUBRICANTS BE USED ON MOVING PARTS IN A SPACECRAFT? TO WHAT EXTENT HAS THE SPACE EFFORT CHANGED RELIABILITY STANDARDS?

The answers to these questions reflect the changes taking place with space applications of electronics. For space electronics involves new and different uses of electronic principles. Conventional systems and components are frequently outdated. Technical breakthroughs come almost daily. Space electronics is as different from the electronics you know as the superheterodyne receiver is from the crystal set.

WHAT DOES THIS CHANGE MEAN TO YOU?

It means specialized knowledge of space electronics is essential for a career in this field. Nearly every major electronics organization and a good many of the smaller companies have become part of the space program. Guiding space vehicles, communicating with them through space and processing the vital information they gather demands knowledge that did not exist when you studied electronics. And this knowledge can't be acquired on the job, unless you are one of the few men privileged to work for a key space engineer or scientist.

Developments in space electronics are affecting almost every area of electronics. For instance, the same techniques used in the space program are used in electronic packaging to reduce computers and television sets to a much smaller size. So knowledge of space electronics is an asset to a man in any field of electronics.

No question about it, for your career in electronics, you must supplement your present knowledge and experience with considerable new knowledge of space electronics.

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CREI now offers a new Home Study Program planned to help you protect your future in electronics by updating your education to space age requirements.

CREI's Program in Space Electronics enables you to study at home, on your own schedule through methods developed in CREI's 36 years of experience in technical education through home study.

Long and painstaking effort has been devoted to the preparation of this program. CREI faculty members have visited 14 government and private technical organizations in the space effort to determine exactly what knowledge of electronics they want in men they employ. Engineers and scientists from some of these organizations have been retained as consultants to supply the technical material that makes up the program.

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ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago 5, Illinois. Subscription rates: one year United States and possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. Second Class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. March, 1964; Vol. 71, No. 3.

Electronics World

CONTENTS

MARCH 1964
VOL. 71, No. 3

MONTHLY FEATURES

THIS MONTH'S COVER shows a cross-section of a Western Electric 444A traveling-wave tube. This tube, shown without its external permanent magnet focusing system and waveguide assembly, is used in a point-to-point radio-relay system that handles high-capacity telephone traffic or TV signals. Other important applications for the traveling-wave tube are also shown. For further details, see the article "Traveling-Wave Tubes" on page 00 of this issue. Photographs: courtesy of Western Electric. (Illustration by Otto E. Markevics.)

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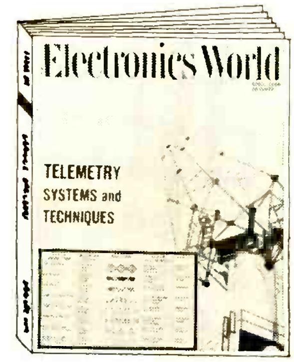

MAGNETIC CORE MEMORIES
Widely used in digital computers, these memory systems consist of a large number of tiny rings of ferromagnetic material. How such memory systems operate is revealed in this interesting article.

SINGLE-FREQUENCY RECEIVER
Hams, SWL's, CAP, and MARS devotees will find this construction article on a spot-frequency receiver an interesting project. William B. Kincaid of Aladdin Electronics has devised a circuit that will operate on either 6 or 12 volts with dynamotor for mobile use or 117-volt a.c. for base-station use. All parts required are standard and readily available items.

UNDERSTANDING TELEMETRY
Telemetry is not confined to exotic outer-space research but has many and ever-increasing down-to-earth applications. In this article the author discusses the various modulation techniques being used and how each type works.

ELECTRONIC SIRENS
These new mobile siren/p.a. systems are gaining wide popularity among law-enforcement agencies and in public-safety vehicles. Here is how such circuits operate and a description of the ways in which they differ from the more conventional and familiar air sirens.

CONSTANT-VOLTAGE TRANSFORMER OPERATION
By altering the magnetic circuit of a conventional transformer and adding an extra winding and a capacitor, a transformer is produced that maintains its output voltage relatively constant despite variations in line voltage.

MICROPHONES FOR COMMUNICATIONS
Various types that are available, along with their characteristics and performance are discussed in this article by R. L. Conhaim. Special emphasis is placed on mikes for two-way radio and mike rating systems.

USING SLUG-TUNED COILS
You can wind a coil to exact specifications, but if you don't pick the right core, it may not tune to frequency. There are many types of cores available, and this article shows the effect of each type on the "Q" and frequency of the tuned circuit. This article will be of special interest to those who like to design and construct a wide variety of electronic equipment—ranging from ham gear to circuits for the control of a number of functions.

*All these and many more interesting and informative articles will be yours in the APRIL issue of ELECTRONICS WORLD . . . **on sale Mar. 19th.***

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SUBSCRIPTION SERVICE: All subscription correspondence should be addressed to Electronics World, Circulation Dept., 434 South Wabash Ave., Chicago, Ill. 60605. Please allow at least six weeks for change of address. Include your old address as well as new—enclosing if possible an address label from a recent issue.

EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.

ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago, Ill. 60605. (Ziff-Davis also publishes Popular Photography, Popular Electronics, HiFi/Stereo Review, Popular Boating, Car and Driver, Flying, Modern Bride, Amazing, and Fantastic.) Subscription rates: one year United States and possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. Second class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. March, 1964. Vol. 71, No. 3.

PAYMENT MAY ALSO BE REMITTED in the following foreign currencies for a one year subscription: Australian pounds (2/16); Belgian francs (310); Danish kroner (43); English pounds (2/4/6); French francs (31); Dutch guilders (22); Indian rupees (31); Italian lire (3900); Japanese yen (2100); Norwegian kroner (45); Philippine pesos (25); South African rands (4.50); Swedish kronor (33); Swiss francs (27); West German marks (25).

For the record

WM. A. STOCKLIN, EDITOR

THE NEW YEAR & THE OLD

IT is that time of the year when one discards the old calendar and replaces it with a new one and, like most individuals, it is time to reminisce about the year gone by and, obviously, plan for the new one.

If we were to pick a single event involving the electronics industry as the highlight of 1963, we would, without hesitation, choose the 22-orbit flight of L. Gordon Cooper on May 15 and 16. The 34-hour, 24-minute flight brought to a successful conclusion the Mercury phase of the United States program to land men on the moon in this decade. With all due respect to the engineers and scientists who brought our technology to this point, it was radio communications that made possible Cooper's manually controlled descent. Not only the dramatic conclusion, but the entire flight, was transmitted around the world *via* radio and TV.

Another unforgettable electronic event occurred in connection with the assassination of President Kennedy. Never in history have our broadcasting media, both radio and TV, been called upon to make a greater contribution than during that 3½-day period. All America must hold our communications industry in high esteem for the tireless and excellent job that it performed. Not only did staff members work hours on end, but the economic sacrifices by the industry were tremendous. The omission of all commercials cost broadcasters approximately $40 million. Yet each station met its responsibilities in a thoroughly professional manner.

These were dramatic events involving the electronics industry, not only because of their effect on people around the world, but as a result of new worldwide communications systems.

Our satellite relays, Telstar I and II and Syncom, linked the world in the transmission of news events. The funeral of President Kennedy, carried by our Relay satellite, was seen in Europe and Japan.

From an economic standpoint the electronics industry concluded 1963 much as was expected. Over-all sales were close to the predicted figure of $15.3 billion compared to $13.8 billion for 1962. This is an increase of almost 11%, a sizable amount. Yet, many were disappointed in their profits.

EIA president, C. F. Horne, in reviewing available statistics, predicts sales for 1964 will reach $16.3 billion, an increase of $1 billion over last year. Yet most industry leaders, including Mr. Horne, view 1964 with caution. There are factors which cloud many issues. Will the TV all-channel law, which becomes effective April 30, 1964, seriously affect sales? To what degree will contemplated reductions in government spending, both for defense and space programs, affect sales? What effect will imports have?

Imports of consumer products and parts have had a serious impact in the past and the future holds little hope of change in this direction. A good example, reported by EIA, is the tally on receiving tubes. Fifty million tubes were imported during the first nine months of 1963 as compared with 52 million for all of 1962.

The forecasts for 1964 are not all pessimistic. The radio and TV segment, on the whole, had another great year in 1963. Many forecasters feel that color-TV, with its assured continued growth, will help to set new industry sales records for 1964, regardless of potential problems.

Components manufacturers expect another increase of $150 million in sales in 1964, reaching a total sales figure of $3.9 billion. Replacement parts are expected to increase $75 million, reaching a total sales of $750 million. Passive components are also expected to increase $30 million to $950 million. Integrated circuits, while sales volume is still low, should show sizable gains in the coming years. Semiconductors, hit hard in 1963, will continue their growth in units produced, but will just about hold their own in dollar sales—at $92 million.

The general reaction within the electronics industry is that the greatest growth potential lies in the computer area. A spokesman for the Univac Div. of *Sperry-Rand Corp.* reports that, at present, there are 12,000 computers in domestic operation and 2000 overseas. Estimates for 1964 are that 3000 domestic systems and 2000 overseas units will be produced. Some will be replacements. It is expected that total sales for 1964 will increase as much as 25%—a very sizable growth figure. ▲

QUIET PERFORMANCE!

Yes, Beldfoil* shielding definitely breaks the noise barrier. It breaks the noise barrier by *being* a noise barrier. Beldfoil gives *total* shielding . . 100% isolation between adjacent pairs. For audio and radio frequency, it completely eliminates cross talk, spurious signal impulses . . and it's ideal for stationary or limited flexing. Beldfoil is lighter in weight, requires less space, and is usually lower in cost.

MINIATURIZES!

Beldfoil shielding reduces the diameter of multi-conductor cables . . by as much as 66⅔%. It gives design engineers extra space . . extra conduit space, extra raceway space, extra console and rack space. Beldfoil shielding means that you can "think small."

ASK FOR DATA SHEET. Get your copy of newly published bulletin 8-63-A and technical data sheet. They give complete information on Beldfoil shielding. Write Belden Manufacturing Company, 415 South Kilpatrick Avenue, Chicago, Illinois 60680.

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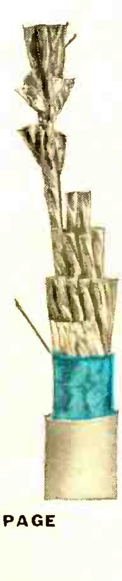

WHAT IS BELDFOIL? It's a lamination of aluminum foil with Mylar** that provides a high dielectric insulation. A patented Belden method of folding*** gives definite benefits. An inner fold creates a continuous metallic path around the surface of the cable. This eliminates any possible inductive effects. An outer fold tucks the cut edge of the aluminum under the Mylar. This gives complete isolation from other adjacent shielded cables.

Typical cross section looks like this.

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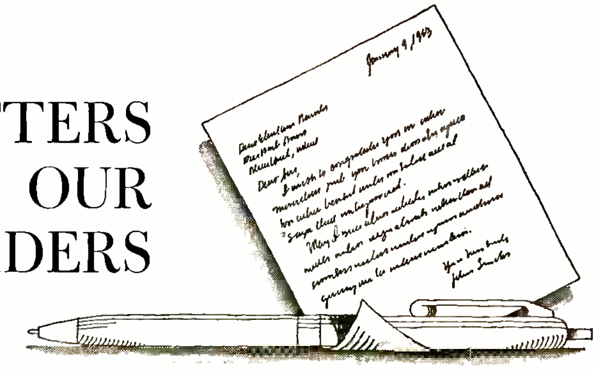
LETTERS FROM OUR READERS



BACKGROUND-MUSIC MULTIPLEXER

To the Editors:

I found your recent article in the December issue by Robert W. Winfree, "SCA Background-Music Multiplexer," very interesting. However, I feel there has been a misinterpretation of the law.

I call to your attention Title 47 of the United States Communications Act of 1934, Amendment #605, which deals with the "unauthorized publication or use of communications."

As you will note it does not imply that interception is lawful as long as no profit is derived from its use, as does your article. The fact is, that interception of this private transmission is unlawful.

George J. Wade, Gen. Mgr.
Good Music Inc.
Portland, Oregon

There is quite a bit of private point-to-point communication taking place throughout the radio spectrum today. Although strictly speaking the Communications Act prohibits interception of these signals, we doubt very much whether such interception could be prevented, or if any harm would result, provided the intercepted signals are not divulged. If this were not true, then just about everybody picking up such signals with a short-wave receiver is breaking the law. Therefore, we believe that the above is an unrealistic interpretation of the Communications Act.—Editors.

* * *

LOUDSPEAKER IMPROVEMENTS

To the Editors:

After thirty-odd years of development, it is apparent that the woofer loudspeaker driving system is about where the electric power motor was in 1900. There appears to be much room for improvement. Consider, the permanent magnetic field in its idle configuration. This field becomes alternately wafted and fringed back and forth with the voice currents such that under high audio power the tendency is to squeeze the flux alternately out of either end of the flux gap. Possibly the cure may be found through use of voice current interpole action similar to that used in d. c. machinery, or the pole pieces might be slotted in order to keep the permanent flux from crossing from one area to another over the intervening higher reluctance slots in the gap.

If we are concerned with maximum efficiency, there is also the problem of eddy currents induced in the faces of the pole pieces caused by these voice coil cross-magnetizing currents. To minimize this loss, the pole pieces might be laminated.

The writer, after about thirty-five years of experience with amplifiers, speakers, and other electrical and electronic apparatus, is of the firm opinion that several good stiff-coned speakers having an equivalent piston displacement of a single larger woofer will considerably out-perform the larger unit under otherwise similar conditions. The smaller units offer less susceptance to ripple breakdown and do not require great sacrifice of efficiency. In fact, the efficiency is raised by mutual radiation resistance.

Also, it has been my study that, while non-vibrating enclosure material and construction is a must, air-tightness through prevention of minute leaks because of joints or small holes in the enclosure is un-registerable on sound pressure measurement apparatus. The enclosure should not be a sieve, of course. But each of us is entitled to believe that he has arrived at the culmination of a perfect sound system. How droll it would be if all such things were required to be alike!

Frank J. Burris
Reg. Elec. Engr.
Yucaipa, Calif.

Although there have been some changes in speaker magnets, voice-coil design, and cone materials, the basic principles of the magnetic speaker are the same as they have been for many years. And it is remarkable how good a sound reproducer such a basically simple device as a loudspeaker is. But with the speaker still considered to be a weak link in the audio chain, perhaps a major breakthrough is what is needed.—Editors.

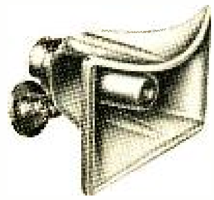
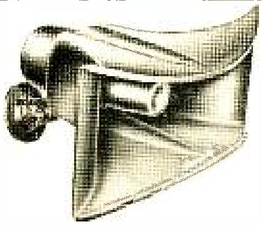
* * *

FIELD-EFFECT TRANSISTORS

To the Editors:

I would like to comment on a few points in the article "Field-Effect Tran-

Plan your paging/talk-back speaker installations around University ...the most complete line.

APPLICATION	REQUIREMENT	RECOMMENDED SPEAKER	SPECIFICATIONS
Complete coverage for small areas with low ambient noise levels. Spot coverage to assure uniform sound volume in large systems.	Wide dispersion. Good frequency response. Weatherproof. Compact size. *OLB	 UNIVERSITY MODEL MIL-A	7.5 watts 350-13,000 cps 120° dispersion $7\frac{13}{16}$" dia. $6\frac{7}{8}$" deep In 4, 8, and 45 ohm impedances.
Same as above and where overhead obstructions are encountered.	Same as above but with greater control of dispersion pattern, reducing reverberation and spill over. *OLB	 UNIVERSITY MODEL CMIL-A	7.5 watts 350-13,000 cps 120° x 60° dispersion $6\frac{1}{4}$" high, $9\frac{1}{2}$" wide, $8\frac{1}{2}$" deep In 4, 8, and 45 ohm impedances.
Coverage of sizeable areas with moderate ambient noise level. Amusement parks, warehouses, loading docks, portable P.A. systems.	High power handling capacity, high efficiency, greater low frequency response. Utmost reliability. Weatherproof. *OLB	 UNIVERSITY MODEL IB-A	25 watts 250-13,000 cps 90° dispersion $10\frac{1}{4}$" dia., 9" deep In 4, 8, and 45 ohm impedances.
Same as above and where overhead obstructions are encountered.	All of the above, but with exclusive University Wide Angle horn for reducing reverberation. *OLB	 UNIVERSITY MODEL CIB-A	25 watts 250-13,000 cps 120° x 60° dispersion $7\frac{3}{8}$" high, 14" wide, 12" deep In 4, 8, and 45 ohm impedances.
Ceiling suspension of speakers to cover wide area. Using minimum number of units. Factories, department stores, depots.	Uniform 360° sound dispersion. Built-in driver. High power handling capacity. *OLB	 UNIVERSITY MODEL IBR-A	25 watts 300-10,000 cps 360° dispersion 13" dia., $10\frac{1}{4}$" deep In 4, 8, and 45 ohm impedances.

*OLB – Patented University Omni-Lok Bracket directs and locks speaker in any plane with a twist of the wrist.

U-36

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sistor" (p. 66, September issue). Although relatively new in the commercial sense, the complete theory and characteristics of the FET were published by Dr. Shockley (also the inventor of the junction transistor) in 1952; and since thousands of experimenters have been using the device for more than a year now, and dozens of circuits incorporating it have been published, it seems a little curious to see it called a "new" device.

Nearly all of the current professional literature I have seen refers to the FET electrodes as "drain," "source," and "gate" (Dr. Shockley's terms), rather than "anode," cathode" and "grid." There is good reason for this, for, as with junction transistors, there are two polarity types of FET (both commercially available), *p*-channel and *n*-channel; while the *n*-channel type is biased like a vacuum triode, the *p*-channel type is biased oppositely, with the drain ("anode") more negative than the source ("cathode"). Since anode and cathode respectively imply positive and negative polarities, these terms are quite inappropriate for the field-effect transistor.

The schematic symbol your draftsman has used for the FET is not the standard symbol being used by the industry. The source and drain electrode symbols should be perpendicular to the bar (rather than at 60°) to indicate ohmic connections at the source and drain. When the lines form an acute angle with the bar, a *p-n* junction is indicated, as, for example, at the collector of a junction transistor (ref. MIL-STD 15-1, proposed American Standard Y32.2-1962 and IRE Standard 62IRE21.S1).

The best available FET's have transconductances considerably higher than the 1000 micromhos mentioned in the article: the 2N2499 and the 2N2609 have typical G_m's of more than 3000 micromhos. Regarding commercially available types, the *Texas Instruments* FET's are no more "experimental" than those of *Crystalonics*, and experimenters might note that one line of germanium FET's by *T.I.*, which has already been on distributors' shelves about a year, sells for less than three dollars (TIX-880 to 883).

Incidentally, the field-effect transistor is also known as the unipolar transistor (or UNIFET), since its conduction mechanism involves only one polarity-type of carrier (electron or hole), unlike the bipolar (junction) transistor. This implies that its maximum frequency capabilities are not limited by thermal diffusion rates, as in the junction transistor, but only by its internal *R-C* time constant (which is unfortunately large in most FET's).

L. Robert Duclos, Lecturer
Radio College of Canada
Montreal, Canada ▲

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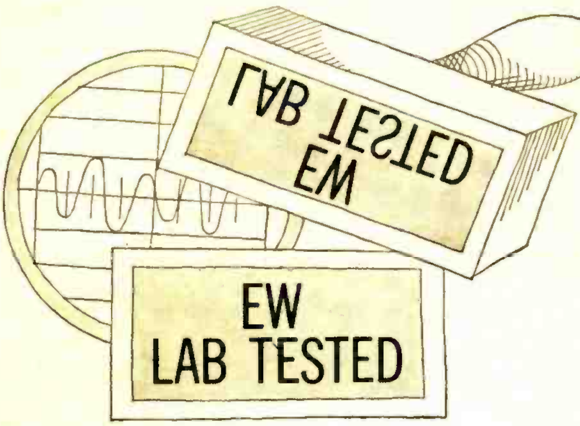


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Dual 1009 Automatic Turntable
Electro-Voice "Coronet I" Speaker System

Dual 1009 Automatic Turntable

For copy of manufacturer's brochure, circle No. 45 on coupon (page 15).

ONCE considered below acceptable levels of performance for high-fidelity enthusiasts, record changers have undergone drastic improvements in recent years and now rival many separate turntable and arm combinations in all aspects of record-playing performance. These "automatic turntables," as their makers term them, generally feature heavy, balanced turntables; balanced motors with low mechanical vibration levels; and low-friction, at least partially balanced arms.

The necessity for operating a trip mechanism at the end of a record has usually imposed a minimum tracking force requirement on the arms of automatic turntables. While not large (sometimes as low as 2 grams), it precludes the use of the ultra-high-compliance cartridges of several manufacturers—those which are claimed to be capable of operating at forces as low as 0.5 gram.

The new *Dual* 1009 "Auto/Professional" turntable represents a further advance in this direction. Possibly its most outstanding feature is the completely balanced arm which, according to its maker, will operate at 0.5 gram with fully functioning changing facilities. The 1009 has a 7-pound non-magnetic turntable, 10½" in diameter, which rotates on very-low-friction bearings. It has a four-speed drive, with a drive shaft having tapered sections. A knob concentric with the speed-change control moves the idler wheel up and down on this shaft, giving a rated variation of ± 3% about each nominal speed.

The unit is not an intermix changer. A lever must be set for 7", 10", or 12" records for indexing the tonearm. For manual playing, a short spindle is inserted in the turntable center hole and the arm is placed manually on the record. Moving the control lever to "Manual" then starts the motor, which reaches full speed in a fraction of a revolution of the turntable. At the end of the record, either in manual or automatic operation, the trip mechanism operates, shutting off the motor and returning the arm to its rest.

The arm of the record player is fully balanced by an adjustable counterweight. The counterweight is mounted resiliently to damp out the natural resonance of the arm mass and cartridge compliance. Tracking force is supplied by a spiral spring operating on the vertical pivot axis, with a scale calibrated from 0 to 7 grams in 0.5-gram intervals.

The rumble level, measured by NAB standards (unweighted), was −35.5 db in the lateral plane and −32.5 db including vertical components. This is one of the lowest figures we have measured on automatic turntables, and is comparable to that of a number of good separate turntables. The speed could be set to exact values using the stroboscope disc supplied with the unit. However, we found that the range of adjustment was less than specified, being from slightly less than 1% slow to slightly more than 1% fast.

The wow and flutter were 0.1% and 0.03% respectively. The low turntable bearing friction allowed the platter to rotate for over one minute after being shut off from 33 rpm.

The arm had a tracking error of less than 0.4 degree per inch of radius, and the tracking error was near zero at the inner portions of records where this is most important for low distortion. The indications of the stylus force scale were accurate within 0.1 gram when compared to a balance-type gage. Over a full ¾-inch record stack, the change in vertical stylus angle was about 6 degrees, and the force did not vary detectably. Being completely balanced, the arm will play well at almost any angle, although the change mechanism does not permit excessive tilts in certain directions. At any rate, the unit certainly does not need any sort of critical leveling in its installation.

The arm proved to be fully capable of operating with a tracking force of 0.5 gram, as rated. The trip mechanism operated flawlessly at this force, with no evidence of side thrust on the cartridge either during playing or when the trip operated. Actually, no cartridge we have seen will track all records at 0.5 gram, but perhaps such cartridges will be forthcoming. This record player will be ready and able to accommodate them. As it is, it will allow the use of any cartridge presently being offered, without compromise in performance.

The installation of a cartridge is very simple, due to the easily removable plastic slide on which it mounts. The changer is quite compact, measuring only 12⅞" wide by 10½" deep. It is finished in black and brushed aluminum, with a liberal use of plastic materials in its trim and for the cartridge shell.

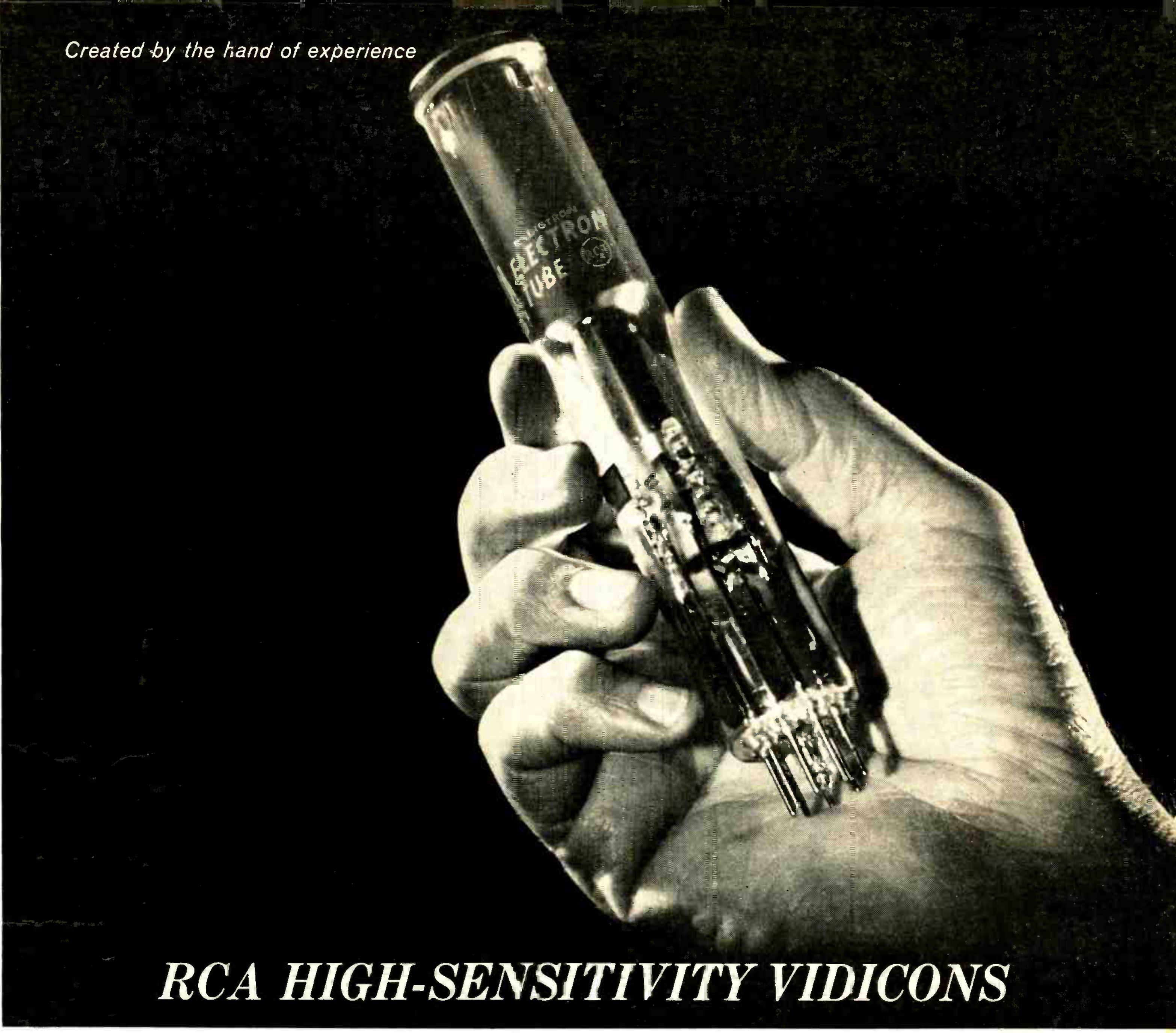
The *Dual* 1009, distributed in the U.S. by *United Audio*, is priced at $94.75. An oiled-walnut base is available for $9.95. ▲

Electro-Voice "Coronet I" Speaker System

For copy of manufacturer's brochure, circle No. 46 on coupon (page 15).

A RECENT addition to the *Electro-Voice* speaker line is the "Coronet." This is an attractive bookshelf enclosure, finished in oiled walnut and sold only in kit form. Measuring 22½" wide by 12½" high by 10⅞" deep, the kit may be had with a choice of three *E-V* 8" speakers. The lowest priced version, which was tested for this report, uses the new "Michigan" MC8 speaker. It is also available with the "Wolverine" LS88, and the long-popular SP8B.

The kit consists of a group of prefinished walnut panels which assemble



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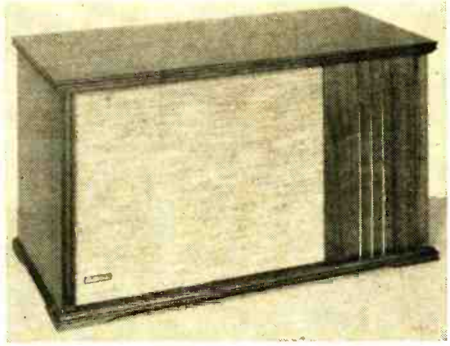


with tongue-and-groove joints. No glue is used; long threaded rods providing the binding force for the enclosure. Gasketing material seals the joints and prevents vibration at the joints. A ducted port reinforces bass response.

The MC8 driver is a low-priced 8" speaker with a dual ("whizzer") cone and mechanical crossover for improved high-frequency response. It is built on a rugged die-cast frame with an edgewise-wound 8-ohm voice coil and a ceramic magnet. The speaker is rated at 12 watts of program material with a 50-13,000-cps frequency response. Its free-air resonance is nominally 75 cps.

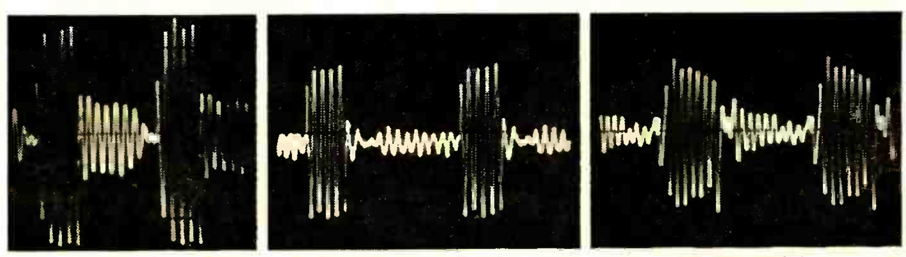
Our frequency-response measurements yielded rather surprising results, with an over-all response within ± 3 db from 70 to 12,000 cps. The high-frequency response actually seemed to be rising above 12,000 cps. At the low end, harmonic distortion rose sharply below 100 cps at the 1-watt test input level, so that the effective lower limit of the speaker's response was between 70 and 80 cps. This response represents the average of nine sets of measurements made at different microphone positions.

At this point it appeared that the "Coronet I" might be a close rival of a number of compact systems selling for two or three times its price. The tone-burst tests, indicative of its transient response, did show up some of the differences. At many frequencies there was considerable ringing—evidence of system resonances.

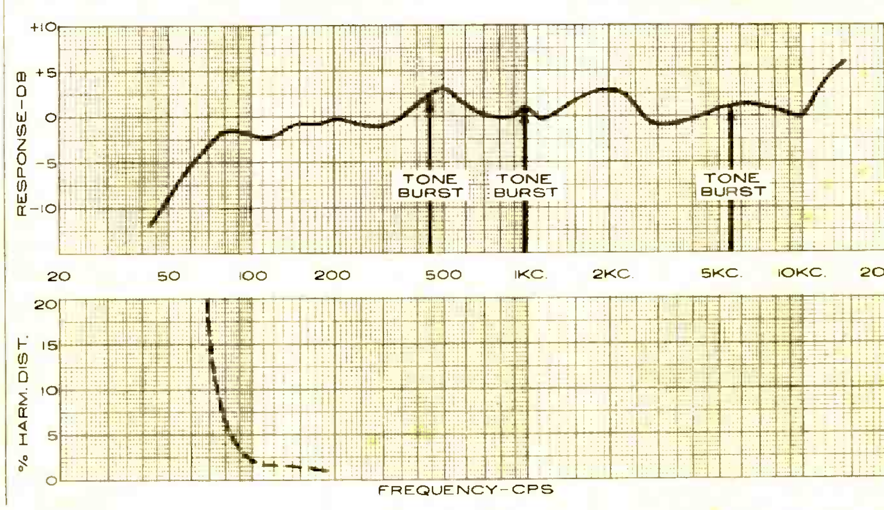
The over-all sound of the system is quite acceptable by any hi-fi standards, and is one of the best we have heard from any speaker system selling at anywhere near its price. It is reasonably well balanced, although the highs tended to sound too prominent due to the limited bass response. Locating the speaker near a corner to improve bass performance would be advisable. The system provides a pleasing, listenable sound although it is in a price class where even tolerable sound quality is a rarity. When its attractive styling and finish are considered, it emerges as a sort of the "best buy" although we do not ordinarily attempt to classify hi-fi products in that particular manner.

While it does not, of course, equal the performance of systems selling for $100 or more, the speaker system should be highly satisfactory for anyone building a music system on a limited budget. We did not have an opportunity of hearing it with either of the other speakers offered, but would expect better transient response and improved bass with either of them.

With the MC8, the "Coronet I" sells for $39.00. As the "Coronet II", using the "Wolverine" LS8, it sells for $43.50; and as the "Coronet III," with the SP8B, it sells for $54.00. ▲



Tone-burst waveforms for 450 cps (left), 1 kc. (center), and 5.6 kc. (right).



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TURN PAGE

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"THE FINEST JOB I EVER HAD" is what Thomas Bilak, Jr., RFD 2, Cayuga, N. Y., says of his position with the G. E. Advanced Electronics Center at Cornell University. He writes, "Thanks to NRI, I have a job which I enjoy and which also pays well."

HAS SERVICE BUSINESS OF HIS OWN. Don House, 3012 2nd Place, Lubbock, Texas, went into his own full-time business six months after finishing the NRI Radio-TV Servicing course. "It makes my family of six a good living," he states. "We repair any TV or Radio. I would not take anything for my training with NRI. I think it is the finest."

MARINE RADIO OPERATOR is the job of E. P. Searcy, Jr., 1916 Fern St., New Orleans, La. He works for Alcoa Steamship Company, has also worked as a TV transmitter engineer and holds FCC Radio-Telephone License. He says, "I can recommend NRI very highly."

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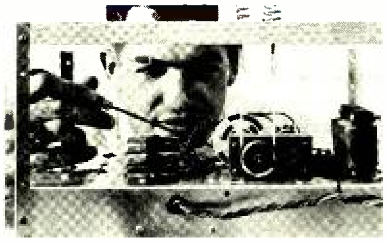

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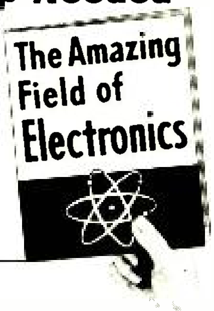

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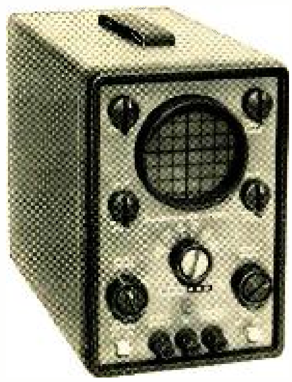

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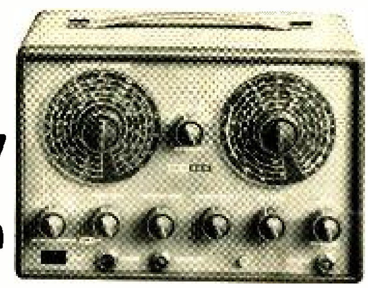

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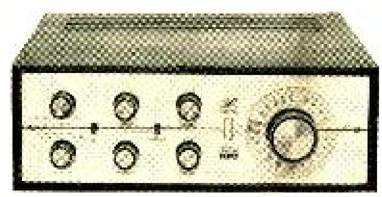

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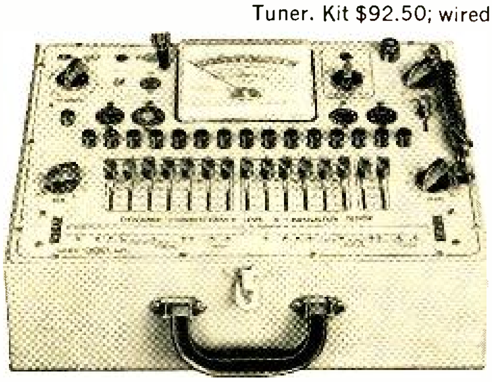

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TRAVELING-WAVE TUBES

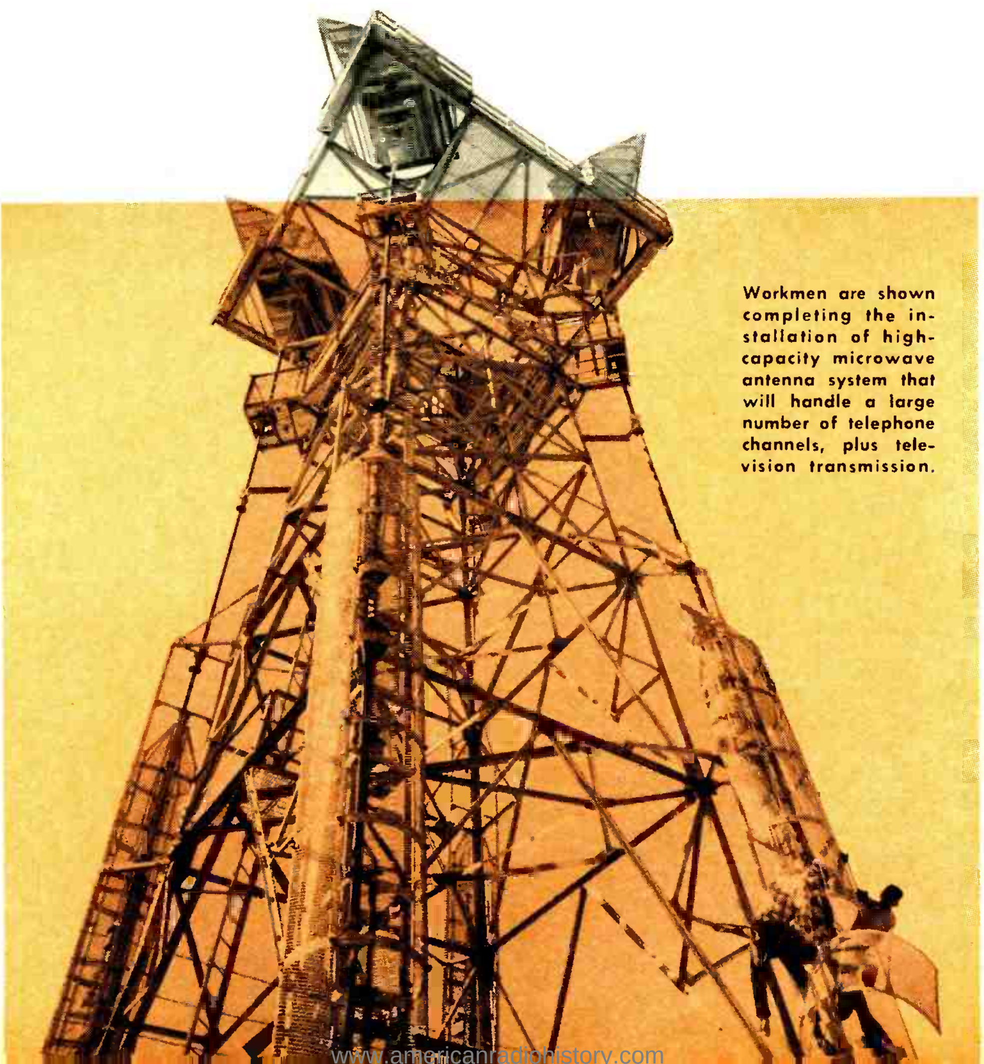
By JOHN H. JARRETT
Dept. Chief, Microwave Devices Engineering, Western Electric Co.

Widely used in present microwave communications systems, radar, and missile-guidance because of their outstanding performance as very wide-band, very low-noise amplifiers, these tubes will play an even more important role in future space communications.

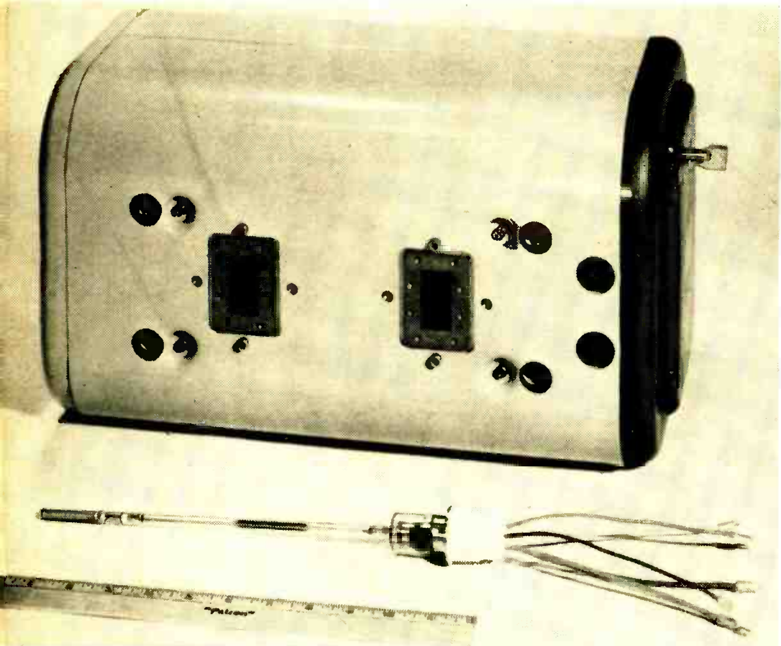
TODAY'S traveling-wave tubes are increasing the capabilities of communications tremendously. They are making possible the handling of a greater number of long-distance telephone calls as well as color and black-and-white TV signals. They are also performing superbly for our Armed Forces in the command-guidance systems developed for "Nike Hercules" and the "Titan" ICBM. Not long ago, the "Telstar" communications satellite was placed into orbit around the earth where its outstanding performance has demonstrated the feasibility of satellite communications. It, too, contains a traveling-wave tube designed and constructed specifically for this spectacular application.

As is the case with most new designs, there have been many problems associated with this device, some of which are: short operating life, unstable operation, high manufacturing cost, and installation and replacement difficulties. Correction of these conditions is well underway and has resulted in tubes which can hold their own with more conventional electron tubes in reliability. Reliability and uniformity of this product depend on sound engineering design, while the precise mechanical construction required depends on carefully tailored manufacturing facilities.

Traveling-wave tubes, like more conventional types, can be designed for a variety of applications. Typical applications of some of these tubes include, in addition to the above,



Workmen are shown completing the installation of high-capacity microwave antenna system that will handle a large number of telephone channels, plus television transmission.



The 444A traveling-wave tube, slightly less than a foot long, is shown in front of its housing assembly. The input waveguide flange is at the right and the output flange is at the left.

PROPERTY	TRAVELING-WAVE TUBE	PLANAR TRIODE	KLYSTRON
Frequency Range	Excellent	Fair	Good
Gain	Good	Fair	Good
Bandwidth	Excellent	Fair	Poor
Voltage	Medium-High	Low	Low-Medium
Output	Good	Low-Medium	Good
Noise	Very Good	Fair	Very Poor
Efficiency	Poor	Good	Fair-Good
Bulk	Fair	Good	Fair
Weight (Lightness)	Fair-Good	Good	Fair

Table 1. Properties of three types of microwave tubes.

their use as c.w. power amplifiers, as low-noise amplifiers, and as high-gain pulse amplifiers.

Background

The traveling-wave tube (TWT) was invented by Dr. Rudolph Kompfner, now of *Bell Telephone Laboratories*, during the World War II period. While with the Physics Department at Birmingham University (1941-1944), his concern for what he considered to be a weakness in the klystron led to his invention of the traveling-wave tube.[1] This weakness was the relatively narrow bandwidth of klystron amplifiers. The importance of his invention was soon realized and intensive development work has been carried out in many laboratories to bring the tube to its present practical state of development.

Theoretical studies by Dr. J. R. Pierce of *Bell Telephone Laboratories* established certain basic design considerations for this type of electron tube from which numerous practical tubes have since been developed. Table 1 illustrates significant property comparisons among typical traveling-wave tubes, planar triodes, and klystrons, all designed especially for microwave use.

The basic feature which characterizes all traveling-wave tubes is that amplification occurs gradually along an extended waveguiding circuit adjacent to an extended electron stream, with energy transferred from the electron stream to the signal wave propagating in the circuit. Thus, use of the bandwidth-limiting resonant cavity, as in a klystron, is avoided—along with its attendant operational problems.

How it Operates

Basically, the traveling-wave tube amplifier consists of a magnetic circuit and an electron tube. The magnetic circuit may be in the form of a solenoid, permanent magnets, or a periodic permanent-magnet structure, along with its associated input and output waveguides or coaxial cables. The magnetic field produced by these magnetic structures is used to focus the beam of electrons. Normally, the electron beam traveling through the helix along its longitudinal axis would tend to disperse itself due to the combined influence of the mutual repulsion of electrons and attraction resulting from positive operating voltage on the helix.

The magnetic field, consisting of uniformly controlled lines of force, threads through the helix along its axis to focus the beam of electrons by spiraling the electrons—which try to reach the positive-voltage helix—back toward the center of the beam. This action permits the electron beam to be transmitted through the helix without appreciable interception of electrons by the helix so that amplification of the input signal may occur. If electrons were allowed to freely impinge on the helix they could cause serious deterioration of both efficiency and tube life. The input and output waveguides, or in some cases coaxial cables, serve to carry the microwave signal to be amplified to the helix of the electron tube; and, after amplification by the tube, from the helix for further use in the microwave system.

The electron-tube portion of the traveling-wave tube amplifier can best be understood by considering its three major sections individually: gun, helix, and collector. The electron gun provides the precisely shaped electron beam that travels through the helix to impart energy to the radio signal to be amplified. Basically, the typical simple gun consists of a heater, a cathode, a beam-forming electrode, and an accelerating anode. Electrons are accelerated from the heated cathode by voltage on the anode and, as a result of the focusing action of the beam-forming electrode, enter the helix in a dense, narrow, circular cross-section beam. This beam then travels through the helix to the collector which is at a positive potential with respect to the cathode and, therefore, collects the energy of the unused beam.

The traveling-wave tube shown in the simplified diagram of Fig. 1 (see also the cover illustration) is typical of the designs which have been manufactured by *Western Electric Company*. The heart of this type of TWT is the helix, which visually resembles a helical spring but which is normally much smaller in diameter and wire size and is precision made. The signal to be amplified enters through the input waveguide and is picked up on the antenna at the gun end of the helix. From there it travels at nearly the speed of light around the helical path of the helix wire until it reaches the antenna at the collector end of the helix. The amplified signal is radiated from this point and leaves the amplifier through the output waveguide.

Although the signal wave travels along the helix wire at nearly the velocity of light, its forward motion along the helix axis is much slower—on the order of about one-tenth the velocity of light. The electron stream is made to travel from the electron gun through the helix, by means of an accelerating electrode, at a slightly faster rate than the signal wave. It is the interaction between the electron stream and the electric field of the signal wave that amplifies the natural wave signal.

The interaction between the electromagnetic wave of the microwave signal and an electron beam is qualitatively illustrated in Fig. 2. The pattern of arrows indicates the instantaneous distribution of the electric field of an electromagnetic wave traveling along the helix. At points corresponding to ½ wavelengths (measured along the helix) the direction of the

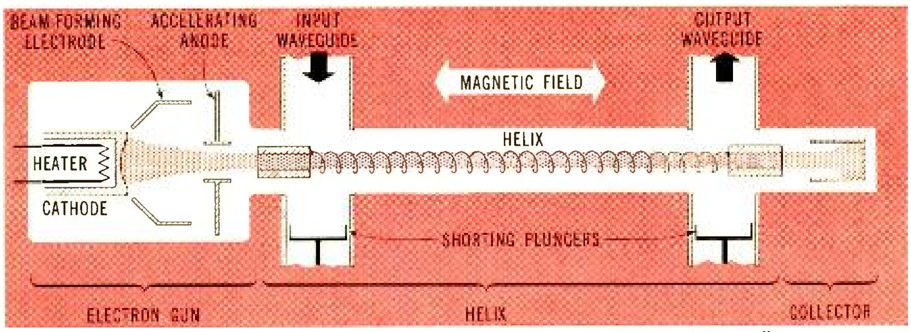
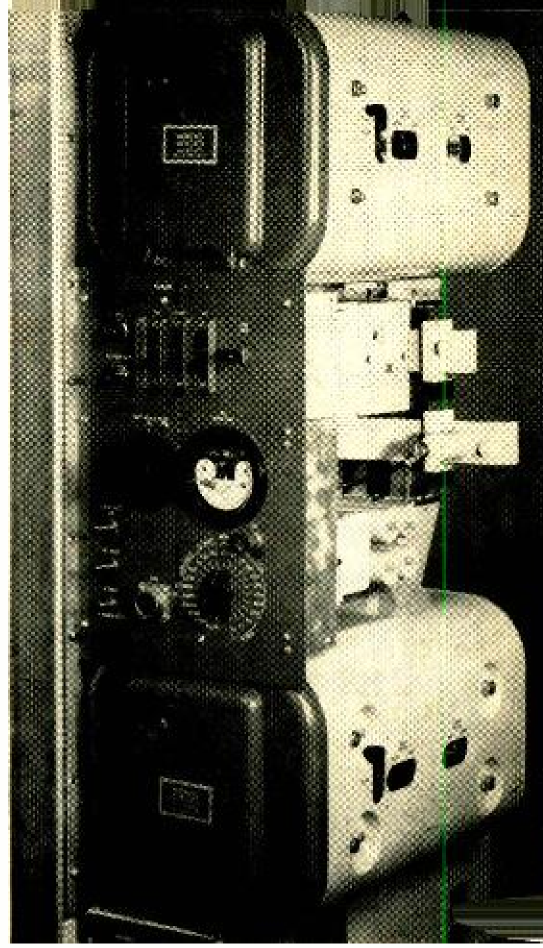


Fig. 1. Simplified diagram of the traveling-wave tube, showing electron flow.

arrows reverses. The field pattern progresses with a phase velocity depending on the diameter and pitch of the helix. If all the electrons in the beam are moving at the same velocity, it can be seen that some electrons are in an electric field which tends to oppose their motion while others are in the opposite condition. Therefore, as the electron beam and the electromagnetic field move along together, a form of "electron bunching" occurs as the faster electrons overtake the slower electrons ahead of them.[2] As the bunches of electrons are slowed down, the kinetic energy they lose is gained by the fields of the wave. Hence, the wave gains energy at the expense of the electron beam and is amplified during this particular process.

Since there are no tuned circuits in the path of the wave being amplified, the process is fairly insensitive to frequency changes, resulting in a tube capable of amplifying radio signals many thousands of times at bandwidths of up to several thousand megacycles. The significant feature of the traveling-wave tube is its freedom from bandwidth limitations at microwave frequencies—even up to 75,000 mc. By varying details of design, various amounts of gain, power, or low noise characteristics can be obtained to fit specific applications, all without reducing bandwidth below the limit of any practical need. Ironically, even many years after its discovery, the inherent bandwidth of traveling-wave tubes tends to exceed that of input and output transducers.



A portion of the broadband radio transmitter used in the TH microwave radio-relay system. Traveling-wave tubes are contained within the housings at the top, bottom of photo.

Applications

This great improvement in microwave tube performance has found ready application in military systems, offering increased range for radar and greater accuracy for missile-guidance systems. Similar improvements have been attained in telephone transmission with systems of the microwave radio-relay type.

The first *Bell System* radio-relay transmission system, the TD-2, was developed at the close of World War II. It was realized after it had been in service for some time that long-haul transmission loads were increasing so rapidly that the system's capacity would soon be overtaxed. It was then that the TH microwave radio-relay system was designed. This uses the traveling-wave tube to achieve a four-fold increase in message capacity over the TD-2 system which uses planar triodes. Table 2 is a comparison of TD-2 and TH radio-relay systems capacities.

The type 444A is the traveling-wave tube designed and manufactured for use in the TH system. Not only does the traveling-wave tube's bandwidth (5925-6425 mc.) contribute to the system's large message capacity, but it permits simplification in equipment design because all tubes can work interchangeably in any of its channels without complex tuning adjustments.[3] In the TH system, this tube finds its major use as the final amplifier stage in the transmitter of each of eight channels. Ideally, a single traveling-wave tube could amplify all channels at once, since its bandwidth is great enough to do this. However, intermodulation between the channels would be excessive in such an arrangement. Also, reliability considerations dictate that a single tube failure not

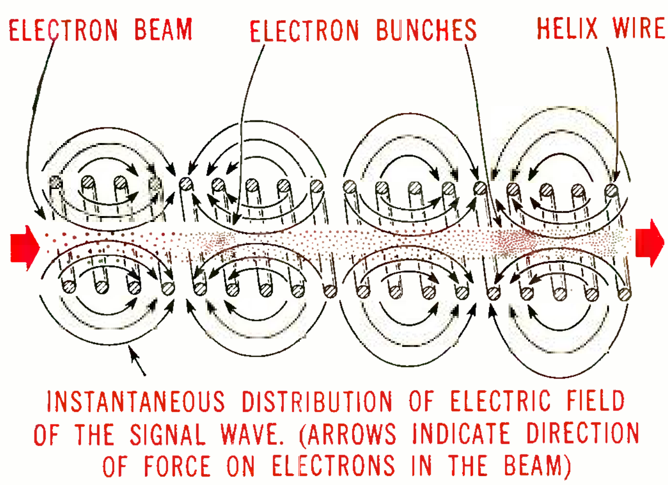
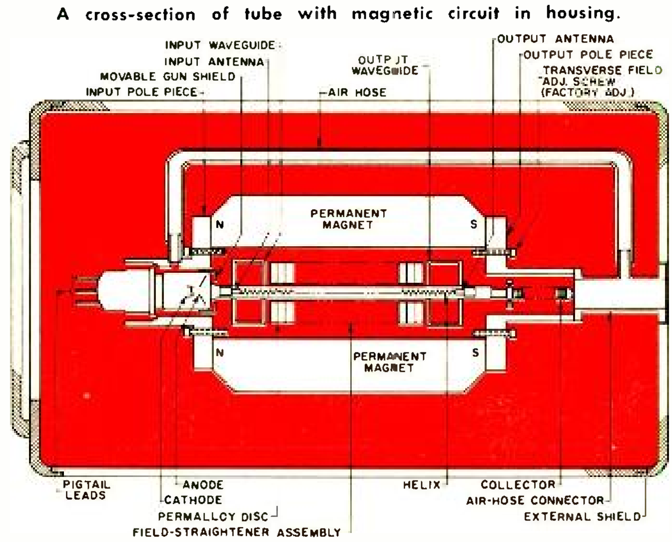


Fig. 2. Interaction between electron beam and helix fields.

A cross-section of tube with magnetic circuit in housing.



FEATURE	TD-2 SYSTEM	TH SYSTEM
Operating Frequency	4000 mc.	6000 mc.
Number of Service Channels	5 (2-way)	6 (2-way)
Number of Protection Channels	1 (2-way)	2 (2-way)
Total Channels (each direction)	6 (2-way)	8 (2-way)
Telephone Messages per Channel	600	1800
Total Message Capacity	3000	10,800
Black-and-White TV Signal	1 per channel	1 per channel + 420 messages
Color-TV Signal	1 per channel	1 per channel + 420 messages
Theater-TV Signal (high definition)	None	1 per channel

Table 2. Capacities of TD-2 and TH radio-relay systems.

CHARACTERISTICS[4]	VALUE
Frequency Range	5925 to 6425 mc.
Helix Voltage	2400 volts
Collector Voltage	1200 volts
Beam Current	40 ma.
Magnetic Flux Density	600 gauss
Maximum Efficiency (11 w. /40 ma. x 1200 v.)	23 percent
Power Output as used in TH (reduced for improved performance)	5 watts
Gain at 5 watts	30 db minimum
Noise Figure	28.5 db

Table 3. Main characteristics of 444A traveling-wave tube.

be responsible for taking more than one channel out of service.

Another 444A tube is used in each TH channel to amplify the local-oscillator signal before it is fed into the transmitting modulator. Together with some additional 444A's used in the microwave generator, there is a total of 36 traveling-wave tubes in each TH system repeater station. Although these tubes operate at many different frequencies and power levels, a single tube design satisfies all of these requirements. Table 3 shows the important characteristics of this tube.

Tube Characteristics

The maximum gain is determined (1) by the stability limit (*i.e.*, the beam current value at which the tube begins to oscillate), (2) the safe emission limit of the cathode, and (3) the maximum current which can be focused through the helix without causing excessive current to be intercepted by the helix or other tube elements, thereby producing overheating. A typical value of low-level gain for broadband operation is on the order of 30 db. However, values of 50 db can be realized. The variation of gain with helix voltage is shown in Fig. 3. For highest gain, the helix voltage must be adjusted so that the electron beam and the r.f. electro-magnetic wave have almost equal axial velocities. This value of helix voltage, called the "synchronous voltage," is indicated by the dashed line in Fig. 3.

For a given beam current, the power output of the traveling-wave tube amplifier is a function of the input power, as shown in Fig. 4. The gain is essentially constant for low input levels, but decreases at higher levels. When the r.f. electric field becomes too strong, as a result of either amplification or large input signal, the amount of energy which the beam can deliver to the wave reaches a maximum limit. This condition, known as the saturation point of the tube, represents the maximum power which can be delivered for a given condition of beam current. If the input power is increased beyond the value which causes saturation, an actual decrease in power output results.

In tubes designed for low-noise operation, the elements of a special electron gun are operated with a particular combination of focusing and accelerating voltages to de-amplify the noise in the electron beam. In low-noise tubes, beam interception must be kept extremely low, less than one percent of the total beam current. Tubes can be designed to have low noise over relatively large bandwidths. When constant electrode voltages are used, however, the noise figure can be expected to increase a small amount above the optimized value as the frequency deviates from mid-band. Slightly better performance, as a function of frequency, can be obtained by optimizing the electrode voltages for each specific frequency band of operation.

Traveling-wave tubes are primarily chosen for their significant ability to amplify microwave signals over a wide band of frequencies. It is this ability that determines the certainty of their continued use in our rapidly expanding communications systems. New developments will also make them an increasingly important part of government-sponsored systems, not only for defense but also for space exploration. ▲

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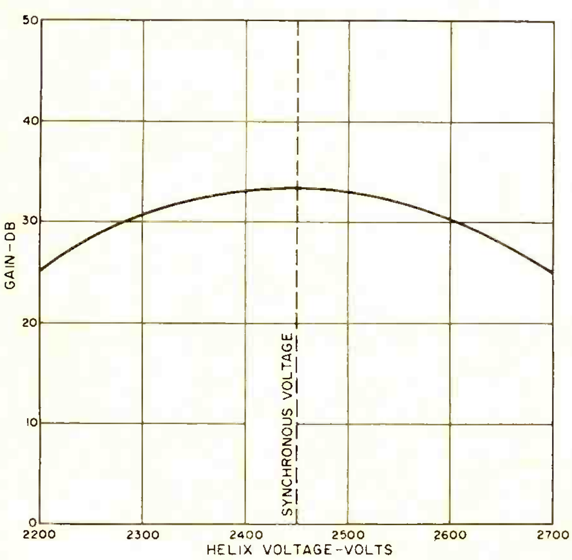


Fig. 3. Variation of the circuit gain with helix voltage.

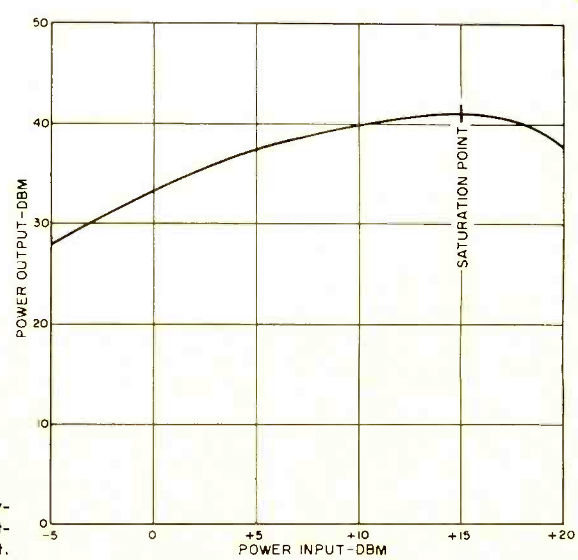


Fig. 4. Output power of the TWT plotted against input.

Voltage-divider nomogram

By DONALD W. MOFFAT

Finding component or voltage values for resistive or capacitive dividers is simplified with this chart.

IN the simple voltage divider of Fig. 1A, a voltage is applied across two impedances, and the output is taken across one of them. With the accompanying nomogram you can quickly find component values or voltages for either resistance or capacitance voltage dividers.

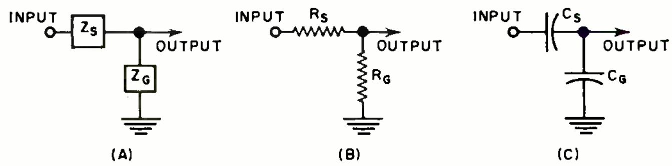


Fig. 1. Basic resistive, capacitive voltage-divider circuits.

Resistance Voltage Divider

Fig. 1B shows the common case where both impedances are simply resistors. All "s" subscripts will go with the components in series and "g" subscripts will go with the component which has one end grounded. Output is, of course, taken across the latter impedance.

When using the nomogram to solve this circuit, locate the value of the output resistor on the long vertical scale and the value of the series resistor on the short vertical scale. Draw a straight line through these two points and extend the line to the left edge of the graph. From there, go straight in to the curve and then straight down to the bottom edge of the graph. Draw a final line from there, through the correct value of "Input Voltage" and read "Output Voltage" where the line crosses the scale.

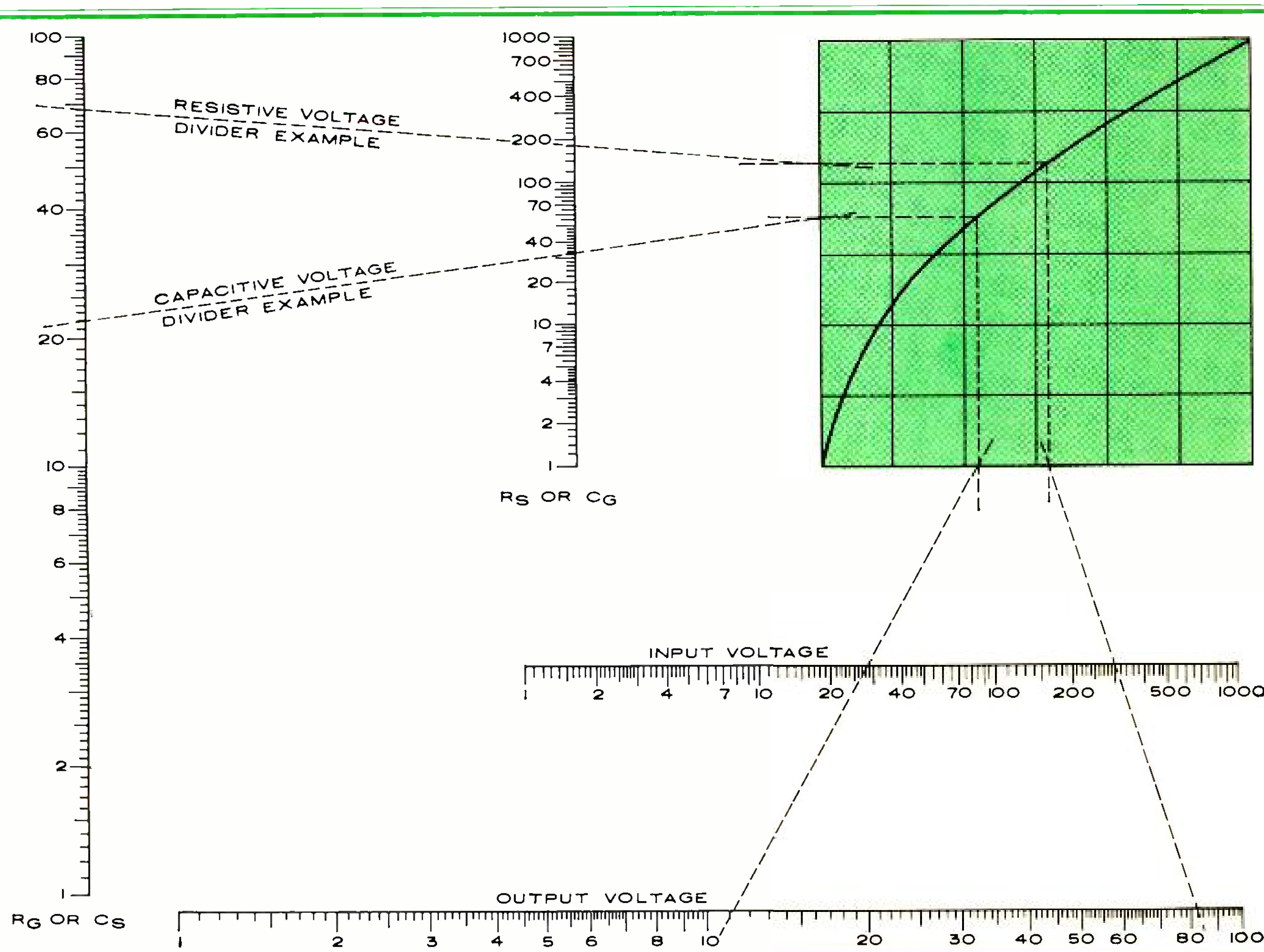
An example will show it's not as complicated as it sounds.

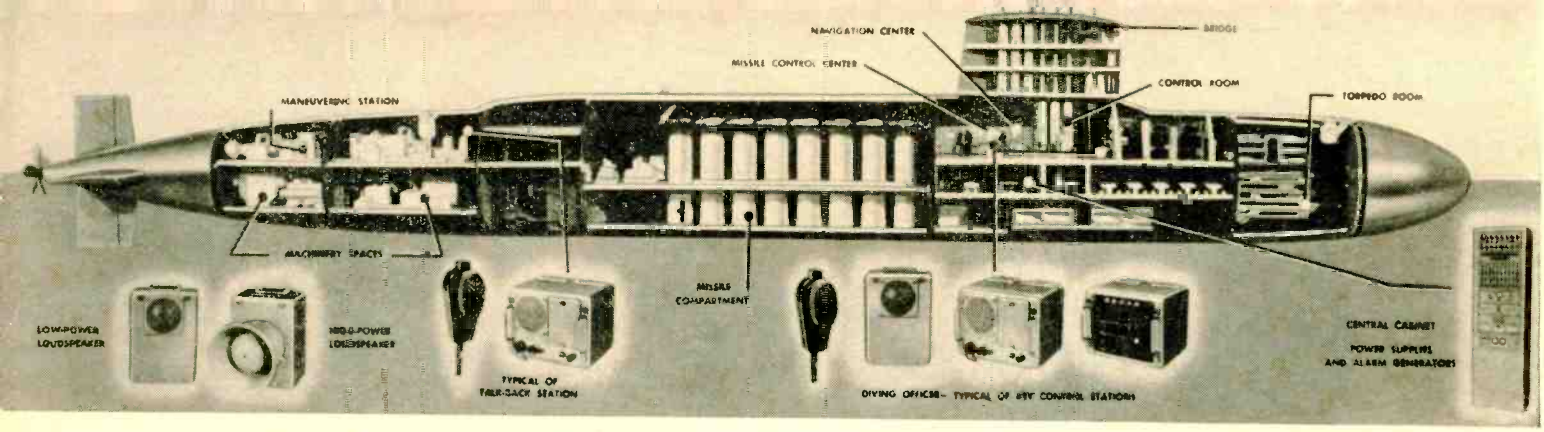
A resistive voltage divider is made up of 68,000 and 180,-000-ohm resistors, with the output taken across the 68,000-ohm resistor. If 300 volts is applied, what will the output be?

Note that no order of magnitude is shown on the vertical scales, therefore you can assume all values are in ohms, or kilohms, or megohms, or any unit you choose. The only restriction is that the same units must be used on both scales.

In this example R_g is 68,000 ohms and R_s is 180,000 ohms; therefore, we will let both scales be in kilohms. Draw a line through these two values and where that line meets the graph, draw a horizontal line straight in to intersect the curve. From there draw a line straight down and at the point where it leaves the graph, draw a final line through 300 on the "Input Voltage" scale. This line crosses the answer, 82 volts, on the "Output Voltage" scale.

Should you be working with voltages outside the ranges of these two scales, the ranges can be extended by moving the decimal point any number (*Continued on page* 69)

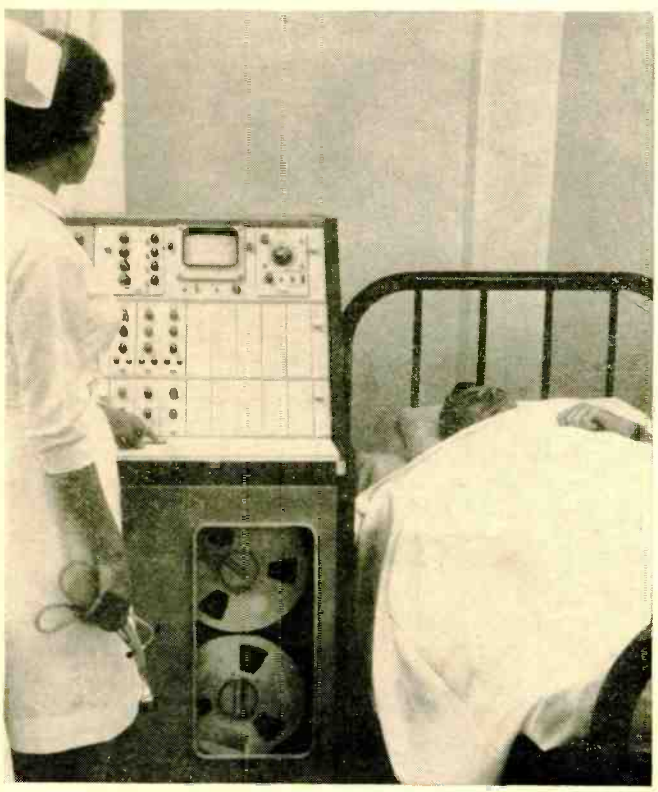


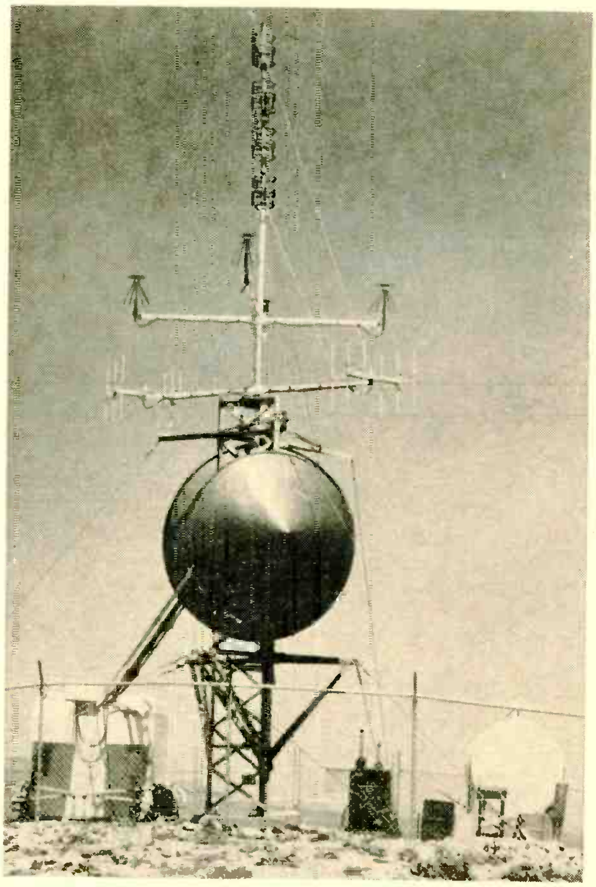


Life-time Intercom for Nuclear Subs. The cut-away model above of the nation's first Polaris submarine, the USS George Washington, shows the location of RCA's ultra-high-reliability intercommunications system. The company will build 14 more systems, bringing to 70 the total built for the nuclear subs. The maintenance-free system, with its 110 stations, is also used to generate the submarine's alarm signals electronically.

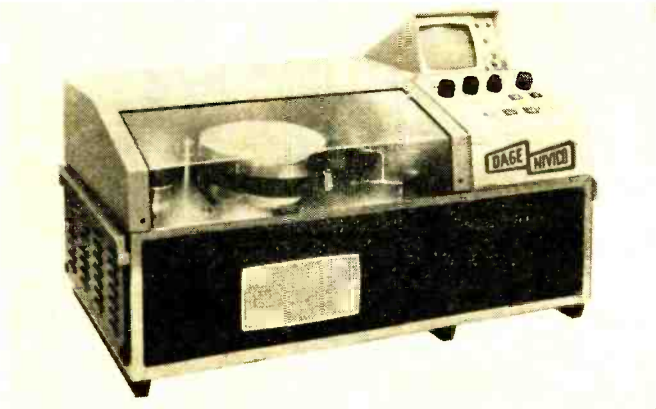
RECENT DEVELOPMENTS in ELECTRONICS

Hospital Instrumentation Recorder. (Below) A new hospital version of an Ampex data-acquisition system has been designed to move easily through narrow doors and corridors, into hospital rooms and between beds. The tape system provides complete facilities for recording physiological data obtained from existing transducers and electrodes. It is presently being used in government hospitals to record cardiovascular data. In this application, electrocardiographic data is amplified, displayed, and recorded on magnetic tape at 1⅞ to 60 ips. The tape is then sent to a centralized facility for computer-aided diagnosis.

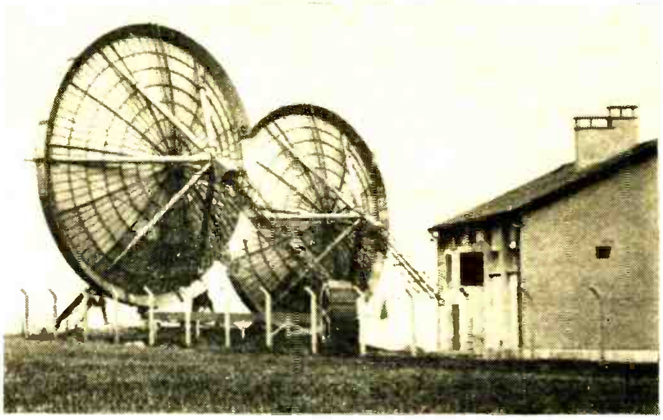




Remote Data-Acquisition System. (Above) Unmanned, completely automatic stations are being used to extend the range-instrumentation capabilities of Edwards Air Force Base, Calif. The new Motorola-designed system makes it possible for control centers at the base to receive, record, and display flight-test data from test vehicles as they proceed over a flight range of several hundred miles. The station shown is transportable by helicopter; it consists of 4 telemetry receivers, 4 u.h.f. communications transceivers, intercoms, provision for radar inputs, subcarrier modulating equipment, 2-way frequency-diversity microwave receivers and transmitters, and the control equipment for remote operation.

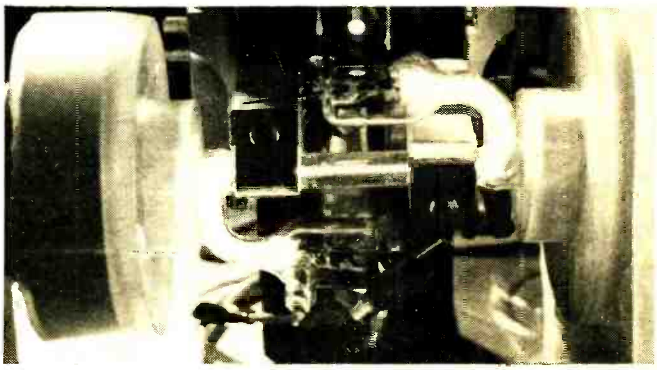


Portable TV Tape Recorder. A video recorder that permits the action to be slowed down or held stationary for up to an hour has been introduced by Dage. The recorder, priced at $12,450, has a bandwidth of 3 mc. and at a tape speed of just under 6 ips will record a 63-minute TV program on a standard 7-in. reel of 1-in. video tape. A built-in monitor shows recorded picture.

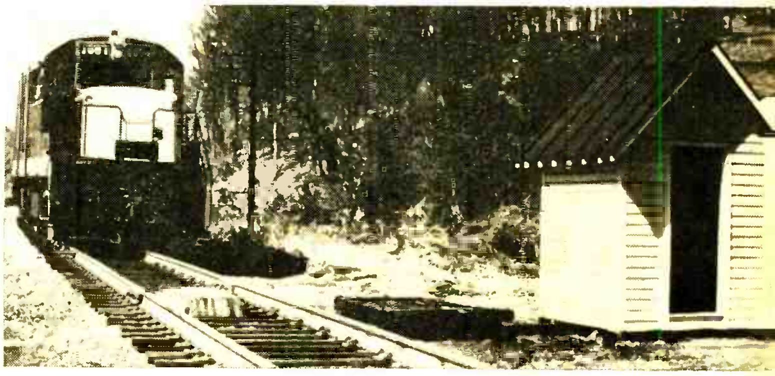


"Ace High" Tropo System Completed. The last station in the NATO communications network that extends from Norway to Turkey has been accepted by SHAPE. The system, engineered by ITT, uses 60-foot antennas to bounce signals off the troposphere, 10 to 15 miles above the earth. Half the 82 stations use forward-scatter (over-the-horizon) method; the rest use line-of-sight.

New Computer Family. (Above) A G-E quality-control technician is shown checking out a new computer system, one of four new decimal-oriented systems announced recently by the company. The equipment features modules extending radially outward to bring the logic elements and the magnetic-core memories closer together. Wire lengths are thus reduced for increased speeds and responses. Electronic assemblies are mounted in the doors of the unit for accessibility.



Miniature Gas Laser (Above) Miniature helium-gas laser developed at Bell Labs has a gas-discharge length of only 2 in. and oscillates at a single frequency of red light. Plastic covers at each end of the discharge tube enclose end mirrors, 4 in. apart.... **Piezoelectric R.R. Car Reader** (Below) A new system for automatically reading and recording moving railroad cars is being marketed by G-E. Piezoelectric elements on the bottom of each car operate with a pickup unit between the rails to produce a signal that is decoded, punched on tape in wayside station.



THE INTEGRATED AMPLIFIER-SPEAKER

By KEN GILMORE

Designing the hi-fi speaker and amplifier together as a single complementary system is considered by some to offer advantages in performance, in cost, and in space.

Editor's Note: Most hi-fi manufacturers are specialists. The loudspeaker company produces the best speaker systems it can for the money, while the amplifier manufacturer does the same with amplifiers. If the user wants high-quality reproduction, he gets a good speaker system and a good amplifier and connects these together. On the other hand, another design approach is possible in which the manufacturer produces an integrated amplifier-speaker system. This article states the case in favor of this approach. Whether you agree with the arguments presented or not, you should at least be aware of the design philosophy behind such systems.

QUITE recently, several high-fidelity loudspeaker manufacturers (*KLH* and *J. B. Lansing*) have been marketing units that may represent an important new trend: the integrated loudspeaker-power amplifier. Several other firms indicate they may be preparing to follow suit.

The concept is, of course, not new. Designers of package radio-phonographs have for years designed amplifiers around the speakers they had to work with. Usually they adjusted the frequency response of the amplifier, attenuating high frequencies or adding bass in an attempt to achieve a "mellow" tone. The sound produced by such instruments is, of course, far from what would usually be considered high-fidelity.

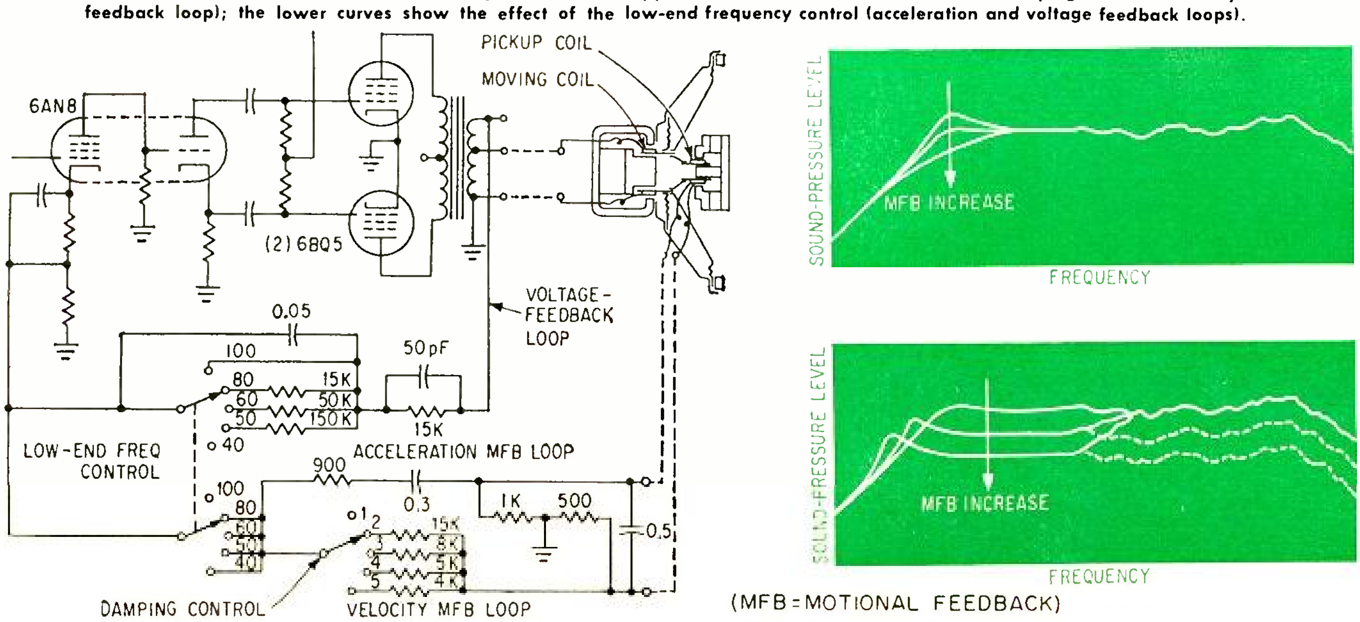
There have also been a few high-quality integrated amplifier-speakers on the market in recent years. *Ampex* builds one such unit, as does *EMI*. Both systems are meant primarily for professional use, generally as portable studio monitors that can operate from a low-level audio distribution bus.

The new integrated units now appearing are similar in some ways to both the package and professional units. Like package units, they are meant for home music systems. Like professional studio monitors, they are of high quality. But despite similarities to both, they are built to achieve design goals attempted by neither. As such, they represent a new trend in the high-fidelity field.

Advantages of Integration

Since modern equipment, with its accent on separate components, is startlingly good, why is a new approach justi-

Fig. 1. Motional-feedback circuit used by Matsushita. Upper curves show the effect of the damping control (velocity-feedback loop); the lower curves show the effect of the low-end frequency control (acceleration and voltage feedback loops).



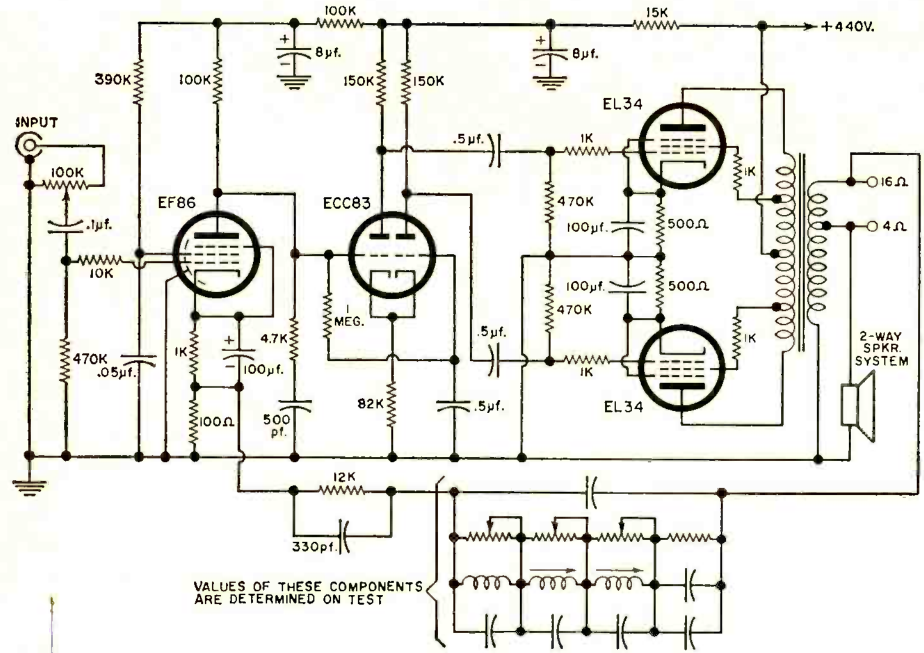


Fig. 2. Circuit of EMI studio-monitor amplifier that is integrated with 2-way speaker system to which its response is matched by use of variable components in feedback loop.

fied or necessary? Engineers who favor the new trend cite four principal reasons. The first three are relatively simple and straightforward; the fourth—and most important—is more complex. They are:

1. *Better sound for the money*: A speaker designed to be used with a wide range of amplifiers will usually be more expensive than one of identical performance built to match a single amplifier, and *vice versa*. When an engineer designs the speaker and amplifier together, he eliminates complexities. He doesn't have to design the amplifier output to match a wide range of impedances, for example. He can also build the amplifier to deliver adequate power for its matching speaker and no more.

2. *New kinds of speakers with integrated approach*: Integrated design allows novel speaker systems not practical under component philosophy. *KLH*, for example, designed a unit in which a large, moderate-efficiency woofer was mated with two electrostatic tweeters. To keep woofer response clean, a crossover frequency in the 300-400-cps range was selected. This meant the electrostatics would be very inefficient as they would have to cover a wide frequency range.

It would be possible, of course, simply to pad down the woofers to the same level of inefficiency. But then the system would require an amplifier capable of putting out tremendous amounts of power, most of which would be dissipated in the pads.

Integration offers an easier approach. Simply build an amplifier capable of delivering most of its power above 300 cps. Such units are used in tape recording, where heavy high-frequency pre-emphasis is built into the system. The total size of the amplifier, delivering only moderate low-frequency power, could be quite modest.

Another interesting approach possible only with integration is the inclusion of the speaker itself in the feedback loop. Fig. 1 shows a recently announced amplifier-speaker built by Japan's *Matsushita* ("Panasonic") company. A pickup coil fastened to the cone moves in a magnetic field. Its output is fed back through a differential circuit to the driver cathode.

Such systems have been used before; the American-made *Integrand* system worked on a similar principle. The more recent circuit, though, introduces a new twist. In previous circuits, the voltage fed back to the amplifier was proportional to cone velocity. As feedback increases, sound output response changes as shown in upper curves of Fig. 1. The familiar overdamped shape was then electronically compensated for a better bass-end response.

In the *Matsushita* circuit, though, the feedback voltage is applied to an *RC* network whose output voltage is proportional to cone acceleration. The resulting family of response curves is shown as the lower curves in Fig. 1. The apparent resonant frequency of the loudspeaker is lowered. The manufacturer claims that the circuit also reduces system distortion.

3. *Contouring*: One of the most powerful—and controversial—tools available to the speaker designer is contouring, that is, shaping the over-all frequency response of the amplifier-speaker system. Purists tend to feel that a manufacturer should build the best speaker he can and not modify its response characteristics. But the conviction is growing that this approach—while it obviously can produce good speakers—may not be the only way to achieve ultimate performance.

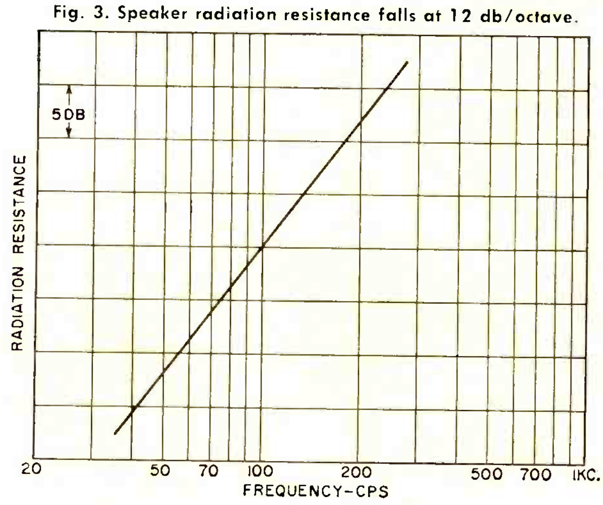
Contouring should not be confused with the practice of beefing up an inexpensive speaker with electronic tricks, such as has been done traditionally in package units. *EMI*, for example, in its studio monitor, indicates the proper approach. This speaker—certainly no cut-rate unit, at $594 per speaker-amplifier combination, twice that for stereo—uses four frequency-compensating networks to achieve added smoothness after starting out with the best speaker system company engineers can build (Fig. 2). After the amplifier is installed, each control is factory-adjusted for optimum uniform response. Of course, no amount of equalization can produce fundamental bass or high-frequency response past a speaker's cut-off points. But minor peaks and dips—which no loudspeaker system is able to avoid completely—can be minimized for smoother over-all response.

4. *Smaller boxes without losing bass response*: Traditionally, speaker designers have put low-frequency speakers in big boxes. This is a valid engineering practice, of course. But it isn't the only way to design low-frequency systems. In spite of widely held beliefs to the contrary, the fundamental physical laws that determine speaker response do not tie size and low-frequency response inexorably together.

Low-Frequency Performance

To illustrate, consider the basic mechanics by which a speaker transfers low-frequency acoustic power to the air. This discussion refers to the range where cone diameter is

Fig. 3. Speaker radiation resistance falls at 12 db/octave.



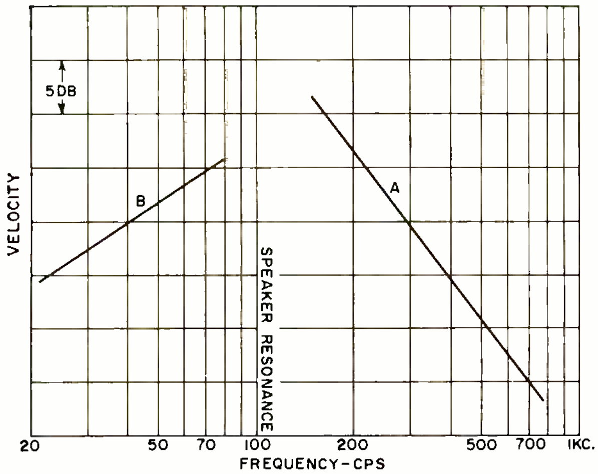


Fig. 4. Above resonance, cone velocity goes up at 12 db/octave as frequency goes down. Below the resonant frequency, velocity falls 6 db/octave as the frequency goes down.

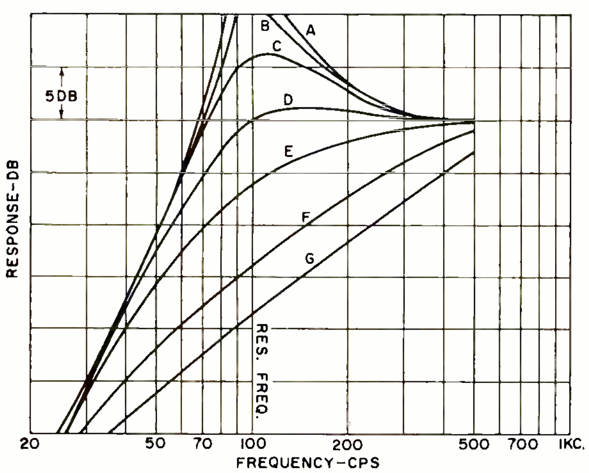


Fig. 5. Effect of various degrees of damping on the speaker.

small compared with the wavelength—say below 1000 cps for a 10- or 12-inch speaker—and in which the cone remains rigid. In this area, radiation resistance decreases with decreasing frequency at the rate of 12 db per octave (Fig. 3). As the frequency drops, in other words, the ability of the air to absorb acoustic power falls off rapidly. But fortunately, an equal and opposite reaction is taking place to compensate for this effect. As long as the speaker is operating in the range where the velocity of the cone is mass-controlled, that is, in the area well above the resonant frequency where the principal factor limiting cone velocity is the inertia of the cone's mass—velocity *increases* as frequency *decreases* (A in Fig. 4). The velocity increases by the same factor that radiation resistance decreases and the two cancel out. Acoustic power output thus tends to be uniform above speaker resonance.

This continues until some point above the resonant frequency at which the speaker is no longer predominantly mass-controlled. At that point, different forces come into play. The first factor that upsets the balance appears as the speaker approaches resonance. A speaker's resonant frequency is the point at which the reactance of the mass of the moving system equals the reactance of the elasticity (compliance) of the speaker's suspension. (This is analogous to the resonant point of an *LC* circuit at which $X_L = X_C$.) At this point the only forces that keep the cone from reaching tremendous velocities (other than the small amount of friction in the flexing cone suspension itself) are acoustic and electrical damping. Except in high-efficiency horn-type enclosures, not here considered, acoustic damping (including radiation resistance) plays a relatively unimportant part in the speaker's total damping.

Electrical damping comes from back-e.m.f. generated in the voice coil. Short the terminals of a speaker together and try to move the voice coil with your fingers. It reacts as though it were impeded by a heavy, viscous fluid. The heavier the magnet and the more voice-coil wire in the gap, the greater the resistance. As the coil moves through the speaker's magnetic field, it acts as a generator and produces back-e.m.f. Current through the dead short across the terminals is very high. The magnetic field generated by the current reacts with the speaker's field and tends to oppose the voice-coil's motion.

Thus as the speaker tends to swing freely at its resonant frequency, back-e.m.f., shorted through the amplifier's low-impedance output circuit, dissipates the mechanical energy rapidly. A speaker with a strong magnetic field is said to be highly damped.

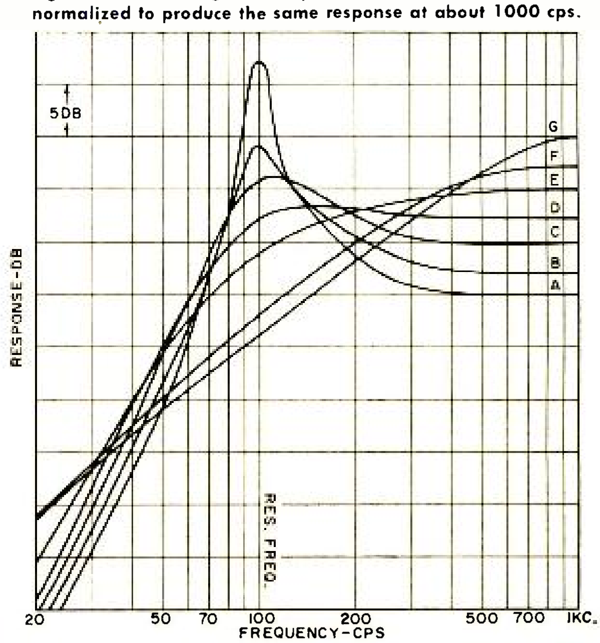
Fig. 5 shows how a given speaker reacts to various degrees of damping. If the damping is low, response rises sharply in the vicinity of resonance (A). As damping increases, response changes as shown. The curve at D shows so-called "critical damping" where low-end response is uniform to the lowest possible point (to near resonance) without ever rising noticeably above mid-frequency response.

The over-all *shape* of a speaker's low-frequency response curve, then, is determined by the "Q" of the system. A "Q" of 1—this means that the effective resistance of the total electro-acoustical system (primarily electrical damping) must equal the mass reactance of the moving system—gives the so-called critically damped curve. Thus for a given mass and a given low-end response characteristic (a critically damped curve, for example) the "Q" determines the size of the speaker motor, and hence the over-all efficiency of the loudspeaker system.

Curves E, F, and G show various degrees of over-damping (the "Q" is substantially less than 1), which bring about a gradual low-end roll-off. (All curves in Fig. 5 are normalized for easier comparison. Actually, increased damping results in the family of curves in Fig. 6. The shape of the curves is the same in both cases.)

Below resonance, the cone is stiffness-controlled. Here, the speaker motor works primarily against the stiffness of the suspension, and velocity falls off with frequency (6 db per octave), as shown at B of Fig. 4. Radiation resistance continues to fall off, too (Fig. 3) so the speaker's ability to deliver acoustic power falls off at 18 db per octave and quickly drops below a useful level.

Fig. 6. Same as Fig. 5 except that curves have not been normalized to produce the same response at about 1000 cps.



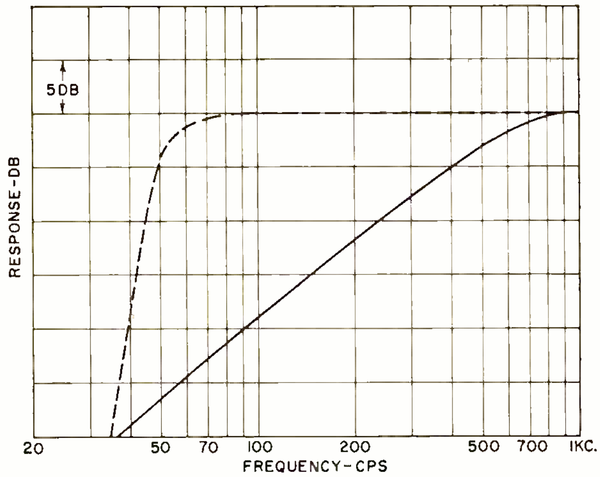


Fig. 7. By electronically compensating the gradually rolling off solid curve, the dashed-line response may be produced.

As can be seen, a speaker of any given size, flat to any given frequency, can be designed using these principles. (The following discussion holds true provided the damping factor of the amplifier being used is above one or two, and the stiffness of the cone is supplied primarily by the air in the box. Without a sealed box, the picture changes somewhat in a way to be shown later.)

Loudspeaker, Enclosure Design

Take, for example, a large infinite-baffle enclosure with a speaker, critically damped, having a resonant frequency of 40 cps. Its frequency response, in other words, will be essentially flat to about 40 cps. Applying design principles cited above, the size of the speaker enclosure may be cut in half, or made even smaller, with the system still retaining the same low-end characteristics. Reducing the size of the enclosure, though, requires other changes if the response curve is to remain the same. First, the size reduction increases the stiffness of the trapped air. Since the resonant frequency is determined by the cone's mass and the compliance of the suspension, this raises the resonant frequency of the speaker. This illustrates the first relationship: with the efficiency remaining constant, resonant frequency increases as volume decreases.

The resonant frequency can be lowered to 40 cps again, though, by adjusting the size of the cone. Paradoxically, reducing cone area can lower the resonant frequency, provided cone mass is not reduced and provided further that compliance is increased.

If the mass of the cone and the size of the speaker motor are not changed, the "Q" will still be 1. The resonant frequency is back again at 40 cps, so the output characteristic of the speaker is now the same as it was when the enclosure was twice as big.

Of course, the decrease in size didn't come free. It was paid for in efficiency. Since the cone is smaller, it will transfer less acoustic power to the air with the same electrical input.

Practical Problems & Solutions

Two factors set a lower limit on speaker size. First, the small system must make up for decreasing radiating area by increasing cone excursion. Practical suspension problems limit maximum excursion and thus minimum speaker size. Second, and more important, efficiency drops at such a rate that impractically large amounts of driving power are needed long before maximum excursion limits are reached. The integrated speaker-amplifier offers a way out of this predicament.

With the integrated approach, a large magnet can be added to the speaker. This raises the efficiency, and cuts input power requirements. But it also increases efficiency more at high frequencies than at low frequencies and produces the familiar over-damped curves shown in Fig. 5. (These are the curves that have been marked E, F, and G.)

The larger magnet, then, while improving efficiency, has destroyed the flat response characteristic, but it has given the system a new kind of response curve that has possibilities. Although a speaker cannot under any circumstances be made to produce output beyond the point at which it begins to fall off sharply (18 db per octave), it is no great trick to compensate electronically the gentle, essentially linear, overdamped roll-off of curve G in Fig. 5 to look like Fig. 7. Thus a speaker-amplifier system using a small speaker enclosure can be designed to have extended bass range and reasonable efficiency, too.

The integrated approach (*Continued on page* 66)

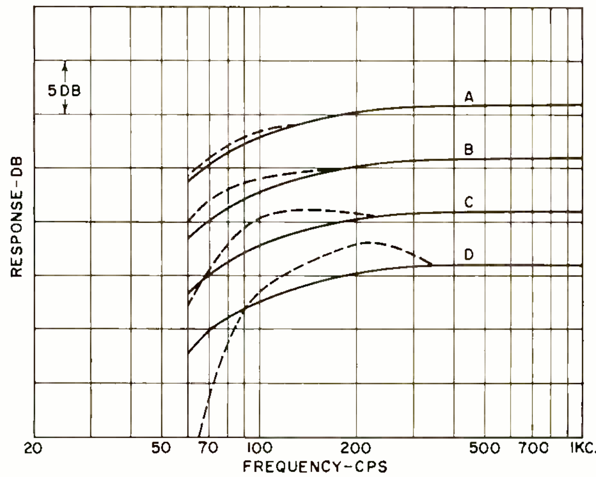
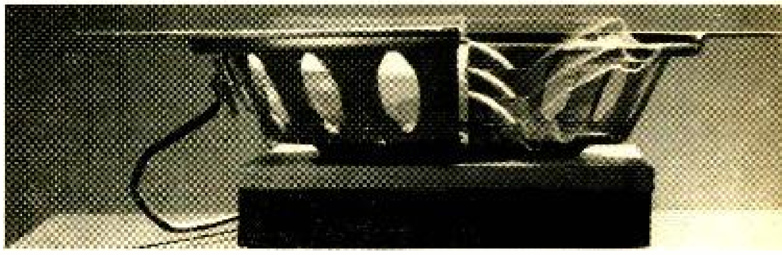
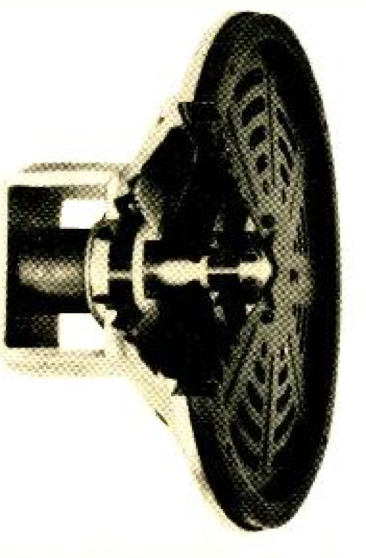


Fig. 8. Effect of various port sizes on compact (1 to 1¼ cu. ft.) enclosure with fairly low efficiency speaker. The solid curves are with the ports blocked, the dashed curves are with the ports opened. Curve A is with the smallest port, curve D is with the largest. The curves have been separated from each other by 5 db for clarity, not to show different levels. The family of curves will move down in frequency for a larger enclosure, and up in frequency for a smaller enclosure size.



Cut-away model of small-diameter, long-cone-excursion KLH speaker showing motion of the cone. This speaker was designed to give improved low-frequency response when used with electronically compensated circuit. Note use of large magnet which results in highly overdamped characteristic.



Cut-away model of special Matsushita "Panasonic" speaker, which uses a separate pickup coil and magnet structure to derive a motional feedback signal. This speaker must be employed with a specially compensated power-amplifier unit.

NEW LOOK IN TRANSFORMERS

By JOHN R. COLLINS

New core materials and new fabrication techniques are making modern transformers smaller and more efficient.

TRANSFORMERS account for a very great part of the weight and size of most electronic equipment, so in this age of miniaturized components and printed circuits, a major effort is under way to shrink them to more compatible dimensions. The drive for improved efficiency has concentrated especially on transformers for airborne use with such success that these are now only a fraction of the size of the best available a decade ago. The materials and technology originally developed for airborne equipment, however, have found wider utilization, resulting in better transformers for less critical applications.

There are many kinds of transformers, as reference to any catalogue will reveal. They are sometimes classified by application (as, for example, horizontal output, isolation, power supply), sometimes by operating frequency or power range (audio, i.f., r.f., high-voltage), and sometimes even by method of construction (hermetically sealed, toroidal). All types, however, can be conveniently grouped under a relatively few functions: step-up or step-down of voltage, impedance matching, circuit isolation, or phase inversion.

Even though only one function is of interest for a particular application, other functions may be performed as well. Thus, an output transformer, intended primarily for impedance matching, will also step down the voltage, invert the signal, and isolate the speaker from the tube.

Power Transformers

Power transformers are used to convert a supply voltage to the proper value for input to rectifiers, and sometimes to supply filament voltage. They are made in a range of values from a few watts to several megawatts. Although in the United States most power transformers are designed for 60-cycle operation, in recent years 400-cycle transformers have found increased use, especially in military and airborne equipment where weight and size are critical. Developmental work has also progressed on models for 800-cycle and even higher operation.

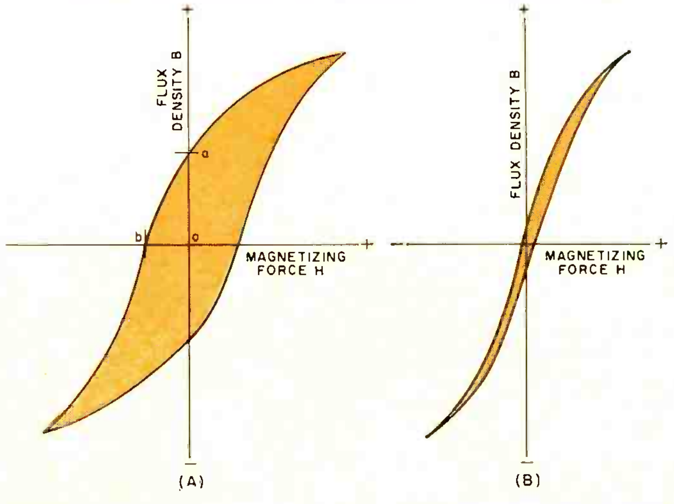
The interest in higher frequency transformers stems from the fact that for equal power, the minimum size of a transformer is inversely related to its operating frequency. A transformer for 25-cycle operation, for example, must be about twice the size of a 60-cycle transformer of equal power. At 400 cycles, the minimum size will be far smaller. However, the reduction will not be in exact proportion to frequency because of increased losses which limit the savings that might otherwise be effected.

A major source of power loss is hysteresis, which results from the tendency of the core to retain flux (called residual magnetism) after magnetizing force has been withdrawn. In a.c. circuits, therefore, power must be expended to overcome residual magnetism each time the current reverses.

In a typical hysteresis curve (Fig. 1A), line *oa* represents the residual magnetism when magnetic force is zero. Line *ob* represents the force which must be exerted in the reverse direction to reduce flux to zero before magnetization in the opposite direction can take place.

Power lost through hysteresis represents wasted energy, the amount of loss being proportional to the area enclosed by the hysteresis loop. For this reason, materials having a narrow loop, as in Fig. 1B, are preferred for transformer use. Since the hysteresis loop is retraced with every cycle, losses

Fig. 1. (A) Shows a typical hysteresis curve while (B) shows narrow-loop hysteresis curve preferred for transformer use.



become very appreciable as the excitation frequency is increased.

Eddy currents induced in the core by the magnetic field are another cause of power loss. These currents may be counteracted by constructing the core of thin laminations of metal which are insulated from each other, and by using materials of low conductivity.

Power lost through hysteresis and eddy currents is expended in heating the core. Early transformers were relatively inefficient devices which were built large not only to accommodate the necessary flux but also to provide enough area to dissipate heat. The first step in making better transformers was to develop better core materials capable of accommodating more flux without becoming saturated and having small hysteresis and eddy current losses.

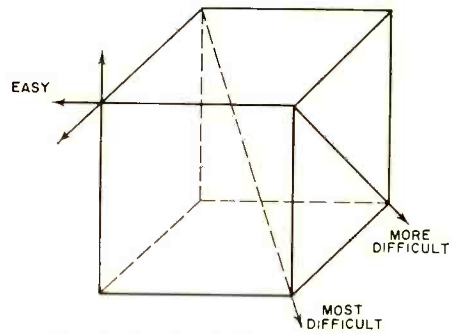


Fig. 2. A cubical silicon steel crystal showing relative difficulty of magnetization along the various crystal axes.

Originally, soft iron used for cores had a permeability of only about 5000. Permeability was increased through purifying the metal until a figure of about 35,000 was obtained. Although iron of much higher permeability was achieved in sample cores, it was found that these were generally too delicate for practical purposes.

The presence of a few percent of silicon was found to substantially increase the resistivity of iron and thus cut down eddy-current losses. Silicon iron or steel is now almost universally used for power transformers, although some developmental work has been done on transformers using alloys which utilize aluminum instead of silicon.

For many years, steel sheets 14 mils thick and containing 4% silicon were standard for transformers, and these provided excellent service for most purposes. A good 4% silicon-steel core, for example, will have a loss of about 0.8 watt per pound at 60 cycles and 12,000 gauss. Its losses become prohibitively high, however, with increased frequency.

Grain-Oriented Steel

The development of grain-oriented silicon steel was a major breakthrough in transformer technology. This process resulted in steel with greatly reduced hysteresis loss, permitting the operation of transformers at 400 and 800 cycles. The great savings in weight and size, previously theoretically possible, thus became an actuality.

The grain-orientation process can be understood by referring to Fig. 2 which represents a cubical crystal of steel. As depicted here, steel can be readily magnetized in the directions of the cube edges, but with greater difficulty along any diagonal. Grain-oriented steel is made by a combination of cold-rolling and heat-treating techniques which align most of the crystals with their edges parallel in all directions. The resulting product, which usually contains 3 to 3.5% silicon, has magnetic properties far superior to hot-rolled steel. It is readily magnetized across as well as along the sheet, a fact which gives far lower energy losses and greater flexibility in designing transformers. Once it has been properly heat-treated its characteristics do not change, so that the transformer will not age with use.

Fig. 3 shows various sizes of "C" cores fabricated from grain-oriented silicon steel by the *Arnold Engineering Company*. These cores have high saturation flux density and lower core losses than any types made from regular silicon steel. They can, therefore, be operated at high frequency and with unusually high flux density. These factors lead to smaller, lightweight transformers.

Core Fabrication

In practice, core material is cut into strips or tapes and is chemically treated on both sides to provide resistance between laminations. The tape is then wound on mandrels to form gapless cores. The cores are then annealed to relieve winding stresses. In some cases they are varnished to provide greater rigidity and ease in handling, after which they are cut in two. This is a precision operation which results in core halves that can be fitted together with a maximum air gap of only about .001 inch.

The effect of an air gap in a magnetic circuit is similar to that of a resistor in an electrical circuit. It offers opposition to passage of flux, just as a resistor opposes current. Since the permeability of air is only 1, compared to 35,000 or more for silicon steel, it is apparent that the effective permeability of a magnetic core may be considerably reduced by even a relatively small air gap. For very critical circuits, toroidal cores which are formed in the regular way, but are not cut, may be used. Special machines are needed to wind coils on toroidal cores.

The thickness of sheet to be used is determined principally by the frequency of operation. Although it might be expected that the thinnest sheet would always be best, this is not the case, as shown by Fig. 4. For 60-cycle use, 12-mil, grain-oriented silicon steel is equal to 4-mil and superior to either a 2-mil or 1-mil sheet. For 400 cycles, however, the 4-mil and 2-mil thicknesses are much superior.

Fig. 5 shows how core loss varies at different flux densities and frequencies for one type of 4-mil core made by the *Arnold Engineering Company*. Even though the loss in watts per pound is substantially greater at high frequencies than at 60 cycles, the fact that a smaller core can be used offsets this difference, so total losses may not be greater. It must be remembered, furthermore, that it is usually more important to conserve weight than power in a high-frequency power transformer.

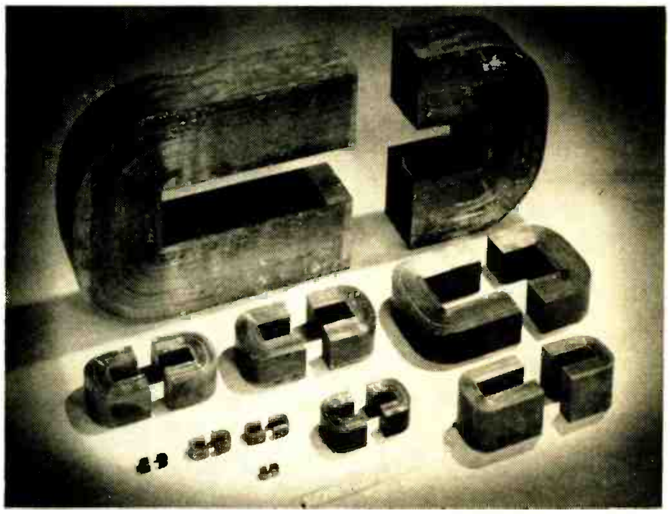


Fig. 3. "C" cores made from 3% grain-oriented silicon steel can be used with flux densities from 15,000 to 17,600 gauss.

Very large power transformers are often liquid cooled, but transformers for electronic circuits are usually air cooled.

In miniature transformers, heat is concentrated in a smaller area, so the operating temperature is usually higher than for larger models. Where weight is an important factor, it has proved best to build small, compact transformers and simply let them run hot. This means, of course, that better insulation must be used on wires. Recently, insulations including asbestos, Teflon, and certain ceramics have been utilized, and high-temperature transformers have been produced capable of operating at hot-spot temperatures to 600° C.

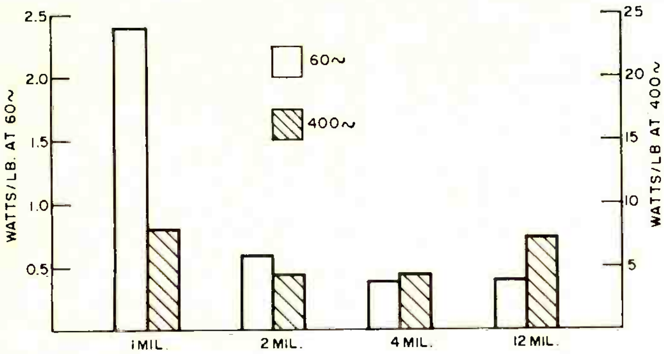


Fig. 4. Core losses for grain-oriented silicon-steel cores of various thicknesses operated at 60 and 400 cps, 10,000 gauss.

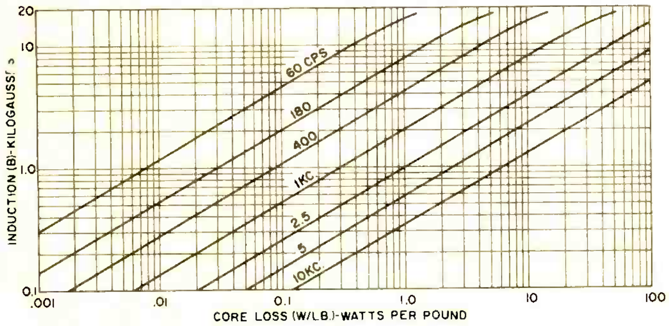


Fig. 5. Core loss in watts per pound at various operating frequencies for 4-mil, grain-oriented silicon-steel "C" cores.

Such transformers can not be used in conventional areas, but only in special applications where such high temperatures can be tolerated.

Audio Transformers

In recent years, there has been an increasing demand for high-fidelity audio transformers to match the high impedance of the amplifier power stage to the low voice-coil impedance, with essentially linear response over a frequency range from about 20 to 20,000 cycles, and higher.

The difficulty of achieving this end is illustrated in Fig. 6, where primary and secondary transformer impedances are represented by Z_p and Z_s, respectively. The inductance of the primary is represented by L_p. And, it is obvious that L_p must be high to prevent a low-resistance shunt across the primary impedance. Inductive reactance decreases as frequency decreases, and unless L_p is large, low-frequency response will be poor.

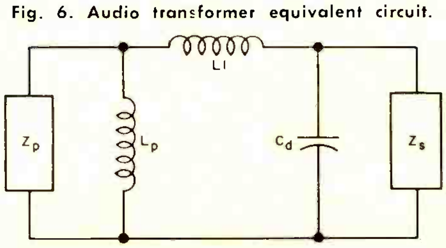
On the other hand, leakage reactance ($L1$) and distributed capacity (C_d), control the high-frequency response. As frequency increases, the reactance of $L1$ increases and offers series opposition between primary and secondary. At high frequency, C_d becomes a low-reactance shunt for the secondary impedance.

The simplest way to obtain the high primary inductance needed for good low-frequency response is to increase the number of turns on the primary. Unfortunately, this procedure results in greatly increased leakage reactance and distributed capacity, and thus poor high-frequency response.

The solution to the problem is to use core materials with exceptionally high permeability. In recent years, various nickel-iron alloys, known under the general name "permalloys," have found increasing use in audio transformers. One of the best is Supermalloy, which contains 79% nickel and 5% molybdenum, and has maximum permeability of about 1,000,000.

With higher permeability core material, fewer turns on the primary will provide the required high inductance leading to smaller leakage inductance and markedly reduced distributed capacity. Special winding methods have been devised to further reduce these effects. With careful design, transformers are now made with thin, high-permeability alloys which are essentially flat over the entire audio range and for some distance beyond it.

Fig. 6. Audio transformer equivalent circuit.



Pulse Transformers

Pulse transformers are basically impedance-matching devices developed originally for radar to permit the coupling of the pulse modulator output to a 50-ohm cable and the 50-ohm cable to the input of a magnetron tube. For this purpose, transformers capable of handling power up to about 50 megawatts are now in demand, and these may weigh several thousand pounds. At the other end of the scale, small, toroidal-type pulse transformers are needed to handle the pulses in logic circuits of digital computers.

Although high power levels obviously introduce special insulation problems, the basic problem is the same in both cases: to design transformers capable of passing square pulses of short duration without distortion. Rise time of the leading edge must be short and decay time of the trailing edge brief to permit high repetition frequency. These requirements imply a wide bandwidth.

Cores for pulse transformers are normally made of 1- and 2-mil magnetic materials, either grain-oriented silicon steel or nickel-iron alloys. Windings are usually interleaved (that is, either the primary or the secondary winding is divided into two sections and the other winding is placed in between) to reduce leakage reactance. In larger cores it is customary to leave an air gap to reduce the residual magnetism resulting from the fact that magnetizing force is applied in one direction only so there is no opposing demagnetizing force as in the case of an a.c. field.

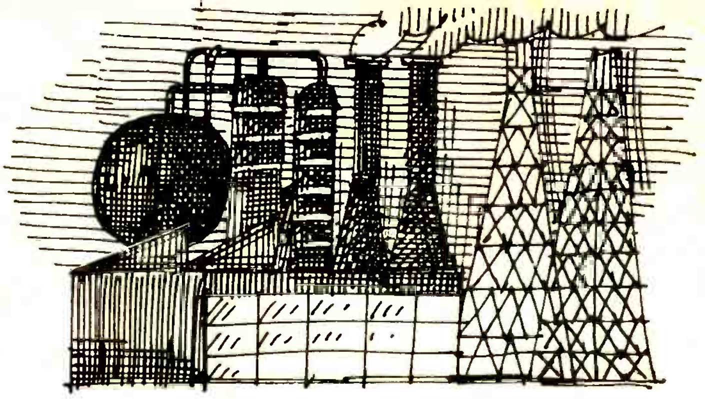
Powder and Ceramic Cores

At radio frequencies, the use of either silicon steel or nickel-iron alloys becomes impractical, primarily because of eddy currents. In early equipment, air-core transformers and coils were used exclusively at radio frequency. Now, however, magnetic metals are reduced to fine particle size, coated with an insulating substance, and embedded in a resin to make cores for r.f. use. Both silicon steel and nickel-iron alloys are used in this manner, permitting substantial reduction in size of components as well as improved operation. I.f. transformers which in standard broadcast-band receivers operate at 455 kc., are among the principal types employing magnetic powdered cores.

In recent years, a class of ferromagnetic ceramics called "ferrites" has become increasingly important as core materials for r.f. use. Their chemical compositions have the general formula XFe_2O_4, where X may be any of a number of metals. Manganese, nickel, and zinc, either singly or in combination, are most commonly used for transformer cores.

Ferrite cores characteristically have permeabilities from about 100 to 2000. Their resistivity is extremely high, so it is unnecessary to laminate or powder them to reduce eddy current losses. They are employed in broadband, untuned transformers for communications equipment, where air-core coils are too inefficient for practical use.

Used as cores for i.f. transformers, ferrites allow these devices to be made in sizes commensurate with transistor circuitry. Probably their greatest application, however, is for flyback transformers in television receivers, where they represent a substantial savings over the very fine magnetic metal cores that would otherwise be required. Their high resistivity makes them particularly useful, especially at the higher frequencies. ▲



ADVANCES IN ULTRASONICS

By CYRUS GLICKSTEIN / Author: "Basic Ultrasonics"

Part 2. Applications covered include ultrasonic welding, echo ranging, nondestructive testing, and medical uses.

LAST month we covered some of the basic principles and techniques used in ultrasonic equipment including the types of transducers. Important applications discussed were cleaning, machining, and soldering by use of ultrasonics. In this article we cover additional important applications.

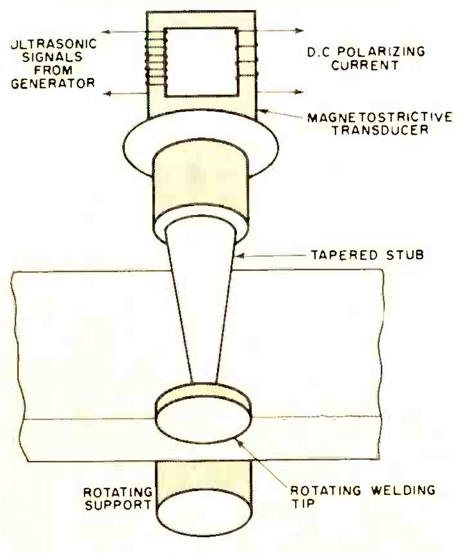
Ultrasonic Welding

Ultrasonic welding is a unique method for joining two similar or dissimilar metals in a strong bond. The vibrational tool (Fig. 1) is applied to the junction to cause molecular diffusion between the two metals. A true weld is obtained, yet the heat produced is considerably below the melting point of either metal. The resulting weld is as strong or stronger than either of the two bonded materials. Typical frequencies for ultrasonic welders are in the range of 18 to 40 kc.

Like metals successfully welded by this method include aluminum, copper, iron, steel, molybdenum, and nickel. In addition, many of these metals can be welded to each other in diverse forms, such as aluminum foil to a copper bar or a corrugated aluminum sheet to an aluminum plate.

A fairly recent application is ultrasonic sealing for plastics. Without adhesives, chemicals, or external heat, this equipment is able to join formerly hard-to-seal films such as oriented polyesters, polyethylenes, polyamides, polypropylenes, polystyrenes, vinyls, some fluorcarbons, and materials like nylon, Saran, and Mylar. The plastic sealer operates very much like the metal welder previously discussed and generates only a small amount of heat in the plastic film. Again, the seal is a solid-state intermolecular diffusion rather than a molecular fusion caused by heat. No special surface preparation, not even cleaning, is required. This method is useful for whole groups of plastics which cannot be sealed by direct heat or by dielectric heating because the required amount of heat would disturb the uniaxial or biaxial molecular orientation and weaken the high tensile strength of the materials. Ultrasonic sealing is used in fabricating endless conveyor belts, splicing magnetic tape, making seams in plastic rainwear, sealing packages, and similar applications.

Fig. 1. Ultrasonic welder used to produce a continuous seam in sheet metal.



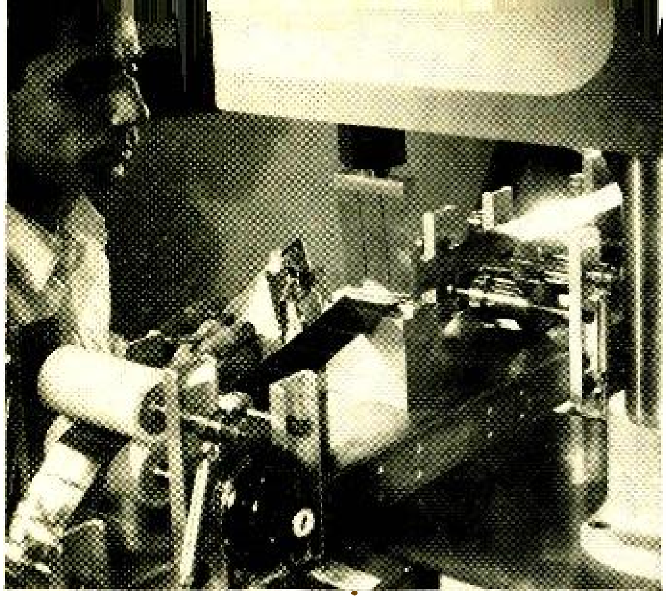
Other cavitational applications include: emulsification of resins, oils, and water solutions; pigment dispersion and/or particle size reduction in materials such as paints and inks; impregnation of porous materials with oils; degassing molten metals; dyeing and bleaching; treating nylon hosiery fiber, thereby altering the molecular structure sufficiently to provide the elasticity and absorbency of natural fibers.

Echo-Ranging Devices

Ultrasonic echo-ranging devices include a generator (transmitter) for producing ultrasonic energy, a transducer for applying vibrational energy to the medium of transmission and receiving echoes back from that medium, a receiver for amplifying and detecting the echoes, an indicating unit for displaying the information, and a control (synchronizing) unit for synchronizing the action between transmitter and receiver.

Sonar is one of the most important ultrasonic echo-ranging applications. Sonar equipment is used extensively in the U.S. Navy for locating submarines. In sonar, as in radar, pulses of energy are transmitted and the time is measured from transmission to the return of the echo. Since the speed of ultrasonic energy through the water is known (approximately 4700 feet per second), the time required for the round trip indicates the distance (range) of the target. In one common type of sonar (searchlight-type), transducers are rotated 360° in the search mode and kept at a relatively fixed bearing when a specific target echo is being tracked.

Fig. 2 shows a simplified block diagram of a sonar set. These sets present precise information about the range and bearing of the target. Echoes are presented audibly, visually, or both. Sonar sets are usually operated with associated equipment for determining the depth of the target. Additional resolving equipment computes data from the sonars and provides precise range and rates of movement to fire-control equipment for



Ultrasonic sealer automatically seals plastic-belt sections.

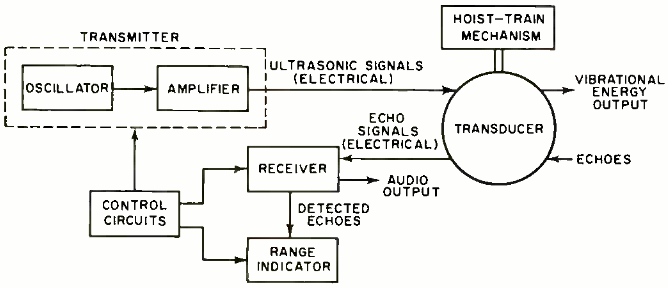


Fig. 2. A simplified block diagram of a typical sonar system.

the solution of attack problems. Many sonar sets include an underwater communications system. Voice-modulated ultrasonic energy is transmitted under water by the transducer of the ship sending the message and converted back to electrical signals and audio through the transducer, receiver, and headphones or loudspeaker of the sonar set receiving the message. Of course, in the communication mode of operation, the transducers of both the transmitting and receiving stations are not rotated but are oriented to each other's bearing.

Bottom-sounding sonars serve as fathometers. Polar-exploring submarines have used look-up sonar to check the distance to the underside of ice formations. Portable scuba sonar units, battery powered, have been developed for frogmen to be used in opaque waters to find unseen objects.

Fish finders operate like miniature sonar sets except that signals are sent directly downward from the transducer in the hull. Echoes are returned by any objects between the transducer and the sea bottom and by the sea bottom. Another type of marine echo-ranging device, using ultrasonics, is the fathometer. This instrument works like the fish finder except that the unit is essentially concerned with measuring depth of the water and operates on bottom echoes. Typical fish-finder and fathometer frequencies range from 30 to 80 kc. and 200 kc. to 1 mc. The display units on these devices commonly employ rotating neon lamps which flash when the transmitted pulse occurs and again when the echoes return. By using a known speed of rotation, a simple circular display of the actual depth can be produced.

Nondestructive Testing

Nondestructive testing (NDT) is an important industrial application related to ultrasonic echo ranging. NDT is the process of inspecting the surface or interior of a solid object without harming the object. Nondestructive testing may be performed on all units in a production run.

X-rays and *gamma* rays are used in some types of NDT. But x-rays, like radio waves, are electromagnetic and can penetrate only a limited distance into metal. The x-ray method, therefore, may not be practical for testing various large units. Ultrasonic NDT does not have this limitation. In addition, ultrasonic waves can find smaller flaws than can x-rays, even though the ultrasonic frequencies used are much lower than x-ray frequencies. The fact that the ultrasonic signal is vibrational energy and therefore travels much more slowly means that an ultrasonic wavelength is actually shorter than an x-ray wavelength. The shorter the wavelength, the smaller the flaw which can be detected. A large wavelength in relation to flaw size means the wave may bend around the flaw and fail to return a tell-tale echo.

Fig. 3 is a simplified diagram of an ultrasonic NDT unit in operation. A discontinuity inside the material is reflected back as an echo. Additional echoes are caused by reflections from the front and rear surfaces of the material. The search unit, which houses the transducer, is moved from point to point against one end of the material to permit a complete exploration. Frequencies used vary from 100 kc. to 25 mc. to permit finding minute flaws. Pulses are 1-3 μsec. wide and pulse-repetition frequencies range from 60 cps to 1 kc. or higher depending on the size and type of material and the production setup. Sufficient time must be allowed for the pulse to travel to the end of the material and return before the next pulse is sent out.

Another form of ultrasonic NDT technique is the straight-through transmission system. In this method, two transducers are used—one transmitting at one end of the material and the other at the opposite end receiving the signals. With this method, uniform signals are received at the receiving transducer except when there is an intervening flaw, which reflects back part of the energy. A flaw is therefore indicated when the energy at the receiving transducer is less than normal at any given point.

Additional echo-ranging applications include: ultrasonic thickness gages used to check the thickness of metal pipes without opening the pipes; bubble-detector systems which detect the presence of bubbles in a static or flowing liquid where bubbles may be harmful (lubrication oils, film emulsions, etc.); devices to determine the proportion of fat to lean meat in live cattle; and many others.

Medical Applications

Medical science utilizes ultrasonics in a variety of ways. Ultrasonic therapy was one of the first medical applications. Doctors in many countries currently apply ultrasonic energy to various parts of the anatomy to treat a wide variety of ailments including neuritis, sciatica, arthritis, bursitis, muscular sprain, and some skin conditions.

Ultrasonic visualization techniques are being used increasingly for medical diagnosis. The approaches used are basically similar to those used in NDT—echo-ranging and straight-through transmission. The transducer(s) is applied to the area under investigation, pulses of ultrasonic energy are applied, and the received echoes are detected and displayed on a CRT.

Ultrasonic examinations are possible in areas where x-rays are either inconclusive or inadvisable, such as examinations of soft-tissue areas, examinations of the cranium and eyes. By studying the displayed data, the examining physician can distinguish between normal and abnormal tissues. These ultrasonic techniques have been found useful in detecting cancers and other tumors in the brain, heart, and breast. Recent research indicates that it is possible to distinguish between certain types of heart conditions that are otherwise difficult to tell apart when only standard techniques, such as electrocardiograms, are used.

In ultrasonic surgery, acoustic energy is focused to a pinpoint and used to remove small growths without damaging surrounding tissues. The method has been reported as successful in some brain conditions which were previously considered inoperable.

Some very interesting ultrasonic applications are difficult to fit into either cavitation or echo-ranging categories.

Other Applications

1. *Ultrasonic signals in air.* Ultrasonic energy has been transmitted through air or other gases in a number of interesting applications and experiments. Remote control of TV sets and garage-door openers are two familiar examples. These utilize the transmission and reception of ultrasonic signals to actuate relays. The same principles are used to remotely focus and change slides in a slide projector.

A more complex application is a self-contained ultrasonic navigator for use by the armed forces, explorers, firefighters, and forest rangers. The equipment provides a continuous indication of the distance and direction of the starting point where the equipment was initially set to begin operation. The equipment consists of a backpack containing a small transmitter, receiver, transducers, computing circuits, and range and azimuth counters. The unit automatically calculates movements in range and azimuth from the starting point without requiring any signals from an external transmitter. Pulsed beams are directed to the ground and reflected back. Doppler effects sense the direction and motion and a miniature computer provides continuous data on range and direction to the point of origin.

An ultrasonic burglar alarm system used in factories, offices, and homes sets up standing waves in the protected room. If an intruder enters, the wave pattern is disturbed and a remote alarm is actuated. The device is sensitive enough to respond to air currents resulting from a burning match.

Several automatic parking and traffic-control systems are based on ultrasonic detectors. In one parking system developed for small lots, ultrasonic waves are used to detect incoming cars, open a gate when the toll is paid, and open another gate when the car leaves. A more elaborate parking system for large garages uses ultrasonic detectors to give information on available space (counting cars in and out), automatically actuate ticket dispensers at count-in locations, actuate information signs when total vehicle capacity is reached, and automatically turn off all of the ticket dispensers.

In the comprehensive traffic system developed for the Congress Street Expressway in Chicago, overhead ultrasonic detectors sense the presence of cars (traffic volume and speed) by reflection of ultrasonic beams. Detected echoes are fed by wire to the central control station where associated equipment, including computers, determines traffic density and automatically controls variable speed signs and lane utilization signs along the expressway and at interchanges. Traffic conditions are displayed on a large map at the control station.

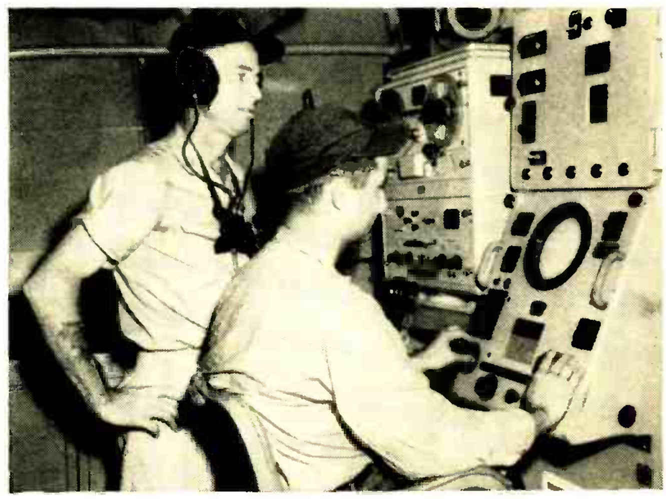
2. *Liquid-level monitoring and switching.* Continuous liquid-level monitoring is provided by fathometer echo-ranging action in reverse. An ultrasonic transducer at the bottom of the tank sends out pulses and measures the time required for the return of the echoes from the surface of the liquid. Time data is automatically converted to liquid-level information by associated equipment.

To obtain liquid-level control action at discrete points in a tank, appropriate switches may be placed at various levels to produce the required action—pumping, actuating a warning device, etc. Such switches may be placed at the high-level point, low-level point, etc. One form of ultrasonic liquid-level switch operates on a rather unique principle, not related to either cavitation or echo ranging. A hermetically sealed probe containing a piezoelectric crystal is inserted in the tank to act as a switch at the desired level. The crystal is part of a miniaturized transistor oscillator circuit and vibrates when not surrounded by liquid, thus sustaining oscillations, as in any crystal oscillator. When surrounded by liquid, vibrations inside the probe are damped, the oscillations stop, and a relay in the oscillator output circuit is energized, starting (or stopping) the desired sequence of operations.

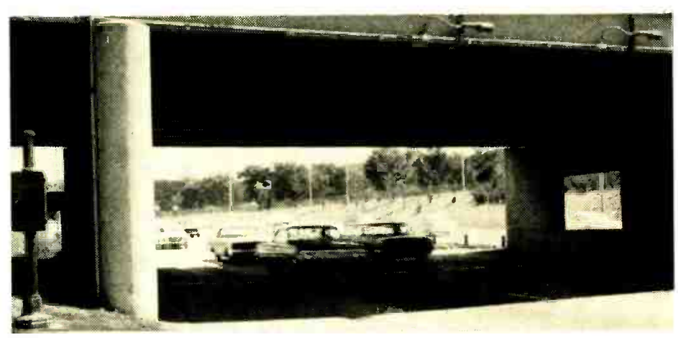
3. *Combustion control.* Acoustic waves provide a possible method for controlling combustion in solid-fuel rockets until burnout. Experimental and analytical studies indicate that the burning rate can be controlled by varying the intensity of vibrational energy applied to the fuel.

An attempt has been made in this article to cover typical industrial, medical, military, and experimental applications in ultrasonics at the present time. Space limitations obviously preclude complete coverage of all significant developments. In addition, there are undoubtedly new developments currently in progress which have not yet been reported to the industry and the public.

It seems safe to predict that coming years will see a continued expansion in many areas of ultrasonics as well as development of a substantial number of new applications. ▲

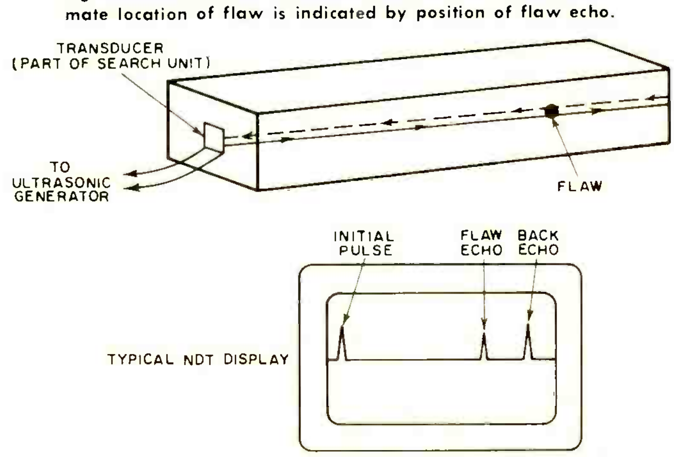


Navy sonar operators view indicator unit providing range and bearing information concerning a nearby submarine.



Overhead ultrasonic vehicle-presence detectors, part of Chicago's Congress St. Expressway traffic-surveillance system.

Fig. 3. Flaw detection with an ultrasonic NDT unit. Approximate location of flaw is indicated by position of flaw echo.



WHY NOT? U.H.F. TWO-WAY RADIO

By HOWARD H. RICE/Motorola Inc.

The 450-mc. two-way radio band has many advantages over the lower frequency bands and may offer the most tangible relief from present-day band crowding.

MOBILE radio communications had its beginnings in April, 1928 when, after seven years of work and frustration, Commissioner William Rutledge of the Detroit Police Department saw his "brain child" become a reality: a reliable radio receiver was installed in one of the department's cruiser vehicles. The first *two-way* mobile radio system was put on the air by the Bayonne, New Jersey, Police Department in March, 1933. By 1937, the FCC had allocated 29 v.h.f. channels (between 30.58 and 39.90 mc.) to police departments.

Power companies became interested in two-way communications and, in 1938, both the *Central Hudson Gas & Electric Company* of Poughkeepsie, New York, and the *Detroit Edison Company* established land-mobile communications networks. The following year, the FCC defined police communications as "Emergency Service" and made provisions for power utility companies to operate radio systems with "Special Emergency" types of licenses.

In 1940, there were only a few thousand such networks in operation, but by 1948 the FCC had opened licensing to many additional services and there were approximately 86,000 land-mobile communications transmitters on the air. Ten years later, the number of transmitters had grown to 695,000! Two-way radio had come of age: more and more organizations were recognizing the contribution radio communications made toward increased efficiency.

The FCC, in 1958, created several additional services, thereby expanding the number of organizations which could qualify for land-mobile radio communications. One of the most important new services was the Business Radio Service, organized under Part 11 of the FCC Rules and Regulations, which allowed virtually any legitimate business, not previously authorized under another part of the FCC Rules, to license a radio system.

But even before the opening of these additional services, the need for more frequency space had become apparent. In an attempt to provide this space, channels were split from 120-kc. bandwidth to 60 kc., and then to 30 kc. (20 kc. in the 25-50 mc. region).

The Electronic Industries Association, in 1959, petitioned the Commission for additional space in Docket 11997. At this writing, a highly controversial proposal is even now before the Commission. Sponsored by the Land-Mobile Communications Section of the EIA, this petition proposes to reallocate television channels 14 and 15 for land-mobile communications needs to relieve congestion.

The Situation Today

The airwaves are crowded. There are close to 2 million authorized transmitters in the land-mobile service. The radio systems represented by these 2 million transmitters are operating on a total of 1300 channels: 600 in the 50-mc. band, 350 in the 150-mc. band, and another 350 in the 450-mc. region. In some cases there are as many as 20 or 30 users on a single channel within radio range of each other. This can produce a lot of interference.

To compound the problem, there is no assurance of interference protection to business radio users. Other services have frequency-coordinating agencies (such as the Associated Public Safety Communication Officers—APCO) which coordinate frequency assignments throughout the country and thus protect the users from co-channel interference.

Furthermore, the distribution of radio systems is not equally divided among the three available frequency bands; the congestion is most severe in the 50-mc. and 150-mc. regions while in some parts of the country the 450-mc. band is relatively unused. Why, then, are so many users still establishing two-way radio systems in the already overcrowded 25-50 mc. and 150-174 mc. ranges when the u.h.f. band seems to offer some relief from the problem of channel sharing? The answers to this question cast some interesting and encouraging light on the critical situation of frequency crowding.

Not that the 450-mc. band is a panacea to all communications channel problems—the Los Angeles area as well as other metropolitan areas are as loaded in the u.h.f. band as they are in the 50-mc. band—but the 450-470 mc. region is far from being saturated throughout the country. For this reason, we might do well to examine this u.h.f. frequency band, for it is this portion of the spectrum which offers the greatest potential for relief from the situation as it presently exists on the communications bands.

The U.H.F. Band

Contrary to the belief of many, the u.h.f. band is not a mere handful of usable channels. There are presently 350 available channels, each with a bandwidth of 50 kc. This is equal to the number of channels available in the 150-mc. region. See Fig. 1.

The major objection to the u.h.f. band has been range; 450-mc. equipment provides less miles per transmitter watt than does equipment operated in the lower frequency bands. Or does it? Fig. 2 shows a base-to-mobile range comparison for a 30-watt base station with a unity-gain antenna mounted on a 100-foot tower, operating in all three frequency bands. Fig. 3 compares the same base station in the 150-mc. and 450-mc. ranges. However, in this second chart the unity-gain u.h.f. antenna has been replaced by an antenna exhibiting 3-db of gain (the equivalent of *doubling* the effective radiated power). The range of the u.h.f. system is now approaching that of the 150-mc. system. In practice, antennas exhibiting as much as 8-db of gain are available for use in the 450-mc. region.

Factors Affecting Range

Another factor affecting range in the u.h.f. region is the relative freedom from impulse noise. In the 25- to 50-mc. region, impulse noise has been known to reduce a system's theoretical range by 10% or more. However, the greatly reduced impulse noise level at 450 mc. means that a signal can usually be "read" all the way out to system limits.

Skip interference, another problem to the lower frequency user, is virtually non-existent at 450 mc. Because of the short wavelengths in the u.h.f. region, the signals tend to penetrate the ionospheric layers rather than be reflected or refracted. Therefore, a 450-mc. skywave being returned to earth is almost unheard of.

A recent series of propagation tests in the Chicago area revealed some interesting facts about desensitization of 50-mc. receivers. The tests were conducted in the "Loop" area, which abounds with high-powered FM and TV transmitters as well as numerous other sources of noise. The desensitization to a receiver operated in the 150-mc. region was 16.9 db. This is not unusual under such conditions; performance degradation of 10 to 25 db may be reasonably expected. The desensitization to a 450-mc. receiver, operated at the same downtown location, was only 5 db.

These results, showing an 11.9-db advantage for the u.h.f. receiver, would indicate a superior range for the 450-mc. system over the 150-mc. system. In fairness, however, we should only say that the two systems would be approximately equal because of the nulls which tend to create dead spots at u.h.f. frequencies. On the other hand, range to a *moving* vehicle—which quickly passes any dead spot—would probably approach more closely the results of the tests.

The 450-mc. band has, for many years, been recognized as a wise choice for systems operating in metropolitan areas. The highly reflective tendency of these short-wavelength signals causes communications to fill in areas (such as between buildings and under bridges) which are shielded from lower frequency coverage.

Yet the u.h.f. band—particularly in view of the crowded channel problems in the lower bands—is not at all an unwise choice for suburban, and even rural communications systems. Only in the 450-mc. band has the FCC authorized mobile relay systems (refer to "Choosing a Two-Way Radio System," Part 2, Electronics World, December, 1963). This arrangement, which uses a relay station atop a building or mountain, is very beneficial in providing extensive area coverage, particularly for mobile-to-mobile communications.

The channel-congestion problem is a critical one. At the present rate of new licenses, the problem is quickly becoming even more critical. Therefore, it is of the utmost importance that we make the most efficient use of all channels which are presently available for land-mobile communications service. There is already a marked increase in activity in the u.h.f. band. More manufacturers are making more u.h.f. equipment available—equipment with improved reliability and operating economy which can meet a wider variety of individual system requirements.

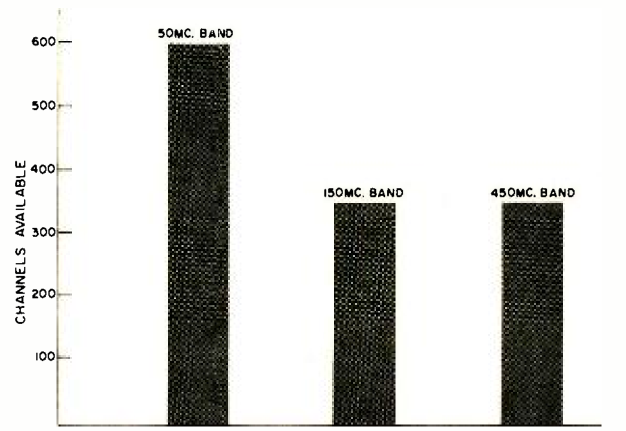


Fig. 1. Channels available in each of the two-way radio bands.

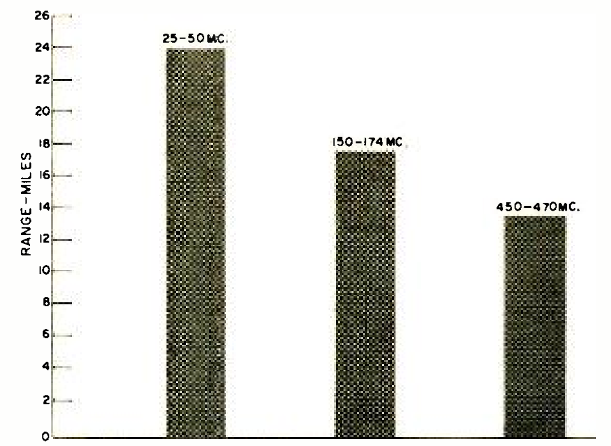


Fig. 2. Range of a typical point-to-point radio system based on a 30-watt transmitter coupled to a 100-foot high antenna.

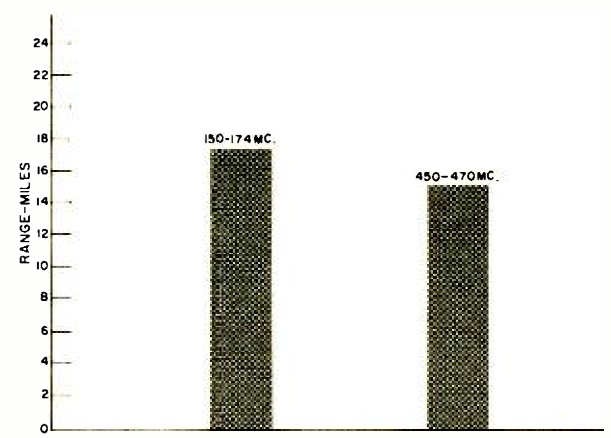


Fig. 3. When a moderate-gain antenna is used at u.h.f., its operating range becomes closer to that of the 150-mc. band.

With proper system design, a 450-mc. system can be made to equal or even surpass the performance of a 150-mc. system. Furthermore, there are some distinct advantages to the u.h.f. band such as noise level, desensitization (in some cases), the use of mobile relay operation, and the generally less crowded channel loading.

As the state of the art advances, there will surely be other answers to the problem. There is still optimistic hope that the FCC will eventually make additional channels available; the Commission is fully aware of, and seems to be sympathetic toward the problem. In the meantime, however, there is a strong recommendation that radio system planning include a careful evaluation of the benefits offered by the u.h.f. 450-mc. band. ▲

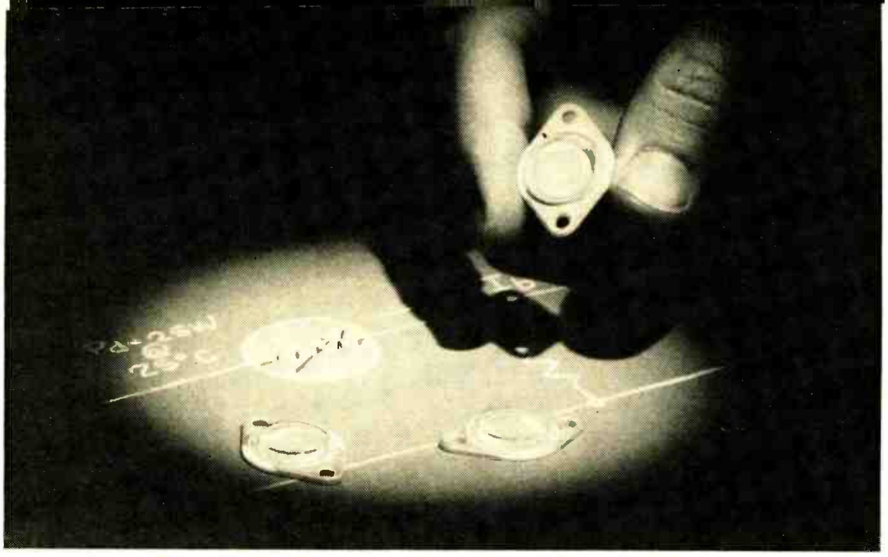


Fig. 1. The Delco type LDR-25 power photocell handles ½ amp.

HIGH-POWER PHOTOCELL

By JAMES E. CAIN/Field Service Engineer, Delco Radio

New semiconductor unit can control 100 watts of power and will operate small motors or large relays directly from line.

WITHIN the broad field of electro-optics, one area that has received relatively little attention up to the past year, but has grown steadily since, is light-sensitive semiconductor devices. These devices, which do *not* use photovoltaic or photoelectric properties in their operation, may be termed *photoconductive* devices.

The recent development of a high-power photoconductive device, known as the LDR-25 (Light Dependent Resistor—25 w.) offers possibilities for many new commercial and industrial control applications. Technicians will find it particularly interesting for experimenting with the control of small motors, especially in view of its low cost (about $1.50). With a ½-ampere current-handling capability and a 25-watt power-dissipation rating, the new cadmium sulfide device developed by *Delco Radio Div.* (Fig. 1) far exceeds ratings of similar devices that have been previously available.

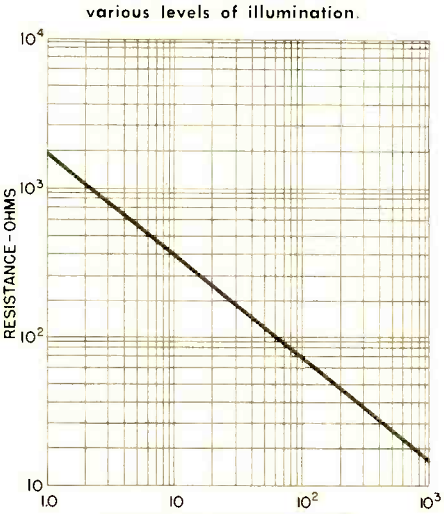
Basic Properties

Photoconductive devices are defined as those in which the number of available charge carriers (electrons) changes as a result of incident light intensity.

Two substances, cadmium sulfide (CdS) and cadmium selenide (CdSe), fall into that category midway between conductors and insulators known as semiconductors. These two semiconductors both exhibit the characteristics of photoconductivity and both normally have very high dark resistance. However, in the presence of light, they decrease in resistance and become better conductors and thus the basic building block of a photoconductive device. The graph, Fig. 2, shows resistance at various illumination levels.

When light energy strikes the semiconductor, much of that energy is absorbed by the material. However, if the light energy is of the proper wavelength, electrons may be broken free from their bonds to the atoms and provide free charge carriers for current. In photoconductors, the photon, which is the basic energy particle of light with specific energy at a given wavelength, will cause the freeing of electrons to carry current.

Fig. 2. Photocell resistance at various levels of illumination.



The wavelength of maximum sensitivity for most photoconductive devices lies within the visible spectrum. As can be seen on a frequency spectrum chart, the visible portion is located between the ultraviolet and infrared frequencies or from just below 4000 angstroms to just above 7000 angstroms. The angstrom unit, which is equal to 10^{-10} meter, is the common unit of light wavelength measurement. Most photoconductive devices attain maximum sensitivity approximately in the middle range of the visible-light spectrum.

General Characteristics

The LDR-25 power photocell is intended primarily for medium- or high-power switching and control applications where switching speeds on the order of tens of milliseconds can be tolerated. It is designed to operate directly from 117-volt a.c. and is conservatively rated at 200 volts d.c. or peak volts a.c.

Because of its high voltage rating and inherently "slow" switching speed, the power photocell is particularly well suited for control of inductive loads where voltage surges encountered with breaker points or junction devices are a problem. Surge currents, up to 1 ampere, of short duration, can be tolerated in some applications.

While the power photocell can be used in a variety of low-power applications, the high power handling capabilities are of prime interest. The LDR-25 is capable of dissipating 25 watts and switching or controlling up to 100 watts. The device, which may be connected directly to the power line, will handle enough power to operate small motors or very large relays. Thus, where applications require servo systems for counting, detecting, or operation cycling, the device provides low-cost control.

Although the device is effective as a non-arcing switch for inductive loads, one of its most promising applications is for controlling the speed of small motors.

When used with captive light sources, the power photocell can provide appreciable power gain as well as complete isolation between control and load circuits. With standard miniature incandescent lights, continuous smooth control of up to 50 watts in the load circuit can be obtained with control inputs of 1 watt or less. When using miniature neon lamps it is possible to switch up to 40 watts with less than 500 milliwatts of input power.

Construction & Mounting

Construction of the LDR-25 power photocell is accomplished with a thin layer of sintered semiconductor (CdS) applied to an aluminum oxide substrate. Hermetic sealing, which is necessary to protect the device from moisture, is accomplished through the use of film adhesives and a glass cap. With this construction it is possible to obtain higher power handling capabilities. However, the devices must be provided with adequate heat sinks when used to handle power. Dimensions of the LDR-25 are shown in Fig. 3A.

In any application of the photocell it is extremely important that it be properly mounted. Conventional heat sinks may be used, with the photocell installed as shown in Fig. 3B. Although the power photocell is a reasonably rugged device, care should be given to the flatness of the surface to which it is fastened. Damage could also occur if the mounting screws are tightened excessively. The use of silicone grease (*Dow Corning* No. 5 compound or equivalent) is mandatory to insure maximum heat transfer.

Motor-Control Applications

Three circuits are shown, utilizing the LDR-25 in three motor-control applications. In all circuits the operating current of the motor must not exceed ½ ampere. However, a starting surge of up to 1 ampere can be tolerated if it is of very short duration.

In the circuit of Fig. 4A, the power photocell is used in series with a motor which can operate at power levels as high as 50 watts.

The application of the LDR-25 shown in Fig. 4B is similar to that shown in Fig. 4A. Here an "on-off" switch is incorporated since the circuit was designed for an electric food mixer. With the LDR-25, an infinite number of speeds is available rather than just a few.

Fig. 5 shows a circuit in which the normal use of the LDR-25 as a control element is subjected to a load monitoring or feedback circuit which serves to maintain a relatively constant motor speed throughout a fairly wide range of motor loading. Lamp *PL*1 is the principal source of illumination on the cell and is adjusted to establish the no-load motor speed. Resistor *R*1 in series with the motor provides an increasing voltage drop as the load increases. The voltage drop causes lamp *PL*2 to increase in brilliance, thereby further decreasing the photocell resistance and allowing more current to flow to help maintain the speed of the motor. Resistor *R*3, in parallel with the photocell, establishes the minimum motor speed.

This circuit was designed for use with an electric sewing machine. The vane between *PL*1 and the photocell is linked to a foot pedal which also controls the "on-off" switch.

Additional Applications

In all applications, care should be taken to establish uniform distribution of light over the entire cell. Concentration of light on a particular spot might very well result in deterioration of that particular section.

Depending on the application, it may be necessary to shield the cell from ambient light which may, if not controlled, affect the circuit operation.

Obviously the applications mentioned thus far do not begin to cover the possibilities.

For example, the device will monitor a flame or heat element in which it "sees" the flame and controls fuel flow to provide a safety valve control in the absence of a flame.

The photoconductive device is also a noise-free potentiometer. Here the applications are many—particularly in hi-fi, radio, television, and test equipment. Usually noisy sliding-contact controls can be replaced by a light-dependent resistor and a fixed resistor whose value is about 20% of the LDR-25 dark resistance. With this combination and a small lamp to control the photocell, a noise-free potentiometer, which is variable by a factor of almost 10,000, is readily obtained.

Other commercial uses include lighting control, both in city-wide street lighting and in automotive headlamps. ▲

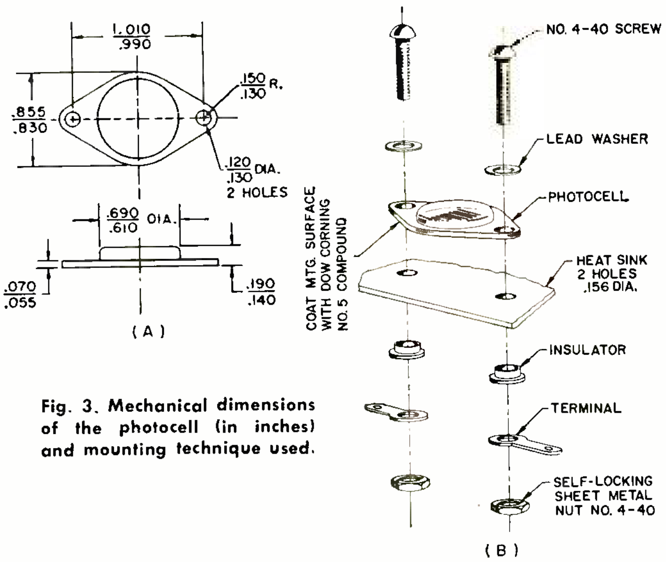


Fig. 3. Mechanical dimensions of the photocell (in inches) and mounting technique used.

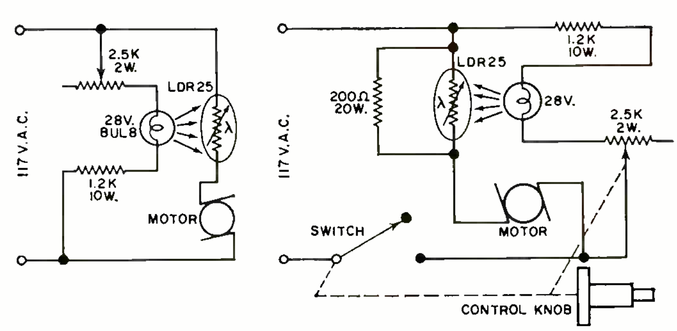
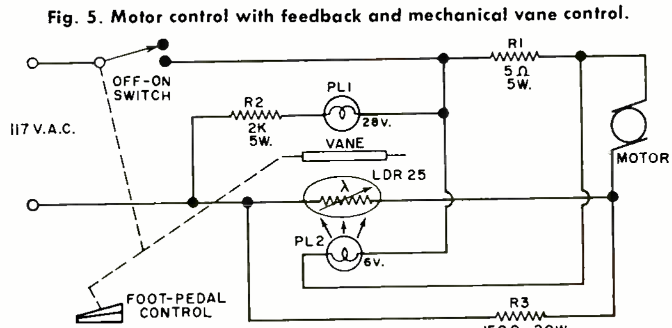


Fig. 4. (A) Basic motor control circuit. (B) Mixer motor control.

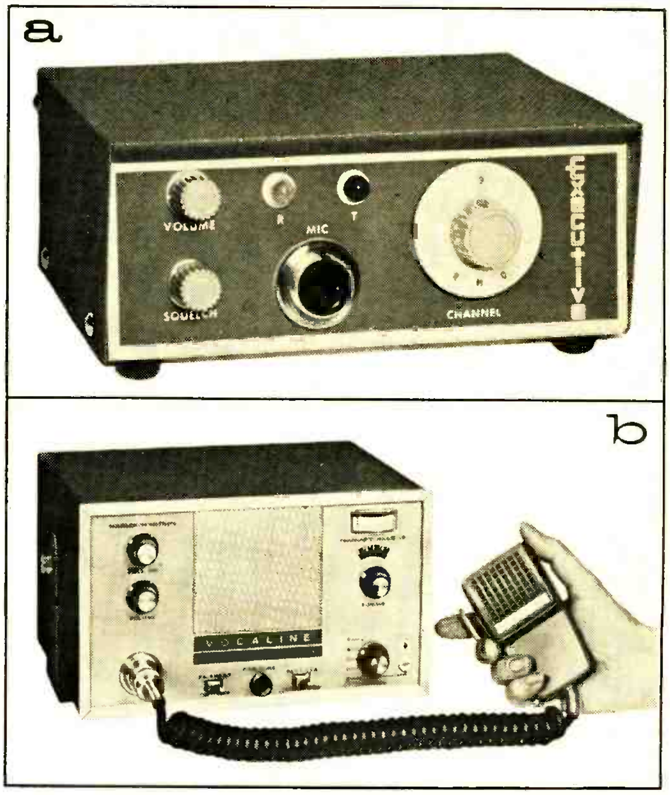
Fig. 5. Motor control with feedback and mechanical vane control.



NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

A remotely controlled transceiver, a transistorized receiver with amplified a.g.c., and an outboard receiver preamp.

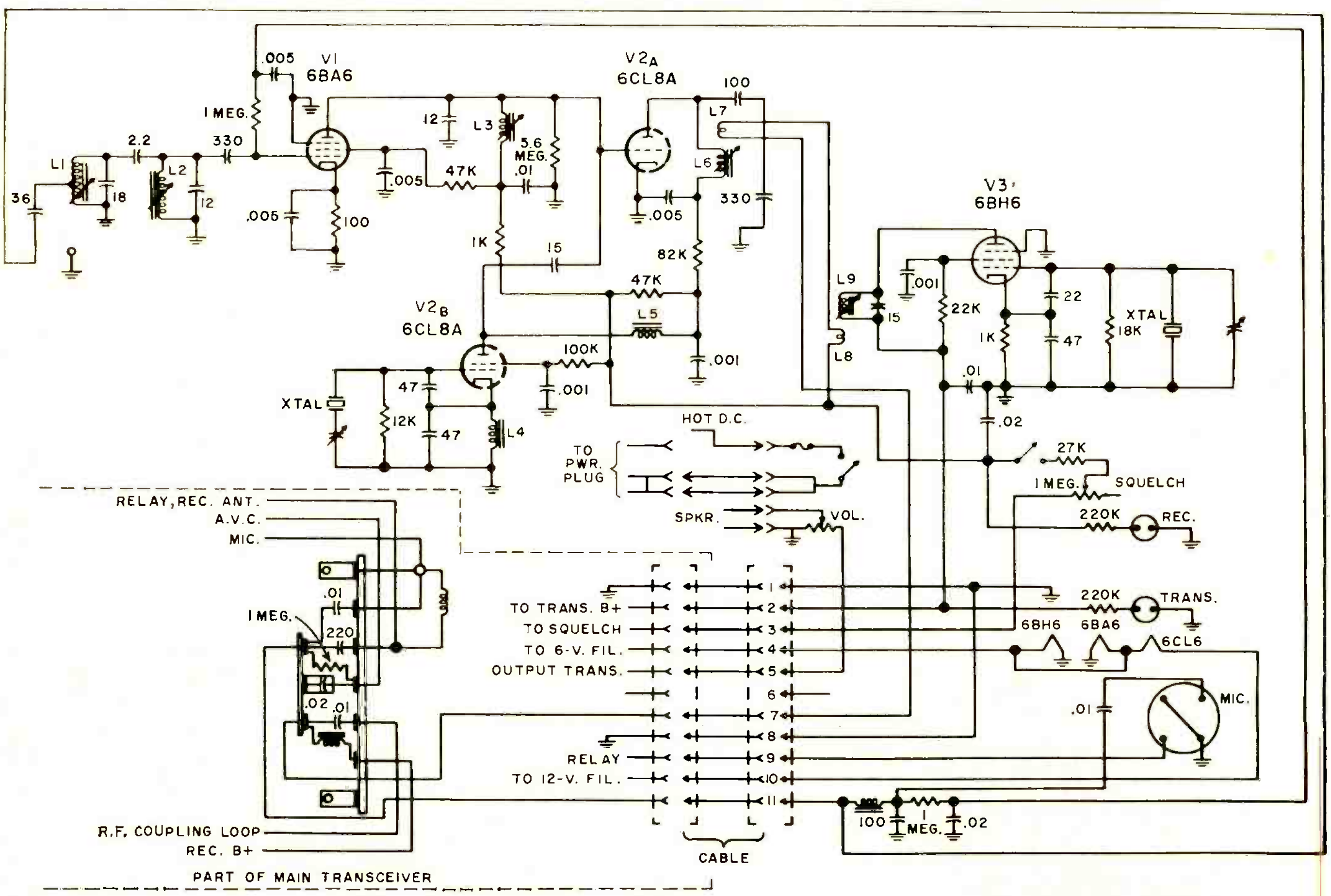


THESE units suggest the trend in CB radio toward more elaborate and specialized circuitry. *International Crystal's* Remote Console, for example, gives the CB operator, for the first time, added flexibility in choosing a mounting position in cramped mobile quarters. *Vocaline* has elaborated considerably on a.g.c. circuitry to provide improved dynamic control of loudspeaker level under the rapidly shifting signal conditions of mobile operation. And, in our last circuit, we'll examine an accessory preamplifier by *World Radio Laboratories* that provides existing equipment with the specific benefits of the nuvistor tube.

(a) International Crystal Remote Control

Due to space limitations in a vehicle, it is frequent practice in two-way radio to mount the basic transceiver at a point remote from the operator. A small control head places the required switches, speaker, and microphone within reach of the operator. Several schemes have been devised for interconnecting a control point with the equipment proper; from rotary solenoids and mechanical cables to all-electronic systems. *International Crystal*[1], in introducing its Remote Con-

Fig. 1. International's remote console contains circuits for receiver front-end and the transmitter crystal oscillator.



sole, utilizes an electronic approach to provide the CB operator with an answer to the problem of installing equipment in a small car, boat, or airplane. The unit measures 2½" h. x 7" w. x 5" d. for convenient under-dash mounting. The bulk of the transceiver may be positioned in a trunk or other out-of-the-way place.

The company's approach to remoting (which works only with its conventional transceivers), is to remove two principal circuit sections from the main transceiver and repackage them in a remote cabinet. The technique lends itself to this manufacturer's favored method of transceiver fabrication; the use of individual printed-circuits for audio, i.f. strip, etc. In this instance, the "converter" and transmitter oscillator are relocated in the remote console. Actually, the "converter" contains the receiver's r.f. amplifier, 1st local oscillator, and mixer.

The schematic of Fig. 1 shows the complete Model RMO–1, the simpler of the two Remote Consoles now being made. (The other is the RMO-9—identical in circuitry except for the addition of a 9-position crystal-selector switch.) At the bottom center of the schematic is the cable interconnection between remote and transceiver units.

Let's consider first what occurs during signal reception. Since the external antenna is connected to the transceiver proper, the signal is sent through a shielded conductor of the cable and applied to terminal 11 of the 11-pin connector. From there it is applied to r.f. amplifier V1. In the next stage, mixer *V2A*, signal is heterodyned with 17-mc. energy from the crystal oscillator (*V2B*). The mixing product is the desired first i.f. on 10 mc., selected by coil *L6*. The coil link *L7* applies the i.f. signal through the cable and back to the transceiver *via* terminal 7. It is then processed by the remaining receiver stages; i.f., detector, and audio. Since the speaker is located at the remote-control point, amplified audio is returned through the line, to terminal 5 on the connector, applied to a volume control, and on to the external speaker positioned near the remote unit.

During transmit, the 6BH6 crystal oscillator (*V3*) is energized and transfers r.f. energy to a link (*L8*) coupled to its plate coil (*L9*). The link feeds the same line (terminal 7) that previously carried the i.f. signal back to the transceiver. Energy, however, now reaches a doubler and final r.f. amplifier for transmission.

Thus, it may be seen that receipt and generation of signals chiefly originate in low-level stages situated in the remote console. Several operating controls, on the other hand, are actually extensions of circuits found in the transceiver. In the case of the "on-off" switch, squelch, microphone, and push-to-talk button, wires have been brought out from the transceiver, with a second control to provide remote adjustment of the speaker. Through shielding and use of low impedance, the effect of the cable path is minimized.

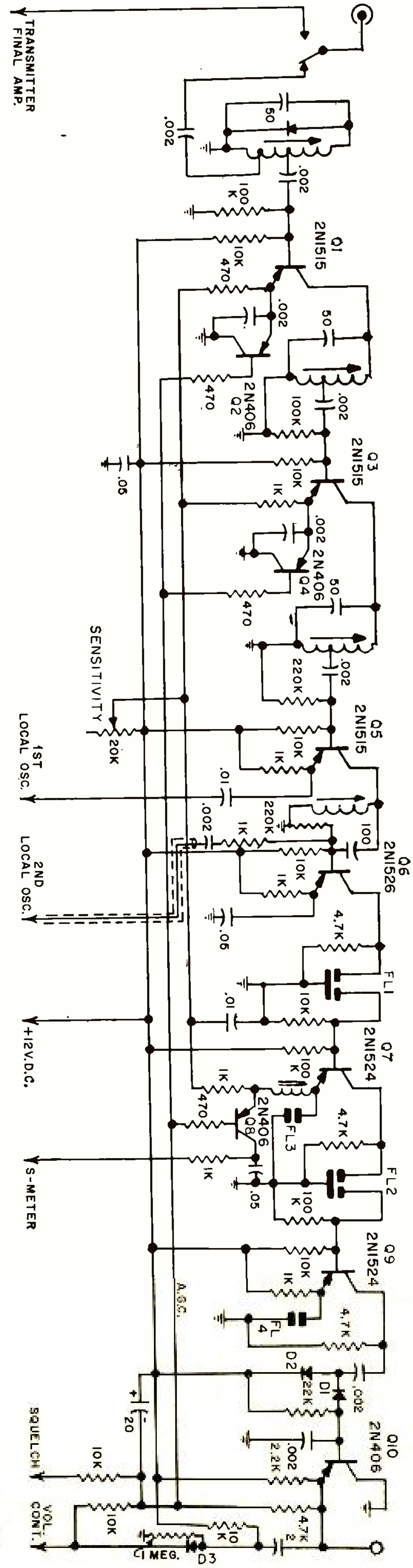
Conversion of the company's Models 50 and 100 transceivers for remote control is principally a matter of removing the converter board and re-installing it in the remote unit (step-by-step installation instructions are provided). The newly introduced Model 500 transceiver is factory-fitted for this type of remote operation and requires no conversion.

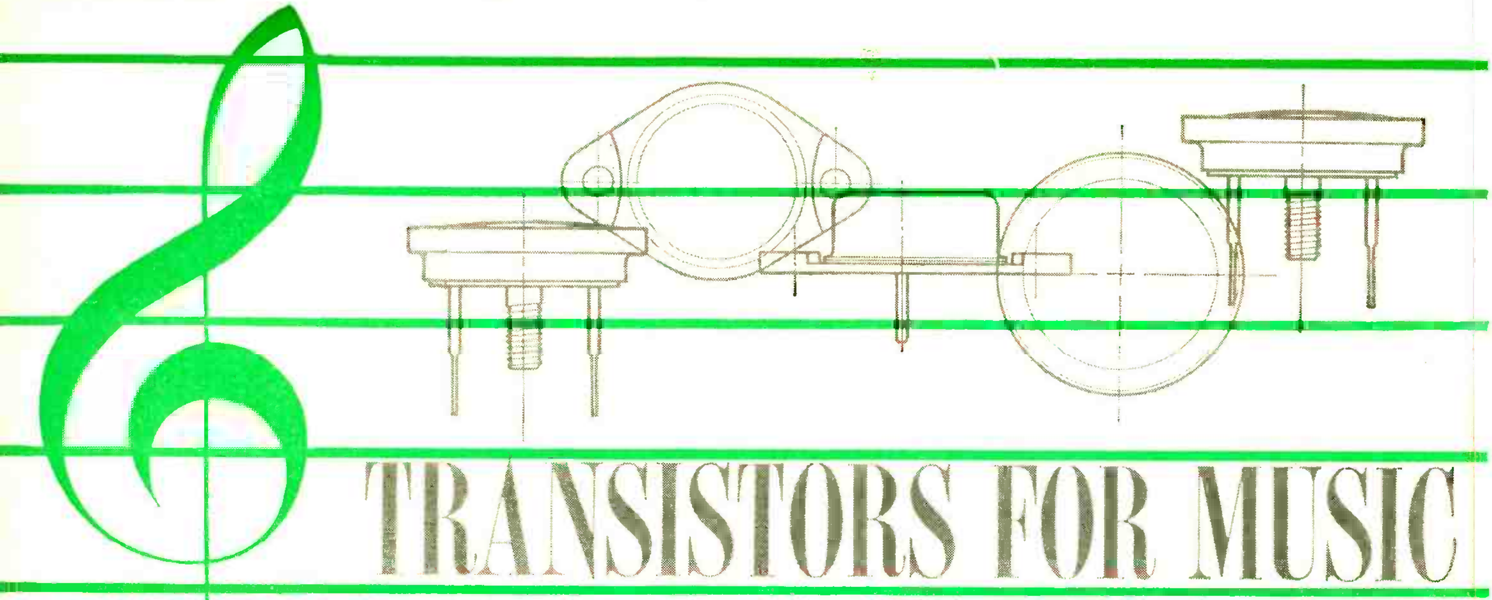
(b) Vocaline ED-276 Transceiver

The function of receiver a.g.c., to keep audio level reasonably constant over a wide range of signal strength, assumes new meaning in CB operation. It can be a safety factor in mobile operation; the fewer volume adjustments by the driver, the better. To achieve precise control of fading and blasting in its new ED-276 transceiver, *Vocaline*[2] has elaborated on the familiar a.g.c. circuit found in most CB units. The customary technique is to sample average carrier level at the second detector and use it to control the gain of such early stages as r.f. and i.f. amplifiers. Although *Vocaline's* design retains the essence of this system, there are significant provisions to keep the action "flat" over a considerable difference in r.f. input. Three control transistors are added to achieve what the company terms "straight-line" a.g.c.

The schematic of Fig. 2 reproduces the receiver of the ED-276 from antenna input to second detector. It is transistorized (although tubes are in the transmit and audio sections) and is novel in its use of two r.f. amplifiers in the front end. These stages, *Q1* and *Q3*, are broadbanded over the 27-mc. CB band by stagger-tuning their respective coils to high, middle, and low sections of the band. Spotted through the i.f. strip are several of the new fixed-tuned ceramic filters (*FL1* through *FL4*) for high selectivity. Other stages are straightforward; *Q5* heterodynes the signal down to 4 mc.; *Q6* (*Continued on page* 75)

Fig. 2. The Vocaline transistorized receiver from antenna to 2nd detector showing "straight-line" a.g.c. circuitry. →





TRANSISTORS FOR MUSIC

The importance of phase shift, transient response, damping factor, noise, and power in the design of a transistor hi-fi amplifier from the viewpoint of a company that believes strongly in the use of transistors for hi-fi.

By ROBERT E. FURST and LARRY ZIDE / Harman-Kardon Inc.

MUCH has already been written, in these pages and elsewhere, regarding the use of solid-state devices in audio components. Pages have been written in an effort to clear the air, only to continue to cloud the truth. Much rumor exists, some of it based on fact, some not. But, one thing is certain. The new technology of transistors requires a new approach to the design of music-reproducing equipment. The standard engineering clichés that fit vacuum tubes must be re-evaluated and changes, if necessary, made in these concepts.

The question may well be asked—why transistors? Why indeed? It is not enough to merely state that they run cooler or are longer-lived than tubes. These are good features, but they are not enough.

The simple fact is that transistors free the engineer from design limitations imposed by the vacuum tube. A transistor component can be made that will significantly improve the reproduction of music at home. In other words, transistors can be used to make equipment *sound better* than their tube counterparts.

This cannot be done by applying tube notions and prejudices to component design. A completely fresh approach must be taken, both in the actual design and in the parameters that are established as a design goal.

The "Transistor Sound"

Almost anyone who has heard a good transistor component will readily concede that it sounds different from a comparable tube unit. (Note that we did not say necessarily *better*, only *different*.) This admitted difference has been referred to as "transistor sound." Is there a transistor sound? Yes, indeed there is.

It has already been stated that a transistor product can sound better than an otherwise comparable tube set. In listening tests conducted by the authors and others, a transistor amplifier of careful design revealed more of the musical nuances that make a concert-hall experience what it is, than did the best of tube units. The most obvious reaction was as if a curtain were lifted, clarifying to a greater degree than before what existed in a musical recording. This, if anything, is the "transistor sound" at its best.

Of course, we have encountered transistor amplifiers that had high distortion and they certainly sounded different, but not better. Since the mere use of transistors does not guarantee *better* sound, what does?

Bandwidth

In a recent article in these pages ("Transistors for Hi-Fi," Sept. 1963 issue), D. von Recklinghausen and his associates made the following statement: "The full power output of the amplifier should, of course, be available for music and not for inaudible signals. Therefore, the response of an amplifier should be flat in the audio range and then cut off rapidly beyond. Extending the range is actually harmful and does not result in better performance."

Certainly, the author of these words agrees that reproduction of the audio range should be as good as possible. How, then, does he reconcile his statement with the following facts?

D. L. Pliminow of the French National Center of Telecommunication Studies performed a series of experiments directly related to this controversy.

Using two groups of pulses fed to a special "Ionophone" speaker system, the response of the listeners to transients was evaluated. The first series of pulses was passed through a variable low-pass filter and the listeners were then asked for their reactions to the differences between these sounds and completely unfiltered ones. The results published by Pliminow indicated that listeners *could* detect the effect of cut-offs at 20,000 cps and *higher*, irrespective of age or hearing ability. Cutting off all frequencies beyond 20,000 cps resulted in an audible change of quality *within* the accepted audible range.

The basic theory of *RC* networks states that a reactance limiting the frequency response at 30,000 cps will introduce significant phase shift into the entire audio spectrum even though the amplifier's gain continues to be flat. The effects of this phase shift will be audible.

Of course, allied component problems exist that make restricted bandwidth desirable at times. High turntable rumble, tonearm resonances, poor multiplex carrier rejection, and the like, can all have their destructive effect on musical enjoyment. But, genuinely good associated equipment does not exhibit these characteristics. Is it right, then, to design an amplifier to the level of the poorer tonearms and tuners on the market? But at the same time, control centers should have *switchable* filters to permit the user to decide for himself when sub- or supersonic problems should be eliminated. (Interestingly enough, the owners of most wide-band control centers tend to prefer the annoyance of a slight rumble to the musically destructive effect of a 20-cps filter.)

Transient Response & Phase Shift

Square waves are the basic tool used for the measurement of transient response and phase shift in an amplifier. These two forms of signal distortion are interrelated. Square waves provide a graphic display of rise time, frequency linearity, and phase shift. These factors must be taken into account when seeking added realism in reproduced music.

In the recent article in these pages, already referred to, Mr. von Recklinghausen made reference to the classic experiment involving square waves and phase shift. In this test, performed in the 1920's by sonic pioneers Fletcher and Munson, a square wave drawn on film was played back to listeners. Then it was played back with the fundamental frequency shifted 180°, 90°, and several intermediate values. The listening panel found *no* audible differences. All the square-wave sounds were alike, no matter how phase was shifted.

It is impossible to state what effect the associated equipment of the period had on this sort of experiment. But, of greater importance, is the ear's ignorance of what a square wave should sound like. An experience of one of the authors is noteworthy in this connection. During a stay in British East Africa, he was exposed to the local language—Swahili. At first the language sounded as if a single gutteral sound were being repeated continually. However, when his ear was "educated," Swahili emerged as a beautiful and musical language with subtle inflection changes that could alter the entire meaning. What was a single incomprehensible noise to the uninitiated was, in reality, a world of communication *to the trained ear*. So it is with the sound of square waves.

Bell Laboratories, in a series of experiments, declared that listeners were unable to discern two separate sounds when a pair of clicks were spaced less than one-quarter of a millisecond apart. From this Mr. von Recklinghausen deduces that phase shift in an amplifier is unimportant and square-wave pictures meaningless. Yet, later experiments on stereophonic perception (also by *Bell Laboratories*) have shown a shift of *two microseconds* is noticeable.

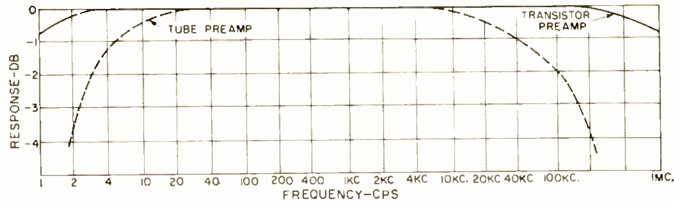
In a recent series of experiments conducted in our laboratories, aural perception of phase distortion was clearly demonstrated. An ultra-wide-band amplifier with flat response to below 2 cps had a decade switch installed that would increase from minimum the phase shift at 20 cps, in increments of 3°, while maintaining constant amplitude. Without exception, trained and untrained ears alike were able to discern distinct bass-response and quality differences as the switch was moved while the music was playing. Hence, a 3° difference in phase *at 20 cps* is readily audible.

Phase shift is additive. Its significant improvement in any part of the chain can provide startling upgrading of a music system's sound. The inevitable conclusion is that ultra-wide bandwidth, coupled with the best possible phase linearity, is the desirable engineering goal. These characteristics are best measured by means of a square-wave display at the upper and lower extremes of audibility.

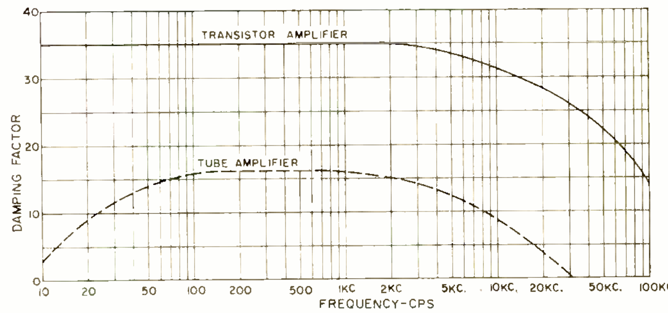
Damping Factor

Damping factor, or the ratio between the load impedance and the internal impedance of the amplifier, plays a vital part in a speaker's ability to follow the complex signals fed into it. High damping ratios, particularly in the bass region, will provide the listener with tight, firm bass response; but how high do damping factors have to be?

All loudspeakers color sound because they are not fully capable of following the amplifier. The higher the damping factor of the amplifier, the more faithfully the speaker will follow the precise contour of the impressed signal. The final limitation is the resistance of the connecting wires. Obviously, this should be as low as possible. Resulting damping-factor curves are logarithmic in nature and we feel that a damping factor higher than 20 is required for ideal sound reproduction.



Comparison between the frequency response of Harman-Kardon's "Citation I" tube preamplifier and "Citation A" transistor unit.



Damping factors for typical tube and transistor amplifiers.

Nominal impedances of speakers are just that. A 16-ohm system might actually show an impedance bump at its resonant point going up to 100 ohms. This is all the more reason for providing the highest possible damping factor.

The damping factor of tube amplifiers is limited by the poor phase linearity of even the best output transformers. This is particularly true at frequencies below 50 cps where the shunting effect of the primary inductance reduces both the feedback and the damping factor at the rate of 6 db per octave.

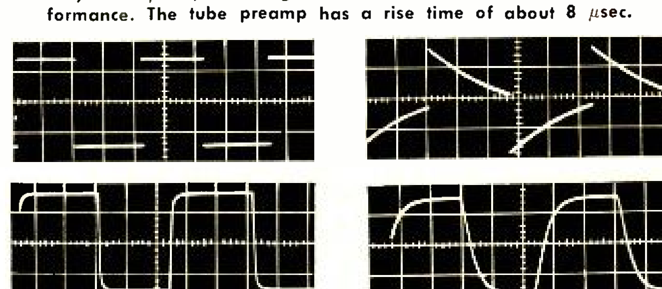
A well-designed tube amplifier may have a damping factor of 15 to 17 at mid-frequencies, dropping to 7 to 12 at 30 cps. Transistor amplifiers, if they are transformerless, can provide factors of 70 to 75 into a 16-ohm load, or about 35 into an 8-ohm, and over a very much wider frequency range. Thus high damping is preserved where it is needed most—at extreme bass frequencies.

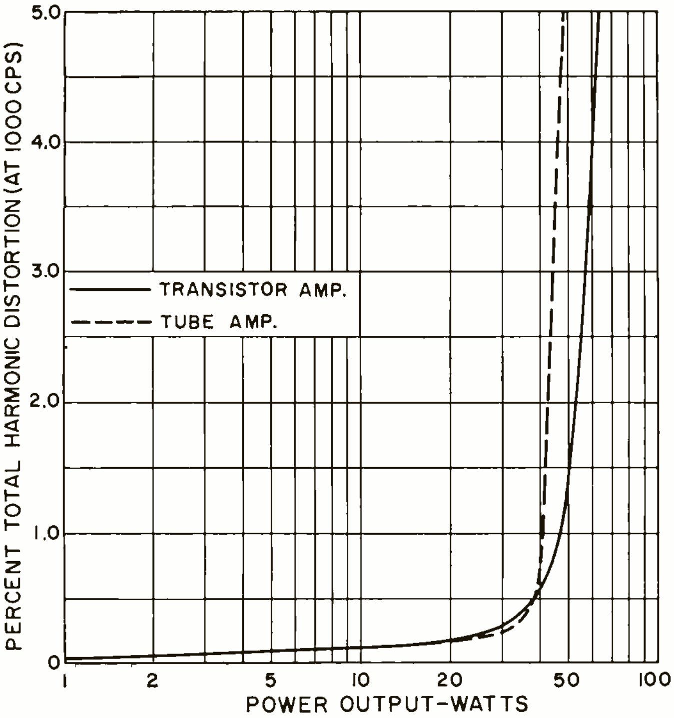
It is also worthy of note that virtually all loudspeaker manufacturers are pretty much in agreement on the desirability of high damping factor.

Noise

How do transistor components compare with their tube counterparts in the production of total noise? Our earlier

Comparative square-wave performance of transistor preamp (2 waveforms at left) and vacuum-tube preamp (2 waveforms at right). The top waveforms are at 20 cps and they show the low-frequency performance. Severe phase shift in the tube preamp produces the tilt shown. The bottom waveforms are at 20 kc. The rise time of the transistor preamp is only 0.3 μsec., showing its extended high-frequency performance. The tube preamp has a rise time of about 8 μsec.

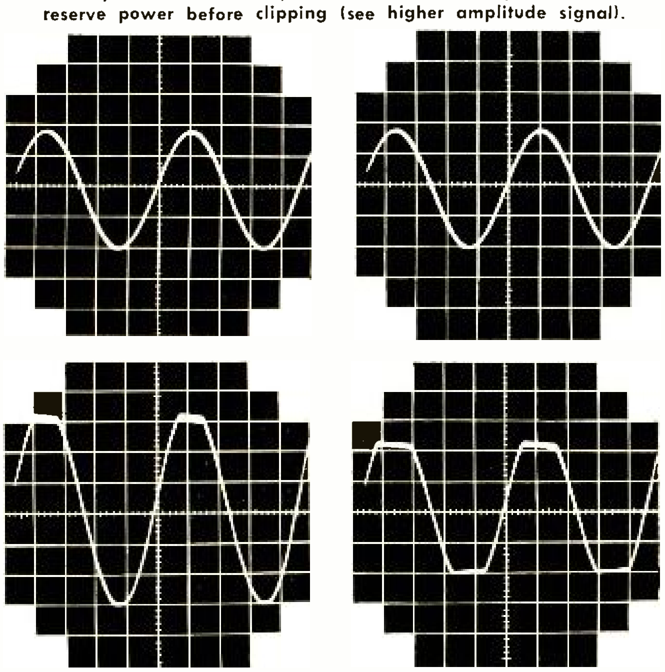




Harmonic-distortion characteristics of typical tube and transistor amplifiers, both of which would be nominally rated at 40 watts output. In this case note that, although both amplifiers have equally low distortion up to about 40 watts, the distortion curve for the tube amplifier rises somewhat more sharply above this power.

author showed us a graph to prove that tubes produce less noise but at a higher source resistance. This is true enough. But note that transistors show their best noise characteristics when fed from a low-impedance source. Tubes, on the other hand, will be quietest at very high source impedances. With top-grade components, cartridges, tuners, and preamplifiers universally employing low-impedance outputs, the transistor amplifier is operated to further noise-elimination advantage. The net result is that in typical circuit use, the transistor circuit will show at least 6 db lower total noise than will the tube circuits.

Comparative power-output and overload performance of transistor power amplifier (2 waveforms at left) and vacuum-tube power amplifier (2 waveforms at right), with sine-wave inputs. The upper waveforms show the waveforms at the maximum rated output power of the two amplifiers. The lower waveforms show what happens during a peak-power overload condition. Note how the tube amplifier begins to clip immediately when rated power is exceeded, but the transistor amplifier shows reserve power before clipping (see higher amplitude signal).



In short, a transistor product can be significantly quieter than its vacuum-tube counterpart.

Distortion

Mr. von Recklinghausen argues that slight differences in the type of distortion are unimportant, thus concluding that tubes and transistors are similar in this respect. This does not stand up when the acoustical effects of the lower phase distortion, which is due to wider frequency response, are considered.

He also states that harmonic distortion curves show a rounded, gradual knee with transistors and a steeper one with tubes. This need not be so. Transistor components can be designed with lower harmonic distortion for equal power ratings. The transistor distortion curve can be just as steep as for a tube circuit with lower starting points.

However, transistor-amplifier design has usually revolved around class-B operation. In this design one half of the output stage works while the other half rests; the output signal is switched from one side to the other. This results in a fixed, measurable switching, or notch, distortion. Since it is fixed, it is usually most obvious at low power outputs, tending to be masked at high listening levels.

Most, but not all, tube amplifiers are operated class AB, or one of its variations. Of course, notch distortion does not exist. The reader is left with the impression that transistor amplifiers have inherently higher distortion figures due to switching transients. Actually, notch distortion, although very strident to the ear, is not readily apparent in the classical total harmonic or intermodulation distortion measurements. Consequently, class-B amplifiers that measure "low distortion" may sound quite raucous. Here is another area in this new technology where the standard form of amplifier evaluation is subject to review.

It is not necessary to design transistor amplifiers for pure class-B operation. This company has designs in production where class-A or AB operation is used up to about 30% of full power output. Then, the amplifier is crossed over to a normal class B type of operation. The result is total elimination of the painful effects of notch distortion.

Amplifier Power

A watt of power is the same whether it is produced by a transistor amplifier or a vacuum-tube amplifier. Why, then, the often-heard statement that transistor amplifiers seem to have greater power than equally rated tube units?

The answer lies in an examination of *peak* power availability. Oscilloscope examination of music waveforms will reveal that the clipping point for peaks is much greater than on a comparable tube unit. The peak power available from a transistor unit is much greater than the usual "two-times the steady-state power" that applies to tubes.

An examination of the mechanism involved shows why. An output device is really a changing resistance placed between the load impedance and the direct-current power-supply source. In a tube set, the maximum current available is limited to the plate current supplied at zero bias voltage. This limitation is not placed on a transistor. The only limit is the saturation resistance of the transistor and the internal impedance of the power supply. Since transistors are operated well below this point, they have a large built-in power-surge factor. It is not unusual for well-designed transistor amplifiers to have peak-power capabilities of three to four times the steady-state values.

The result is an amplifier of 40 watts steady-state rating that may have far greater audible power reserve than a 60-watt tube unit. ▲

NEW TV DESIGNS FOR 1964

This year shows several new design changes both in circuits and components with many of the new ideas being shared by a number of the set manufacturers.

By WALTER H. BUCHSBAUM

THE 1964 crop of television models can be characterized simply by the phrase "bigger, smaller, and better." Some inexpensive models are available with bigger picture tubes, a number of manufacturers have introduced smaller sets with 9" and 11" tubes, and all of the circuit changes are designed for better performance. The use of high-gain frame-grid tubes started a few years ago and this year practically all sets employ these new tubes. Because of closer element spacing, frame-grid tubes offer gains not previously possible and therefore receivers with only two i.f. stages have as much, or more, sensitivity than older sets with three or even four stages. This gain is obtained by using the new high-gain tubes in the tuner, the i.f., and the video amplifier. The availability of picture tubes with lower cut-off voltage has hastened the arrival of the 23" a.c.-d.c. television set.

In color TV, 1964 has brought practically every major manufacturer into the game, but there are still only two basic models. The *RCA* CTC-15, which now takes the pioneering place of the old *RCA* 630, is offered by many manufacturers in their own cabinets. The second basic model is the *Zenith* color set which has been slightly modified since 1963, but still uses its unique high-level demodulators.

More details concerning color and monochrome receivers are given below, but certain common circuit trends which make the 1964 models different from their 1963 predecessors can be pointed out. All sets in 1964 will be delivered with u.h.f. tuners included in accordance with the FCC requirement which goes into effect in April. Horizontal blanking is finding wide application. The reason for this is the sharpening of the sync pulse at the transmitter and the resulting transient which can occur during flyback interval to cause a vertical white stripe. Horizontal blanking eliminates this. In other areas, various circuits are used to make the a.g.c. more effective in sets using only two i.f. stages, while vertical sweep circuits use stabilizing features, such as thermistors, to prevent loss of height due to warm-up or line-voltage variations.

Improved sync separator circuits and variable video peaking are offered by many manufacturers. This latter feature permits control of the high-frequency response of the video amplifier to "snap-up" received pictures.

Another innovation is a picture tube which requires no safety glass because it is implosion-proof. By placing a prestressed steel band around the rim and a fiberglass backing around the funnel, all danger of an implosion is removed. If the tube breaks, the glass is caught safely in the fiberglass and no damage is done to the rest of the set or to the viewer.

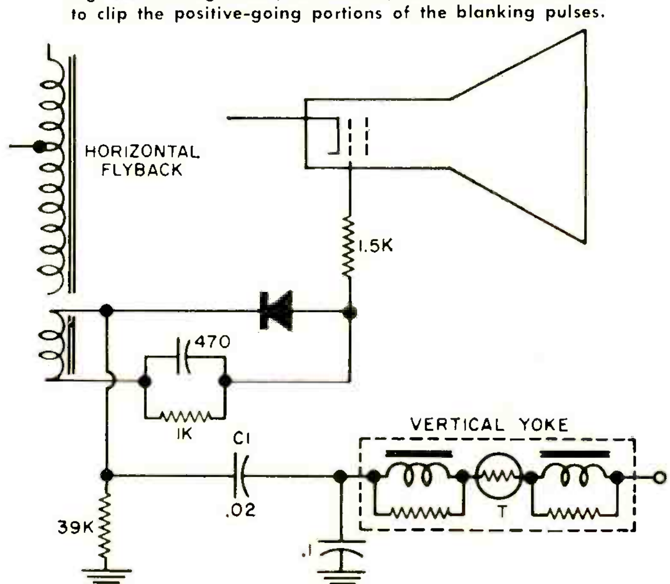
A description of new 1964 circuits follows under the alphabetical listing of TV manufacturers. Practically all of these manufacturers offer a color set but, except for *Zenith*, the *RCA* CTC-15 circuits are usually used.

Admiral

This manufacturer uses the same basic circuit for the 11-, 16- and 19-inch portables, but there are no new circuit features in these sets. The 23-inch model, however, contains a number of circuit innovations over last year. The picture tube is the new, implosion-proof type and one new control has been added for the customer's use. This control is a rheostat connected across a video peaking coil, making it possible to change the video response from slight ringing or "crisping" to the point where fine lines appear smeared. When turned to one end, this control will make old movies appear crisper while at its other extreme it will "wash out" the effect of snow in the picture.

The horizontal blanking circuit used in the *Admiral* 23-inch model differs from those found in many other sets because it has a separate winding on the flyback transformer and uses a diode as shown in Fig. 1. The diode clips off the positive-going portion of the blanking pulse, allowing only strongly negative horizontal and vertical pulses to reach the control grid of the picture tube. The vertical blanking is provided through *C*1 which is connected to the low end of the vertical deflection coils. Another feature of the same

Fig. 1. Blanking circuit, featured by Admiral, uses a diode to clip the positive-going portions of the blanking pulses.



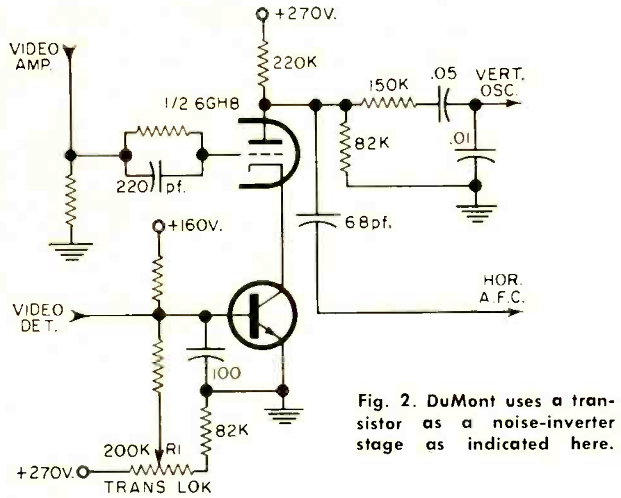


Fig. 2. DuMont uses a transistor as a noise-inverter stage as indicated here.

chassis is the means for varying the picture width. A jumper is used to short out a portion of the horizontal output tube screen-grid resistance network, controlling sweep power by controlling the screen voltage.

DuMont

While most models use well-established circuitry, the 120692-A may well be unique this year as the first set which uses a transistor together with the usual vacuum-tube complement. This single transistor performs the noise inversion function in the sync separator and its circuit is shown in Fig. 2. The cathode of the sync separator stage goes directly to the collector of an *n-p-n* transistor which receives the signal from the video detector. Negative-going sync and noise pulses are inverted in the transistor so that they appear positive-going at the cathode of the 6GH8 sync separator. The grid of that tube receives positive-going pulses from the video amplifier, so that noise pulses riding over the sync pulses will be cancelled out in the tube. To control the amplitude of the transistor signal, the base d.c. bias is set by *R*1, the "Trans Lok" control. If the amplitude at the collector is too high, the amplification of the sync pulses themselves will be reduced. The "Trans Lok" control is set as a secondary adjustment for good locking action under worst noise.

Emerson

Announcing that the time for a.c.-d.c. television models is definitely here, *Emerson* has equipped its 16- and 19-inch portables with a polarized line plug. Sets using remote control and those having an electric clock can only be used on a.c. This company's sets now feature a new version of a horizontal sweep circuit which combines the a.f.c. control and oscillator in a single stage and uses a resonant *LC* circuit between the grid and cathode. Another novel circuit feature is the application of some of the a.g.c. bias to the grid of the video amplifier. This gives better a.g.c. action in sets using only two intermediate-frequency amplifier stages.

General Electric

As the originator of the Compactron, the single envelope-multiple function tube, *G-E* uses as many as 8 Compactrons in the LY and AY chassis. The SY chassis features an 11-inch rectangular picture tube and uses 6 Compactrons, 3 conventional tubes, and 2 diodes with a transistor u.h.f. tuner, probably the 1964 TV set with the fewest tube envelopes. In addition to very extensive use of the implosion-proof 23DYP4 the new *G-E* line follows the over-all trend in using horizontal blanking and single rectifier power supply.

The LY models, which have power transformers and parallel filament tubes, use a single silicon rectifier for half-wave rectification for the entire set. In those models offering photoelectric automatic brightness control, this feature can be disabled by a switch and, when it is operating, controls not only the picture-tube brightness but also affects the contrast because it is connected as part of the a.g.c. bias network.

Magnavox

This manufacturer continues to use three i.f. stages in all models and applies horizontal blanking in some. A unique video detector and a.g.c. circuit is used in the 16-inch models. In this circuit, the i.f. signal is applied to the cathode of a triode with the control grid acting as the plate to furnish the detected video signal and 4.5-mc. sound i.f. to the video amplifier. The plate of the triode is connected as a rectifier to produce the a.g.c. bias. A potentiometer in the plate load controls the amount of a.g.c. supplied to the tuner and the first two i.f. stages. While this model does not have keyed a.g.c., other models have conventional keyed a.g.c. Technical details of the new line for the summer of 1964 have not been announced at the time this article was written

Motorola

This manufacturer expects to release a new line of models during the middle of 1964 which will include a number of circuit innovations, but the "early '64 line" uses basically the same chassis as the '63 line. While complete data on the "late '64 line" is not available at the time of writing, some of the new features are already known. *Motorola* will go back to using doubler circuits in its power supply which will permit the firm to use picture tubes having a higher cut-off voltage and other tubes in the set which require the higher voltage. The available 250-volt "B+" will also enable the company to use the two i.f. stages in d.c. series, a technique also used in the 1964 *Zenith* color sets. It has the advantage of preventing a.g.c. "charge-up" and produces a more linear a.g.c. action. As will be explained in connection with the *Zenith* circuit, the a.g.c. bias applied to the first stage also affects the second stage because of the series d.c. connection.

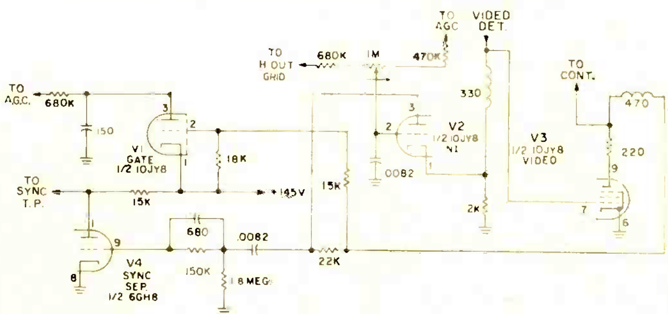
Olympic

This company follows the general trends closely this year, using Compactrons and frame-grid tubes widely in all models. The 16- and 19-inch portables have horizontal blanking, provided by a special winding on the flyback transformer. In other respects this company's circuitry is not substantially different from the 1963 models.

Philco

While *Philco* joins other manufacturers in several new 1964 features, a novel noise eliminator and a new deflection yoke in which the horizontal windings are wound as toroids are unique. Much greater deflection sensitivity and therefore a reduction in deflection power are obtained by the new yoke. The noise eliminator uses a grounded-grid amplifier with adjustable bias to control the level of the sync pulses which are then fed out-of-phase to the sync separator. Fig. 3 shows how the signal from the video detector is applied to the cathode of the grounded-grid amplifier *V*2. Gain of that tube is controlled by varying the bias on the grid. At the

Fig. 3. Philco's noise eliminator uses a grounded-grid amplifier with adjustable bias to control the sync pulse level.



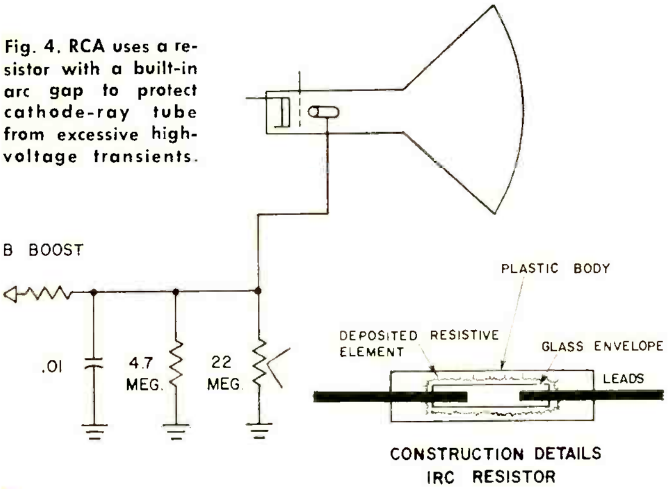


Fig. 4. RCA uses a resistor with a built-in arc gap to protect cathode-ray tube from excessive high-voltage transients.

plate, the amplified pulses, noise and sync, appear negative-going and are applied to the grid of the sync separator *V4* together with the signal from the video amplifier *V3*. The positive and negative noise pulses cancel each other, providing the sync separator with relatively noise-free sync pulses. The level of the bias control is set for best sync locking action on the station having the worst noise conditions.

RCA

This company has a number of new circuit features which distinguish its 1964 color and monochrome sets from the 1963 versions. In the monochrome area, the KCS 142 and 146 chassis have several novel features. D.c. coupling is used in the video section so that d.c. restoration is not necessary. A new, simplified automatic-brightness control, which is available in some models, consists of a light-sensitive resistor, shunted by a potentiometer, to control the level of automatic control. To protect picture tubes from arc-over due to static charges, a problem becoming more pronounced because of the higher anode voltages being used, a special 22-megohm resistor is connected as ground return of the first anode. As illustrated in Fig. 4, this resistor has a glass body coated with the resistance element. Inside the glass envelope, an arc gap is provided so that a static discharge can take place safely.

With the advent of universal u.h.f. tuners in TV sets it has been found that "snivets" or Barkhausen oscillations in the horizontal output amplifier, not visible on v.h.f. sets, become a problem with u.h.f. reception. To eliminate this, the suppressor grid of that stage, normally returned to ground together with the cathode, is connected to a low positive voltage for u.h.f. reception. While this reduces the efficiency of the output amplifier slightly, it gets rid of "snivets." Another occasional u.h.f. interference results from transients due to the silicon rectifier action. In all new *RCA* sets, these rectifiers are mounted on feedthrough r.f. capacitors to bypass the transients.

The new color set, chassis CTC-15, serves as model for practically all of the other manufacturers with the exception of *Zenith*. As compared to the 1963 color sets, the CTC-15 still uses the same basic circuits and tubes, but with some novel improvements. As described for the *Admiral* 1964 models, the *RCA* color set has a special video peaking control which permits "crisping" or "smearing" the brightness signal. It does not affect the color portion.

In the flyback section, an "adder" voltage circuit uses a separate diode to increase the normal 800-volt boost voltage, as shown in Fig. 5, for use on the picture-tube screen grids. A less filtered portion of this voltage provides 1200 volts to the vertical oscillator. Another diode has been included in the high-voltage cage to provide the picture-tube focus voltage. This diode replaces a rectifier tube, saving the filament power required in last year's model and thereby reducing the power required from the flyback transformer. The rectified voltage is adjusted by a slug-tuned transformer, as shown in the circuit of Fig. 6, which varies the pulse fed to the cathode side of the rectifier.

To improve high-voltage regulation when predominantly bright pictures appear, a 12-megohm resistor is connected from the 3rd video amplifier to the control grid of the regulator tube, as shown in Fig. 7. During "white" pictures, more anode current is drawn through the picture tube, which would reduce the high voltage. At this time, the negative-going voltage at the video amplifier reduces the regulator grid voltage causing it to reduce its current thereby increasing the high voltage. The long time constant of the 12-megohm resistor and the .01 μf. capacitor insures that this compensation occurs only during relatively long periods of high brightness levels in the picture.

Setchell-Carlson

This company offers no important new circuitry in its monochrome receivers, but continues use of the "unitized" chassis construction. With the advent of color TV, *Setchell-*

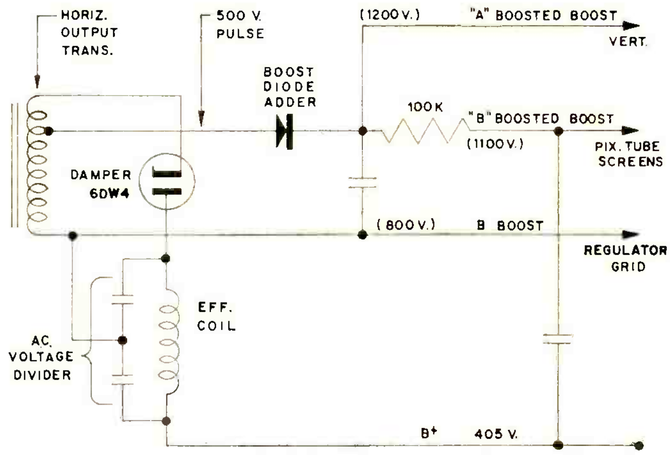


Fig. 5. An extra diode is used in the RCA high-voltage section to further increase the level of the boosted voltage.

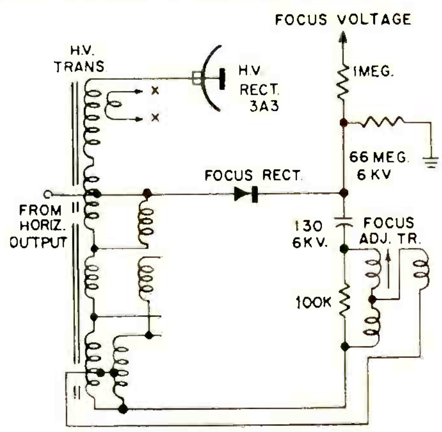


Fig. 6. RCA uses a diode to replace the rectifier tube in the focus voltage circuit. Voltage is adjusted by slug-tuned coil.

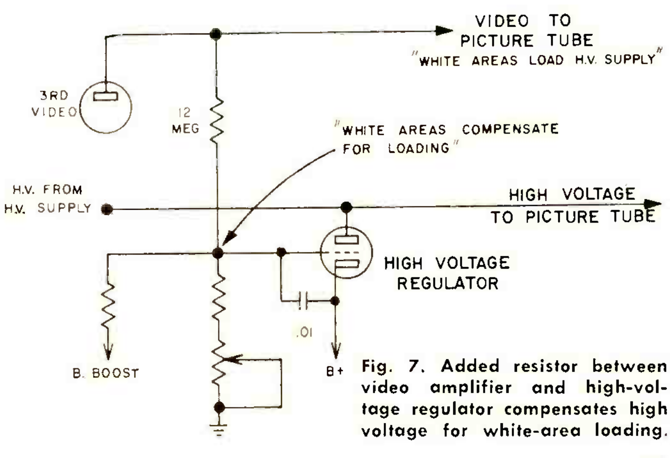


Fig. 7. Added resistor between video amplifier and high-voltage regulator compensates high voltage for white-area loading.

Carlson has extended the unitized chassis technique to the color models. The major set feature is that the entire color section can be removed as a subchassis from the main frame and the receiver will retain its monochrome performance.

While the *RCA* CTC-15 circuit is used, a unique circuit feature of the new *Setchell-Carlson* color set is the use of a special diode to rectify some of the flyback pulses for driving the screen grid of the horizontal output amplifier. This reduces the current through that tube to a safe value in the event the horizontal sweep signal is missing.

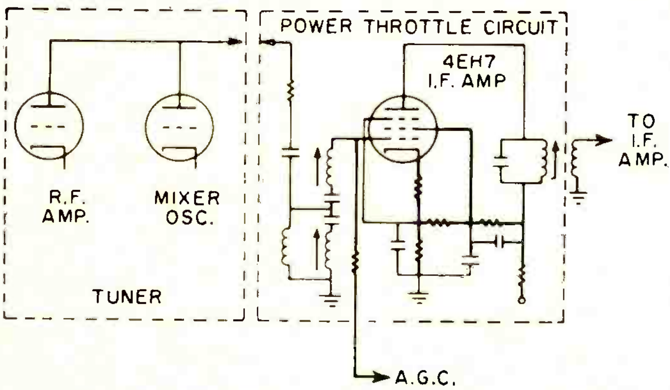


Fig. 8. Sylvania features a unique form of a.g.c. system.

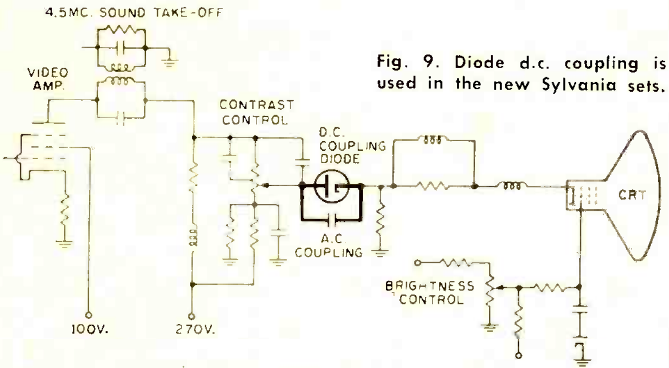


Fig. 9. Diode d.c. coupling is used in the new Sylvania sets.

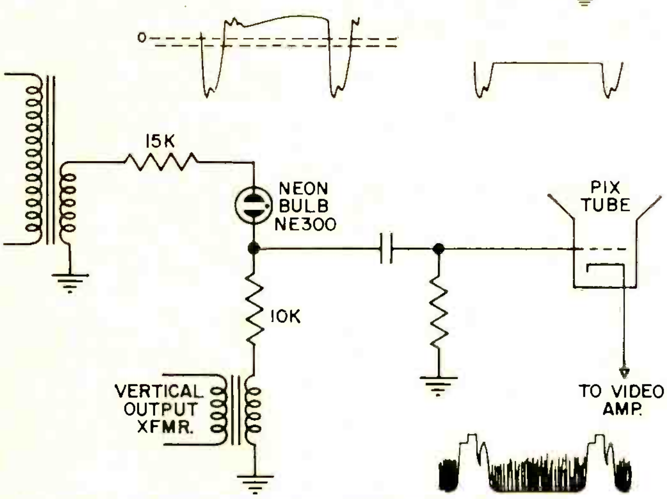
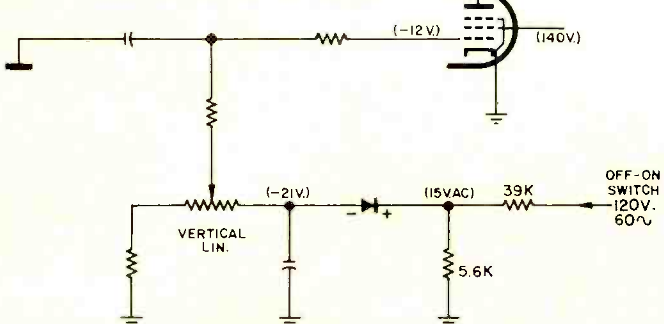


Fig. 10. Horizontal blanking circuit used by Westinghouse.

Fig. 11. Vertical sweep bias stabilizing circuit maintains picture height despite fluctuations in the line voltage.



Sylvania

The 1964 models differ from the '63 versions in several important respects, but three novel features deserve special mention. Horizontal blanking is provided by a special winding on the flyback transformer. One end is grounded and the other goes to an *RC* circuit where the horizontal flyback pulse is mixed with the vertical pulse to blank out the picture-tube grid. In the "power throttle" circuit of the first i.f. amplifier, shown in Fig. 8, a.g.c. bias is applied to the control grid and the screen grid is returned through a voltage divider to the cathode circuit. When the a.g.c. bias reduces the current through the tube, the screen grid also draws less current, increasing the positive voltage on the cathode. This, in turn, has the effect of reducing the tube current still further. Because of this feedback effect, a.g.c. bias in this set can vary from −7 volts on a strong signal up to +20 volts on a very weak station. The third innovation is really a rediscovery of the d.c. restoration of much earlier sets. In the *Sylvania* models, a diode is used to provide d.c. coupling, shown in Fig. 9. To our knowledge, *Sylvania* is the only manufacturer using diode d.c. restoration.

Trav-Ler

This company makes a number of television lines under such private labels as *Truetone* and *Airline,* and does not claim to pioneer any new circuitry for 1964. The major innovation is use of printed wiring for the first time.

Westinghouse

This manufacturer has introduced several new chassis which are characterized by the use of low cut-off voltage picture tubes and the a.c.-d.c. type of power supply. While *Westinghouse* has followed most major trends, new solutions to old circuit problems deserve special mention. Horizontal blanking is provided, but to limit the blanking pulses to the negative portion required to cut off the picture tube grid, a neon bulb is connected in series with the horizontal blanking pulse. The basic circuit is shown in Fig. 10. Note that the secondary of the vertical output transformer contributes vertical blanking while a special winding on the flyback transformer provides the horizontal pulse. The neon lamp conducts only during the peak negative pulses, and also provides the service technician with a handy guide to the presence of signals in the horizontal sweep.

The problem of shrinking pictures due to variations in the line voltage is particularly severe in sets using 135 volts "B+," but *Westinghouse* seems to have found an ingenious solution. The circuit of Fig. 11 shows a half-wave rectifier fed by a portion of the line voltage and followed by a filter. The d.c. output of this rectifier is used as the negative grid bias for the vertical output tube. If the line voltage drops, the bias automatically drops by the same percentage, allowing the vertical output tube to conduct more and thereby compensate for the reduction in "B+."

Zenith

While quite conventional in its monochrome line, *Zenith* is the one major manufacturer that continues to market a color receiver which is unique and quite different from the basic *RCA* version. One indication of *Zenith's* conservatism is the fact that all of its models, even the portables, still use three stages of i.f. and all operate from 250-volt "B+." Silicon rectifiers are used in a doubler circuit in all sets, with or without a power transformer. There are some new circuit features which represent improvements over the 1963 versions. Almost all models (*Continued on page 87*)

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CIRCLE NO. 109 ON READER SERVICE PAGE

JOHN FRYE

An unusual antenna shielding problem on a radio-controlled garage-door opener plus an unplanned ground prove puzzling.

ANTENNAS AND GROUNDS

"DON'T take off your coat!" Mac ordered Barney, his assistant, as the latter came into the service department. "Go on out back and turn on the ignition of the Olds you'll find out there; then, after about half a minute, push the little red button beneath the left side of the dash and keep it pushed until I tell you to quit."

"May I ask why?" Barney said cautiously with his hand on the doorknob. The dour look on the face of his boss said plainly something was annoying him. It was a time to tread softly.

"I want to make sure that cussed garage door opener receiver is perfectly aligned with the actuating signal transmitted by the owner's car," Mac explained impatiently, waving his alignment tool at a little green box resting on the bench. A wire several feet long, obviously the antenna, was plugged into a phono jack on the side of the box and was stretched along the top of the bench. "The r.f. signal from the transmitter is tone-modulated, and I want to peak the two r.f. coils and the audio resonating circuit so negative bias on the tube with the energizing relay in its plate circuit is reduced to a minimum by the signal from the car. Well go on! Get going!"

Barney did as he was instructed, but Mac's face still wore a puzzled frown when he opened the back door a few minutes later and yelled for Barney to turn off the ignition and come inside.

"I just don't get it," he confessed, scowling down at the little receiver. "At the customer's home, you have to put the bumper of the car almost against the garage door to make the transmitter control the door; yet when you pushed the button out there, with the car a good fifty feet away, the actuating relay in the receiver closed at once. The negative grid voltage reading of the relay control tube dropped from six volts to one volt on the v.t.v.m., and all my aligning reduced this only .2 volt more. Obviously the receiver could not have been far off."

"Is this a new installation?" Barney asked.

"No, the opener was installed last spring and worked well for several months, ordinarily operating the door from a distance of fifty feet. Occasionally, on a cool morning, the car would have to be moved closer; then when winter arrived the sensitivity really went to pot. Well, let's go see if we've helped things. I'll drive the Olds, and you follow in the truck. If by some fluke the nasty little thing works, you can bring me back."

They were soon in the alley behind a garage which stood right on the alley line. To garage his car, the owner of the Olds had to drive past the building and then back in a tight curve through the eight-foot door. A green-painted control box, about 14" x 8" x 4" and with a ¼-h.p. motor mounted on one end, was fastened to the ceiling joists in the center of the garage. A small T-beam about 9' long was bolted to the side of this box and ran to a point directly over the center of the door. It served as a rail for the door-opening-and-closing trolley that was moved back and forth with a looped chain. The receiver was fastened to the outside of this garage door opener control box by four machine screws.

The receiver in place, Mac walked across the alley and pushed the button in the Olds. Nothing happened. The car had to be driven very close to the garage before the transmitter would raise and lower the door.

"I'm really not surprised," Mac admitted glumly. "I may as well confess this is the second time I've taken that receiver down and checked it out. Everything works fine on the bench, but it won't work here. You tell me why. That antenna stapled to the joist is the same 8'4" length as the one I use on the bench, and my ohmmeter tells me there's nothing wrong with the wire. Notice the antenna runs along the joist right beside the T-beam so that the end of it is as close as possible to the alley. Running it that way also makes it parallel to the transmitting antenna stretched across beneath the bumper when the car is coming up the alley. That should provide maximum signal transfer. Maybe something's wrong with the car transmitter. Back the car in here, and we'll shut the door to get out of the wind and check out the transmitter on a dummy antenna."

The dummy antenna consisted of a #47 pilot lamp connected with stiff wires to a phono plug. When this replaced the regular antenna, the bulb lit dimly. Mac took the case off the transmitter and turned the slug of a coil in the plate circuit of the output tube. The bulb brightened, and he found a peak setting that made the bulb glow beyond normal brilliance.

"I'll bet that's the trouble!" Mac exclaimed, pulling out the dummy antenna and replacing the regular wire. "Now hit the button."

Barney did, but the door never budged. "We better quit," Barney suggested with a grin. "Now we can't open the door with the transmitter sitting right under the receiving antenna!"

Mac opened the door with the push-button on the wall. Surprisingly, it was found the transmitter would close the door while the car was in the garage but would not open it. When the car was driven outside, the transmitter would neither open nor close the door.

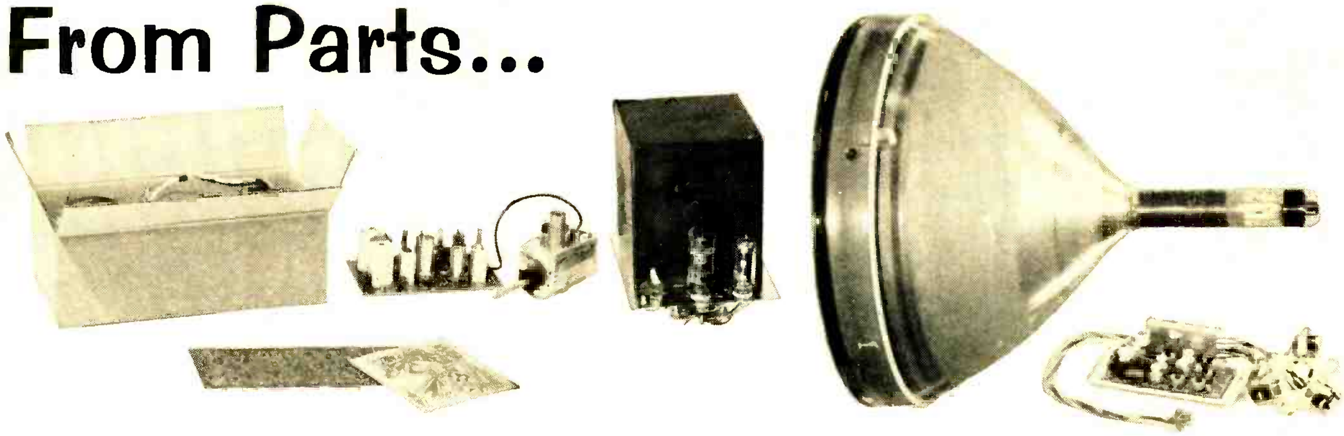
"This thing is getting crazier by the minute!" Mac exclaimed. "We increase the output of the transmitter and lose what little range we had. With the car in the garage, the transmitter will close the door but not open it; yet all the receiver does in either case is momentarily close the same pair of relay contacts. It *can't* make any difference to the receiver whether that wooden door is up or down."

"Hold it, Boss; I think I'm getting an idea," Barney interrupted. "In the first place, I suspect that bulb is a poor substitute for the wire antenna. The wire lies right against the metal of the car in places and must have lots of capacity. Let's retune the transmitter output stage using a field-strength meter."

"*What* field-strength meter?" Mac inquired sarcastically.

Without answering, Barney got a v.o.m. from the truck and stuck the leads of a germanium diode into the test-prod receptacles. A short length of wire was fastened to one diode

From Parts...



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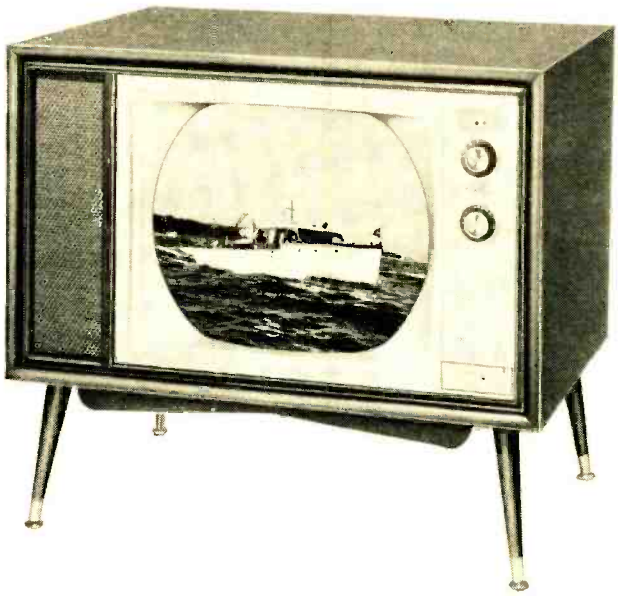

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CIRCLE NO. 119 ON READER SERVICE PAGE

lead; and the v.o.m., set to its lowest d.c. scale, was placed on the ground in front of the car. A low meter reading was obtained when the transmitter was activated, but retuning the output stage made the reading climb rapidly. When the transmitter was tuned for maximum output on the improvised field-strength meter, it would operate the door the way it did before the dummy antenna was tried.

Antenna Troubles

"Now for the second half of my hunch," Barney said. "Unstaple the antenna from the joist and let it hang straight down."

Mac did, and he was astonished to find the car now controlled the door from fifty feet away. Under Barney's direction, he ran the wire directly away from the door and stapled it to a joist. The operating distance of the car increased another twenty-five feet.

"OK, you smart aleck, tell me how and why," Mac ordered.

"My ham experience has taught me an actual antenna and a dummy antenna seldom look the same to an output stage. When going from a dummy to a wire, you usually have to retune the final stage for maximum output."

"What made you think of changing the position of the antenna?"

"The triggering clue lay in the fact the weakened transmitter output would close the door but not open it. I noticed when the door is closed those two big lifting springs on either side are stretched out parallel to the antenna and doubtless shield it from r.f. the way iron bridge girders shield a car antenna. When the door is up, the springs contract and reduce the shielding effect. This set me to wondering about the effect of the T-beam running along right beside the antenna. Think of the beam and the antenna as being two halves of a dipole antenna. Both are approximately a quarter-wavelength long. With the antenna in the old position, our half-wave dipole was folded together so that it looked more like a length of open-wire feedline. Voltages induced in one half were cancelled by those in the other. Now, with the T-beam and the antenna going in opposite directions, you have the electrical equivalent of a half-wave antenna."

Paint Insulation

"Why did the system work OK at first?"

"I suspect paint on the receiver case and the control box prevented a good ground between the two. This left the receiver case 'floating'; so pickup by the antenna was not cancelled by pickup on the T-beam. The wire antenna performed exactly the way your wire antenna did on the bench: as a quarter-wave Marconi. Contraction with colder weather probably tightened the mounting screws and improved the connection between the receiver case and the control box, thus converting the antenna into one side of a feedline. The trouble would have been present right from the beginning if the receiver grounding had not been poor.

Another Ground Problem

"And that reminds me of another poor ground that cost—or saved—me money, depending on how you look at it. Our electric bill this month was just about double what it usually is. A check of the meter revealed we had already used a half month's worth of electricity in the six days since the meter was last read; and with everything in the house turned off, the meter was still going around merrily. I started pulling plugs, one at a time, and checking the meter each time. When I pulled my ham receiver, the meter practically stopped. Checking with an ohmmeter revealed a direct short between one side of the line and the chassis.

"Then I remembered a sneak thunderstorm about six weeks ago had caught me with my plugs in. I heard something snap in the ham shack when the first bolt struck. I hastily pulled the plugs, and when I checked the next morning I found nothing wrong; but the surge from that stroke of lightning had shorted out a .01-μf. capacitor between the hot side of the line and the chassis. Since the chassis was grounded, the line current flowed through the capacitor and the ground back to the pole transformer. Only the resistance of my ground limited the current. Measuring revealed this current was between three and four amperes. No wonder my bill shot up! I'm just glad I didn't have a better ground."

"Isn't the receiver fused?"

"Yes, there's a fuse in one side of the line and a switch in the other, but the line bypasses go to the chassis ahead of both the fuse and the switch. I thought about it a good bit, and I decided the best protection against a situation of this kind—one that protects the line switch against overload among other things—is a double-fused line plug, and that's what I installed. Now any time my receiver draws more than one ampere of current for any reason whatever through either wire, a fuse will blow. It still makes me feel a little creepy to know that if I had touched anything connected to the neutral side of the line while I was handling the microphone or touching any part of my receiver or transmitter, the full 120 volts of a.c. would have been coursing through my body."

"Well, you've convinced me today that a well-grounded ham makes a pretty good technician," Mac commented as he headed for the truck. ▲

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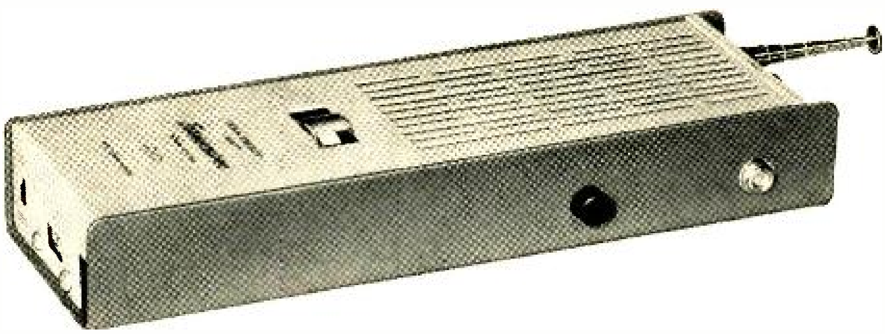

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CIRCLE NO. 119 ON READER SERVICE PAGE

NOISELESS REMOTE SWITCHING

By CHARLES W. MARTEL
Manager, Tech. Info. Svce., Raytheon Company

A simple switching circuit that employs a number of "Raysistors," photocells with built-in light sources.

HOW many times have you wished you could eliminate the clicks, pops, and thumps which occur when you change the input selector of your hi-fi or similar audio equipment? It's easy with the *Raytheon* "Raysistor," and simple remote switching at any number of locations is a bonus feature. With the circuit to be described and a "Raysistor" for remote volume control, you can switch inputs to your audio system and adjust volume easily and noiselessly.

The "Raysistor" CK1121 can be made to vary its resistance from 150 ohms or less to a typical value of 100 megohms with 50 volts applied to the variable resistance or signal element. For audio control, the applied voltage is usually around one volt but even if we assume voltages as high as 5, the minimum or "off" resistance will certainly be at least 100 megohms.

Most input circuits following the selector switch have a maximum resistance of one megohm and, more often, 0.5 megohm, 0.25 megohm, or even 0.1 megohm. These values are 1%, ½%, ¼%, and 0.1%, respectively, of the "off" resistance of the "Raysistor." When used as in Fig. 1, it will, for all practical purposes, result in zero signal when "off."

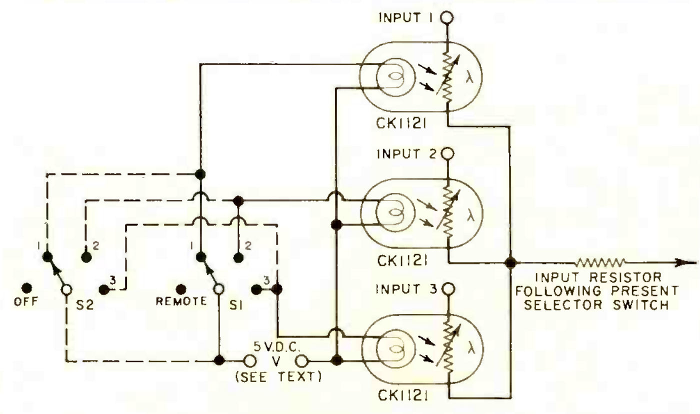
In Fig. 1, S1 is an ordinary single-circuit switch with as many contacts as you have input circuits. We have shown only three for simplicity, but each additional input is connected exactly the same as any of the three shown. Note that S1 may be the existing selector switch if you add the "Raysistor" circuit to existing equipment.

Inputs 1, 2, 3, etc. may be record player, tape recorder, TV, or whatever you wish. If you are revising existing equipment, just remove the inputs which are connected to the present selector switch terminals and re-connect each to one signal terminal of each CK1121 "Raysistor." All of the second signal terminals of the CK1121 then connect to the lead presently attached to the moving-contact connection on the existing selector switch. The selector switch is thus free to switch control voltage to the "Raysistors."

With further reference to Fig. 1, note that if S1 is set to the remote position, S2, the remote switch, can be used to control the inputs. Because the control voltage is only 5 volts at 55 ma., the wires to the remote switch may be small, flexible, and with low-voltage insulation allowing them to be run in an inconspicuous manner. Note that two inputs can be fed into the amplifier simultaneously if S1 and S2 are set on different input positions at the same time. Obviously, the switch not in use should be set on the open contact unless use of two inputs simultaneously is desired. Furthermore there may be more than one S2 if you desire more than one remote-control location.

In Fig. 1, *V* is shown as a 5-volt source. This may be obtained from your present equipment, from a d.c. heater, or transistor supply. Remember to include a suitable series resistor to drop the "Raysistor" to 5 volts (at 55 ma.) if your supply gives more than 5 volts. In addition, batteries may be used, such as four 1.35-volt mercury cells in series or four standard flashlight cells in series. A series-dropping resistor of 7 to 7.5 ohms is needed with four 1.35-volt cells or 20 ohms for four 1.5-volt cells in series. Of course, a 6.3-volt a.c. filament supply can be rectified and filtered to provide suitable d.c., again using a series resistor to drop the voltage at the CK1121 to 5 volts. ▲

Fig. 1. Switching arrangement using "Raysistors" and remote switch S2.



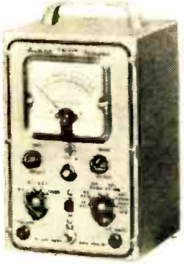


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Chart the course of Heathkit's VTVM throughout the past 15 years, and you'll discover many refinements, many advances. To improve sensitivity, the meter movement was changed from 500 microamps to 200 microamps, and the minimum voltage range was lowered from 3 volts to 1.5 volts. There's now a choice of 7 ranges for AC, DC, and Ohms readings instead of 6. The meter face has been enlarged from 3½" to 4½" for easier reading. We did, however, keep the same shatterproof quality of the cover. A voltage doubler replaced the half-wave rectifier, and the range switch was simplified for easier assembly and improved circuitry. With the V-7A came circuit board construction for greater stability and quicker, easier assembly. And our newest, the IM-11, has a single test probe instead of three for all readings. Although the basic compact shape and size has changed very little, the color styling has been modernized for a more attractive, "up-to-date" appearance.

This is just a sampling of the improved design, the higher quality components, and the advanced features that have been incorporated into Heathkit's VTVM over the years. And you enjoy all of these improvements for only 45c more than the original V-1! No wonder Heathkit has sold more VTVM's than anyone else!

Although some of these advances have come from our own laboratories, many of them have evolved from the largest Research & Development department in the world . . . *You!* Yes, you and the hundreds of thousands like you who buy and use our products. Many of you have written us and suggested changes, refinements, and improvements. And we've *listened.* We've *acted!* And we will continue to do so in order to bring you *constantly improving* value.

Check the specifications for the IM-11 (below), and see if you don't agree that for all-around performance in the electronics servicing industry there's not a better buy than Heathkit's IM-11 VTVM!

Kit IM-11, 5 lbs. $24.95
Assembled IM-11, 5 lbs. $46.75

SPECIFICATIONS—Meter scales: DC & AC (RMS): 0-1.5, 5, 15, 50, 150, 500, 1500 volts full scale. **AC peak-to-peak:** 0-4, 14, 40, 140, 400, 1400, 4000. **Resistance:** 10 ohm center scale x1, x10, x100, x1000, x 10K, x 100K, x1 meg. Measures .1 ohm to 1000 megohms with internal battery. **Meter:** 4½" 200 ua movement. **Multipliers:** 1% precision type. **Input resistance DC:** 11 megohms (1 megohm in probe) on all ranges. **Circuit:** Balanced bridge (push-pull) using twin triode. **Accuracy:** DC ± 3%, AC ± 5% of full scale. **Frequency response:** ± 1 db, 25 cps to 1 mc (600 ohm source). **Tubes:** 12AU7, 6AL5. **Battery:** 1.5 volt, size "C" flashlight cell. **Power requirements:** 105-125 volt 50/60 cycle AC 10 watts. **Dimensions:** 7⅜" H x 4-11/16" W x 4⅝" D.

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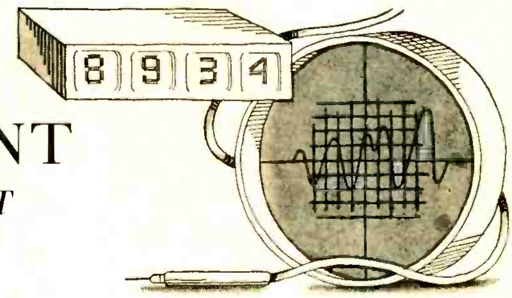
TE-121

CIRCLE NO. 119 ON READER SERVICE PAGE

TEST EQUIPMENT
PRODUCT REPORT



RCA WR-50A R.F. Signal Generator

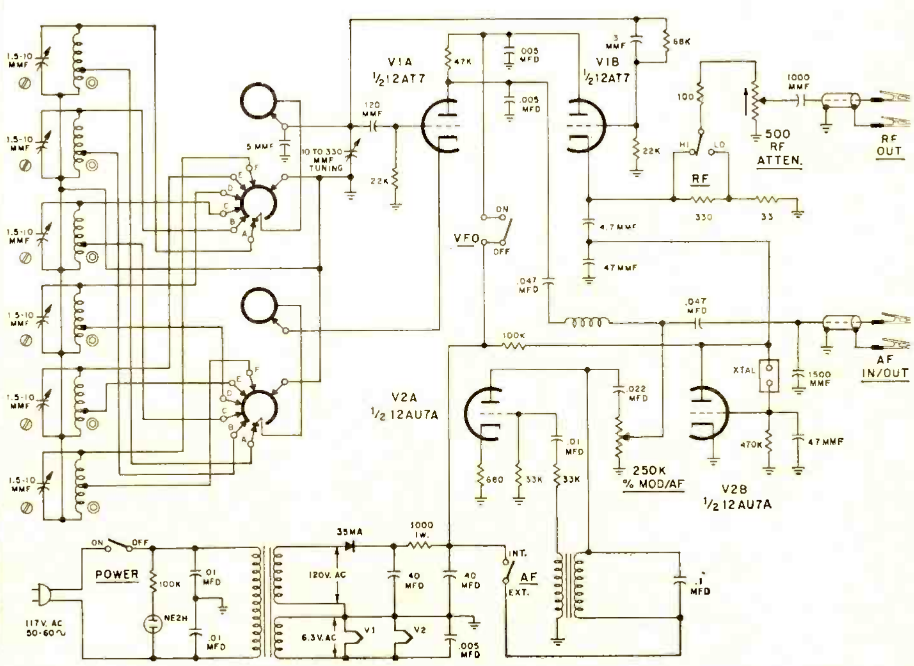
For copy of manufacturer's brochure, circle No. 47 on coupon (page 15).

WITH bench space at a premium, technicians will find the small size of *RCA's* new WR-50A r.f. signal generator especially attractive. Measuring only 7¾ x 5⅝ x 4¾ inches, this instrument incorporates familiar and special features for radio/TV troubleshooting and alignment.

Fundamental r.f. output is available from 85 kc. to 40 mc. in six bands; vernier tuning is provided. An internal 400-cps oscillator modulates the r.f. signal or provides separate audio output. The separate audio signal can be used for servicing all types of mono and stereo equipment. Attached output cables for r.f. and audio output are shielded to minimize undesired "spraying" of signals into external circuits and to reduce stray pickup. Blocking capacitors are built into both leads to isolate d.c. voltages. A "Hi-Lo" switch and a potentiometer in the r.f. attenuator circuit provide for setting the output signal at any level. A separate potentiometer adjusts the amount of internal 400-cps or external modulation applied to the r.f. signal, and sets the separate audio output signal that is available from the WR-50A.

Unique with this generator is a front-panel jack for a quartz crystal. When an appropriate crystal is plugged in, the unit can be calibrated precisely, or will provide a crystal-controlled output signal for general servicing of communications equipment.

This type of r.f. signal generator is generally stereotyped as "alignment equipment." Experienced technicians, however, know that it also can be used



in countless troubleshooting applications in audio, radio and black-and-white and color-TV servicing. The excellent instruction booklet provided with the WR-50A is a valuable text on troubleshooting *via* signal injection and signal tracing.

Basic circuits are proven and familiar (see schematic). A Hartley oscillator (*V1A*) generates the fundamental r.f. signal. The individual *L-C* circuits, which are switched in for each band, have both trimmer capacitors and adjustable coil slugs to assure good frequency tracking at extreme ends of each band. Oscillator output is fed to a cathode follower (*V1B*), which isolates the external load and the oscillator, and permits connection to a wide range of loads. A transformer-coupled oscillator circuit (*V2A*) provides the 400-cps modulation to the Hartley oscillator or to the audio output cable.

A Pierce-type crystal oscillator (*V2B*) is complete except for the frequency-determining crystal, which plugs into the panel jack. Because this type of circuit is rich in harmonics of the fundamental crystal frequency, calibrating beats can be obtained at many points throughout the tuning range.

Optional user price of the factory-wired instrument is $59.95. ▲

Ferris 24-D CB "Microvolter"

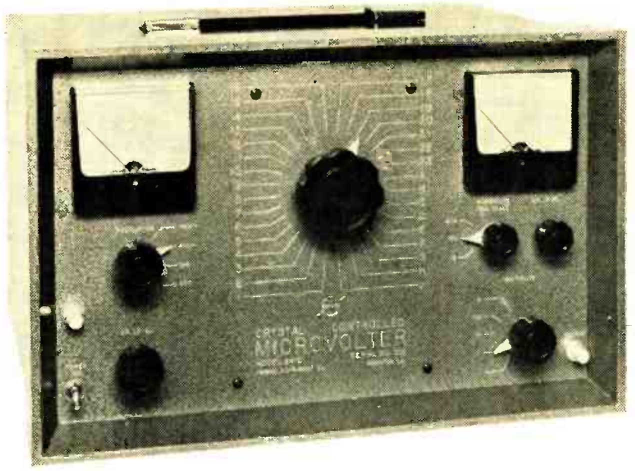
For copy of manufacturer's brochure, circle No. 48 on coupon (page 15).

THE *Ferris Instrument Co.*, which has been in the precision r.f. instrumentation field for over 50 years, has entered the CB market with the Model 24-D "Microvolter." This is a high-accuracy signal generator with up to 32 switch-selectable, crystal-controlled carrier and i.f. frequencies. The instrument has a calibrated output adjustable from 0.1 to 100,000 microvolts. Frequency accuracy of all outputs is 0.005% with a stability of 0.001%.

The generator was designed for production testing of CB receivers and transmitters and for maintenance-depot applications. It can be used for accurate calibration and alignment and as a standard reference source for design, development, and test-lab use.

The unit is equipped with individual crystals for each of the 23 CB channels plus two crystals (frequencies chosen by user) in the intermediate-frequency band from 200 kc. to 15 mc. Up to 7 more i.f. crystals may be added. Each crystal circuit is factory-calibrated, by adjustment of individual piston-type glass capacitors.

Seven metered output ranges are available, all at 50-ohm loading. Multiple shielding and filtering reduce radiation and leakage to negligible values, even when highly sensitive receivers are being tested. On the lowest output range,



for example, the full-scale output of the instrument is only 0.1 microvolt. The r.f. output signal is indicated on the voltmeter on the right-side of the panel.

A Wien-bridge oscillator provides internal audio modulation at 400 or 1000 cps. External modulation from 100 to 5000 cps may also be used. The modulation level is measured by a separate meter at the upper left-hand corner of the panel. Modulation is adjustable from 0 to 90%. Incidental frequency modulation is said to be virtually unmeasurable.

The Model 24-D is priced at $785, including all 23 channel crystals and 2 i.f. crystals. Also available is the Model 24-E, which is identical to the 24-D except without i.f. provisions, at $680. ▲

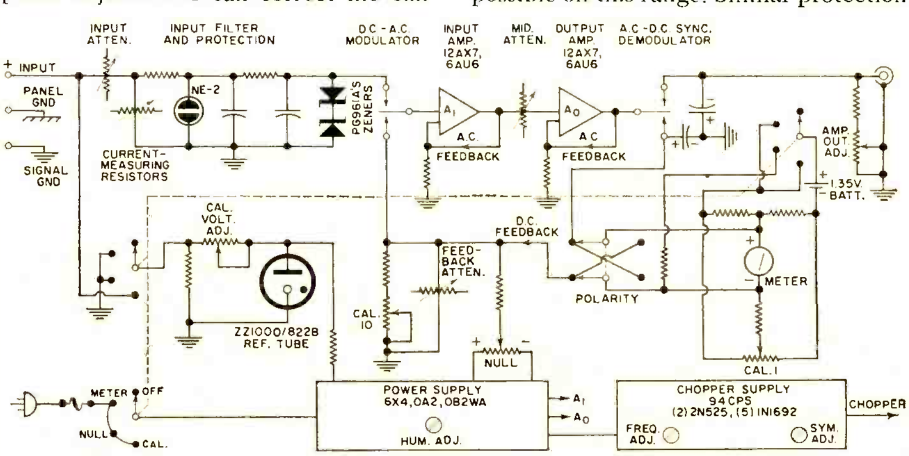
Ballantine 365 D.C. Volt-Ammeter

For copy of manufacturer's brochure, circle No. 49 on coupon (page 15)

D.C. voltages ranging from as low as 1 μv. to 1000 v. and currents from as little as 1 nanoampere (0.001 μa.) up to 1 ampere can be measured on this non-digital voltmeter with an accuracy said to be unavailable in any other commercial instrument. The *Ballantine* Model 365 sensitive d.c. volt-ammeter, with its single log scale and range selector, measures voltages above 1 mv. to within 1% of the indication. Currents above 0.1 μa. are measured with an accuracy of 2% of the actual indication. Note that these percentages are *not* of the full-scale readings.

The accuracy of the meter is maintained by the high stability of its amplifiers, resulting from both a.c. and d.c. feedback techniques, and by conservative operation of all components. To maintain the accuracy, a simple and reliable internal standard is available to check the calibration accuracy. Front-panel adjustments can correct the calibration, if necessary, in a few seconds.

Special input circuitry protects the instrument against momentary overloads of 1 kv. on the most sensitive voltage range. Sustained overloads of 100 v. are possible on this range. Similar protection



is provided for current measurements.

Warm-up drift has been made negligible for measurements above 1 mv. The meter is usable a few minutes after being turned on. Even on the most sensitive range, the drift, after a half-hour warm-up, is less than ±2 μv. per day.

The basic circuitry of the Model 365 is shown on the simplified schematic. Tracing the d.c. input, the signal is attenuated as necessary and then, if a current is being measured, it develops a d.c. voltage across an appropriate current-measuring resistor. This d.c. voltage, or the signal voltage, if a voltage measurement is being made, then passes through an input filter and protection circuit to a mechanical modulator or chopper. Here the d.c. voltage is converted to a 94-cps square wave whose amplitude is proportional to the d.c. input. This resulting a.c. signal is amplified in an input amplifier, attenuated again if necessary, amplified further in an output amplifier, synchronously demodulated, and finally passed through a meter to provide an indication. This voltage is also applied to a resistor to provide a simultaneous d.c. output. The d.c. output can be used to drive a recorder or the unit can serve as a sensitive, high-gain d.c. amplifier.

The choppers are driven by an internal transistorized supply at 94 cps. Hence, the instrument is little affected by power-line pickup and can be operated on any common a.c. power-line voltage around 115 volts or 230 volts at frequencies from 50 to 420 cps.

The instrument is available in a portable version, 13" h. x 7½" w. x 10½" d., or in a rack-mounted version. The price of the portable is $650, and the rack version is $670. ▲

PHONO CHASSIS SUPPORT

By ART TRAUFFER

MOTOR and chassis boards, removed from portable record players, are usually unwieldy things to work on. If you lay it on the bench turntable down it isn't good for the turntable and pickup arm, and if you lay it on the bench chassis down, it isn't good for the chassis and motor fan.

As shown in the photo, the author supports the board vertically by means of two large C-clamps. One clamp is positioned to give a left-hand support, and the other is positioned to give a right-hand support, as shown. Thus the board is held upright and you can work on either side. ▲

Integrated Amplifier-Speaker

(Continued from page 35)

gives another advantage. As illustrated in Fig. 5, the overdamped speaker does not begin to fall off sharply (18 db per octave) until well below resonance. Underdamped speakers, on the other hand, start their sharp roll-off at a much higher frequency. The slow roll-off characteristic of the overdamped speaker can thus be compensated to produce essentially flat output below the resonant frequency of the speaker.

In practice, such a speaker can be built with a sharp roll-off point one to two octaves below resonance. Thus the speaker's resonant frequency becomes less important in determining the speaker's low-frequency response. This makes it possible to design an extended-range speaker by using a small, highly compliant cone and a large magnet. Although the resonant frequency of such a cone would be relatively high—perhaps as high as 100 cps—it could be designed to produce essentially uniform output to a point between one and two octaves below resonance, *i.e.*, somewhere between 25 and 50 cps.

The above discussion assumes that the box is sealed. A ported box, of course, can be, and frequently is, used to change the shape of the low end of the curve. While porting has its value, it also has its limitations. With a hole in the box, you trade response in one region for response in another. Useful differences in acoustic output, while sometimes desirable, are likely to be small in small enclosures.

Fig. 8 shows basically what might be achieved using a port in a 1 to 1¼ cubic foot enclosure. The solid lines show the response curves of non-ported overdamped speakers. Dashed lines show the results of using progressively more "effective," that is, larger ports. Each port is adjusted for optimum length and resistance.

In general, as the curves show, the higher the frequency at which the porting is designed to be effective, the greater the effect it will have on the shape of the output curve. It can, in other words, give a substantial boost in the high bass range with a concomitant drop off in low bass (C and D). If it is used, instead, to extend the low bass range, then the total effect achievable will be small (A and B). Sometimes such manipulation of the curve is useful, sometimes not. While porting somewhat complicates the basic relationships among size, resonant frequency, and efficiency, and while its effects are sometimes useful, it does not basically change the principles that are involved in the design of high-quality low-frequency speaker systems.

The matter of tampering with the

frequency response curve is usually considered to be improper in the high-fidelity industry, and is equated with trying to cover up deficiencies in an improper way. (This applies only to the power amplifier; curves are almost universally adjusted in the preamplifier to compensate for recording characteristics, cartridge or tape head curves, etc. Enclosure porting is certainly manipulating the response of the speaker.) There is no physical law, however, that makes a flat response at any given point—the amplifier's output terminals, for example—either good or bad. The important thing is the over-all response of the entire system.

The aim of responsible backers of the integrated approach is to use electronics to free them to design the best speaker possible. By building a highly over-damped speaker, for example, and compensating its low-end slope with electronics, the over-all response of the system can extend far below the region it could cover otherwise.

The same results could be achieved, of course, by building a larger, more efficient speaker and housing it in a larger cabinet. If money and space were no object, the advantage of the integrated technique in designing smaller, high-performance systems would disappear. But in the average living room, both money and space are important. And it is here particularly that the integrated approach has its value.

How important is the integrated amplifier-speaker idea likely to become? At least two earlier integrated units—the *Lund* and the *Integrand* failed. But this may have been caused by outside factors rather than by the basic approach. The *Integrand* had troubles with transistors. The *Lund* made only a brief appearance and was then withdrawn before it had a chance to show whether it would be successful or not.

Chances for the success of units appearing now seem much better. They are being produced by companies that have both the resources and established marketing channels to launch new products. Second, technological advances in the past few years have solved some of the problems that bedeviled earlier attempts. Most important is that the reliable, reasonably priced transistor amplifier is now an established fact. And the integrated speaker—far more practical with a solid-state amplifier—may follow the path of other technological advances that could not be realized until the technology was equal to the concept.

Although separate amplifiers and speakers will continue to be built—and certainly for the foreseeable future to dominate the market—it seems quite possible that the integrated unit, with its real advantages, will win a permanent place on the high-fidelity scene. ▲

JAPANESE COLOR-TV HAS SIMPLE CONTROLS

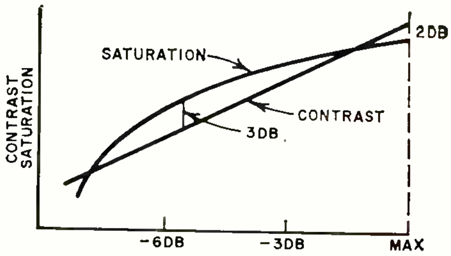
FEATURING single control of both contrast and color saturation, the new *Toshiba* type 16WM color-TV set uses a 16-inch rectangular shadow-mask color tube and is slated for introduction to the U.S. in the near future.

Both 14- and 16-inch versions have been made and sold in Japan, but only the 16-inch version will be seen here. Using a modified phosphor arrangement, the 16-inch tube develops about 60 ft.-lamberts highlight brightness. Although this set sells for about $500 in Japan, the manufacturer claims that price will be competitive here.

The chromatic portion of the circuit incorporates a direct demodulator system that eliminates the matrix circuit and a new "Uni-Control System" that simplifies color adjustment.

The new portion of the chromatic section is shown in the schematic. The remainder of the set is conventional.

Simultaneous control of both picture contrast and color saturation is provided by operation of contrast control *R1*. An independent color control *R2* is located on the side of the cabinet and provides separate saturation control if desired. The contrast is controlled by *R1* located in the second video amplifier. A part of the positive-going voltage present on this control is fed to the control grid of the second bandpass amplifier. In this way, both contrast and color saturation are controlled at the same time, with any further desired saturation controlled by *R2*.



The control characteristics of this composite circuit is shown above.

The color demodulator uses one-half of a 12BH7 with the other half acting as the color amplifier. The outputs of each circuit, demodulated on the *R-Y*, *G-Y*, and *B-Y* axes are as follows:

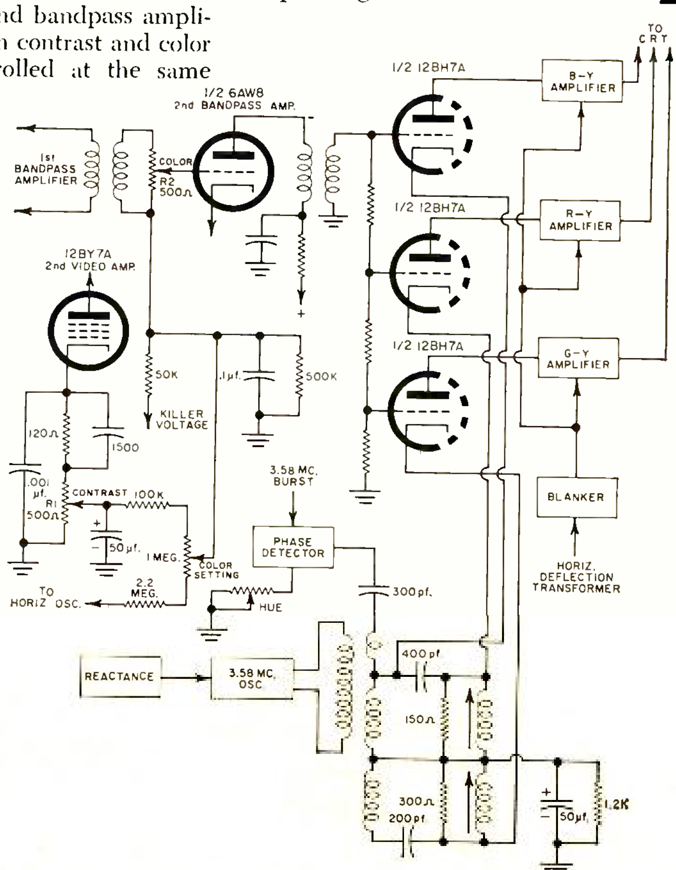
$R\text{-}Y = -(E_R\text{-}E_Y)/1.14 \times \cos(\omega t + 90°)$

$G\text{-}Y = -(E_G\text{-}E_Y)/0.71 \times \cos(\omega t + 237°)$

$B\text{-}Y = -(E_G\text{-}E_Y)/2.03 \times \cos(\omega t - 90°)$

The ratio of each color signal for each demodulator tube is $(1.14 \times 38):(0.71 \times 32):(2.03 \times 30) = 100:53:140$. Therefore, the ratio of each signal going to the grid of the color tube is, $(E_R\text{-}E_Y):(E_G\text{-}E_Y):(E_B\text{-}E_Y) = 100:53:140$.

The blanking signal is fed to the video output stage. ▲



Chromatic portion of the new TV set shows how the contrast control varies both the video contrast and the color saturation simultaneously.

Voltage-Divider Nomogram

(*Continued from page 29*)

of places, in either direction, as long as you do the same thing to both scales.

Capacitive Voltage Divider

Since capacitive reactance depends inversely on capacity, it is necessary to interchange subscripts on the vertical scales. Now the series capacitor is located on the long vertical scale and the output capacitance on the short vertical scale.

Once again *you* supply the units: μf., pf., or whatever is appropriate. You may want to move the decimal point at the same time. For instance, to locate .01 μf. on the scales, one way would be to move the decimal point 3 places to the left and then say all values are in μf. Then the point now marked 10 would be .01 μf. *Do the same thing to both scales.*

Example

A voltage divider is made up as in Fig. 1C, with $C_x = 0.22$ μf. and $C_y = 0.33$ μf. How much output will result from 28 volts applied to the input of this capacitive-divider circuit?

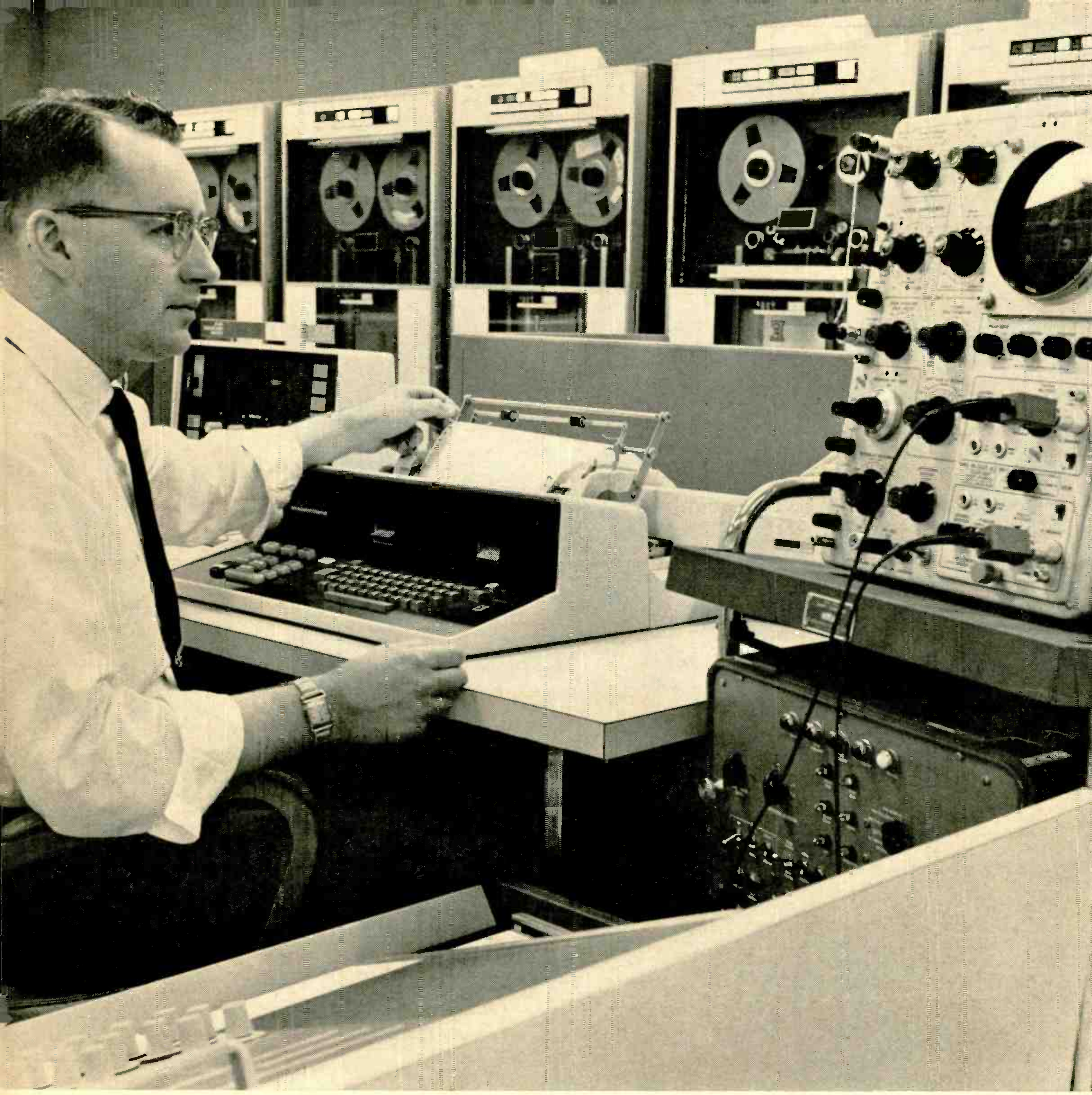
First, let all values on both vertical scales be in microfarads, then move all decimal points on these scales two places to the left. Now 0.22 is located on the C_x scale at 22 and 0.33 on the C_y scale at 33. You could have moved the decimal one place on both scales, and then 0.22 μf. would be located at 2.2 and 0.33 μf. at 3.3.

Draw a line through the two capacitor values and where that line meets the graph, go straight in to the curve. From the curve, go straight down to the edge of the graph and then draw a line through 28 on the "Input Voltage" scale. This last line answers the original question when it crosses 11 volts on the "Output Voltage" scale.

When Output Voltage is Known

When the problem is to design a voltage divider which will reduce a known input to a certain required output, the nomogram is extremely convenient. Start by drawing a line through the correct values of input and output voltages and where that line meets the graph, go straight up to the curve, then straight out to the left edge of the graph.

At this point the advantage of designing by nomogram becomes evident. Place a pencil point on that spot at the left edge of the graph, and rotate a straightedge against the pencil. As the straightedge crosses the two vertical scales, every pair of values it joins is a combination that will give the specified attenuation from input to output. You can then select values which are available and convenient. ▲



Why Fred got a better job . . .

I laughed when Fred Williams, my old high school buddy and fellow worker, told me he was taking a Cleveland Institute Home Study course in electronics. But when our boss made him Senior Electronic Technician, it made me stop and think. Sure I'm glad Fred got the break . . . but why him . . . and not me? What's he got that I don't. There was only one answer . . . his Cleveland Institute Diploma and his First Class FCC License!

After congratulating Fred on his promotion, I asked him what gives. "I'm going to turn $15 into $15,000," he said. "My tuition at Cleveland Institute was only $15 a month. But, my new job pays me $15 *a week* more . . . that's $780 more a year! In twenty years . . . even if I don't get another penny increase . . . I will have earned $15,600 more! It's that simple. I have a plan . . . and it works!"

What a return on his investment! Fred should have been elected most likely to succeed . . . he's on the right track. So am I *now*. I sent for my three *free* books a couple of months ago, and I'm well on my way to Fred's level. How about you? Will you be ready like Fred was when opportunity knocks? Take my advice and carefully read the important information on the opposite page. Then check your area of most interest on the postage-free reply card and drop it in the mail *today*. Find out how you can move up in electronics too.

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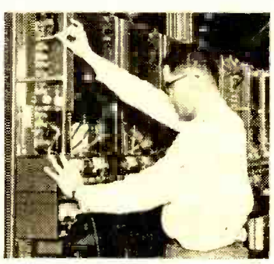

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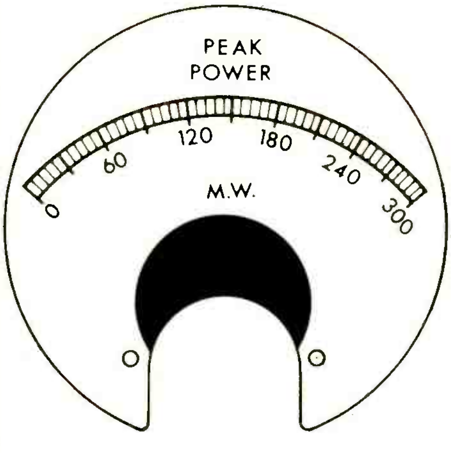
CONVERTING METER SCALES

By BOB APPERSON



WHEN you have a meter calibrated in one function and would like it to read another function, the existing scale can be altered very easily.

Remove the scale face from the movement—only two screws hold it in place. The scale graduation can be maintained if the new function is linear. Simply take a pencil eraser and carefully remove the unwanted numbers and scale identification from the painted white scale face. Now you have a graduation that can be marked with any value you need. This is done either with decals or dry transfer lettering available at electronic wholesalers at a nominal cost. The result will be a scale calibrated to satisfy your particular need that looks like a professional item. If decals are used, take care to trim each number or letter closely.

If the new function is non-linear, such as a power meter which will be logarithmic, the lined graduations can be removed leaving the upper, lower, and end markings of the scale to act as a guide line for placing the numbers. The new graduations can be put on with India ink or decal after proper spacing is determined. The scale face is now ready for calibration. ▲

"And this little machine decides what the big one will work on."

New Citizens Band Circuits

(*Continued from page 47*)

repeats the process for a second i.f. frequency of 455 kc. Signal is then amplified in i.f. transistors *Q7* and *Q9*.

The focus of interest, the a.g.c. signal, is established at stage *Q10* at the right side of the schematic. Applied to the base of this transistor is the 455-kc. signal from the last i.f. amplifier. Since rectification occurs through diodes *D1* and *D2*, the signal produces a negative-going bias and *Q10* conducts current according to average carrier level. The output of the stage from the emitter is split into two portions; audio is coupled to the 2-μf. capacitor and passed on for further amplification, while d.c. travels down through the 4.7-k resistor as the a.g.c. signal. (The large 20-μf. electrolytic removes audio products.) A close look at *Q10* reveals that it is connected as a common-collector amplifier, or emitter-follower. Thus, polarity of the a.g.c. signal will be the same as that of the input to *Q10*—negative in this case—since no phase reversal occurs.

If the a.g.c. bus is traced to the left, it will be seen that it is applied to the bases of three control transistors; *Q8*, *Q4*, and *Q2*. In succession, these transistors are connected across the emitters of the second 455-kc. amplifier and second and first r.f. amplifiers. Since all three control transistors perform in identical fashion, we'll single out the action of *Q2* (across the emitter circuit of the 1st r.f. amplifier).

If a received signal is increasing in strength, a.g.c. is similarly rising in a negative direction at the base of *Q2*. This produces an increase in conduction through the transistor and an amplified d.c. signal appears at the *Q2* emitter. Again, a common-collector amplifier is used. Amplified a.g.c. retains the same polarity through the transistor. Note that amplified current through *Q2* is made to flow through the 470-ohm emitter resistor of the 1st r.f. amplifier. The result is a decrease in the r.f. amplifier's gain; control transistor *Q2* has caused the emitter of *Q1* to shift in the negative direction.

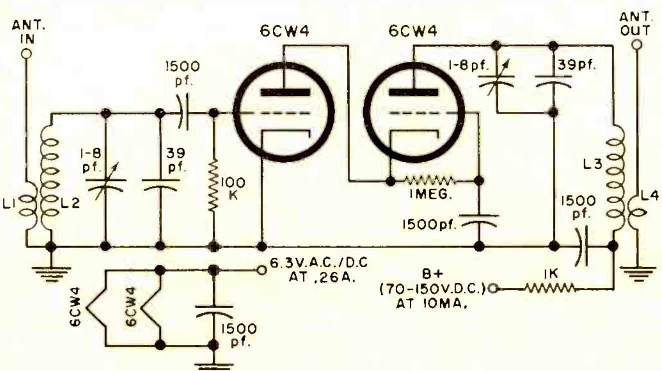
Similar control is exercised simultaneously on the other r.f. and i.f. stages mentioned earlier. The over-all effect is a leveling of wide excursions in received signal and a steady volume in loudspeaker audio under most conditions.

(c) WRL NA-27 Nuvistor Preamp

Although the 27-mc. Citizens Band lies just under the low end of the v.h.f. band, there has been a definite infiltration of v.h.f. techniques in CB receiver construction. It occurs principally in the front end.

A look at a number of CB units reveals that the use of a nuvistor as the r.f. amplifier has been increasing. For those CB operators who wish to upgrade an older, more conventional transceiver, *World Radio Laboratories*[*] offers the NA-27. This is a small printed-circuit board containing a complete r.f. preamp stage with two nuvistor tubes. Especially in those cases where no r.f. stage exists in a receiver (antenna signal is applied directly to the mixer), a preamplifier of this type

Fig. 3. WRL's dual-nuvistor cascode preamp for CB receivers.



can significantly improve sensitivity, reject spurious signals, and lower the noise figure. The board is mounted inside the transceiver case if space permits and electrically connected between receiver input and antenna relay. Power for the circuit is obtained from the transceiver's power supply.

A study of the circuit of Fig. 3 indicates the use of the popular cascode configuration. The first 6CW4 is a grounded-cathode triode followed by a second 6CW4 wired as a grounded-grid amplifier. In usual cascode fashion, the tubes are in series.

One significant different between this circuit and similar types, in TV tuners for example, is the absence of a neutralizing coil. This is generally used to counteract grid-plate capacitance of the first triode. (The grounded-grid arrangement of the second triode renders a second coil unnecessary.) But the relatively low operating frequency and small internal capacitances of the nuvistor permit the coil to be eliminated in this application. The manufacturer of the NA-27 suggests lowering the applied "B+" if any instability is experienced with the circuit. ▲

REFERENCES

1. International Crystal Mfg. Co., Inc., 18 North Lee, Oklahoma City, Oklahoma.
2. Vocaline Company of America, Inc., Old Saybrook, Conn.
3. World Radio Laboratories, 3415 West Broadway, Council Bluffs, Iowa.

SSB DINNER & HAMFEST

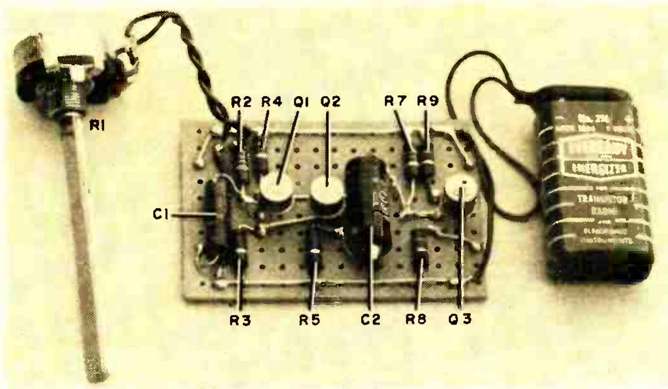
THE SSB Amateur Radio Asociation will sponsor its 13th Annual Dinner and Hamfest, Tuesday, March 24th at the Hotel Statler-Hilton, New York.

The event is scheduled the week of the IEEE Convention for the convenience of visitors as well as members.

Equipment displays will open at noon and the buffet-style dinner starts at 7:30 p.m. Tickets are $10.00 each.

Reservations must be accompanied by payment in full. Send to SSBARA, c/o Buddy Robins, W2JKN, 4665 Iselin Ave., New York, N.Y. 10071. ▲

"Yes, I sent for the radiologist. Your equipment, sir, is raising heck with my reception!"



SIMPLE SQUARE-WAVE/ PULSE ADAPTER

By JOHN POTTER SHIELDS

Construction details on a simple adapter that converts sine waves to fast-risetime, variable-width square waves.

◀ Suggested layout of the generator board.

THIS little three-transistor, square-wave/pulse adapter will convert your sine-wave audio generator into a source of fast-risetime, variable-width pulses whose width may be continuously varied from a series of sharp "spikes" to completely symmetrical square waves. The adapter's output pulse or square-wave frequency is the same as the applied sine-wave signal, and only a single potentiometer is used in controlling the pulse width.

Unlike the familiar clipper type of square-wave adapter which merely chops the tops and bottoms off an applied sine wave and thus cannot provide quality square waves, this adapter uses a modified Schmitt trigger multivibrator that is capable of providing extremely high-quality square waves. Another feature of this adapter is that two 180° out-of-phase outputs are provided so that either positive- or negative-going pulses are available. This is especially useful in certain triggering applications.

The uses for this adapter are many. For example, as a source of square waves, it will greatly speed the determination of an audio or video amplifier's over-all frequency response as well as indicating any tendency toward ringing. The pulse output is useful in determining scope sweep linearity, as a source of trigger pulses, and as a source of blanking pulses which are useful in the identification of certain types of scope displays.

Circuit Description

Fig. 1 is the schematic of the adapter which consists of two basic sections. The first section, which generates the variable width pulses, is a modified Schmitt trigger multivibrator consisting of *Q1*, *Q2*, *C1*, *R1*, *R2*, *R3*, *R4*, and *R5*. The second section, which consists of *Q3*, *C2*, *R6*, *R7*, *R8*, and *R9*, forms an isolating and phase-splitting amplifier that isolates the load connected to the adapter's output from the Schmitt trigger.

The pulse-width control, *R1*, determines the forward base bias level of *Q1* thus the point on the applied sine wave where the multivibrator will be triggered. (See Fig. 2.) With *R1* set for a slight forward bias, only a small portion of the applied sine wave is of sufficient amplitude to trigger the multivibrator resulting in a narrow pulse. With *R1* set for a greater forward bias, the resulting pulse width will be greater. *R2* limits the base bias applied to *Q1*.

The signal appearing at the collector of *Q2* is coupled to the base of *Q3* by the coupling capacitor *C2*. *R6* and *R7* form a voltage divider that supplies proper operating bias for *Q3*, while *R8* and *R9* are the collector and emitter load resistors respectively for *Q3*. These two resistors are of equal value to provide essentially equal outputs at terminals 1 and 2.

Note that no isolating capacitors are indicated between the emitter and collector of *Q3* and their respective output terminals. The reason for this is that insertion of capacitors would serve to introduce an additional source of phase shift which will cause distortion of the output signals.

Proper operating voltage for the adapter is supplied by a single 9-v. miniature battery which, due to the small current consumption of the adapter, should last nearly its shelf life.

Construction

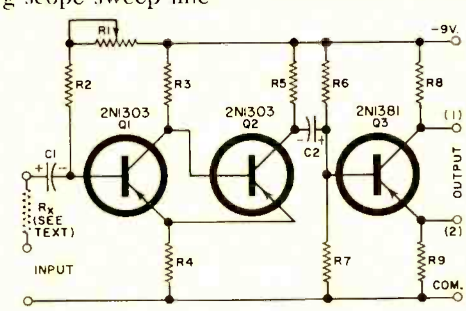
The adapter is assembled on a small piece of phenolic perforated board as shown in the photo. Since the device was designed for use with an existing audio generator, no cabinet is shown. The unit was mounted in one corner of the generator's chassis by four 1" spacers. Of course, the unit could be mounted in a small "Minibox" along with its 9-v. battery, potentiometer, and suitable terminals for its input and output connections. A small toggle or slide switch will serve as a power switch when the adapter is not in use.

Parts placement is not overly critical, although the layout shown in the photo is recommended. Brass eyelets were placed in the board perforations and used as convenient tie points for the various components. The three transistors were soldered directly to the eyelets, thus eliminating sockets with their possible poor contact problems. Soldering transistors directly into a circuit causes no difficulty if their leads are first tinned and then soldered *quickly* with a hot, well-tinned iron.

Note that *R6* is not shown in the photo. The reason for this is that the photo was taken of an early version of the adapter in which *Q3* was operated without any forward base bias. It was later found that symmetry of the low-frequency square-wave output was improved with the addition of a slight amount of forward base bias, hence *R6* was inserted into the circuit.

Test and Operation

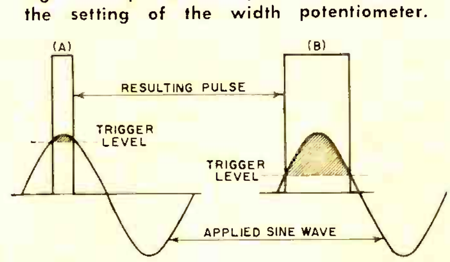
If your audio generator has a low impedance output, it will be necessary to connect a 68,000-ohm resistor (R_X) in series with the input of the adapter for proper circuit operation. The actual value of this resistor will depend some-

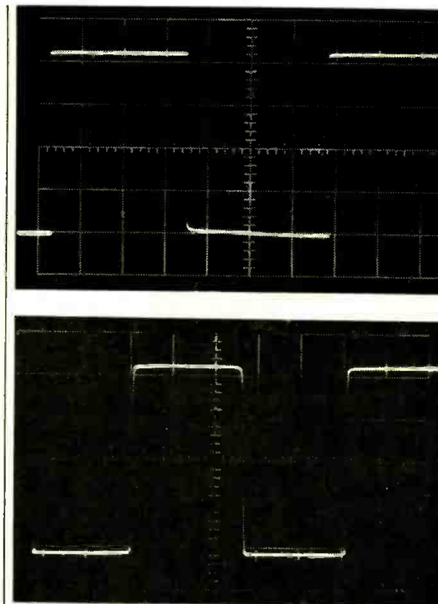


R1—500,000 ohm, ½ w. linear pot.
R2—33,000 ohm, ½ w. res.
R3,R5—2200 ohm, ½ w. res.
R4—680 ohm, ½ w. res.
R6—180,000 ohm, ½ w. res.
R7—18,000 ohm, ½ w. res.
R8,R9—1800 ohm, ½ w. res.
C1,C2—8 µf., 15 v. elec. capacitor
Q1,Q2—2N1303
Q3—2N1381

Fig. 1. Schematic and parts list for the three-transistor square-wave/pulse adapter.

Fig. 2. Output waveshape is dependent on the setting of the width potentiometer.





Ouput waveshape when generator is triggered at 20 cps (top) and 20 kc. (bottom).

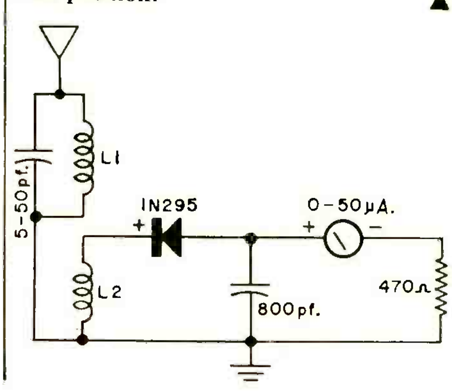
what on the output impedance of your generator, and it is suggested that a potentiometer be temporarily inserted and adjusted for the best range of the "pulse width" pot, *R*1. The pot's resistance may then be measured and a fixed resistor substituted.

For proper operation of the adapter, the audio generator should provide an output of at least 5 v. r.m.s. Since there is some interaction between the "pulse width" control and the amplitude of the input signal, it is necessary to carefully adjust the generator's level control when first setting up the adapter. Once set, however, the generator level control need not be re-adjusted when varying pulse width with the "pulse-width" control. ▲

FIELD-STRENGTH METER

THERE have been many circuits of field-strength meters published during the past few years. A recent issue of Westinghouse "Tech-Lit News" carried this very simple, signal-powered unit.

Coil L1 consists of 12 turns of #14 enamel-coated wire, wound on a 7/16-inch diameter form and L2 consists of 3 turns of stranded, insulated #14 wire, wound over the cold end of L1 and glued into position. ▲



THE TECHNICAL INSTITUTE

By R. E. BAIRD / Head, Electronics Technology
Oregon Technical Institute

An educational institution whose main goal is to train top-grade technicians in the minimum amount of time. Students are "college able" but not "college oriented."

Editor's Note: Our author, who has taught both high-school and college students, finds the technical-institute student quite special in a good many respects. Here are his observations about the students, the institute itself, and its important role in our modern technological society.

MUCH has been written of late about the inadequacies of American education. Even a definition of education itself is hard to come by, and certainly the objectives of the American college today are numerous and nebulous. It is exceedingly doubtful whether all of these objectives can be realized and, in some cases, none of them is fully realized.

There is one portion of our educational system that is little known and even less understood by both the public and, in many cases, leading educators. This is the technical institute. Unlike a college, it has a single objective which is sharply defined. If you pick up the bulletin of a nearby technical institute, you may find a page or two of copy explaining the school's objectives. Boiled down, however, the aim is to "train a top-grade technician." If the school can concentrate on this one objective, its chances of success are greatly enhanced. All courses, in and out of the specialized technical field of the student's major, can be oriented in this direction.

The author has drawn a number of conclusions from observations made at what seems to be a representative school of this type, the Oregon Technical Institute.

To borrow an apt phrase from the Oregon Board of Higher Education, "The technical-institute student is college able but not college oriented." Actually, the technical institute is designed for the student who has as much mental ability as the average college student but who wants to work with his hands as well. In addition, he usually wants to get into industry or an allied field at an earlier age than the college graduate, for either personal or financial reasons.

What It Is

A technical institute is *not* a trade or vocational school. It is *not* a place to send a student interested primarily in learning manual skills. In general, specialization is kept to a minimum and, instead, broad general areas of knowledge are explored. For example, in the field of electronics with which the author is most familiar, we do not train a radar specialist, a computer specialist, a specialist in telemetry, a radio or TV specialist or in any one of a hundred other very narrow fields of specialization. In our two-year course, we provide a very broad background in the field of electronics. This provides the necessary foundation on which to build. Education is a never-ending process and industry is expected to take over at this point—this is the way industry wants it.

A technical institute is *not* the same as a school of engineering, metallurgy, or medicine, as exemplified by the modern university subdivisions. But matriculation on campus is similar. The student has numerous classes under as many instructors. He must take English—English slanted toward its application in the technical field. For this reason, many technical-institute graduates can write a better technical report than the average college graduate. In nearly all curricula he must take mathematics and physics, in some cases as far as calculus and nuclear physics. These subjects are again slanted toward application and tend to be less abstract than the same subjects given in a four-year college course.

In general, the student's time is evenly balanced between theory and practice in the area of his major courses. There are, however, courses that are strictly theory, based on the college formula of two hours' preparation for one hour of class. More demonstrations, by means of various visual aids, are to be found in the classrooms at technical institutes than would take place in most four-year colleges. Heavy emphasis is placed on laboratory work to provide practical application of the theoretical material presented.

Types of Students

Although the author has taught in high schools, junior colleges, and at a four-year college, there is no doubt but what the student at a technical institute is a radically different type. First of all, there are practically no loafers. Every high-school class is plagued by this variety of human being and college classes are not exempt. The few of this type who do enroll leave early in the school year. Also, there are no playboys. Our school, for example, is co-educational, but it is not the sort of a place where a rich parent would send his spoiled son to get him off the street for a few years.

The average student is one with limited funds who often travels hundreds or even thousands of miles to get an education. This is what he came for. He expects to graduate with an Associate in Engineering or Associate in Science degree in approximately two years and he expects to get a good position in industry when he graduates.

While in school, he will work. If he doesn't understand, he will let you know in no uncertain terms, and will hound you until he does understand. He really wants to learn.

Another factor which contributes to the atmosphere of serious purpose is the sizable percentage of older students. These are either people who have put in their time in military service or those who have worked in industry and have realized the need for post-high-school training.

What to Look For

Some special mention should be made of criteria for picking a good technical institute in the field of electronics. First of all, it should be understood that some schools calling themselves "technical institutes" are, in reality, vocational schools. One question that might be asked in this connection is "Does the program parallel an established profession and aid and assist the professional person?" In electronics this may mean that the graduate is qualified to aid and assist an electronics or electrical engineer or physicist.

Another standard that might be applied is "Is the institute ECPD accredited?" ECPD stands for the Engineers Council for Professional Development and is the same body that accredits colleges of engineering. Some state and many private schools, who are not interested in this type of accreditation, may still be quite acceptable so far as their training is concerned.

A quick run-down on the qualifications of the faculty will yield additional evidence. A record of their experience in industry is as important if not more important than their degrees. The number of faculty members will be some index of the school's excellence. If the school offers 20 courses in electronics—all taught by one man—such a program is likely to be of questionable value. On the other hand, if there are between six and ten specialists handling this curriculum, the student has a better chance. There is no better yardstick than the number of successful alumni who have compiled an impressive record of industry acceptance.

Prospects for the Graduates

In engineering and scientific fields today there is an expressed need for from three to five technicians for every engineer or scientist. Industry is still hiring the mechanic off the street because of the scarcity of technical graduates. The good technical-institute graduate should have little trouble getting a job—at least in the foreseeable future. Automation is his stock in trade. The man who takes care of automation equipment is not apt to be replaced by a push-button.

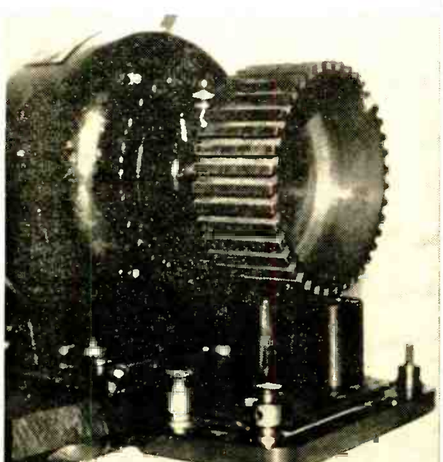
In terms of total life earnings, the usual technician will lag behind the engineer or scientist but this lag may not be evident for ten years or more. In the first place, while the engineer or scientist continues his schooling for 2 to 5 years longer at a cost of $1200 or more a year, the technician will be out earning from $6000 to $8000 a year at the time the college man is just starting out—at a somewhat lower figure. Although the engineer will take several years to catch up, eventually the total will swing in favor of the man who is the greatest value to his company.

No matter in what field of technology the technician is trained, he can look forward to a good future. As our world becomes more and more technical, the technician will continue to grow in importance and stature. ▲

1911 TONE WHEEL
By HOWARD S. PYLE

NO, this is not an infernal machine nor is it a squirrel exerciser! It is a home-made 500-cycle alternator or "tone wheel" designed and built by Thomas Appleby in 1911 and used to supply audio tone to all of the code practice tables at the Philadelphia School of Wireless Telegraphy.

The tone wheel shown has been outmoded for many years having been replaced by the modern vacuum-tube oscillator. In operation, the serrated wheel shown was revolved over two iron-core coils. This produced an alternating current which fed the code tables. ▲



CIRCLE NO. 146 ON READER SERVICE PAGE →

CONSTRUCT A MILLIWATT METER

By WILLIAM L. BLAIR, K6QXW

Good to 500 mc., this milliwatt meter measures r.f. power from less than 1 mw. to 300 mw. Complete details on designing an attenuator network are also included.

As more amateurs and experimenters try their hand at designing transistor circuits, the need for additional specialized pieces of test equipment becomes evident. In particular, the design of transistorized r.f. oscillators, amplifiers, and multipliers could be greatly simplified with a low-level milliwatt meter.

For those who may have a requirement for this type of instrument, complete construction details are presented. As a matter of general interest, attention is also given to the theory of operation of the device. If we look at what is required in the measurement of power, we may then proceed to select electronic parts which will perform the required functions.

The equation for power delivered to a load in terms of voltage and load impedance is: *power* = (*r.m.s. voltage*)^2/*load impedance*.

This means that keeping the load impedance constant, the power delivered to the load is directly proportional to the square of the r.m.s. value of the applied voltage.

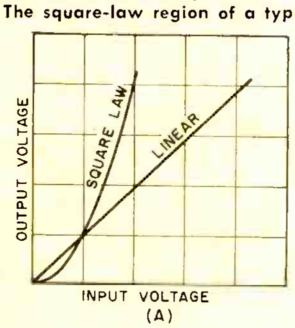
A plot of applied voltage *versus* output voltage for two devices having different responses is shown in Fig. 1A. In one device, the output is directly proportional to the input. This relationship is characterized by a straight line and is labeled "Linear." The output voltage is a linear, or straight-line, function of the input voltage. In the second device, the output voltage is proportional to the square of the input voltage. This curve is designated as "Square Law." It results when the output voltage increases by a factor of four, every time the input voltage is doubled.

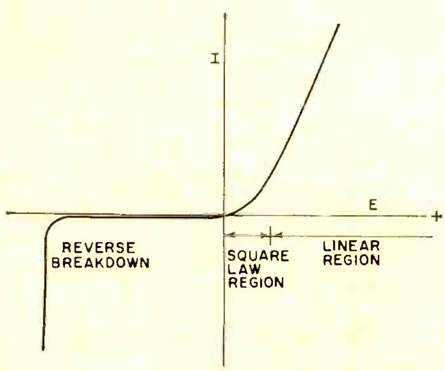
It is this second characteristic which can be of value in constructing a wattmeter, for if the output voltage of a square-law device is rectified, filtered, and applied to a meter, the deflection of this meter is a linear indication of the power level being applied to the input of the test circuit.

Fortunately, there exists a very common circuit element that possesses characteristics nearly identical to a perfect square-law device. This element is the crystal diode. However, the crystal diode is not a square-law device over a wide range of input voltages. As will be seen in Fig. 1B, for input voltages in the negative direction, the output is essentially zero until the critical reverse breakdown voltage is reached. In the forward direction, however, for the first few volts the voltage is very nearly the square of the input voltage. As the input is made greater, the output bears a linear or straight-line relationship to the input. It is a characteristic of the high-frequency diode to display this square-law effect for inputs between zero and two or more milliwatts of power. Therefore, we can use such a diode as the square-law device in a milliwatt meter with a high degree of accuracy as long as the input level applied to the diode is kept below one milliwatt. This makes a very convenient minimum range for the meter. It is a simple matter to adjust the input circuitry so that on the most sensitive scale, the meter will show a full-scale deflection for exactly one milliwatt. It will be found that one-half scale will correspond to an input of ½ mw., one-quarter scale to ¼ mw., and so forth.

To extend the usefulness of the meter, it is then necessary to provide an input attenuator which may be adjusted in convenient steps. In the design of this unit, it was decided to switch the input attenuator in steps of 5 decibels. A ceramic wafer switch having six positions, indexed every 60 degrees, was chosen, thereby giving full scale readings of 1, 3, 10, 30, 100, and 300 mw. The 5-db increments do not give quite full-scale deflections for the 3, 30, and 300 mw. ranges. It is necessary then to calibrate the dial for a minimum of two scales. (*e.g.*, 1 and 3 mw.) These same scales may also be used on the corresponding multiple of 10 ranges. By using a little care in the calibration of these two scales, the accuracy of the meter can be held to ±5%.

Fig. 1. (A) Output voltage vs input voltage for linear and square-law devices. (B) The square-law region of a typical diode.





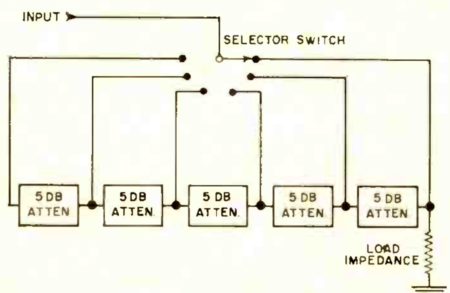
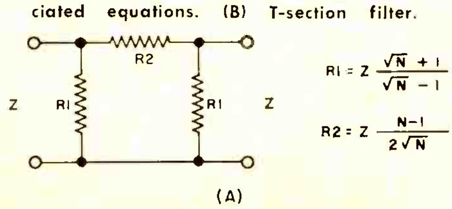
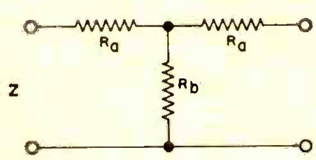


Fig. 2. Block diagram of the attenuator network as used in the milliwatt meter.

Fig. 3. (A) Pi-section filter with associated equations. (B) T-section filter.





Attenuator Theory

Probably the most interesting part in the design of this meter is the computation of the attenuator component values. By describing briefly the design procedure for this attenuator, one has the tools by which attenuators for other applications may be calculated.

Basically, Fig. 2 shows what we are trying to achieve. The diode detector, subsequent filter, and microammeter can be considered as being equivalent to a load. The assumption is made that this load may be neglected in comparison to the 50-ohm impedance that the input terminals are required to match. The attenuator network is depicted as a block between each of the six switch terminals. The attenuation presented by each block should be 5 db, and the input impedance at each terminal should be 50 ohms. The wafer switch connects the input jack to the desired tap on the attenuator line. Only two equations are required to compute the values of the components to be used in the attenuator network.

Fig. 3 shows two different resistive networks, and either could be used to achieve desired results. The first is a pi-network consisting of two shunt resistors to ground with a series resistor between them. The second is a T-network consisting of two series resistors with one shunt resistor between them going to ground. It will be seen shortly that by choosing the pi-network, the resulting attenuator circuit will require fewer components.

The equations in Fig. 3 make it possible for us to compute the parts values to be used in each section. These sections are then repeated between switch positions until the desired amount of attenuation is achieved. Looking first at the computation required to find the value of the series resistor $R2$, it may be seen that only the ratio of input power to output power (N) and the input and output impedances (Z, in this case the same) need be known. The desired attenuation per section is 5 db, which corresponds to a power ratio of 3.16 (*i.e.*, $N = 5$ db $= 10 \log 3.16$). A little thought must be used in substituting a value for Z. When the networks are connected one after the other, the output impedance of one is connected directly across the input to the next. This amounts to connecting two resistors in parallel. To create an apparent 50-ohm impedance at the switch contact, the input and output impedances at the switch contact must both be made equal to 100 ohms so that the parallel combination will be just one-half that value, or 50 ohms.

Using these values, the top equation in Fig. 3 gives

$$R1 = Z\,\frac{\sqrt{N}-1}{\sqrt{N}+1} = 100 \times \frac{\sqrt{3.16}+1}{\sqrt{3.16}-1} = 358 \text{ ohms}$$

and the lower equation gives:

$$R2 = Z\,\frac{N-1}{2\sqrt{N}} = 100 \times \frac{3.16-1}{2\sqrt{3.16}} = 61 \text{ ohms.}$$

Fig. 5A shows how the sections should be connected together to achieve the desired result. Since the sections were designed to be loaded by the input and output impedance of adjacent sections, the input to the first section and the output to the last section must be terminated in 100-ohm resistors to avoid signal reflections and subsequent errors in the network attenuation characteristic.

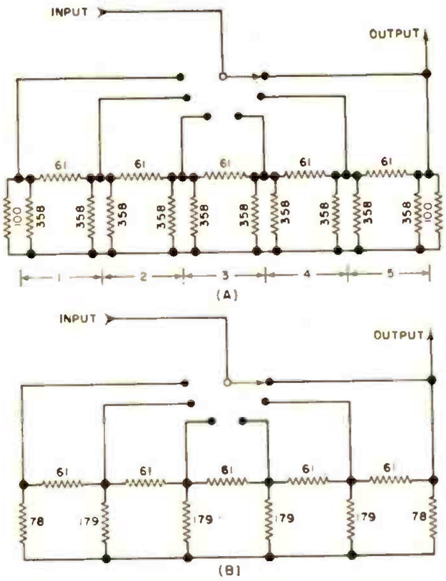


Fig. 5. (A) Theoretical attenuator and (B) the equivalent that uses fewer parts.

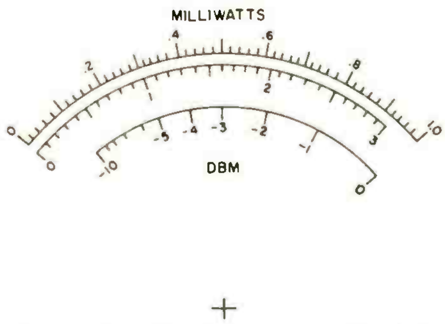


Fig. 6. Meter face for the milliwatt meter.

Now the reason for choosing the pi-attenuator network becomes apparent. Each pair of parallel resistances may be replaced by its equivalent single resistance, as shown in Fig. 5B.

Fig. 4 is the complete schematic of the practical milliwatt meter. The values of the resistors used in the attenuator are the nearest available 5% tolerance resistors. If the meter is to be used at 50 mc. or below, $C1$, $C2$, $C3$, and $L1$ may be omitted without seriously affecting the accuracy of the instrument. However, with the addition of these components the meter's accuracy is maintained for input frequencies greater than 500 mc. Their use is necessitated by the fact that distributed capacity of the wiring and switch contacts shunts more and more of the r.f. energy to ground as the frequency is increased. This means that the resistive attenuation of each section appears to be greater than 5 db. $C1$, $C2$, and $C3$ balance this loss by providing a proportional decrease in the impedance of the series attenuator element as the frequency is raised.

In the last attenuator section, a different effect occurs. Since a rotary switch is used, $R6$ is physically adjacent to $R11$ and some of the input signal is capacitively coupled directly to the detector. This causes the 25-db attenuator position to differ by less than 5 db from the 20-db position. To increase this attenuation, a small inductance, $L1$, is inserted in series with $R1$. Since $R2$ is located such that these two effects are approximately balanced, no compensation is required in that section.

$D1$ is a half-wave diode rectifier operated in its square-law region as described earlier. $C4$ constitutes a filter which smoothes the d.c. output from the rectifier for application to the microammeter. $C5$ is not necessarily required, although it is always advisable to place a small capacitor across the terminals of a sensitive meter. It serves as protection against destruction of the meter movement due to the inductive coupling of strong r.f. fields into the leads running to the meter.

Using the parts shown on the schematic, it was found that the diode had to be selected to find one which would give full-scale deflection of the meter for exactly 1 mw. of r.f. input power. This requirement may be eliminated by using a 0-50-μa. meter movement and inserting a 5000-ohm potentiometer in series with the meter. A reference level of one mw. r.f. may be applied to the input, and the potentiometer adjusted for exactly full-scale deflection.

Fig. 6 shows how the scale face may be marked for the 1 mw. and 3 mw. full-scale readings. For those accustomed to working with power levels in terms of db relative to one milliwatt, dbm scale is also included. Since any practical diode departs to a small extent from a perfectly linear output, the accuracy of the meter may be improved slightly if both meter scales are calibrated against a known, variable-level source of very-low r.f. power. ▲

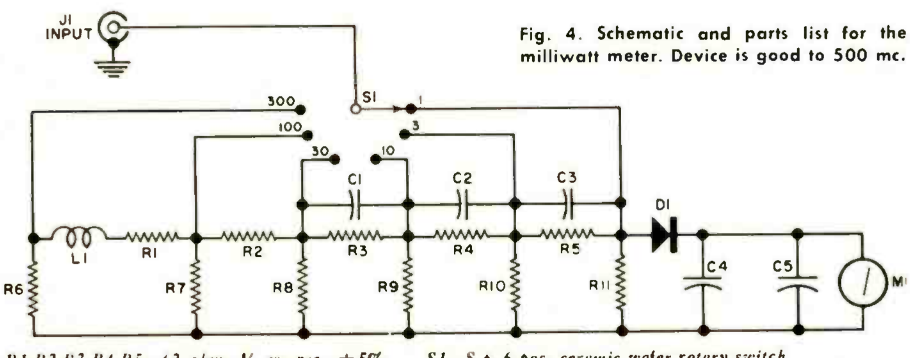


Fig. 4. Schematic and parts list for the milliwatt meter. Device is good to 500 mc.

R1,R2,R3,R4,R5—62 ohm, ¼ w. res. ±5%
R6,R11—75 ohm, ¼ w. res. ±5%
R7,R8,R9,R10—180 ohm, ¼ w. res. ±5%
C1—2.2 pf. mica capacitor
C2,C3—3 pf. mica capacitor
C4,C5—.001 μf. disc capacitor
S1—S.p. 6-pos. ceramic wafer rotary switch
J1—BNC coax panel connector (UG657/U)
L1—1½ t. #20 wire, 3/16" i.d., 3/16" long, air wound
D1—1N21B diode
M1—0-50 μa. microammeter

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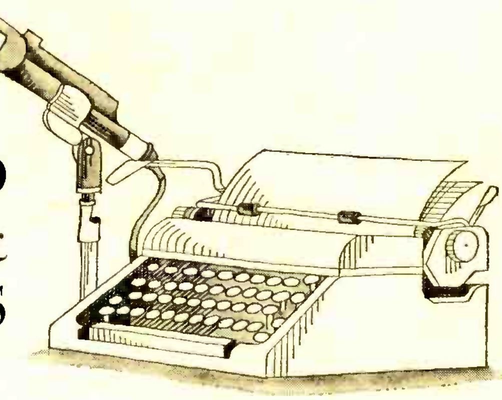
RADIO & TV NEWS



A COUPLE of months ago, we were discussing molecular circuits and the possibility that future repair work might possibly consist only of isolating a fault to a particular molecular block, then removing the faulty block and replacing it with a new one. This seemed to be about the ultimate in service simplicity.

A recent announcement by *Honeywell* brought us up cold and, with shades of science-fiction monster makers hovering in the background, we found out that *Honeywell's* Aeronautical Division in Boston has developed and successfully tested some electronic circuits that can actually "grow" to regenerate themselves if they fail under stress. Actually, two approaches to self-healing electronics have shown promise. The first involves the growth of metallic whiskers across a circuit break while the other uses a special remeltable alloy coating over the conductors.

Whisker growth on metals has been with us for a long time, but this seems to be the first practical application of this strange phenomenon. Greatest whisker density and fastest growth rates are observed in an alloy of tin, aluminum, and magnesium. The whiskers grow from this alloy at compressed or stressed regions, no external energy is required, whiskers grow only where needed, and whisker growth can occur many times repaired regions are re-opened.

Time is a problem in this self-repair area. At present, circuits containing hairline breaks are placed in a 120° F oven until whisker growth is complete. This may take several days for a hairline break to many months if the break is a large one.

In the second self-repairing system, a remeltable alloy is coated over the conductors and "ohmic resoldering" occurs by alloy melting as the heat from the failing connection causes the alloy to flow into the break to maintain the conductivity.

At present, self-repair circuits are under Air Force investigation and may not reach consumer devices for many years, but a pattern dimly takes shape through the mist. The service shop of the future may consist of an oven, a refrigerator, and a couch. The faulty device is placed in the oven, the repairman takes a beer from the refrigerator, and takes a rest on the couch.

Imports On The Rise

According to a speech made by EIA president Charles F. Horne at the past winter EIA conference, 16% of the domestic market for TV receiver components was taken over by foreign producers in the first half of 1963. This included all components in the 156,000 imported TV sets plus 12% of the content of 3.5-million domestically produced receivers. During the same period, 46% of all imported radios and 12% of American-made radios were using imported components.

Receiving tubes imported during 1962 totalled 52 million units. Through September 1963, these imports had already risen to 50 million units.

Television set makers in 1963 felt a significant impact from imports. In 1962, only 128,000 TV sets, mostly of the small-screen type, were imported. Through September 1963, this figure more than doubled to reach 273,000 sets and may reach 450,000 when the final figures are in for 1963.

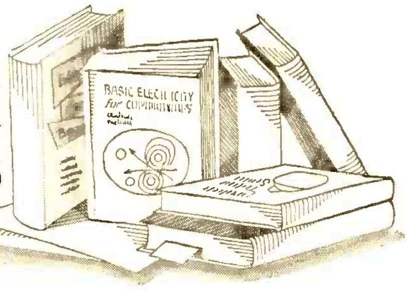
A threat to the consumer market arises from the fact that after April 30, 1964, all set manufacturers will be limited to producing only all-channel TV sets. These sets will cost more to make and will consequently command a higher selling price. The net result could be a decline in TV receiver sales once the inventories of v.h.f. sets made before the deadline are exhausted.

The EIA hopes that Congress can avert this threat, to a large degree, by removing the excise tax on all-channel sets thus making them competitive in price with former v.h.f.-only sets.

Another threat to the increasing growth of our electronics industry is the possibility that the present low tariffs on electronic imports may be further reduced, as much as 50%, at the GATT international trade conference.

The EIA will attempt to persuade the U.S. Tariff Commission that further reductions may be disastrous to our industry. ▲

BOOK REVIEWS



"SEMICONDUCTOR PARTICLE DETECTORS" by J. M. Taylor. Published by *Butterworth Inc.* 175 pages. Price $8.25.

This is a highly specialized volume devoted to a still-infant science but one which shows promise in space and biophysical research applications. The book describes the factors governing the design and performance of these detectors, their advantages, and their limitations.

The text starts from first principles and includes those aspects of solid-state physics which are most relevant. The design and production of three main types of detector are described and examples given about their employment and the results achieved. The important new technique of ion drifting to obtain a *p-i-n* configuration is included as well as a chapter on the electronic equipment used with the detectors and the problem of electrical noise.

Those involved in nuclear physics, biophysics, solid-state physics as well as electronic engineers will find this volume helpful. The treatment is mathematical and an engineering or physics background is prerequisite.

° ° °

"A PROGRAMMED COURSE IN BASIC ELECTRICITY" by Staff, Electrical Technology Dept. N.Y. Institute of Technology. Published by *McGraw-Hill Book Company, Inc.* 327 pages. Price $6.95. Soft bound.

This is the first volume in the current "Programmed" series being prepared by the Technology staff as teaching guides for Institute courses. The programmed course was designed specifically for students working toward electronic specialization but who were without the requisite electrical background.

The carefully organized logical sequence of interrelated steps permits the student to proceed at his own pace and his work can be checked at every point along the way. Visual instruction is aided by clear, uncomplicated diagrams. Mathematics has been kept to a minimum, especially in the earlier sections of the book, in order to permit the nonmathematically minded reader to grasp the necessary concepts.

The text is designed as an introductory two-semester course and is followed by two additional texts, also in linear programmed form: "Basic Electronics" and "Basic Transistors." Each may be used independently or all three may be studied in sequence.

° ° °

"TRANSISTOR INVERTERS AND CONVERTERS" by Thomas Roddam. Published by *D. Van Nostrand Company, Inc.* 235 pages. Price $7.75.

The flood of portable transistor equipment in the past few years, involving everything from radio receivers and tape recorders to scientific instruments of varied complexity, has made necessary a light and efficient means of providing both a.c. and a range of d.c. voltages from low-voltage d.c. sources.

The transistor inverter and converter satisfy these requirements but, unfortunately, the literature is scattered and characterized by a lack of agreement. In this volume the author has produced a single theory to cover the various types of transistor inverter circuits available and, after a general introduction, he deals with the large-signal operation of transistors and then discusses linear and saturable inductors.

The unified circuit theory for transistor inverters is developed from a consideration of the negative circuit impedance of oscillators. From this premise, he goes on to consider in detail various types of inverters, such as push-pull, square-wave, transistor bridge, sine-wave, and driven, devoting a chapter to each. Further chapters deal with single-ended and converter systems.

* * *

"INTRODUCTION TO MICROWAVES" by Gershon J. Wheeler. Published by *Prentice-Hall, Inc.* 237 pages. Price $12.00.

This is an elementary text designed especially for the training of microwave technicians. Since the design of such systems is not involved, the use of higher mathematics has been avoided although a knowledge of algebra would be desirable.

Emphasis is on the practical aspects of microwaves and after an introductory chapter explaining what microwaves are and how they are used, the balance of the book is devoted to discussions of transmission lines, microwave measurements, waveguides, coaxial lines, methods of matching, tees and couplers, microwave components, resonant cavities and filters, mixers and detectors, switching, antennas, and microwave tubes.

Questions and problems are included at the end of each chapter for review and to facilitate group discussion. A useful appendix on microwave schematics is also included.

* * *

"RCA PHOTOTUBES AND PHOTOCELLS" by Electronic Components & Devices Dept., *RCA*, Lancaster, Pa. 189 pages. Price $1.50. Soft bound.

RCA has added this new technical manual (PT-60) to its list of handbooks intended to assist equipment designers in selecting the proper vacuum, gas, and multiplier phototubes; solid-state photocells; and associated circuits

This handy volume covers not only theory, characteristics, and applications of the four classes of devices, but provides information on selecting the right type of device for a specific application. The section on Technical Data contains detailed information on the phototubes and photocells presently in the company's line. This material is offered in typical tube-manual format.

* * *

"UHF BUSINESS RADIO HANDBOOK" by Leo G. Sands. Published by *Howard W. Sams & Co., Inc.* 190 pages. Price $3.95. Soft bound.

This volume covers all aspects of the Business Radio Service and is specifically slanted toward use of the 450-470 mc. u.h.f. bands. In ten chapters the author provides the answers to questions concerning the purpose of business radio, types of u.h.f. equipment and its design and operation, u.h.f. mobile and fixed stations, relay stations, antenna systems, servicing, class-B equipment, and the interpretation of FCC regulations governing the service, including technical standards, type-accepted equipment, installation and maintenance rules, license applications, etc.

The book can serve not only as a complete guide for users and potential users of the service but as a handbook for service technicians, students, and others interested in the field of radio communications.

* * *

"LOGICAL ELECTRONIC TROUBLESHOOTING" by Donald H. Schuster. Published by *McGraw-Hill Book Company, Inc.* 296 pages. Price $5.95. Soft bound.

This is a programmed book, written by Dr. Schuster of *Collins Radio Company*, designed to aid the electronics technician and radio or television repairman in gaining the knowledge necessary to deal with most troubleshooting situations. Users of this text will learn to analyze malfunctioning systems logically and to correct the trouble rapidly without guesswork.

The presentation is unique in that the pages are scrambled. The first unit of information is found on page one and at the end of this information unit a question is asked and three alternative answers are given. The user chooses what he believes is the correct answer to the question and turns to the page number referenced in the answer. If he has chosen the correct answer, the page to which he turns will present the next unit of information and a new question. If the incorrect answer is chosen, the page he turns to will explain why the answer was incorrect and will direct him to return to the original information unit and select another. Thus, in order to progress through the book, the correct answer to each question must eventually be chosen.

A background in basic electronics and some familiarity with the theory of operation of radio and television sets is prerequisite but he does not have to be a TV serviceman or electronics technician since the less familiar circuits are explained as required.

* * *

"TEST EQUIPMENT CIRCUIT MANUAL" by Robert C. Middleton. Published by *Howard W. Sams & Co., Inc.* 191 pages. Price $4.95.

This handy volume contains complete test-equipment circuits and specifications for the most popular service instruments of the past few years. The text can be used both as an instruction aid and as a practical handbook for servicing and maintaining a wide variety of instruments.

Included are v.o.m.'s; v.t.v.m.'s; signal, sweep, and pattern generators; tube and transistor testers; oscilloscopes; bridge-type instruments; signal tracers, circuit analyzers, among others. ▲

New TV Designs for 1964

(*Continued from page 54*)

have a video peaking control, part of the video detector load, which permits "crisping" or "smearing." The 16L24 chassis also uses horizontal blanking and, similar to the *Westinghouse* circuit, employs a neon tube to allow only the negative flyback pulse portion on the control grid. The vertical blanking circuit is entirely separate and drives the first anode or second grid of the CRT.

Zenith's 1964 color set uses the same basic circuits as the '63 models, with some interesting variations. The brightness channel now contains only a cathode follower and a single, high-gain video amplifier, but the horizontal oscillator and a.f.c. circuit use three stages in addition to the dual-diode phase detector.

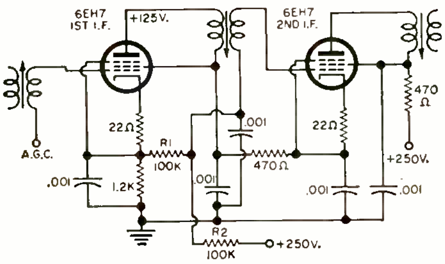


Fig. 12. Cascaded i.f. arrangement used in the new Zenith color sets.

Just as in its monochrome receivers, and in the new *RCA* color sets, a variable video response control is provided. Probably the most interesting new circuit is the cascaded i.f. arrangement shown in Fig. 12. For a.c., this circuit is practically the same as in any two i.f. stages, but for d.c., the second i.f. is in series with the first. One of the important features of this arrangement is the effect that a.g.c. bias variations on the first stage must have on the gain of the second stage. Since the grid voltage of the second stage is held relatively constant, due to *R*1 and *R*2, the change in cathode current, due to the plate current change of the first stage, has the result of reducing the gain of the second stage too. This provides linear over-all a.g.c. control. ▲

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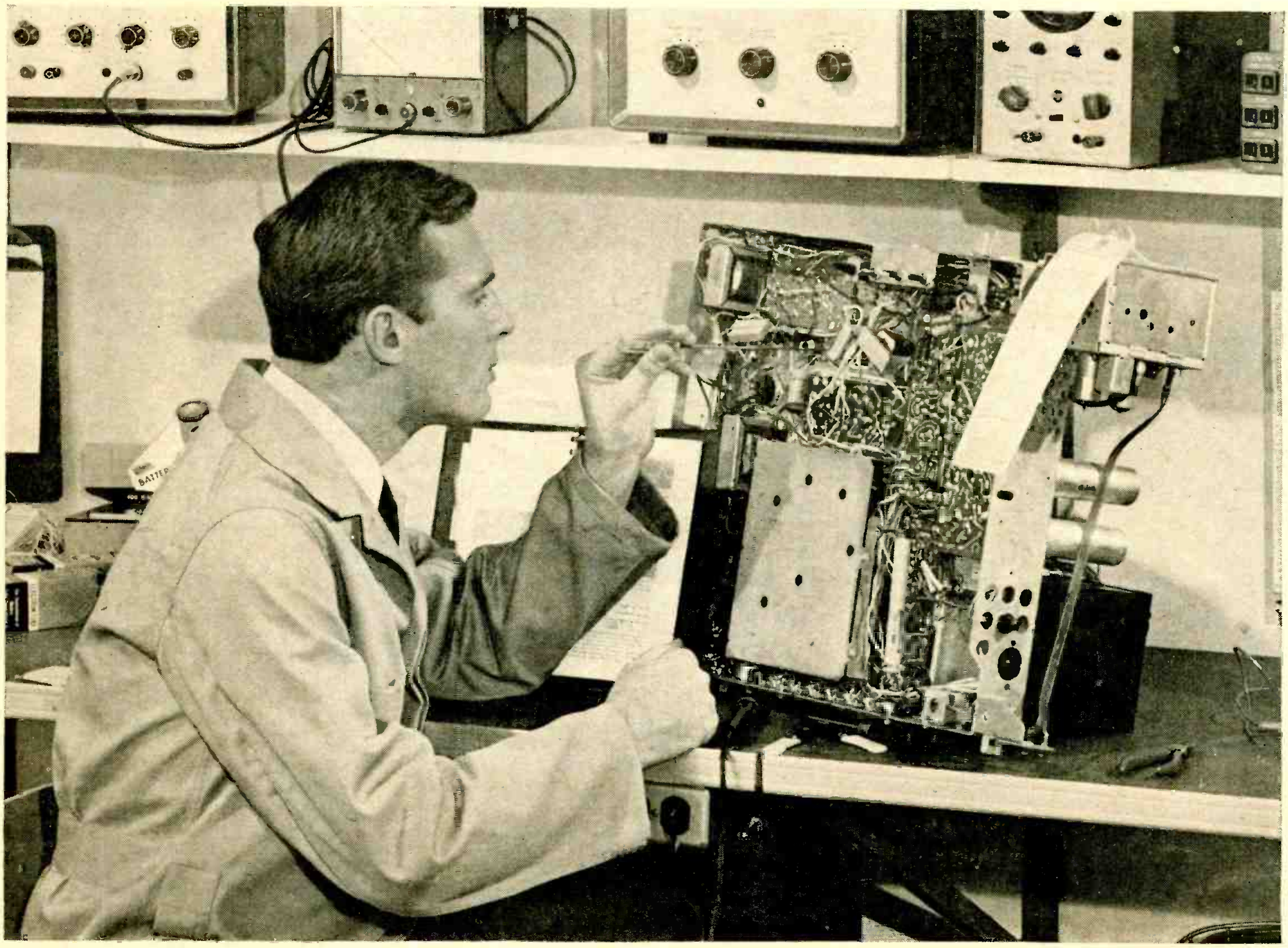

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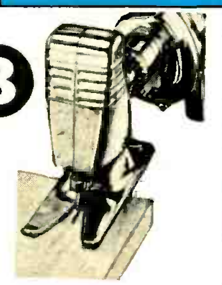

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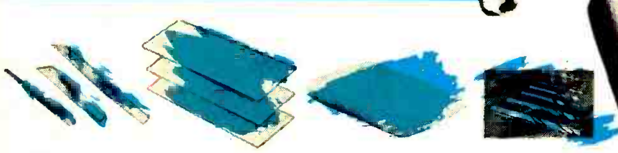

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NEW PRODUCTS

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

PORTABLE V.H.F.-U.H.F. TRANSLATOR

1 **Standard Kollsman Industries, Inc.** has developed a new multipurpose, portable v.h.f.-u.h.f. translator that provides u.h.f. television signals when none are available on the air. The time-saving test instrument is designed for use by the TV service technician for servicing all-channel television sets as well as making it possible for the dealer to demonstrate all-channel TV sets in his showroom. The instrument can also be used in TV production plants.

This portable 10-pound unit will convert any v.h.f. channel to any u.h.f. channel and will transmit color picture information as well as black-and-white. Its bias control will vary signal strength from 100 µv. to 10 mv. or higher depending on the signal strength of the v.h.f. station. It operates on 110-125 volts, 50-60 cps, with 30 watts maximum power consumption.

HEAT-SHRINKABLE TUBING

2 **Radiation Materials Inc.** is now marketing "Electro-Shrink," a heat-shrinkable tubing for electronic circuit applications. The product is an irradiated, thermally stabilized and flame resistant polyolefin tubing which is supplied in expanded form designed to slip over electronic components. Upon application of heat in excess of 235 degrees F. the tubing will shrink in seconds to form a tight mechanical bond over a variety of materials.

ANTI-STATIC PLASTIC CLEANER

3 **Wilco Company** has developed an anti-static plastic cleaner which is being marketed as "Surefire." The product both cleans and removes static charges and provides all plastics with a dust-repellent surface.

The cleaner is packed in 8- and 16-ounce plastic refillable, self-dispensing containers or in gallon plastic jugs.

CLIP-ON POCKET TOOL

4 **Exclusive Products Co.** is now offering a compact 7-in-1 service tool which clips to the pocket like a pen.

It can be used as an everyday service tool for TV and radio technicians since in addition to having a high-voltage tester to check receivers, the "Tenite" handle also houses an accurate 1" spirit level, ⅜", ¼", and 5/16" hex sockets, as well as a standard screwdriver and reversible Phillips-head driver.

The tool measures less than 4½" long and weighs only 2½ ounces.

TOWER LIGHTING EQUIPMENT

5 **Rohn Manufacturing Co.** is now offering a complete line of obstruction lights and beacons for installation on towers or other structures where required.

The B-I 300 MM code beacon meets complete FAA and FCC specifications. It is designated for use on TV, microwave, and transmission-line towers, water tanks, stacks, bridges, and other lofty structures as an aircraft warning system.

The obstruction lights are available in either single or double models and meet both FAA and FCC regulations for use as warning lights on towers and other hazards to aerial navigation.

TRIMMER FOR PC

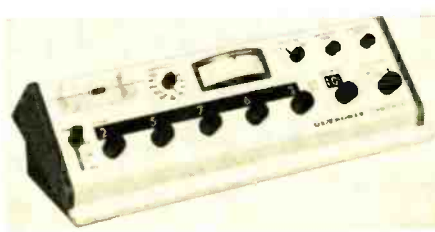
6 **Corning Electronic Components** recently unveiled a new miniature trimmer capacitor for printed circuits which is designed to take up minimum board area and allow vertical trimming. All models of the "Pin Terminal Mini Trimmer" are only 5/16" in diameter. The 1-to-5-pf. model stands only .480 inch above the board the 1-to-10-pf. model only .680 inch, and the 1-to-14-pf. model only .870 inch.

The metallized glass trimmer has a center pin terminal as one electrode on its base and parallel side leads its top. The leads fit .1-inch grid hole spacing of circuit boards.

RESISTANCE MEASURING SYSTEM

7 **Ultronix, Inc.** has announced a new Kelvin/Wheatstone bridge system for highly accurate measurement of resistance from 0.001 ohm to 111.11 megohms.

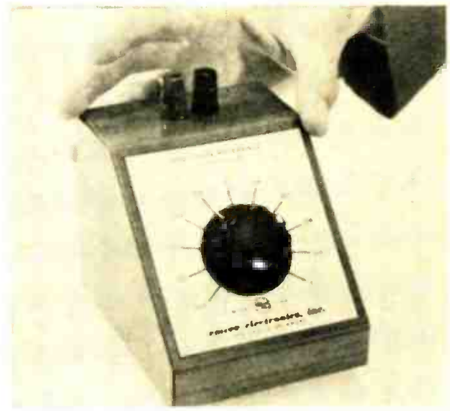
Tradenamed the "Ohmicron", the Model PKW-100 resistance measuring system has an accuracy of 0.05% + 0.001 ohm up to 11.111 megohms. Minimum resolution is 0.01%. The instrument is battery operated, completely self-contained, and easily portable. A built-in deviation dial indicates resistance error as a percentage of the bridge setting. The maximum inaccuracy of the deviation reading at full-scale is 0.02% of the bridge setting.



The instrument is housed in a heavy aluminum case measuring 17" x 4¾" x 7" and weighs 10 pounds.

VOLTAGE REFERENCE

8 **Emcee Electronics, Inc.** is offering a low cost precision voltage reference which covers the range of 10 µv. to 1/10 of a volt with an accuracy of ± 0.5%. Completely self-contained, accuracy is obtained by use of a precision mercury cell and 0.25% resistors. The cell has a capacity of 14,000 ma./hr., giving a life expectancy of one year. Intermittent or continuous short circuit of the output terminals will have no effect upon the accuracy of the decade.



These units are especially suited for the precision calibration of d.c. amplifiers, recorders and indicators in plant instrument repair shops, electronic labs, and instrument calibration work.

SEPARATION FILTER

9 **United Transformer Corp.** is now offering sharp cut-off low- and high-pass filters with common inputs connected in parallel, packaged in a single case. The source is 600 ohms and the load for each filter is 600 ohms.

The low-pass filter is within 3 db from d.c. to 1350 cps, has at least 14 db attenuation at 1410 cps, and is down at least 40 db at 1465 cps and higher frequencies. The high-pass filter is within 3 db from 100 kc. to 1470 cps, has at least 14 db attenuation at 1410 cps, and is down at least 40 db at 1355 cps and lower frequencies.

The unit is hermetically sealed and guaranteed to MIL-F-18327B. MIL type designation is FR4RX13YY. Size is 4" x 7" x 2" and the unit weighs 6 pounds.

TV TAPE MACHINES

10 **RCA's** Broadcast and Communications Products Division has announced three new television tape machines, representing the first machine designed exclusively for playing back TV tape, a transportable tape recorder compatible with TV broadcast standards, and a complete recording-playback system in compact form.

The new machines, because they use the quadraplex recording method, are fully compatible with the approximately 2000 professional TV tape recorders now in world-wide use. Each of the new TV tape units is available in two models, one for operation at U.S. television industry line standards and a second, or international, model that can be switched for operation at either of two standards in foreign countries.

9-INCH PORTABLE TV

11 **Sony Corporation of America** is currently introducing a nine-inch portable model as a companion unit to its "Micro-TV." Known as the Model 9-304, the new set is designed for group viewing. It weighs only 12 pounds and is 9⅜" high x 8⅝" wide x 7⅝" deep. It can operate on regular house current, its own rechargeable battery pack, or 12-volt car or boat battery.

The circuit uses 29 transistors and 16 diodes and has a.g.c. built in to insure stability The set can be converted for all-channel reception by using the company's all-transistor u.h.f. converter.

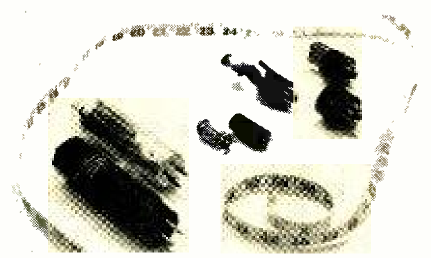
FILM-PACK ADAPTER

12 **Beattie-Coleman, Inc.** is now offering a retro-fit kit that adapts any of its K-5 or Mark II Oscillotron oscilloscope cameras for use with the new **Polaroid** film pack. Consisting of a slide mount that attaches easily to the camera, it incorporates a new style spacing bar with positive detent to permit recording up to 13 traces on one frame.

THYRATRON REPLACEMENT

13 **General Electric Company's** Rectifier Components Department is in production on custom-made solid-state assemblies that serve as direct replacements for thyratron tubes.

These solid-state units are built around a semiconductor assembly which can be plugged directly into sockets occupied by thyratrons. The



assemblies are being designed and fabricated on a special basis to replace tubes like the 2D21, 2050, and 6011 thyratrons.

Unlike its predecessor, the solid-state assembly does not require a time delay before application of anode voltage since it does not have a filament. Hence, it is immediately available for operation.

REGULATED POWER SUPPLY

14 **Electro Products Laboratories, Inc.** is in production on a stable well-regulated d.c. power supply which provides a continuous rated output of 0-500 volts d.c. at 0-250 ma. Maximum ripple is 5 mv. r.m.s. Output voltage regulation is 0.03% or .015 volt, whichever is greater, for combined line (105-125 volt) and load (no-load to full-load) variations.

The unit is built for continuous heavy-duty production testing, design, and electronic circuitry development. It measures 13½" x 8" x 14" and weighs 32 pounds.

SCR'S IN TO-5 PACKAGE

15 **Motorola Semiconductor Products Inc.** has announced the availability of a new 1.6-amp silicon-controlled rectifier series in a TO-5 package, featuring a diffused-in shunt resistor and improved turn-on and turn-off switching times.

The devices are available in standard forward breakover voltage ratings from 25 to 400 volts but can also be obtained on special order with forward blocking voltages up to 800 volts.

A unique feature of the MCR914-1 through 6 SCR series is the diffused-in shunt resistance which eliminates the need for an external gate-to-cathode bias resistor commonly required to lead mount SCR's The new series is particularly suited for applications such as: flip-flops, low-power inverters, relays, power logic, temperature sensors, and as a general thyratron tube replacement.

TUBE-REPLACEMENT RECTIFIER

16 **International Rectifier Corporation** has announced the availability of a compact silicon tube-replacement rectifier equipped with a tube base to allow direct replacement (with suitable dropping resistor) of vacuum-tubes 6BW4 and 12BW4. Used in two-way radio and mobile communications, TV and audio applications, the new silicon rectifier provides instant operation, requires no filament supply, has low operating temperature, and demonstrates no aging characteristics.

The ST-13 is rated at 1600 volts p.r.v., 1130 volts maximum r.m.s., and has maximum output current of 0.5 amp d.c. at 100 degrees C. Operating temperature range is −40 to 140 degrees C.

FLASHLIGHT/CONTINUITY TESTER

17 **Union Carbide Corporation** has recently introduced the "Eveready" No. 308CT, a rugged flashlight with built-in continuity tester. Shatter-proof and oil, grease, and water resistant, the flashlight case is in black with a red lens guard and replaceable switch. The continuity tester has plug, clips, and insulated leads for checking wiring circuits, fuses, grounds, shorts, opens, controls, switches, and relays for appliances, radio and TV tubes, lamps, and bulbs. Two size-D batteries power the end-loading flashlight with built-in jack and bulb protector.

RELAY SOCKET PUNCHES

18 **Greenlee Tool Co.** is now marketing the No. 731-R relay socket punch which is designed to provide clean, accurate finished holes for **Potter & Brumfield** series KHP and similar miniature relay sockets.

Holes in up to 16-gauge metal can be made quickly and easily on the job or in the shop. The drive screw is simply inserted in a 9/16" drilled hole and the drive nut is given a few turns with a hand wrench and the job is done. All holes are exactly 1.015" x .859", assuring a perfect fit for each relay socket.

CAPACITOR SAMPLING KIT

19 **JFD Electronics Corporation** is now offering a sampling kit for "Uniceram", the firm's new line of ultra-miniature glass-encapsulated, ceramic fixed capacitors.

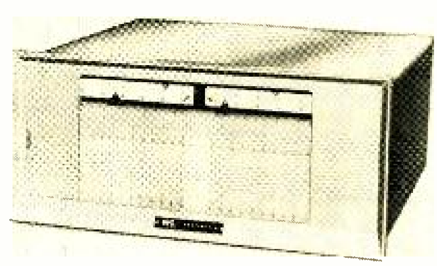
The sampling kit, USK-63, includes four UY02, two UY03, two UY04, and two UY05 units with capacitance ranges of the representative units between 5 and 2000 pf., although the UY06 series is obtainable with up to 10,000-pf. capacitance.

This moderately priced kit is housed in a translucent styrene container.

DUAL-ZONE RECORDER

20 **Westronics, Inc.** has announced availability of a new universal dual-zone series of strip chart recorders featuring two, three, or four independent channels writing on one chart.

The complete recorder is housed in one compact case which includes all four amplifiers and two 5-inch-wide recording zones on a 12⅜ inch-wide strip chart. One or two pens may record



in each zone giving a two, three, or four pen capability. The recorders operate on the null balance or potentiometric principle and are capable of recording spans as low as 1 millivolt full-scale.

Internal fixed-span, plug-in range modules for millivolt and thermocouple ranges make range changing a simple task. The recorders may also use universal external input units such as the adjustable span and zero, resistance bulb, pot follower, or strain-gage units.

TV-FM ANTENNA LINE

21 **RMS Electronics Corp.** is now offering two new antennas designed to provide maximum TV-FM reception capability.

Among the features offered in the "Trans-power'd" and "Fringemaster Dart" are high gain, high front-to-back ratio, flat response for maximum low- and high-band response, broad bandwidth, all elements reinforced with 7/16 crimped slip-proof aluminum sleeves, high-impact Styrene plastic insulators, snap-lock element positioning, gold aluminum protective finish and the firm's "Quadro-Grip" U-bolt assembly to permanently attach the antenna to the mast.

AEROSOL FLUX REMOVER

22 **Miller-Stephenson Chemical Co.** has introduced a new aerosol flux remover for printed circuitry. Known as S-190 "Freon" TMC Flux Remover, the product comes in a 16-oz. aerosol container and is especially efficient in cleaning fragile and delicate circuitry where mechanical means are out of the question.

The new spray removes both lightly and highly polymerized solder flux residues. It is a non-flammable product with a low level of toxicity.

HI-FI — AUDIO PRODUCTS

HI-FI CARTRIDGE

23 **Shure Brothers, Inc.** has announced a radically new "Stereo Dynetic" cartridge with a no-scratch, retractile stylus that tracks at an effective vertical angle of 15 degrees.

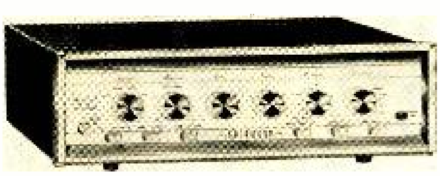
Designated the M44, the new cartridge is designed to track records at the same effective vertical stylus angle major recording companies are now using when cutting records. The company claims this reduces IM and harmonic distortion by 75% to 90%. Also crosstalk between channels has been negated in the critical low-frequency and mid-ranges.

Frequency response is 20-20,000 cps in both the .5-mil and .7-mil diamond stylus versions. Output voltage is 5 mv. for the .5-mil unit and 10 mv. for the .7-mil version. Channel separation is better than 25 db. Tracking range is ¾ to 1½ grams for the M44-5 and 1½ to 3 grams for the M44-7.

80-WATT STEREO AMPLIFIER

24 **Sherwood Electronic Laboratories, Inc.** is currently introducing the S-5500III, a stereo preamp, stereo control center, and stereo power amplifier on a single chassis.

The phono channel features well-filtered d.c. filaments for extremely low noise and hum.



measuring 72 db below rated output. Phono input sensitivity is 1.2 μv. Tape-head sensitivity is 1.6 μv. and tuner sensitivity is 0.25 volt. Frequency response is 20-20,000 cps ±½ db.

Each channel provides 40 watts of music power or 36 watts continuous at 1½% IM distortion. Speaker outputs are 16, 8, and 4 ohms. The circuit uses 9 tubes and 4 silicon rectifiers. Novar output tubes are used to increase performance quality and improve dependability.

TRANSISTOR STEREO AMP

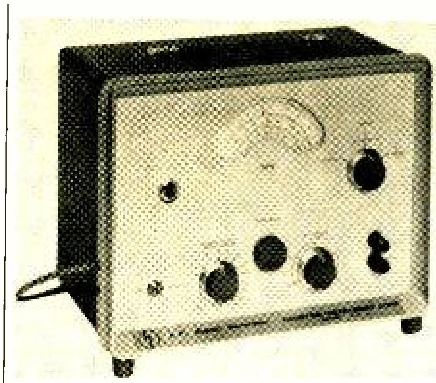
25 **Allied Radio Corp.** is now offering a 70-watt transistorized stereo amplifier in its "Knight-Kit" line of hi-fi components. The Model KG-870 features 22 transistors and 4 silicon diodes. For easier assembly, the model includes modular printed circuits and plug-in transistor sockets.

Power output is 70 watts IHF music power, 35 watts per channel. Response is 20-25,000 cps ± 1 db. Distortion at rated power is 0.5% harmonic and less than 1% IM. Channel separation exceeds 30 db.

The instrument measures 2¾" x 13" x 11".

AUDIO SIGNAL GENERATORS

26 **Houston Instrument Corporation** has added the Models H-1, J-1, and J-2 to its line of audio signal generators to provide a sinusoidal signal over the entire audio frequency spectrum



from 15 to 50,000 cps. The Model H-1 (photo) also provides a square-wave output which may be selected by means of a panel-mounted switch.

With a continuously variable sine-wave output of 0.25 volt to 35 volts, the J-1 and J-2 signal generators have less than 2% distortion at 1 watt output. The output impedance of these two units is 600 ohms, with an alternate 5-ohm output with one side grounded.

The H-1 provides a continuously variable square-wave output of 80 mv. to 80 volts peak-to-peak and a continuously variable sine-wave output voltage of 200 mv. to 20 volts r.m.s Distortion is less than 1% at 1000-cps at a level of 20 volts.

Frequency response of all the signal generators is flat ±1 db over the instrument range.

VOICE-ACTUATED RECORDER

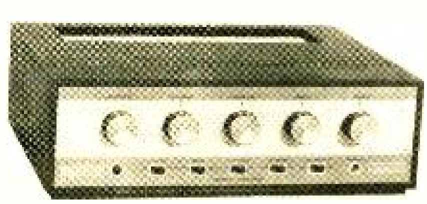
27 **Miles Reproducer Company** has developed a miniaturized, lightweight, fully transistorized tape recorder that is voice-actuated. Recording starts instantly at the sound of voice or telephone and stops automatically after sound ceases. This feature eliminates supervision as well as the recording of silent periods. Up to five hours of solid recording may be automatically accumulated at intervals over an extended period of time.

Designed for dictating applications, the recording is made on a thin plastic belt which costs as little as 3 cents per hour of recording time. Belts are easily replaceable within 2 seconds.

40-WATT STEREO AMPLIFIER

28 **Grommes, Division of Precision Electronics, Inc.** has added a new 40-watt stereo amplifier to its "Allegra" line of hi-fi components in the moderate price class.

The new amplifier provides 20 watts per channel, IHF, rated ±0.5 db 20-20,000 cps at one watt. The unit features eleven controls con-



sisting of selector for tape, phono, tuner and two auxiliary; balance, loudness, bass, treble, stereo-mono switch, filter switch, contour switch "off-on," speakers "off-on," and phones (stereo).

The amplifier has a satin gold and desert bronze panel with gold-swirl knob inlays.

BROADCAST CARTRIDGE UNIT

29 **KRS Electronics Corp.** has recently introduced a new multi-deck broadcast audio tape cartridge unit which is being marketed as the "Stact-Broadcaster."

The new equipment provides reversible continuous-loop operation and eliminates reel-to-reel production and transfer to cartridges. The unit will hold six tape cartridges in less space than normally required for one reel-to-reel unit. It includes five playback decks plus one combination record-playback deck. It provides full-length program capability for broadcast stations.

The tape tray and hub are designed to be compatible with reel-to-reel recorders. By removing the five assembly screws, one may remove the tape tray and place on a reel-to-reel recorder and load master material if desired.

FM-STEREO RECEIVER

30 **Eico Electronic Instrument Co. Inc.** has added the Model 2536 FM-stereo receiver to its "Classic Series" of instruments.

Supplied in kit form, the front-end and i.f. strip, consisting of four i.f. stages and the ratio detector, are prewired and pre-aligned for best performance on weak signals. A high-quality circuit board is provided for the stereo demodulator circuit and the coils supplied are pre-aligned.

The amplifier section provides 36 watts IHF music power and 28 watts continuous power. Frequency response is 15-40,000 cps ±1 db. Inputs are magnetic phono or adapted ceramic phono, tuner, and tape auxiliary while 8- and 16-ohm outputs are provided. A wired version of this receiver is also available.

STEREO/MONO RECORDER

31 **Martel Electronics** is now importing the Uher "Royal Stereo 8000," a four-track stereo-mono record and playback unit.

The machine has two separate recording heads which permit monitoring ahead of the recording head, or from the tape after record-

ing, with a built-in mixer control for both channels. Two input level controls are also provided.

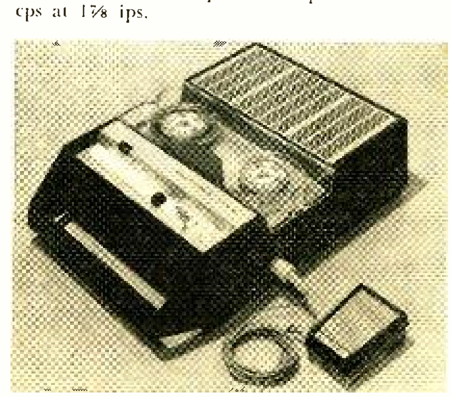
Tape speeds are 7½, 3¾, 1⅞, and 15/16 ips. It will handle up to 7" reels. Frequency response at 7½ ips is 50-20,000 cps ±3 db; channel separation is 50 db.

The recorder measures 14" x 13" x 7" and weighs approximately 23 pounds.

TRANSISTORIZED RECORDER

32 **Stanford International,** U.S. distributor for **Butoba** recorders, has announced receipt of the Model MT-7 recorder which uses a 4" x 6" speaker, push-button controls, and features push-button dynamic microphone for remote solenoid operation.

Fully transistorized, the new recorder will operate 20 hours on four ordinary flashlight batteries, as well as on 6- or 12-volt car batteries or a.c. power. The circuit features transistor speed control, record-level indicator, and a response of 70-12,000 cps at 3¾ ips and 100-5000 cps at 1⅞ ips.



The unit measures 8" x 11" x 3" and weighs 5 pounds.

CB-HAM-COMMUNICATIONS

NEW HAM TRANSMITTER

33 **The Hallicrafters Company** has added the HT-44 transmitter to its line of equipment for the ham. It is a table-top unit providing the amateur radio operator with SSB, AM, and c.w. communications modes and is designed to transceive with the company's SX117 receiver.

The new unit has automatic amplified limiting

control plus full VOX, press-to-talk, and full c.w. break-in features. In the AM position, carrier and both sidebands are transmitted for true AM.

The transmitter measures 15" w. x 7⅛" h. x 13" d. and weighs 16 pounds.

ELLIPTICAL HORN ANTENNAS

34 **Dorne & Margolin, Inc.** has announced the availability of two new elliptically polarized horn antennas. Designed for use with receivers or low-power transmitters, the antennas are available in models DM P9-A and DM P9-B. Both are mechanically identical, elliptically polarized, and operate in the x-band frequency range of 7.5 to 10.8 gc.

By virtue of their in-line coaxial feeds, these antennas use no waveguide sections and weigh only three ounces.

MOBILE ANTENNAS FOR V.H.F.

35 **Hy-Gain Antenna Products Corporation** is now offering a complete line of over 40 base-station and mobile antennas for amateur v.h.f. bands. Included in the new line are optimum spaced beams for 6 and 2 meters, stacked jaypoles for 2 meters, log periodics for 6 and 2 meters, gain mobile whips for 6 or 2 meters, gain stacked halos for 6 or 2 meters, gain ground planes for 6 or 2 meters, duo-band 6- and 2-meter utility gain ground planes, single-band and duo-band mobile whips and halos, among others.

TWO-WAY RADIO SCRAMBLER

36 **Delcon Corp.** is now marketing a new compact electronic voice scrambler which provides privacy for two-way AM and FM radio communications. Compatible with standard two-way radios now in use, the Model 214 and 215 scramblers electronically re-arrange the sound of the spoken voice into totally unintelligible patterns.

The scrambling system includes both mobile and base-station units. The Model 214 mobile

unit weighs only 3 pounds, 11 ounces and operates on the vehicle's 12-volt power supply. The base-station scrambler (Model 215) weighs just under 6 pounds and uses 117-volt a.c.

148-174-MC. ANTENNA

37 **Decibel Products, Inc.** is now marketing a new model high-gain antenna for use in the 148-174-mc. range. The DB-264 has four external folded dipole elements fed by a completely enclosed feed system. It also features optional 6-db omni-directional or 9-db directional radiation pattern, all metal and grounded construction, 12-mc. bandwidth, and optional u.h.f. or Type N connectors.

HEAVY-DUTY BUMPER MOUNT

38 **Webster Manufacturing** is now offering a heavy-duty bumper mount designed especially for attaching two-way radio antennas to late model automobiles.

Known as the "**Band-Spanner H-215**," the new unit features a special, extra-long stainless steel strap with a worm-type adjustment that permits the mount to be installed on vehicles where the clearance between bumper and splash pan is scant. The base is a bronze die casting with heavy chrome plating. Accepting all standard ⅜"-24" butt antennas, the brass whip socket is secured to the bracket with a sturdy ⅜" stud.

SIX-CHANNEL CB TRANSCEIVER

39 **Raytheon Distributor Products** has just introduced a new six-channel CB transceiver for home and office use. The "Ray-Tel" TWR-4 has a built-in "S" meter to indicate transmitter and receiver performance and is pre-wired with an external socket to accommodate a selective-calling unit. Trim tabs are provided for precision frequency control.

Automatic volume control and an adjustable squelch circuit combine for optimum reception. The unit's large speaker is front-mounted, per-

mitting the radio to be used either on a desk or installed under the dashboard for mobile operation.

TUNABLE CB ANTENNA

40 **G.A.M. Electronics, Inc.** is now offering the CB-11 antenna, a base-loaded type mobile unit for use in the 27-mc. Citizens Band. The vertical whip is only 38 inches long, making it feasible to mount the antenna on the roof of an automobile or, optionally, on the cowl or trunk lid.

Key feature of the antenna is its tunable loading coil at its base. The whip is rotated to adjust the tuning slug and is locked in place by tightening a nut. When correctly adjusted, v.s.w.r. is less than 1.2:1 on all 23 CB channels.

NEW TUBE FOR MOBILE

41 **RCA Electronic Components and Devices** has announced a new conduction-cooled beam-power tube which requires a warm-up time of less than one second.

Designed for low-voltage mobile or stationary equipment, the RCA-8462 may be used as an r.f. power amplifier, oscillator, regulator, distributed amplifier, or linear r.f. power amplifier.

In c.w. operation with a plate voltage of only 700 volts, the new beam-power tube can provide useful power outputs of 110 watts at 50 mc., 105 watts at 175 mc., and 85 watts at 470 mc.

Because of the fast warm-up, the new tube eliminates standby filament power in push-to-talk emergency equipment.

NOISE-SUPPRESSION KIT

42 **Webster Manufacturing** is marketing a new noise suppression kit, as the "Band Spanner 6400-AG1" alternator-regulator/generator suppression unit. The new unit controls whines associated with worn generator brushes and popping caused by the making and breaking of voltage regulator contacts.

COMMUNICATIONS RECEIVER

43 **Lafayette Radio Electronic Corporation** is now marketing a new low-cost, 7-tube general-coverage receiver for the beginning SWL or novice amateur.

The HA-63 offers fingertip coverage of AM broadcast, marine, and aeronautical bands, civil defense, WWV, amateur, and foreign frequencies. The b.f.o. permits c.w. reception as well. The four bands cover 1.6-4.8, 4.8-14.5, 10.5-31, and 0.55-1.6 mc. Full electrical bandspread on all frequencies with a 0-100 logging scale and built-in "S" meter assures accurate tuning.

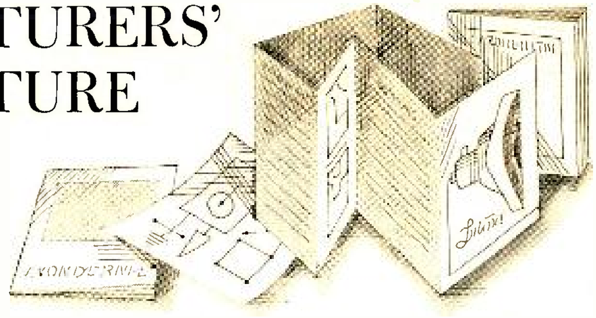
Other features of this receiver include switchable a.v.c./m.v.c. to reduce blasting or fading; automatic noise limiter; and antenna trimmer control for optimum reception on all bands. All controls are located on the front panel. There is a headphone jack for private listening. An external PM speaker (4-8 ohms) is required, but not supplied.

TRANSISTORIZED TRANSCEIVER

44 **Stoner Electronics** is now on the market with a low-cost portable transceiver which the company claims will operate three months from a car battery without recharging.

The TCS-2 provides single-channel service in the 2-8 mc. range. One-knob control permits easy operation. Nominal input is 15 watts, 12 volts d.c. It measures 11" x 4" x 7". ▲

MANUFACTURERS' LITERATURE



RIBBON CABLING DATA

50 **Whitney Blake Company** has issued a four-page bulletin (TT-1) which describes the firm's "Teletape" adhesive-backed ribbon cable system for communications and electronics. The bulletin describes how the four flat copper conductors are encapsulated in Mylar to resist abrasion, tearing, or cutting. The pressure-sensitive adhesive backing simplifies and speeds application of the cable to standard surfaces.

MINIATURIZED CCTV

51 **Kin Tel Division, Cohu Electronics, Inc.** has issued a new technical application bulletin (8-19) which covers unusual uses of miniaturized closed-circuit television. The bulletin contains photographs and details of operations at station KING-TV, Seattle, for outdoor sporting events where expensive studio equipment cannot be transported without possible damage.

RECORDER HEAD DATA SHEET

52 **Michigan Magnetics, Inc.** is now offering copies of a technical catalogue page which describes the firm's tape recorder head 3K17. This unit, which is designed for microminiaturization in all fields of magnetic recording, is a half-track mono record/playback head. A dimensional diagram, electrical characteristics, and performance curves are included in the data sheet.

CONVERSION FACTORS

53 **Duramic Products, Inc.** has issued a 36-page pocket guide which features 906 conversion factors. The conversion factors are alphabetically arranged for easy reference and begin with abcoulombs and end with yards. In addition, the guide contains a table for converting centigrade to Fahrenheit as well as a table of temperature interpolation factors.

A third section deals with the determination of the thermal expansion of metals.

TRIMMERS & POTS

54 **Dale Electronics, Inc.** is offering copies of a new 40-page catalogue which describes a complete line of wirewound trimmer pots and precision potentiometers.

Catalogue B contains complete specifications, descriptions, and dimensional outlines of 15 military grade trimmers, 8 commercial grade trimmers, plus 13 standard variations of these models. A quick reference chart precedes the listing for easy location of the proper unit.

READOUT TUBES

55 **National Electronics, Inc.** has available an 8-page booklet on numerical readout tubes which lists the electrical and mechanical specifications on a variety of such components. A second section of the booklet is devoted to ratings and characteristics and explains the various electrical specifications and how to make use of them in designing equipment. A third section is devoted to circuits and applications.

STEREO COMPONENTS

56 **H. H. Scott, Inc.** has just released a 24-page catalogue covering its comprehensive line of stereo components, plus general information on stereo reproduction.

The booklet is lavishly illustrated with photos of actual stereo installations in various period settings as well as color pictures of components in the line. Both assembled and kit units are covered. Amplifier and tuner specifications are presented in easy-to-use tabular form to assist the prospective buyer in making his choice of models.

TAPE-RECORDING HINTS

57 **Sarkes Tarzian, Inc.** has announced publication of a second edition of its popular handbook entitled "Lower the Cost of Fun with Tape Recording" which provides a unique variety of information of interest to tape recorder users.

Beginning with a discussion of tape recorder applications, the booklet continues with a variety of tape tricks including how to record from various sound sources, easy tape quality tests, a handy table of recording times, and a "notes" page to carry important information about the owner's tape equipment.

PRECISION WIREWOUNDS

58 **Shallcross Manufacturing Company** has just issued its catalogue PR200 whose 23 pages describe seven complete precision wirewound resistor groups including the new HR series of high-reliability types, the new SP series of subminiature resistors, the new VA series of high-

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precision types, the EP series of economy precision units, MIL-R-93C and MIL-R-9444A resistors, printed-circuit resistors, and ceramic bobbin resistors.

Complete information for correctly specifying wirewound resistors and a new commercial order code are also included.

COMPUTER BOOKLET

59 **Westinghouse Electric Corporation's** Computer Systems Division has just released a 32-page booklet entitled "What is a Computer" as an introduction to process control computer systems.

The booklet contains a number of practical examples that are worked out in informal and easy-to-understand fashion.

SILICON RECTIFIERS

60 **Tung-Sol Electric Inc.** has issued a 16-page catalogue covering high-current silicon rectifier stacks. Detailed specifications are given in the catalogue for single-phase center-tap assemblies, single-phase bridge assemblies, three-phase bridge assemblies, and six-phase star assemblies.

Data provided includes a selection chart, p.r.v. rating information, and a graph for each family of stacks which shows output current as a function of ambient temperature.

TELEMETRY SYSTEMS

61 **Vitro Corporation of America** is offering copies of its new brochure which contains full data on its telemetry and other electronic communications systems. The illustrated 20-page booklet gives complete data on the firm's solid-state telemetry receivers and other equipment.

Among the products covered are r.f. tuners, demodulators, spectrum display units, recording converters, telemetry and surveillance receivers, diversity combiners, preamplifiers and multicouplers, as well as related products and accessories.

R. F. INSTRUMENTS

62 **Alford Manufacturing Company** has published a 104-page catalogue containing complete information on all r.f. instruments and components produced by the firm. It includes automatic impedance and phase-measuring plotters, slotted lines, precision connectors, precision reducers, adapters, probes, detector mixers, instrument loads, calibrated mismatches, adjustable matching networks, tracking-antenna feed assemblies, s.w.r. meter, hybrids, mixers, r.f. bridges, coaxial switches, line stretchers, power dividers, attenuators, dipoles, and many other products.

Details include prices, photographs, dimensions, applications, detailed descriptions, and applicable specifications.

BATTERY CASE HISTORY

63 **Yardney Electric Corp.** is offering copies of a 15-page case history entitled "Batteries for Cordless, Portable Appliances." The publication deals with the selection of suitable batteries and includes charts, curves, and illustrations. Also discussed are the calculation of energy requirements for various end products, latest packaging techniques, and integration on charging equipment.

APARTMENT BURGLAR ALARM

64 **Door Alarm Devices Corporation** has issued a single-page data sheet on its "Dadco" electronic entry alarm. This particular unit is designed specifically to guard an apartment 24 hours a day. The bulletin details special features of the unit, how it operates, and pictures a typical unit and its installation.

SOLENOID GUIDE

65 **Pickering and Company, Inc.'s** Industrial Division has just issued a new 8-page guide to standard-design d.c. solenoids. The booklet defines basic solenoid terms and illustrates plungers, terminations, mountings, and configurations in outline.

Performance curves and typical electrical characteristics are shown for continuous, intermittent, and pulse duty solenoids of various standard sizes and types.

COMMERCIAL SOUND EQUIPMENT

66 **Atlas Sound** has published an up-to-date catalogue covering its line of public-address loudspeakers, microphone stands, baffles, and other accessories for commercial sound applications.

The illustrated, two-color brochure lists a complete range of indoor and outdoor paging and talkback speakers, sound projectors, explosion-proof speakers, sound columns, and other special-duty speakers, drivers, matching transformers, desk and floor mike stands, booms, baffles, and accessories.

STANDARDS BULLETIN

67 **General Radio Company** has issued a new illustrated booklet "Standards and Components" which describes an extensive line of standard resistors, inductors, and capacitors. The 8-page brochure covers, in addition to fixed-value components, decade boxes, attenuators, voltage dividers, and variable inductors. Over 150 different standards are included.

TAPE-RECORDER CATALOGUE

68 **Superscope Inc.** has issued a 16-page full-color catalogue covering the 1964 line of Sony tape recorders, microphones, and accessories. The catalogue carries individual color photographs, descriptions, features, and specifications on 11 recorders.

PRECISION INSTRUMENT DATA

69 **Waveforms, Inc.** is offering copies of its 32-page catalogue covering precision low-frequency electronic instruments.

Covered in considerable detail are generators, transmission measuring sets, and miniature instruments. Each instrument is described thoroughly and its special features pointed out. In addition to specific product information, the catalogue has sections on portable, panel, or rack mounting; the theory behind instrument performance; how to order; warranty data; plus charts covering generator specifications, transmission measuring set specifications, distortion curves, and panel mounting details.

DISC PLAYBACK COMPONENTS

70 **Empire Scientific Corp.** is now offering copies of a new 8-page brochure which describes the technical features of its latest line of record playback components. There are details and diagrams on the "Troubador 398" and the new 488 "Troubadour," tailor-made for console or equipment cabinets; plus specifications on the 880p mono/stereo cartridge and 980 playback arm. ▲

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30 (center)	Motorola Inc.
31 (top left)	Dage
31 (top right)	ITT
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CIRCLE NO. 153 ON READER SERVICE PAGE

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25	.75	1.25	1.60	250	3.00	3.50	4.00
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100	2.00	2.50	3.00	400	4.25	4.50	4.95
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200	2.50	3.10	3.75	600	5.85	6.00	6.25

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12	.60	.80	.90	1.00
*18	.35	.55	.70	.95
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100	2.25	3.00	3.50	4.00
240	4.50	5.70	6.90	8.40

D.C. Amps	300Piv 210Rms	400Piv 280Rms	500Piv 350Rms	600Piv 420Rms
3	.50	.65	Query	.75
12	1.25	1.50	1.75	2.00
*18	1.15	1.45		
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6BA6, 6BC5, 6BD6, 6BG6, 6BH6, 6BJ6, 6BL7, 6BN4, 6BN6, 6BQ6, 6BZ6, 6C4, 6C6, 6CB6, 6CD6, 6QF6, 6CG7, 6CG8, 6CM7, 6CZ5, 6D6, 6DA4, 6DE6, 6DQ6, 6EM5, 6F6, 6H6, 6J5, 6J6, 6K6

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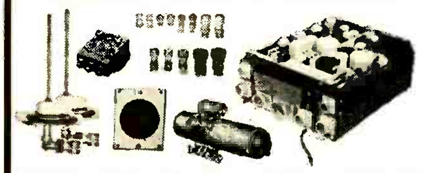

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Shipping weight 25 lbs. **SPECIAL!** . . . **$19.50**

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Complete Set of 10 Plugs 5.50
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BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE. BRAND NEW While Stocks Last **$29.50**

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100-156 Mc. radio telephone communication aircraft to ground. Complete with tubes and dynamotor, operates from 24 volts DC. Excellent condition, LIKE NEW.
AN/ARC-1 10-channel unit **$59.50**
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Model DM35
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DM-36	28V 1.4A	220V	.080A	1.95	2.95
DM-43	28V 23A	925V	.220A		
		460V	.185A	—	7.95
DM-53A	28V 1.4A	220V	.080A	3.75	5.45
PE-73C	28V 20A	1000V	.350A	8.95	14.95
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Terrific buy! VHF Transmitter-Receiver, 100-156 Mc, 4 channels, Xtal-controlled, Amplitude modulated voice. Complete with all 18 tubes, top rack and metal case. Clean. LIKE NEW Condition **$49.50**
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11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$79.50 EXC. USED
complete with Tubes

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ALL COMPLETE WITH TUBES

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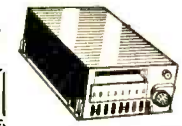

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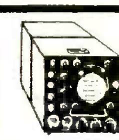

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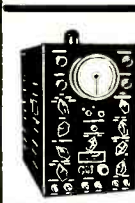

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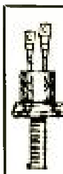

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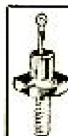

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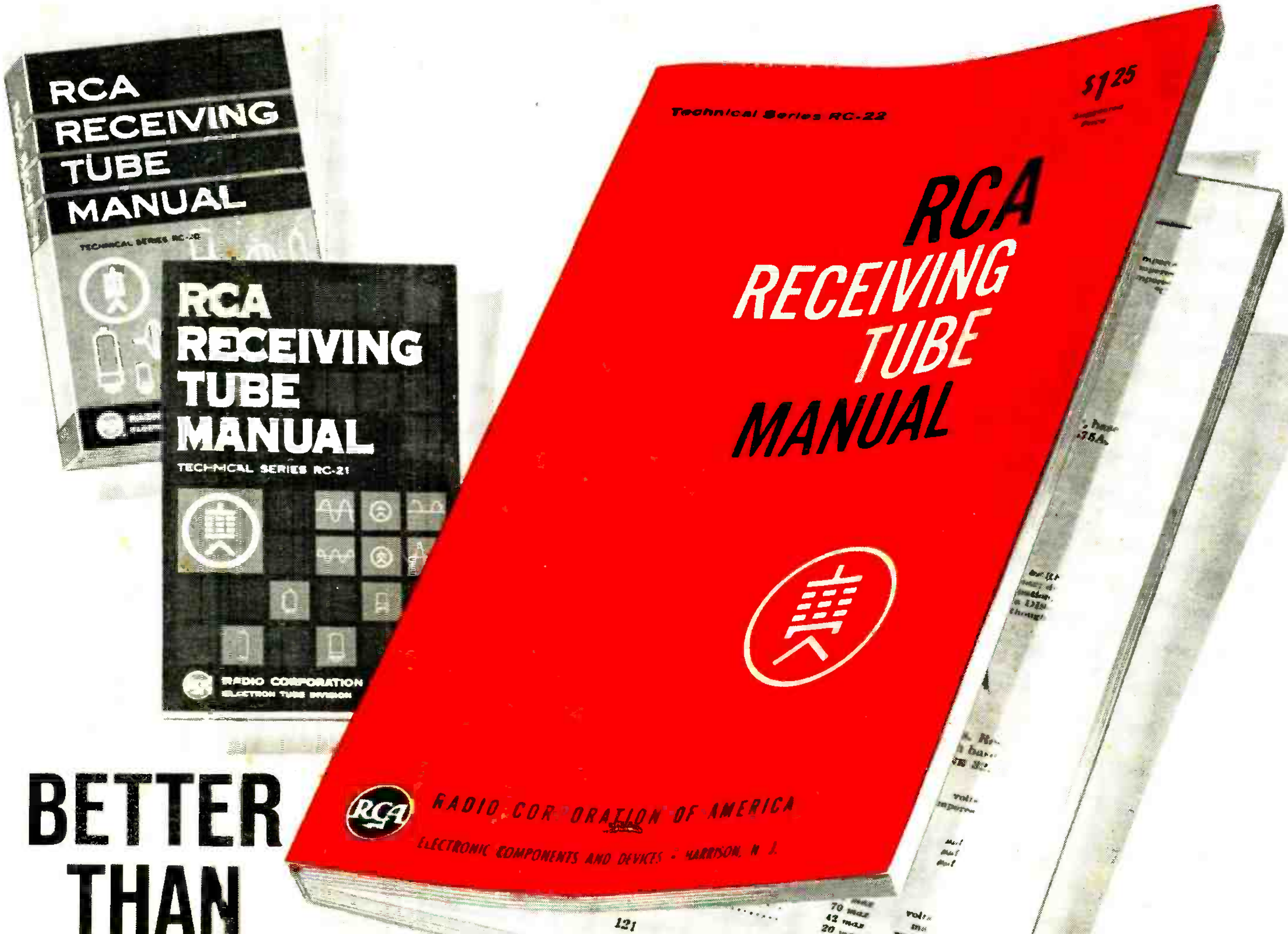

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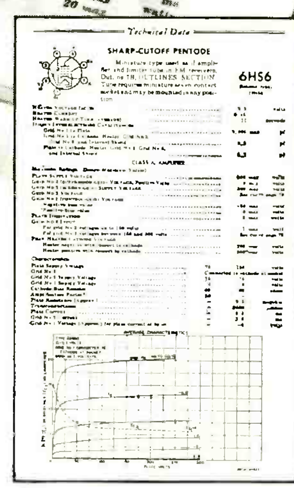

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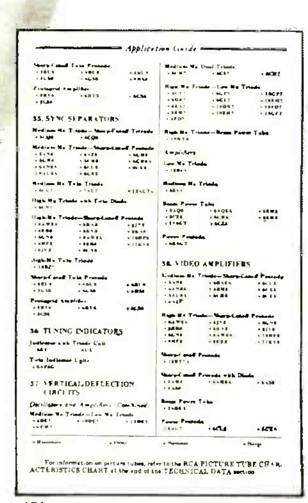
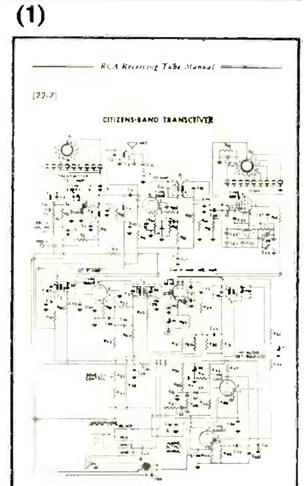
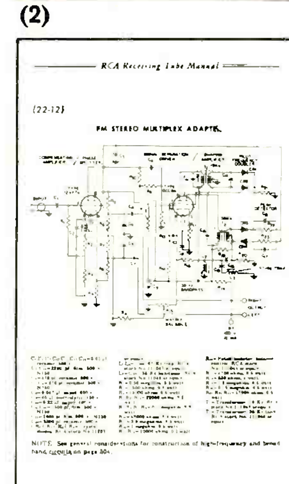


(2)





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