Electronics World

SEPTEMBER, 1963
50 CENTS

TRANSISTORS FOR HI-FI—Panacea or Pandemonium?

THIN LOUDSPEAKER SYSTEMS

ELECTRONIC ANESTHESIA

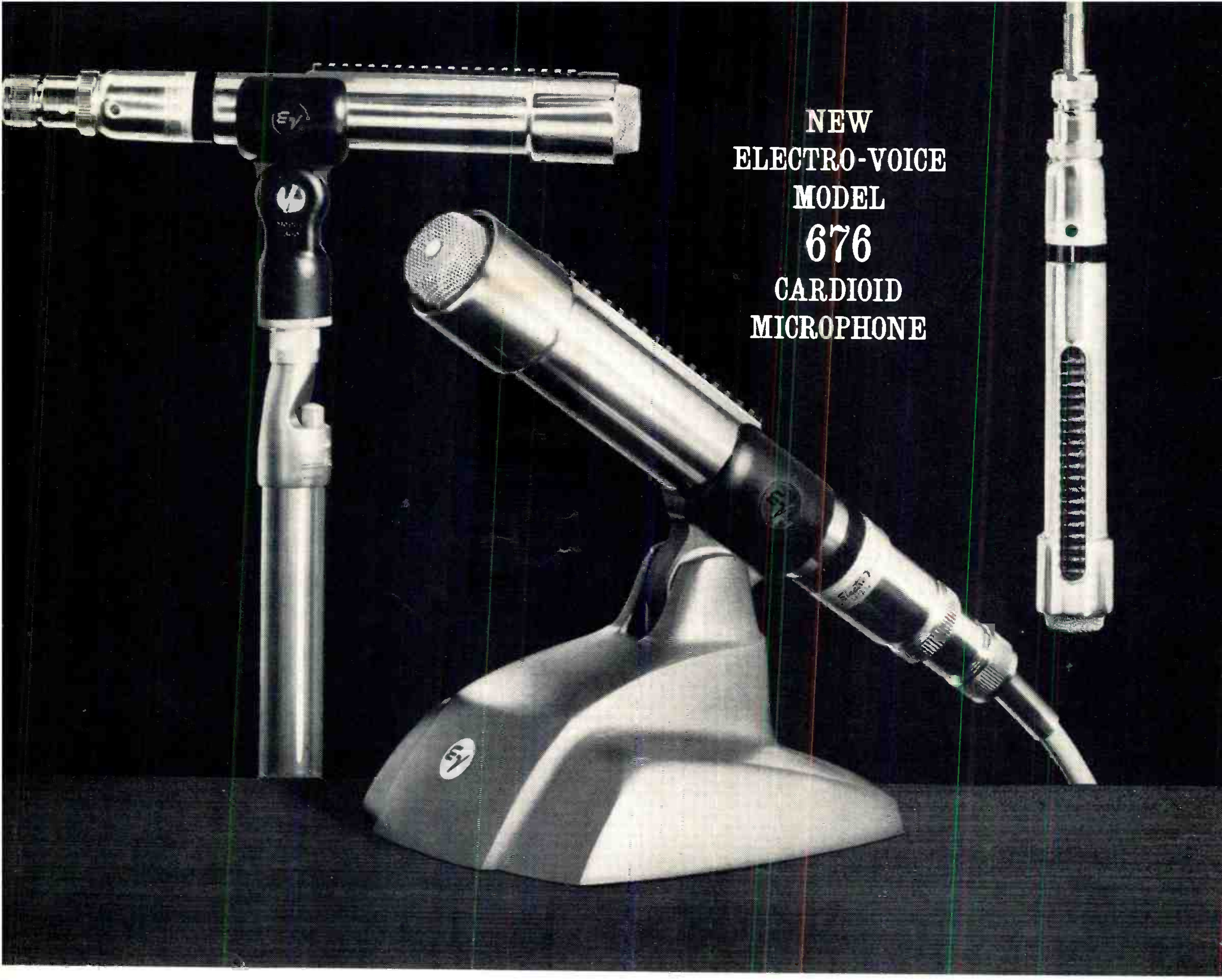
FREQUENCY MULTIPLICATION & DIVISION

Construction of a

TAPE-SLIDE SYNCHRONIZER

featuring new silicon controlled switch

A ZIFF DAVIS PUBLICATION



Outperforms them all . . . or your money back!

In the last 36 years, Electro-Voice engineers have developed many important microphone firsts*, but their latest achievement, the new E-V Model 676, may well be their most significant contribution.

The goal of 676 design was to overcome some of the most basic problems in PA, hi-fi recording, and communications. The result of this engineering effort is a uniquely versatile dynamic cardioid microphone with the best field performance of any we have tested. In short, the 676 does *everything* a little better.

For instance, response is wide, uniform, and smooth in the E-V tradition of natural sound. But the 676 also allows you to *change* response. Now you can "neutralize" room reverberation and rumble (usually encountered in larger rooms). A built-in three-position switch allows selection of flat response (for small rooms or recording), or bass attenuation "tilted off" from about 800 cps, with response down either 5 db or 10 db at 100 cps.

This means you get higher average sound levels, better intelligibility, and less likelihood of feedback. Yet there is no "missing bass" effect, common with most tone controls or filters, because of the flat-slope characteristic of the 676 bass tilt-off.

The cardioid pattern and response superiority of the 676 results from a creative variation of the famed E-V Variable-D® principle, called Continuously Variable-D (CV-D). It reduces size and weight without compromising quality, and it's responsible for reducing wind noise and shock noise pickup far below that of any other small cardioid. Bass-boosting "proximity effect" is gone, too, to give you well-balanced sound, even when performers work ultra-close.

Basis of the CV-D™ design is a slotted tube, coupled to the back of the 676 diaphragm. The CV-D tube appears to vary in length—acoustically (and automatically)—so that low tones "see" a long tube, while high tones "see" a short tube. The apparent length of the tube is always just right to phase out sound arriving at the back—for maximum front-to-back cancellation.

Modern styling by noted designer Lute Wassman adds grace and beauty to 676 practicality. The one-inch case fits all present E-V slip-on stand mounts, and its balanced weight distribution is just right for hand-held use.

But there's more to the 676 than just new features—built into it are the many characteristics that make E-V the choice of more professional sound engineers than any other brand: high output level, exclusive E-V Acoustalloy® diaphragm, dual impedance selection, efficient dust and magnetic filters, and the most important ingredients of all—fine materials and quality workmanship.

Accept our invitation to try the 676 soon—and the more difficult the job, the better. We guarantee you'll find the 676 will outperform any other PA cardioid microphone you are now using . . . or your money back!

Model 676—$100.00 list (less normal trade discounts). Complete specifications available at your E-V sound specialist's or write to: ELECTRO-VOICE, INC., Dept. 932N, Buchanan, Michigan.

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*Some of the E-V microphone firsts include: The Differential, Mechanophase, Variable-D®, Cardiline and Sound Spot®, plus slim dynamic and lavalier microphone designs, Acoustalloy® and Acoustifoam. And the E-V Model 642 has earned the first Academy Award microphone citation in 22 years, for its contribution to motion picture sound.

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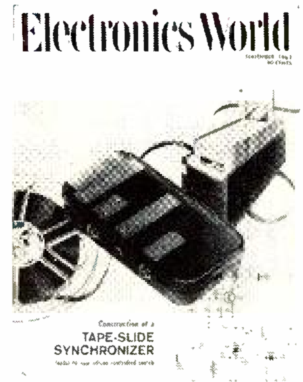
Electronics World CONTENTS

SEPTEMBER 1963
VOL. 70 NO. 3

MONTHLY FEATURES



THIS MONTH'S COVER shows a device that is able to automatically advance a 35-mm. slide projector when it is triggered by an audio signal that has been pre-recorded on an accompanying taped commentary. The synchronizer is small enough to fit into the palm of the hand. The circuit shows that the switching is done by a relay operated by a silicon switch. Also built inside the case is transistor phase-shift oscillator that generates the pulse that does the triggering. For construction details, turn to page 50. . ...(Photo: Bob Loeb. Illustration: Otto Markevics.)

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What happens to the man in Electronics without a degree?

If you work in electronics, you have probably asked yourself that question. You know the educational preparation of the degree man has its advantages—not only in pay, but in prestige, fringe benefits, security, working conditions and opportunity. But what kind of a future is there for a man without a degree—if his job and family responsibilities make going back to school impossible?

According to the National Science Foundation less than half the needed number of engineers are graduated each year. That means there are wide career opportunities for you, if you are prepared to move ahead. You don't have to worry about your future in electronics if you have a knowledge of advanced electronics. If you are familiar with latest developments, know breadboarding and circuit design, have a broad knowledge of systems and components and can pull your weight on the job, you can become a valuable career man.

You don't have to accept second-best for yourself and your family just because you didn't attend or finish college. Employers in the electronics industry pay for your ability to use advanced knowledge on-the-job. If you have this knowledge, you'll have plenty of opportunities for advancement in the fast moving field of space age electronics.

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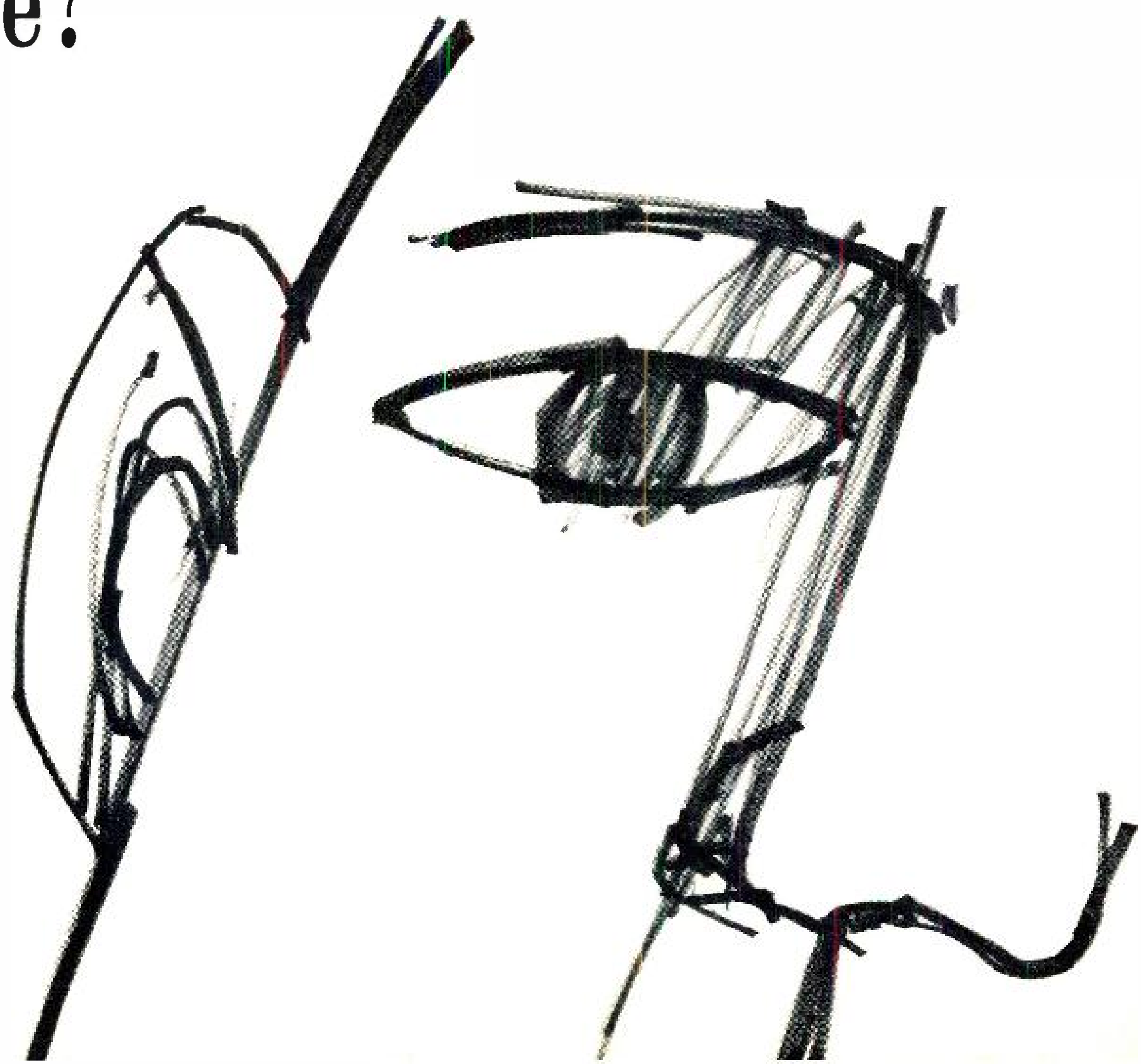

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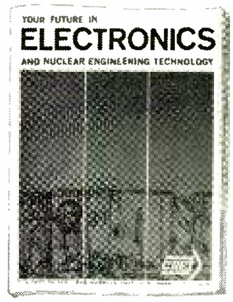

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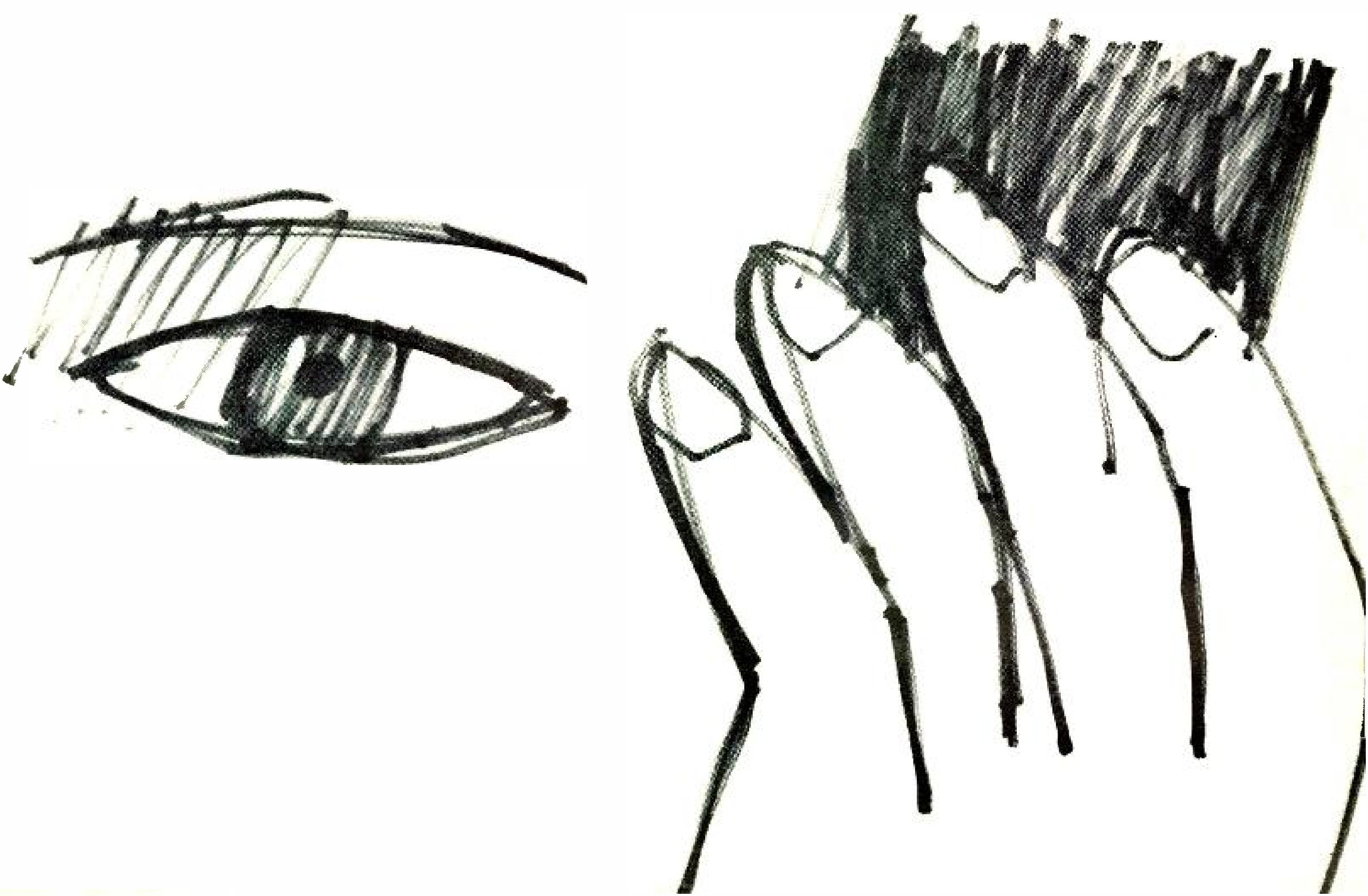
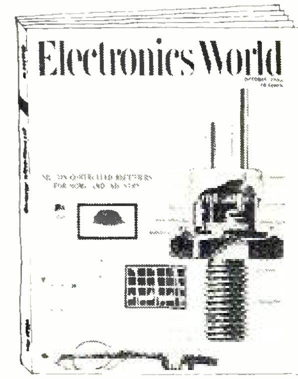


COMING NEXT MONTH



SILICON CONTROLLED RECTIFIERS—NEW APPLICATIONS IN THE HOME
Although widely used in industry for power control applications, recent drastic price cuts now make the SCR attractive for use in electrical appliances and lighting circuits in the home.

SOLID-STATE 3-WATT CB-HAM TRANSMITTER
Construction of a miniature mobile rig for 10 or 11 meters that features some unusual output circuitry. Parts required are standard and readily available.

MODERN BATTERIES
The right battery in a particular application can last up to ten times longer than one chosen at random. John R. Collins discusses the many types of batteries currently available, how they work, and where they can be used to the best advantage.

NOVEL ELECTROMETER TUBE
A description and operational details on a rugged, yet ultrasensitive low-voltage tube that is employed for automatic headlight control and for industrial equipment. The article also includes details on a build-it-yourself headlight dimmer incorporating the electrometer tube.

MEASURING STEREO SEPARATION AND PHASE
Construction details on a simple device for monitoring dynamic separation and phase with music-signal input. This compact unit can be built from standard, non-critical parts.

R.F. POWER OUTPUT MEASUREMENTS
This type of measurement on communications transmitters is now being specified by the FCC for many radio services. The basic methods and types of equipment used are described in this article by R. L. Conhaim.

TRANSISTORS FOR HI-FI—PANACEA OR PANDEMONIUM?
Concluding article of a two-part series by D. R. von Recklinghausen, A. W. Linder & E. H. L. Mason of H. H. Scott, Inc. covers the transformer myth, germanium vs silicon transistors, semiconductor protection, and the design of a new commercially available transistorized integrated stereo amplifier.

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Wayne A. Taylor, 4111 Nicholson St., Hyattsville, Md.	1st	30
Ralph Munday, 417 West Pecan, Rogers, Arkansas	1st	13
Harold F. DeBruin, 1621 N. Morrison St., Appleton, Wisc.	1st	12
Floyd R. Henderson, 3219 Andrita St., Los Angeles, Calif.	1st	24
Gerald D. Herbert, Route 6, Bloomfield, Iowa	1st	12
Alexander Mikalaski, 4510 Rittenhouse St., Riverdale, Md.	1st	30
Joseph J. Hytovick, 260 Poplar St., Dickson City, Penn.	1st	12
Wayne F. Murphy, 317 Jefferson St., Roanoke Rapids, N.C.	1st	12
John L. Marlow, Box 384, Umatilla, Oregon	1st	12

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For the record

WM. A. STOCKLIN, EDITOR

ANOTHER NUMBERS GAME

THE widespread misuse of power-output figures for high-fidelity amplifiers is not new, but several press releases that have recently crossed our desk point up a ridiculous situation. *Admiral* has just announced a transistorized packaged hi-fi system with a peak output of 250 watts. This is an impressive figure and is, no doubt, correct, but, by itself, it is absolutely meaningless. Just what is the wattage to which they are referring? Do they mean music power or continuous sine-wave power? What test procedures were followed, was the EIA standard method of measurement used, or was it the IHF component-industry standard?

One sometimes wonders whether important omissions are the result of ignorance or whether they are made on purpose in the belief that the consumer is a gullible idiot who either doesn't care or enjoys being deceived.

Zenith, on the other hand, deserves a little more credit. In a release from them on a packaged hi-fi system, they rated its performance as "240 watts peak music power or 120 watts EIA undistorted power output." This defines the performance so that the technically knowledgeable person would not be confused. We do, however, wonder about the use of the term "undistorted" since, by EIA standards, a harmonic distortion figure of 5% is actually specified.

Unfortunately, these same press releases are nationally distributed to newspapers and publications outside of the electronics industry. For the benefit of these editors manufacturers must be more specific so that the facts can be interpreted correctly and so that confusion at the consumer level will be eliminated.

It is interesting to note that the *Admiral* 250-watt peak-power set actually provides 125 watts total r.m.s. power, or 62.5 watts per channel. We are also assuming that these power figures all represent *music power*. From this point on we can only guess that the continuous sine-wave power may be approximately 40 watts per channel and, if the EIA standard is followed, even this would be at 5% harmonic distortion. The hi-fi component industry, on the other hand, although not tied down specifically to any one figure, commonly rates power output of amplifiers at 2% harmonic distortion or less. Hence, this same 250-watt amplifier might now become equivalent to a 30-watt-per-channel continuous sine-wave power amplifier at 2% harmonic distortion. It is even conceivable that if both channels were driven to full power simultaneously, as we do in our lab tests, the power per channel might be even less than this amount.

Apparently, the hi-fi industry has found an electronic version of the numbers game.

This is only part of the problem. Our staff has been working on the 1964 STEREO/HI-FI DIRECTORY for the past few months. This is an 180-page annual publication, separate from ELECTRONICS WORLD, that will appear on newsstands September 17th. As the name implies, it is a listing of consumer high-fidelity component products. All of the original material is solicited directly from manufacturers and rewritten in directory form.

Here again we found almost a third of the manufacturers' literature received did not provide us with sufficient details. In some cases, it seemed obvious that those preparing the literature were not completely qualified; in other cases, it seemed that efforts were made to mislead—not quoting wrong figures—but by simply omitting pertinent information.

Power-output figures were shown without any indication as to whether they were peak, music, or continuous sine-wave power. Frequency response was shown as being "relatively flat" instead of indicating db deviations. In some cases where the frequency response wasn't impressive, we found the term "frequency range" being used. There were many occasions where manufacturers specified power and distortion without indicating whether both channels were driven when measurements were made. In some cases, a frequency response was quoted as extending "beyond audibility." The question arises, "Whose audibility?"

Obviously, the entire hi-fi industry lacks many standards and the manufacturers must do the best they can. But in promoting their products through literature or advertisements, when there is an intent to mislead the consumer by omission of important facts, then this is an unhealthy situation.

Fortunately, the majority of manufacturers are ethical, so there is some hope. Let us not forget, either, that the hi-fi industry is not the only one faced with this problem. We are sure all other industries engaged in marketing consumer products have similar problems. The Federal Trade Commission can certainly vouch for this. ▲

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FROM TEXTILE WORKER TO TECHNICIAN. That's the story of Harold L. Hughes, 225 Civiley Blvd., Indian River City, Fla. After graduating from NRI he worked in a TV shop, is now employed by an engineering firm as a Senior Electronics Technician. He says, "I shall be eternally grateful to NRI."

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."

WORKS FOR FIRM BUILDING DC WELDERS. "Your school helped me get this job," writes Lawrence S. Cook, 529 South Bounds St., Appleton, Wis. He has also done broadcast work, TV repair, and builds custom stereo systems and medical electronic equipment. "I thought very highly of the Communications course. I still use the texts."

ELECTRONIC TECHNICIAN FOR POST OFFICE. "NRI training enabled me to land a very good job as Electronic Technician with the Post Office Dept.," reports Norman Ralston, 1947 Lawn Ave., Cincinnati, Ohio. "I finished 6th out of 139. I also have a very profitable spare-time business fixing Radios and TV."

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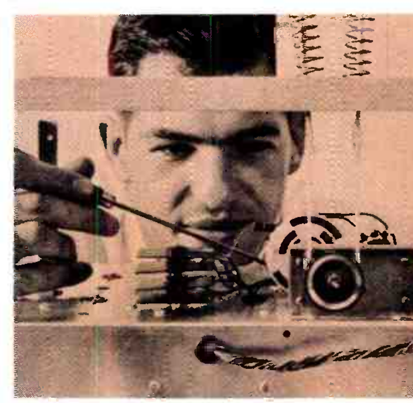

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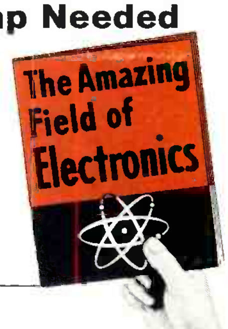

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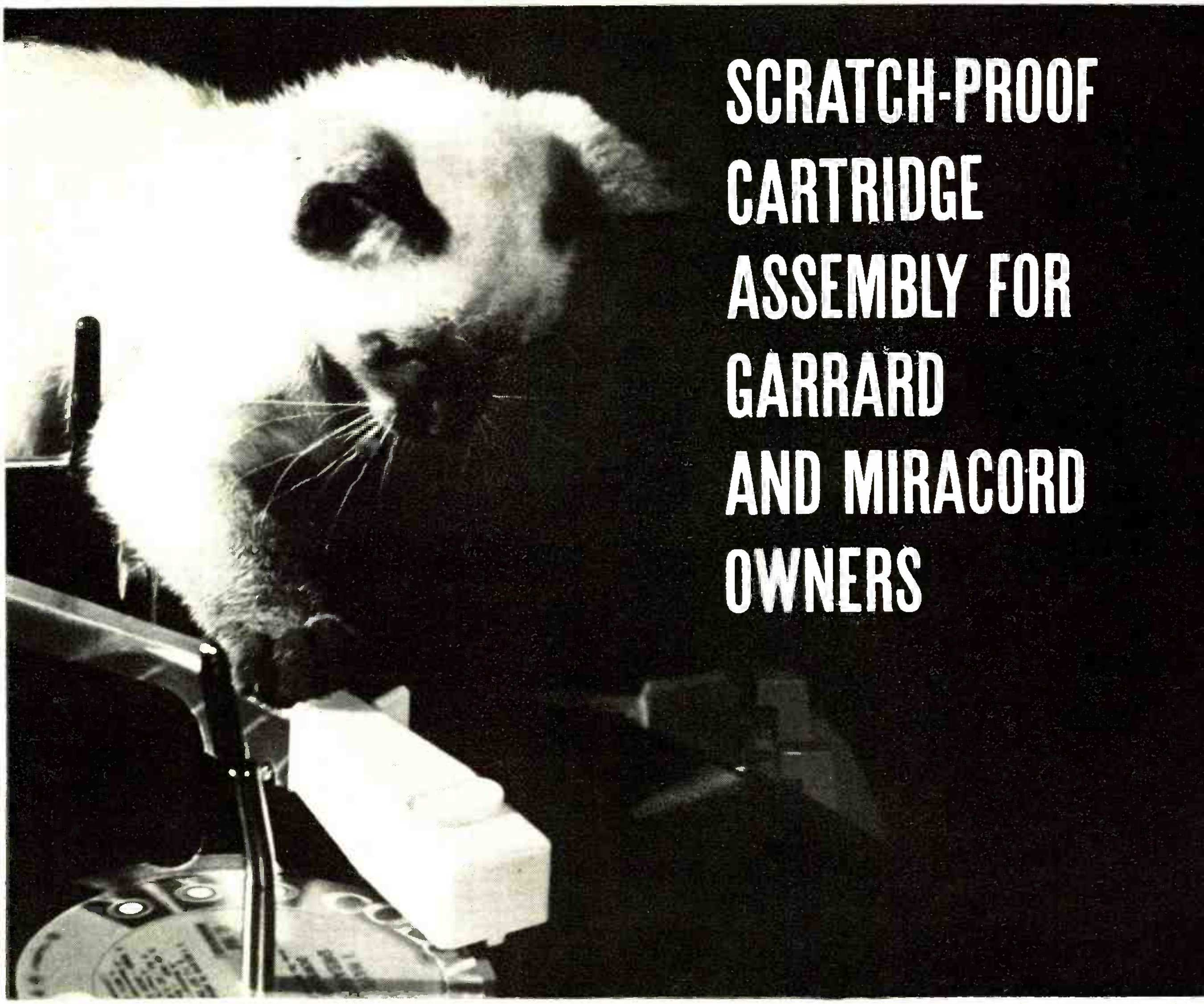
originators of scratch-proof high fidelity tone arms



Attention music lovers and felinophiles: interesting to note that both cat and cartridge have retractile styli for gentleness and protection from scratching

GREATER RECORD AND NEEDLE PROTECTION . . . FINER RECORD REPRODUCTION

Now, owners of Garrard Laboratory® Type "A" and AT-6 and Miracord Model 10 and Model 10H Automatic Turntables can assure themselves unprecedented and unparalleled record and needle protection, and highest sound quality simply by plugging in the Shure Stereo Dynetic GARD-A-MATIC "floating" cartridge assembly. Nothing else to buy . . . no wiring, no soldering, just plug in.

Ingenious GARD-A-MATIC cartridge inside a special tone-arm shell ends scratching due to dropping the tone arm or accidentally dragging it across the grooves . . . records stay new, sound new. Needles last longer—can't be damaged by pressing arm on record. Does away with tone arm "bounce" from floor vibrations, etc. Even plays warped records. And, the performance characteristics are those of the famed Shure Stereo Dynetic cartridges.

SPECIFICATIONS

Frequency Responses:	From 20 to 20,000 cps
Output Voltage:	6 millivolts per channel
Channel Separation:	more than 22.5 db at 1000 cps
Recommended Load Impedance:	47,000 ohms
Compliance:	20.0×10^{-6} cm per dyne
Tracking:	1.5 to 3.0 grams
Inductance:	600 millihenries
D. C. Resistance:	750 ohms
Stylus:	.0007" diamond
Stylus Replacement:	N99

MODEL M99/A. Fits Garrard Laboratory® model "A". Includes tone arm head, factory mounted cartridge, .0007" diamond. **MODEL M99/AT6.** Fits Garrard AT-6. Includes tone arm head, factory mounted cartridge, .0007" diamond. **Model M99/M10.** Fits Miracord Models 10 or 10H. Includes tone arm head, factory mounted cartridge, .0007" diamond. **MODEL N99.** Replacement stylus assembly, .0007" diamond.

SHURE Stereo Dynetic® GARD-A-MATIC T.M.

Patented and Patents Pending

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WRITE FOR DETAILS TO: SHURE BROTHERS, INC., 222 HARTREY AVE., EVANSTON, ILLINOIS

LETTERS FROM OUR READERS

TECHNICIANS AND DIVERSIFICATION

To the Editors:

I was very much interested in the first letter of your "Letters From Our Readers" column in the March issue, in which the irate writer bemoaned the fact that ELECTRONICS WORLD does not publish a steady stream of articles on the repair of television receivers. Instead, he states that you have been wasting space writing such nonsense as "Lasers and Their Uses" (and who has ever seen a laser?).

A good piece of advice for the thousands of TV service technicians throughout the country who are of similar opinion is that they raise their eyes from the unstable sync circuits on their service benches and take a good hard look at the world around them.

In five to ten years the television receiver with which they are so familiar will be as modern as the console radio. TV servicing as it is today will be pushed out of existence and replaced by top-flight electronic professionals who must service a wide range of devices, especially industrial and commercial equipment.

What will the TV serviceman of the present do when the sync circuit no longer becomes unstable, or when there are no more tubes for him to replace, or to effect a repair on a TV receiver all he need do is snap a new circuit board into the offending section? The only course of action open to him will be to so diversify his activities that he will eventually find himself in direct contact with devices now considered fantasies of the future.

I consider ELECTRONICS WORLD the finest magazine available for electronics technicians who do not wish to find themselves facing the wall of ignorance when present laboratory curiosities such as the laser become commonplace devices.

Remember the blacksmith who laughed at the automobile, and the radio repair man who laughed at that great big box with the tiny screen? The laser of today is in the same position as the TV set of 1939.

Electronics will not stand still for you, you must keep one step ahead of it or be brushed to the wayside.

I sincerely hope that ELECTRONICS WORLD does not let itself become fettered by the stagnant ideas of some persons who do not realize that they have chosen to pursue a career in the most dynamic and progressive field existing.

ROY A. WELLS
Project Director
Radon Laboratory
Brooklyn, N. Y.

* * *

TRANSISTOR IGNITION SYSTEM

To the Editors:

Referring to the article "High-Performance Transistor Ignition System" in the June, 1963 issue of ELECTRONICS WORLD, I would like to bring up the following: Although a low current might seem desirable through the breaker points, it has been established that too low a current is actually detrimental to the satisfactory operation of a solid-state ignition system.

Engine heat, in conjunction with oily fumes, will form a black oxide film on the surface of the breaker points, and a current of between 0.5 to 1.0 amp. is necessary across the points to burn off this oxide.

The pitting of the points on a conventional ignition system is caused by the high-voltage inductive kick of the coil which is across the points. In a solid-state ignition system, the breaker points are isolated by the transistors from the inductive component and will see a maximum voltage less than the battery voltage. This will drastically reduce point pitting with a current of 1.0-amp. magnitude.

The very low current mentioned in the article will not be able to burn off the oxide film and hard starts will result in a short time.

BOGHOS N. SAATJIAN
Los Angeles, Calif.

To the Editors:

The ignition system in your June issue shows a heat sink in the parts list, yet I don't see it in any of the photos. Is the sink required?

Also, I wonder if you have had any experience with a 400:1 ignition coil rather than the 250:1 coil originally specified in the parts list.

RICHARD SULLIVAN
Chicago, Illinois

Author Mayfield has had quite a lot of experience with transistor ignition systems, particularly the one using the circuit he described. Neither he nor others who are using the circuit report any indication of blackening of the points, even after thousands of miles of operation.

On the matter of a heat sink, if .06-inch aluminum is used as the chassis, the transistors will run cool and a heat sink is not necessary. This is particularly true if the electronics circuit is mounted beneath the dash and away from the engine.

On the matter of a 400:1 turns ratio ignition coil, Author Mayfield reports that performance is superior with this coil due to the lower primary impedance. He now recommends the 400:1 coil. Primary current with this coil is 8 amperes compared with 7 amperes for the 250:1 coil.

Finally, the author has suggested that a 5-ohm, 25-watt fixed resistor be shunted across R7 and a 100-ohm, 2-watt fixed resistor be connected from the emitter to the collector of Q3. These circuit changes will compensate for transistor leakage currents and provide better long-term reliability.—Editors.

° ° °

TOUCH CONTROL

To the Editors:

Your recent article on "Latest Advances in Touch Control" (May issue) was most interesting, but I believe there is a drafting error in the schematic diagram for the vacuum-tube oscillator (Fig. 1A, page 35). Should there not be a blocking capacitor between the tickler winding and plate of the tube? It seems the normally closed contact would place a ground on the plate, thus energizing the relay prematurely.

EDGAR N. SMITH
Weatherford, Okla.

Reader Smith is right. The circuit was simplified since the article did not deal directly with this particular version of a touch-control device. However, that is no excuse for omitting the capacitor.
—Editors ▲

ADDENDUM TO KIT TEST EQUIPMENT DIRECTORY

JUST after we went to press with our "1963 Directory of Kit Test Equipment" (August issue), we learned that the Hallicrafters Co. had announced a new line of test-equipment kits. Since we did not have information on these kits at the time our directory was prepared, we are listing these new kits and their prices below:

Capacitance decade HD-1: $14.95.
Resistor decade HD-2: $14.95.
Capacitor tester HC-1: $29.95.
R.F. generator HG-1: $29.95.
5-inch oscilloscope HO-1: $84.95.
Vacuum-tube volt-ohm-milliammeter: HM-1: $29.95.
Battery eliminator HP-1: $49.95. ▲

READER SERVICE PAGE

Please use the coupon at the bottom of this page to obtain more information about products advertised in this issue.
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Additional information on items mentioned in **"New Products & Literature"** can also be obtained by following this same procedure.

PRINT your name and address on the coupon and mail it to:

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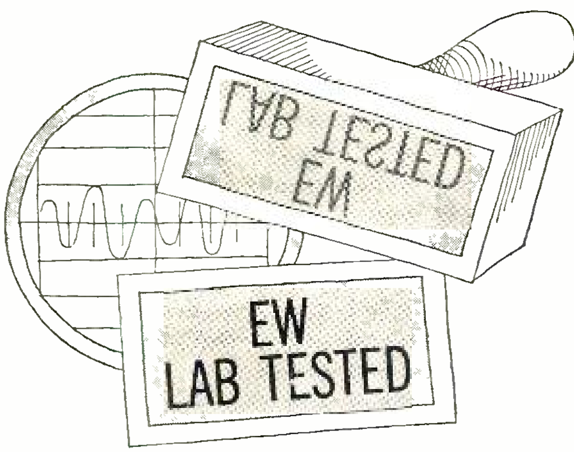


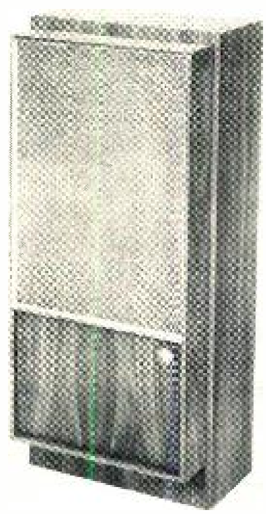
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Audio Dynamics ADC-18 Speaker System
"Knight" KN-3050 Public-Address Amplifier

Audio Dynamics ADC-18 Speaker System

For copy of manufacturer's brochure, circle No. 56 on coupon (page 15).



THE largest of the *Audio Dynamics Corporation* speaker systems is the Model ADC-18. This is a full-sized, floor-mounted, two-way system, measuring 17 inches wide by 40½ inches high by 12½ inches deep. The woofer, based on British-made *KEF* driver units, is quite unconventional in design, with a 12- by 16-inch rectangular radiator made of expanded styrene foam. The front surface of the radiator is covered with aluminum foil. The compliant cloth edge surround fastens directly to the baffle board rather than to the usual basket structure. The voice coil is mounted in a massive nine-pound ceramic-magnet assembly.

The design of the woofer not only provides the large radiating surface needed for good bass reproduction, but is practically free from cone breakup effects. The combination of high stiffness, low mass, and inherent internal damping offered by the expanded foam radiator is highly desirable from the standpoint of natural bass and mid-range reproduction.

The high-frequency speaker has a light, rigid Mylar dome radiator of the same diameter as the 1½-inch voice coil which drives it. Like the woofer, this speaker has a powerful magnet which contributes to its excellent transient response, while the dome-shaped radiator gives wide high-frequency dispersion.

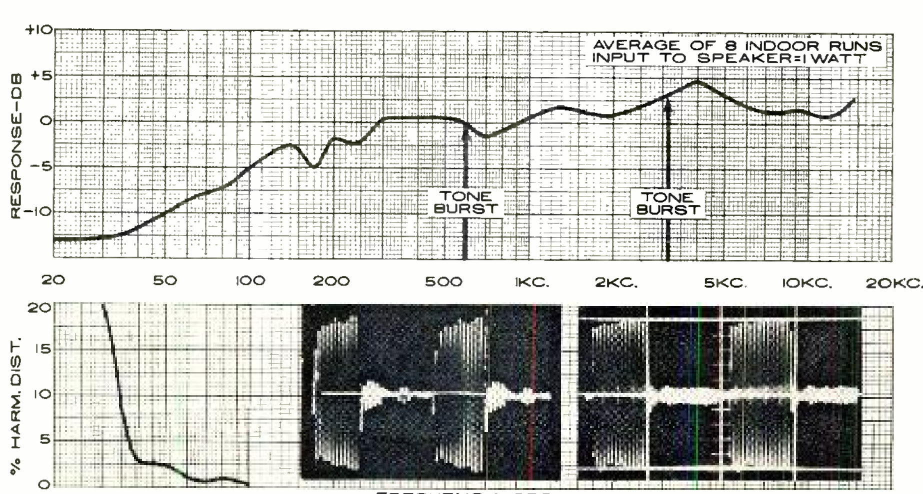
The built-in crossover network has two level-control switches mounted on the rear panel of the cabinet. One switch reduces the high-frequency output, while the other boosts the middles. The cabinet is ported, through a rectangular slot in its bottom, which is raised off the floor by the design of the base of the cabinet. The port is covered with a heavy acoustic absorbing material to provide resistive damping. The result is a system with no discernible low-frequency resonance in its acoustic output. The interior of the cabinet is also heavily padded with absorbing material to damp other cabinet resonances.

The frequency-response curve was obtained by averaging eight automatically plotted response measurements made at different microphone positions. In this way the effects of room resonances are largely eliminated, and the averaged curve is a reasonable approximation of the response of the speaker in a typical listening room. The averaged curve of the ADC-18 was very smooth, and was uniform within ±3 db from 200 to 15,000 cps, which is the upper limit of our microphone calibration. Below 150 cps there was a smooth roll-off, free from peaks or holes. This frequency region is subject to variation due to listening-room characteristics, as well as speaker location. Harmonic distortion was low to below 40 cps, and a solid fundamental output could be obtained down to 28 cps. This places the ADC-18 in the top echelon of high-quality bass reproducers.

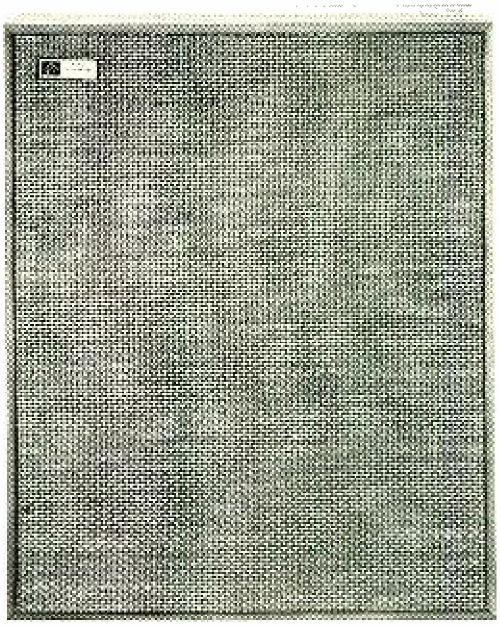
The tone-burst measurements pointed up the excellent transient response and freedom from breakup and ringing of both drivers.

The sound of the system was eminently musical and clean. In common with other speakers having low bass distortion, it did not produce any audible low-frequency output unless the program contained such signals. As a result, the output sometimes sounded thin or deficient in bass, in comparison with inferior systems. The true capabilities of the ADC-18 became evident when the program contained frequencies below 50 cps, in which case the output could often be felt as well as heard. This almost tactile sensation is one of the distinguishing characteristics of true bass response.

The highs were clean and so well dispersed that one was never aware that they originated from a 1½-inch diameter source. We found the "normal" speaker



How can you be sure the speaker you own is really well-made?



Build it yourself!

(with the new KS-2 StrataKit)

NOT CONTENT with developing the world's first true slim-line speaker system in kit form (the KS-1), Fisher now presents the KS-2, the newest, most advanced 3-way slim-line speaker system available in *any* form at anywhere near the price.

By simply installing the drivers, wiring the crossover network and completing the assembly of the cabinet, you'll be well on your way to hearing why.

The KS-2 features a 12″ free-piston woofer with a half-roll cotton surround, massive 6 lb. magnet structure, and a free-air resonance of 25 cycles. The 5″ mid-range has a butyl-coated surround and is sealed off in back to avoid interaction with the woofer and tweeter. The 3″ cone-type tweeter has a hemispherical dome bonded directly to a 1″ voice coil with a big 2 lb. magnet structure. Highs are silky smooth and widely dispersed.

The full 3-way inductance-capacitance network crosses over at 1200 and 2800 cycles and has a continuously variable tweeter level control to compensate for room acoustics and variations in pickup characteristics.

Measuring 20″ wide x 25″ high and only 6½″ deep, the completely sealed, fiberglass-packed cabinet weighs 35 lbs. when assembled.

Response of the KS-2 is 35 cycles to well beyond audibility. It requires as little as 10 watts of power and will handle up to 60 watts. Price, in unfinished sanded birch, $89.50*.

FREE! $1.00 VALUE! The Kit Builder's Manual: an illustrated guide to high fidelity kit construction.

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Long Island City 1, N. Y.

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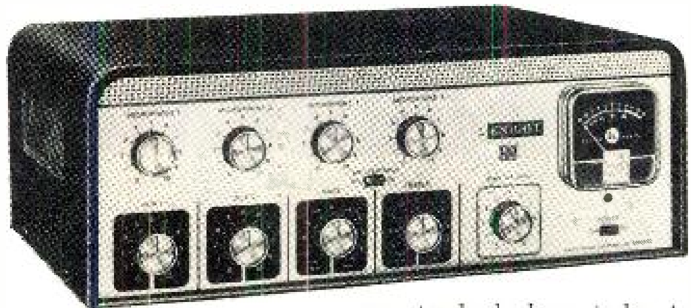
response settings to be optimum for our taste. "Hard" or "bright" listening rooms might call for some reduction in high-frequency response of the speaker system.

The ADC-18 speaker system sells for $250.00. ▲

"Knight" KN-3050 Public-Address Amplifier

For copy of manufacturer's brochure, circle No. 57 on coupon (page 15).



THE "Knight" KN-3050 is a highly flexible public-address amplifier, rated at 50 watts output. It incorporates operating conveniences and features not often found in moderate-priced amplifiers.

The unit has independent level controls and mixing facilities for four microphones and two high-level signal inputs, all of which may be used simultaneously. One microphone input may be used for a magnetic phono cartridge, with RIAA equalization, by operating a chassis-mounted slide switch.

There are bass and treble tone controls, providing boost or cut on the combined signals. A master gain control adjusts the over-all amplifier gain. To reduce feedback and prevent burn-out of trumpet-type speakers by excessive low-frequency power inputs, there is a front panel "Anti-Feedback" switch. This reduces the low-frequency gain of the amplifier.

A 3" square meter on the front panel gives an indication of output level from the combined inputs. Calibrated like a vu meter, it operates from the 70-volt output tap of the amplifier. A top-of-chassis switch adjusts the sensitivity of the meter to give 0 db indications at six power output levels from 1.5 watts to 50 watts.

Other on-chassis controls include "Hi-Lo" impedance selector switches for the four mike inputs, a "Mag.-Mic." switch to insert RIAA phono equalization on the "Mic. 4" input when a phono pickup is used, a "Remote-Local" switch for remote mixing of three mike channels, and an impedance selector for outputs of 4, 8, and 16 ohms, plus 25-volt and 70-volt line outputs.

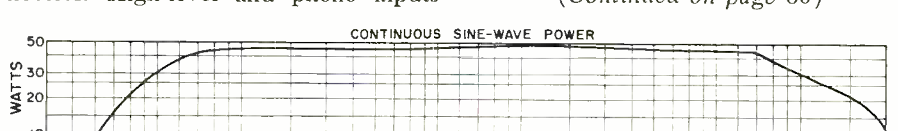
The four microphone inputs are through rugged, lock-in audio connectors. High-level and phono inputs use standard phono jacks. As shipped, the KN-3050 is equipped for high-impedance microphones. Low-impedance microphones (50 to 600 ohms) require plug-in matching transformers, for which sockets are provided on the chassis. A tape output jack for feeding a recorder is connected to the 4-ohm speaker output and is affected by all amplifier controls.

The amplifier uses ½-12AX7A triode sections for microphone preamplifiers. Their outputs are summed with the two high-level inputs at the input to a 12AX7A amplifier, whose second section is a cathode-follower driving the tone controls and master gain control. Another 12AX7A serves as a voltage amplifier and half of a phase inverter, together with a 6AV6 triode. The output stage is a push-pull pair of 6CA7's, operated with fixed bias. The −35-volt bias supply also biases the heaters of all tubes for hum reduction.

The basic frequency response of the KN-3050 is flat from 20 to 2000 cps, rolling off to −10.5 db at 10,000 cps. RIAA phono equalization is low by about 9 db at 30 cps and by 8 db at 15,000 cps, but is satisfactory from 150 to 9000 cps.

The power response of the amplifier (maximum available sine-wave output power at a fixed distortion value) is very uniform over the normal range of frequencies used in p.a. work. It will deliver 45 to 48 watts from 70 to 7000 cps at 2% harmonic distortion, and more than 30 watts from 50 to 10,000 cps at the same distortion level. Hum levels at standard gain settings are about −54 db on microphone inputs and −84 db at high-level inputs, referred to 50 watts. A microphone signal of 38 millivolts, or a high-level input of 0.225 volt will drive the amplifier to 50-watts output.

(*Continued on page* 60)



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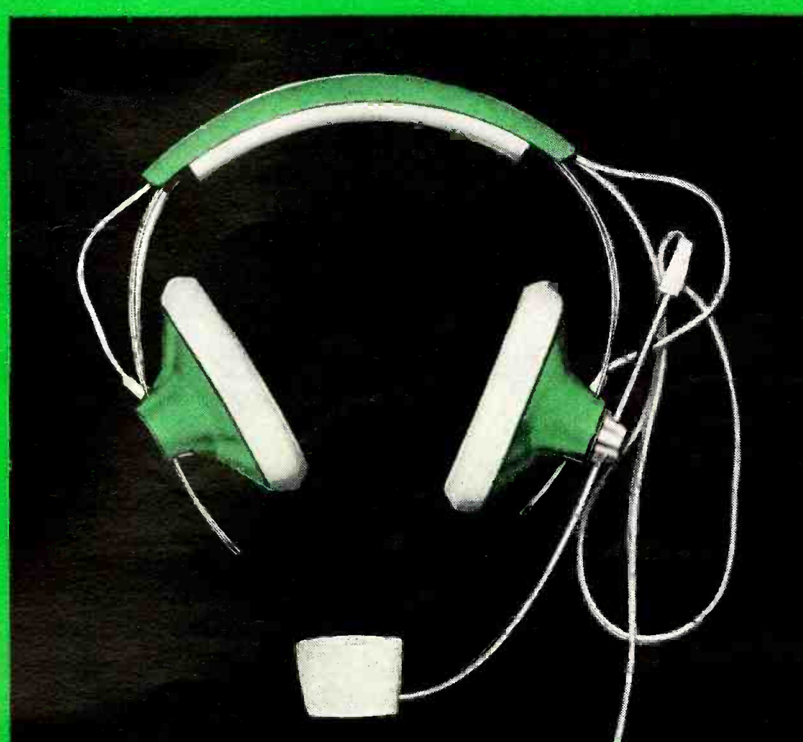

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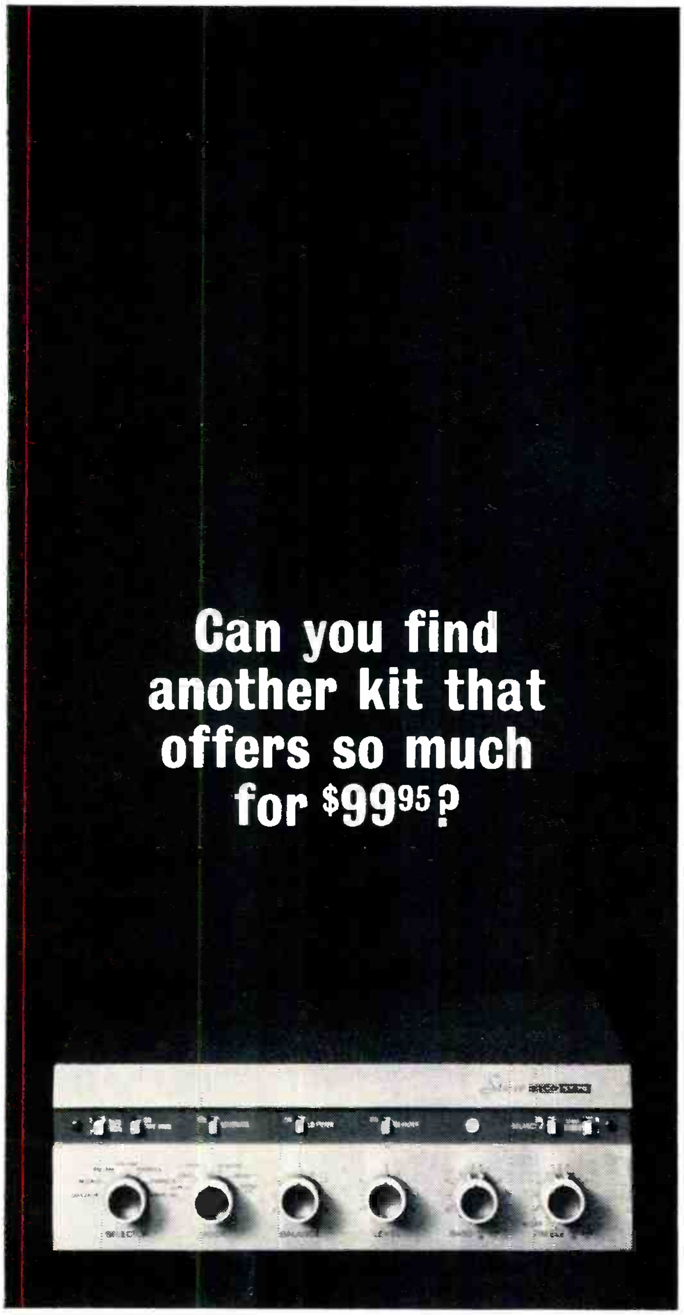
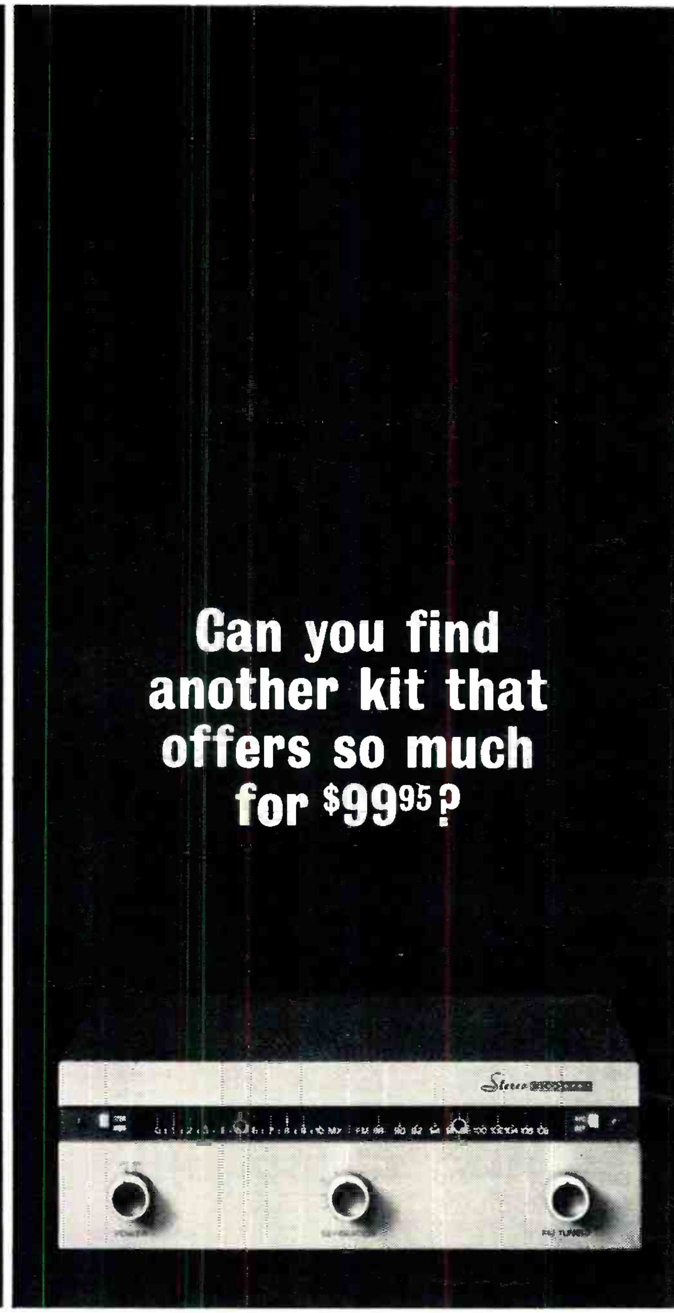


EICO ST70, 70-WATT STEREO AMPLIFIER



EICO ST97 FM STEREO TUNER

Beyond the performance level of these two units, possible improvement is merely marginal and very expensive. That's why with EICO's ST97 and ST70 you strike the optimum balance of cost and performance—each costs less than $100 as a kit. You can also get the ST70 and ST97 factory-wired for $149.95 each—and you couldn't find comparable wired units at the price.

If high power isn't your primary need, you can get superb sound for even less with EICO's ST40, the 40-watt counterpart of EICO's outstanding ST70. The ST40, essentially equal to the ST70 in all but power, costs $79.95 as a kit, $129.95 factory-wired.

ST70 DATA: As the center of your stereo system, the ST70 accommodates all program sources. It even has separate inputs for both turntable and record changer, preamplified tape signals and tape head with correct equalization for both fast and slow tape speeds. A center channel output feeds directly on a center channel speaker or, where desired, extension speakers throughout your house without any additional amplifier. Critical parts — filter capacitors, rectifiers, output tubes—all operate well below their ratings to assure long, trouble-free life. Oversize output transformers deliver full rated power all the way down to 30 cps. . . . And as a kit builder, you'll like the spacious layout. We got rid of all those tight places. Kit $99.95. Wired $149.95 (includes metal cover).

SPECIFICATIONS ST70 *Output Power:* 70 watts (continuous sine wave 35-watts per channel) *IM Distortion:* 1% at 70 watts. *Harmonic Distortion:* less than 1%. *Frequency Response:* ±½ db 10-50,000 cps. *Inverse Feedback:* 17 db. *Stability Margin:* 10 db. *Hum and Noise Level:** mag. phono —63 db; tape head —54 db; tuners, auxiliaries —78 db. (all measurements according to IHFM standards.)

ST97 DATA: Building the ST97 FM stereo tuner requires no instruments, no critical adjustments. The front end and IF stages are fully pre-wired and pre-aligned. The tunable coils of the stereo demodulator are factory-adjusted. With four IF stages plus a stable, sensitive front end, the ST97 pulls in clear stereo even under fringe conditions, and EICO's filterless zero-phase shift stereo detector (patents pending) maintains reliable channel separation. EICO's unique traveling tuning eye makes tuning simple and precise. Stereo stations are automatically identified by a pilot light. Semi-kit **$99.95**. Wired **$149.95**. (Includes metal cover and FET.)

SPECIFICATIONS ST97. *Sensitivity:* 3μv (30 db quieting), Sensitivity for phase-locking (synchronization) in stereo: 2.5μv. *Full limiting sensitivity:* 10μv. *Detector Bandwidth:* 1 megacycle. *Signal-to-Noise Ratio:* —55 db. *Harmonic Distortion:* 0.6%. *Stereo Harmonic Distortion:* less than 1.5%*. *IM Distortion:* 0.1%. *Frequency Response:* ±1 db 20 cps-15 kc. *Capture Ratio:* 3 db. *Channel Separation:* 30 db. *Controls:* Power, Separation, FM Tuning, Stereo-Mono, AFC-Defeat (all measurements to IHFM standards).
**Actual distortion meter reading of derived left or right channel output with a stereo FM signal fed to the antenna input terminals.*

See these superb components at high fidelity dealers everywhere. For FREE 32-page catalog, 36-page Stereo Hi-Fi Guide (enclose 25c for handling) and dealers name, write: EICO ELECTRONIC INSTRUMENT CO. INC., 3300 Northern Boulevard, Long Island City, New York. EW-9

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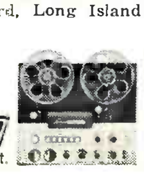
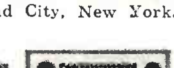
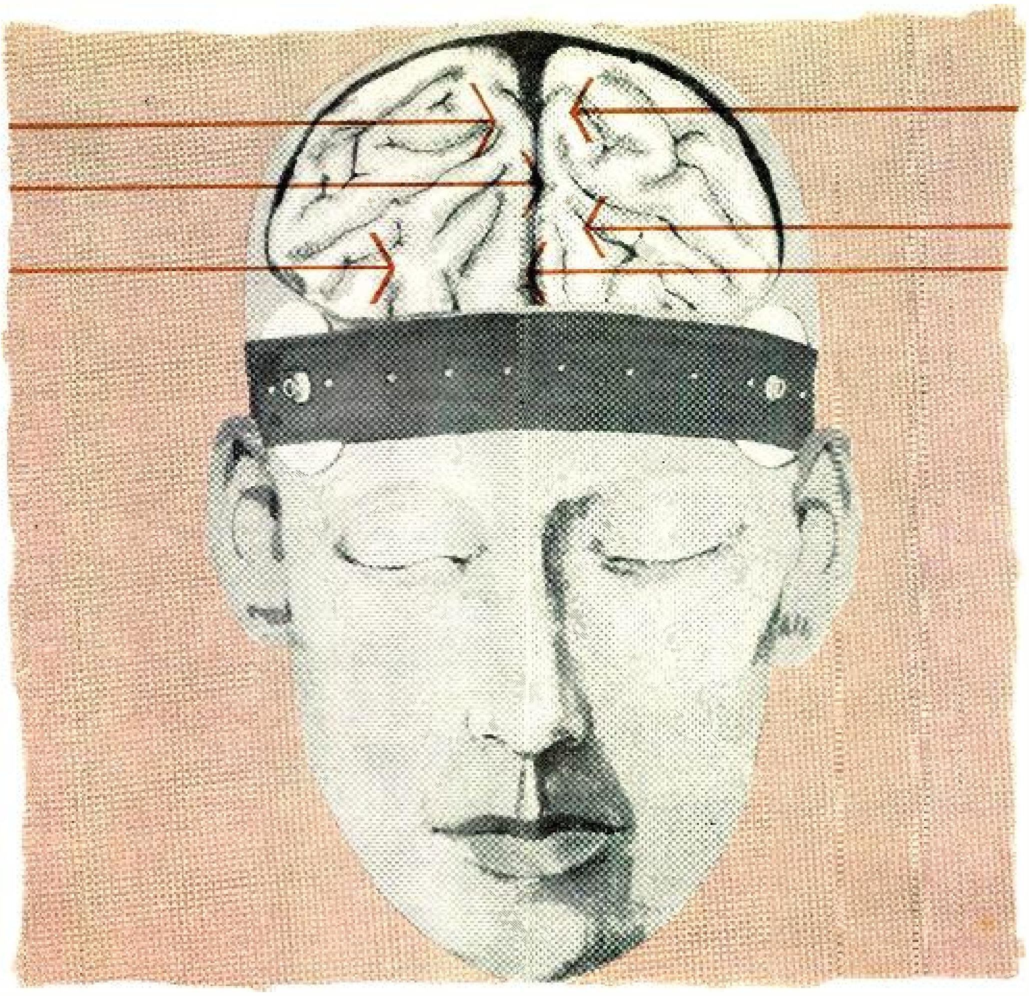


RP 100 STEREO TAPE DECK semikit $299.95 wired $399.95



HFT-90 FM TUNER kit $39.95 wired $65.95

HFS-6 3-WAY, 3-SPEAKER SYSTEM kit $52.50 wired $62.50



ELECTRONIC ANESTHESIA

Though the technique is far from perfected, electrical signals in the audio range can be used successfully to make patients unconscious of pain during surgery.

By WALTER H. BUCHSBAUM / Industrial Consultant

A DESIGN engineer we know recently remarked that human beings lack a basic feature found in every piece of electronic gear—an "on-off" switch. How convenient, he speculated, it would be if we could turn people "on" and "off" at will. This apparently whimsical idea has been taken seriously by doctors concerned with anesthetizing patients during surgery.

Not too long ago, at the University of Mississippi, a doctor threw a switch and his patient, lying on an operating table, became unconscious. When the current was turned off, the patient woke up. There was no dizziness, nausea, or any of the other common aftereffects of anesthesia. The operation, an exploration of the abdomen, had lasted about 30 minutes and the patient had felt nothing and could remember nothing of his experience. The patient had been "put under" by the application of a 700-cps sine-wave signal, connected to electrodes mounted at his temples.

Simple as it sounds, the use of electronic anesthesia could have far-reaching consequences. It could mean a minor revolution in anesthetic procedures and would also affect surgical techniques to a great extent.

Today most surgical work is performed under some form of chemical "pain killing." This involves getting the chemical into the body and, eventually, out again. The problems of drug tolerance, reaction time, absorption, elimination, and aftereffects could all be avoided with electronic anesthesia. It would be practical to use this kind of anesthesia for many minor operations, and even for dental work. The entire field of anesthesia, now a highly specialized branch of medicine and pharmacology, would be changed and doctors would have to become more familiar with electronics.

But all of this depends on perfecting electronic anesthesia to a degree that has not been possible to date. Only a small number of human patients has been subjected to electrical anesthesia in this country, and only a few hospitals have experimented with the method. A great deal more research and study will be required before people can simply be "switched on and off" for varying periods of times as required.

The least understood portions of the human body are still the brain and nervous system. Electronics has, during the past ten years, made an invaluable contribution to-

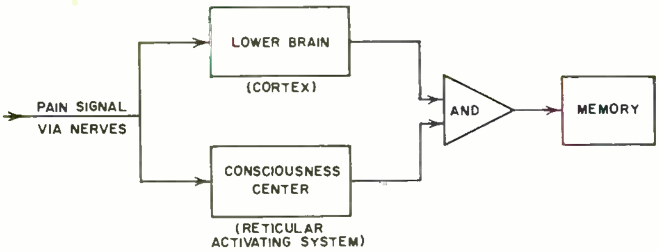


Fig. 1. Electronic equivalent of the pain-sensing system.

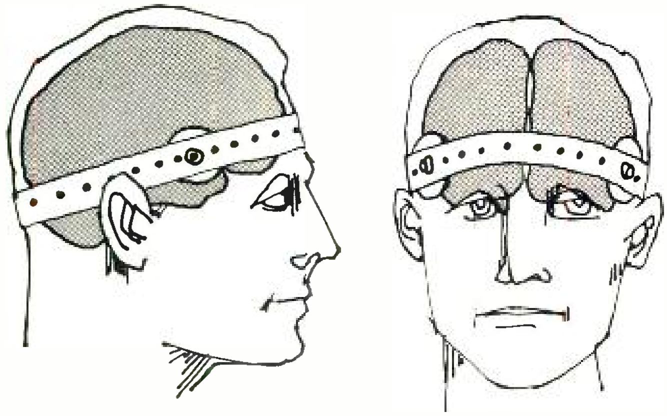


Fig. 2. The arrangement of the electrodes for anesthesia.

ward explaining some of the mysteries, but our understanding is still very limited. We know that the nerves transmit electrical signals between the brain and other parts of the body. Recently we have learned that this signal transmission takes place by electro-chemical means, with each nerve cell acting as a unity-gain amplifier. It also appears that these signals are digital in nature rather than analog.

Just how they are generated or how the brain receives them is not clear, but as far as pain perception is concerned, two separate functions appear to be performed in the brain. Fig. 1 shows the electronic interpretation of this phenomenon. Pain signals are carried by the nerves to the cortex (lower part of the brain) and, at the same time, they go to the "consciousness center." This region, referred to as the "reticular activating system," seems to be located in the center of the brain. The "outputs" of these two pain receivers are combined in some kind of biological "and" circuit, and only when both outputs are present is the pain sensation passed on to the memory.

It is possible for people to be unconscious and yet react to pain without being aware of it. It is also possible for conscious people to feel no pain during analgesia but afterwards pain is felt even though the painful process is over. For complete anesthesia, both *analgesia* or painlessness and *amnesia* or forgetting must be achieved. Anesthesiologists believe that deactivation of the "consciousness center" accomplishes this. In chemical anesthesia the drugs act on the cells of the brain in that area while in electronic anesthesia the current passes through it.

Although no one knows definitely, most of the researchers in electronic anesthesia think that the alternating current used affects the action of the brain cells in passing through the "consciousness center." When current is removed, the cells immediately resume normal activity. Electrical action is therefore much more direct than chemical anesthesia, if it is only possible to get the current to the proper portion of the brain without damaging other cells.

In most of the research done thus far, the current is applied through external electrodes located at the temples. See Fig. 2. The brain itself is a fairly good conductor of electricity, but the surrounding bone and the skin present a relatively high impedance. To reduce this, the electrodes are coated with a conducting jelly and pressed against the skin.

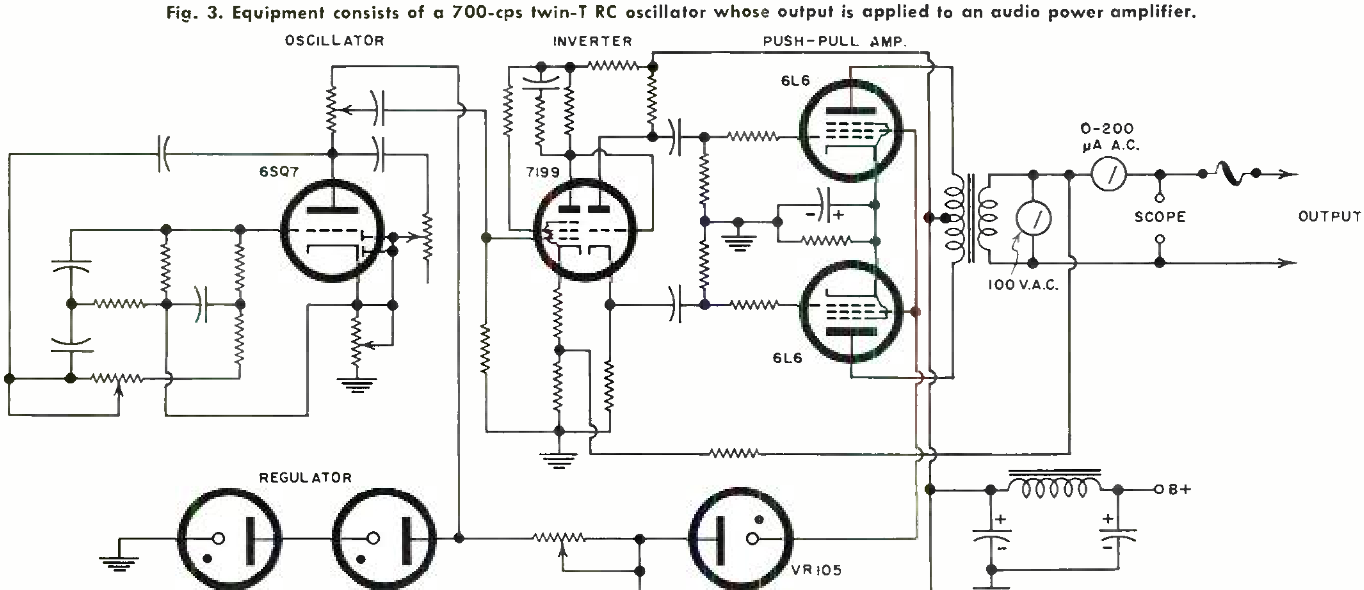
A variety of different signals has been investigated. One that has been used successfully on humans is a 700-cps sine wave. Voltages range from 12 to 47 volts and current varies from 50 to 110 ma. Voltage and current are adjusted during the course of the operation to maintain the minimum electrical energy while still producing full anesthesia. From the technical point of view the equipment is still quite crude and will undoubtedly be improved when more experience has been gained in applying this process of anesthesia.

Equipment Employed

Fig. 3 shows the circuit used to produce anesthesia on twelve human patients by the research team at the University of Mississippi Medical Center. This team consisted of Drs. L. W. Fabian, J. D. Hardy, and M. D. Turner, and Mr. C. D. McNeil as the electronics expert. A twin-T *RC*-type of audio oscillator is followed by an amplifier and phase inverter which drives a pair of 6L6's in push-pull. The secondary of the output transformer is fully metered, fused, and monitored by an oscilloscope. Power-supply voltages are regulated with VR tubes, but no effort is made to automatically regulate either voltage or current of the output signal.

In earlier experiments on animals, different equipment was used. Dr. R. C. Knutson at St. Luke's Hospital in St. Paul, Minn., working first with dogs and then with human patients,

Fig. 3. Equipment consists of a 700-cps twin-T RC oscillator whose output is applied to an audio power amplifier.



found that skin resistance varied during the course of the operation and he therefore used a constant-current amplifier which maintained the signal current at the same level throughout the operation. The simplified circuit, shown in Fig. 4, includes a cathode-feedback resistor in the output transformer secondary so that, as the load impedance varies, the gain of the amplifier is adjusted accordingly. Dr. Knutson's experiments were conducted, in part, on mental patients who had previously undergone electric shock treatments and his results were not an unqualified success. Rigidity, convulsions, and mental reactions discouraged further tests along these lines.

Still another approach was taken by a team at the Medical College of Georgia which performed a number of experiments with animals, using a combination of d.c. and a.c. The Georgia team consisted of Drs. R. H. Smith, G. W. Smith, and P. P. Volpitto, assisted by Messrs. C. Goodwin and E. Fowler. Their system was based on results reported by a Russian team under Dr. M. G. Ananev and used a 100-cps rectangular waveform. The circuit is shown in Fig. 5 and includes a switch for reversing the polarity of the d.c. voltage. At the beginning of the anesthesia, a.c. of about 2.5 ma. was sufficient to quiet the animal. Then 20 ma. of d.c. was applied throughout the operation and the a.c. was increased to 15 ma. and eventually to 22 ma.

Recently the Russians, who have claimed great success in using electronic anesthesia on human patients, have shipped a machine for "electrical sleep induction and anesthesia" to the Rockefeller Institute in New York but so far the results obtained with this unit have not been conclusive. A number of institutions in this country are planning to try the Russian machine and also construct systems of their own to permit more detailed experimentation in this field.

Problems Remain

Although the research team at the University of Mississippi has reported successful anesthesia with electronic signals, a great many problems remain to be solved before this technique is ready for mass application. The team's careful work has established that, with proper technique, brain damage is not likely, but much more clinical evidence is required concerning the effects on various types of patients, mental conditions, and tolerances. In addition, such anesthesia is known to have certain undesirable side effects. The most common is muscle tension and the danger of convulsion and muscular rigidity. So far, this has been avoided by giving the patient muscle-relaxing drugs prior to the start of the electronic anesthesia, but to obtain the full benefits of this process it would be desirable to eliminate the need for such drugs. Because of the muscle-relaxing drugs, breathing becomes difficult. For that reason all the subjects receiving electronic anesthesia have also had a tube inserted into the trachea for controlled respiration. This is sometimes done when using regular anesthesia, but it seems to be a necessity with the electronic method.

In order to apply the current with a minimum of skin resistance, it is often necessary to shave a portion of the head. This may make the patient susceptible to minor skin burns. Observations to date indicate some changes in bodily chemistry and excessive secretions by certain glands. While none of these seemed dangerous in the patients treated thus far, doctors understandably want to know much more about these effects. Careful studies of patients with differing physical and mental structure, various types of blood chemistry, and possible complicating diseases are all required before electronic anesthesia becomes an accepted technique.

Future Research

In addition to the medical problems which must be investigated, a great many of the electronic aspects merit further study. Dr. A. Van Poznak and Dr. J. F. Artusio of Cornell Medical Center, New York, N.Y. conducted studies on dogs

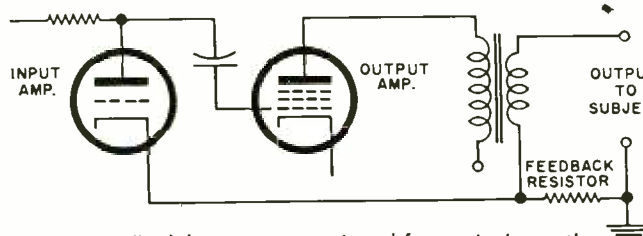


Fig. 4. Feedback-loop arrangement used for constant-current output. An increase in the patient's skin resistance tends to reduce output current and the feedback. This results in an increased output voltage acting to keep current constant.

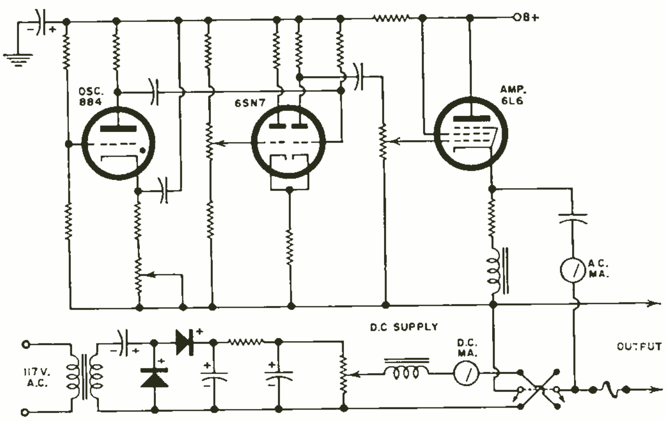


Fig. 5. The cathode-output circuit of the 6L6 provides an a.c. signal that is superimposed on the d.c. voltage from the voltage doubler. Either polarity of d.c. is available.

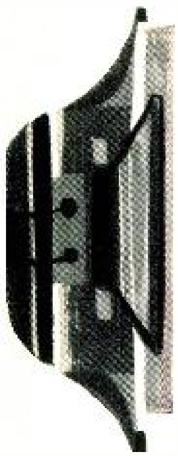
to determine the effects of frequencies ranging from 1 to 10,000 cps and various waveshapes from sine and square waves to triangular and trapezoidal shapes. Their findings, while not conclusive, showed that anesthesia was possible when sufficient power was applied but that such power was close to the threshold that would produce convulsion. Also irregular breathing and a rapid heart rate occurred.

The author talked with Dr. Van Poznak about possible future approaches. One of them may attack the problem of getting sufficient current to the proper brain area without having to apply too much power. If the alternating signal depolarizes the brain cells, as some researchers believe, then it should be possible to use short pulses at a repetition rate close to the apparently suitable 700 cps. This would reduce average power and overcome the problem of possible skin burns while permitting application of larger peak power. Another approach would be to use several electrodes, spaced together and in parallel, to reduce skin resistance.

Still another approach would be to try various coil arrangements to rely on electromagnetic induction, possibly at r.f. frequencies, which would be modulated at the lower signal frequency. While brain cells apparently cannot "receive" r.f., they are non-linear elements and therefore should act as detectors for the r.f. and the detected signal would then be the 700-cps anesthetizing signal. Other approaches such as low levels of modulated ultrasound beamed to the proper brain area from several transducers, or the use of electrostatic fields, all should be investigated.

The mechanism which produces the side effects of convulsion and muscle rigidity will have to be investigated and then perhaps some other technique of electronic anesthesia can be found that does not produce these effects.

Intriguing as it seems, electronic anesthesia is not yet ready for routine use, but the successes achieved so far give great promise for the future. In electronic anesthesia we have an instance of direct interaction between an electronic signal and a major function of the brain. The marriage of anesthesiology and electronics will not only produce great advances in that area of medicine but will also increase man's knowledge of the source of his thinking power. ▲



THIN LOUDSPEAKER SYSTEMS

By GEORGE L. AUGSPURGER

Survey of methods being used to make the hi-fi speaker and its enclosure as shallow as possible. These new units permit good listening without taking up very much space.

HOW many of today's audiophiles remember the *Bozak* "kettledrum" speaker system? Looking like a kettledrum standing on edge (or an orange sliced in half), it was one of the quality loudspeaker designs popular about two decades ago. But it wasn't the only loudspeaker system which carried an engineering concept to the point of rather outlandish physical appearance. The serious music listener had his choice of folded horns, labyrinths, and various other tuned and untuned variants—all very large and mostly very ugly. They were designed only to reproduce sound and the buyer was expected to camouflage them as best he could.

Loudspeaker manufacturers and piano builders discovered about the same time that a sizable portion of the musically minded public was interested in smaller, more inconspicuous instruments. The attitude was, "I need something that will blend with my furniture. You're the experts; *you* make it sound good."

As a result of this expressed preference on the part of the consumer, we have seen two trends in "miniature" high-fidelity speaker system design. The first was the small bookshelf system and the most recent is the extremely shallow "ultra-thin" unit. Almost all the major speaker manufacturers have been making bookshelf systems for some time now, but it is only within the last year or two that you could count on finding your favorite brand of speaker in a thin version.

Conventional Speakers in Thin Cabinets

The easiest way to make a loudspeaker system thin is to use components already designed for small enclosures and then mount them in a cabinet of suitable volume which has been squashed into a shallow configuration. Most of the presently available systems fit into this category.

For example, both the *Jensen* TR-9 and the *Electro-Voice* "Regina 200" use 10-inch low-resonance woofers in small ducted enclosures only about 5½ inches deep. The bass capabilities of these and similar small systems relate to the internal volume of the enclosure rather than its shape. The same components are often available in more conventionally styled bookshelf cabinets and performance is not noticeably affected one way or the other.

An interesting styling variation on this type of system is the *University* "Syl-O-Ette." The beveled sides of the enclosure make it look shallower than it actually is. In addition, *University* can supply several different grille patterns, and even matching drapes and wallpaper.

Another noteworthy design in this general category is the *James B. Lansing* "Trimline 54." Most other thin speaker systems use a ducted port to get maximum bass efficiency from a small enclosure; the duct usually has to be bent or folded to fit in the shallow cabinet. *JBL* uses a different approach. With the grille removed, the "Trimline 54" appears to house two LE8T full-range reproducers. In fact, however, just one of the loudspeakers is "real." The other consists only of a matching cone and frame assembly—but no magnet or voice coil. The second "passive radiator" takes the place of the port. It is driven by the air inside the enclosure and at low frequencies effectively doubles the radiating area of the "real" LE8T.

The systems just described are all at least four inches deep. As long as the internal volume of an enclosure is sufficient to match the loudspeakers installed, one may ask why it can't be made even shallower? The limiting factor turns out to be the depth of the loudspeakers themselves.

Slimming the Dynamic Speaker

There are at least four ways in which a familiar cone-type loudspeaker can be reduced in depth. These are illustrated by the cross-sections shown in Fig. 1.

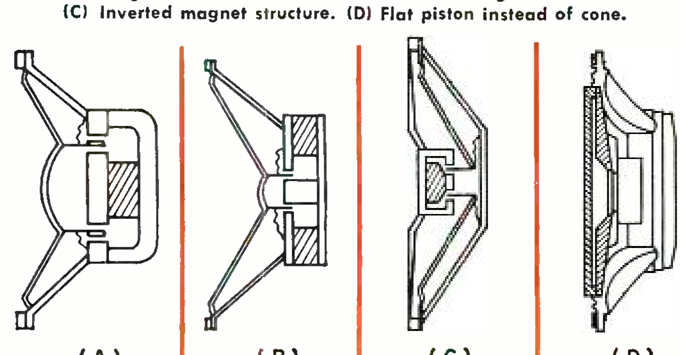
1. *Large voice-coil diameter.* A loudspeaker cone doesn't extend all the way to a point. It is cut off where it meets the voice coil and the remaining hole is filled with a felt cap, inverted cone, or dome. Other things being equal, the larger the voice-coil diameter, the shallower the cone. Unfortunately, this is a rather expensive way to make a speaker thin—a larger magnetic structure is required and the forming of the voice coil is more difficult. *JBL* cone speakers, for example, have always been noticeably shallower than comparable units, not because they were made to fit shallow enclosures, but as a result of a design philosophy based on performance objectives rather than appearance.

2. *Shallow magnetic structure.* Magnets are available in a wide variety of shapes and sizes—slug magnets, ring magnets, skinny magnets, and squat magnets. The magnetic structure can be made either long and thin or short and squat without changing the field in the voice-coil gap. The availability of ceramic magnets, which tend to be shaped like pineapple slices, has helped make possible speakers which will fit into shallow spaces.

3. *Inverted magnetic structure. Utah* and others now make thin general-purpose speakers in which the magnetic structure is mounted in *front* of the cone. This is obviously the way to make a cone-type loudspeaker as thin as possible since the total depth of the unit is that of the cone itself. The same sort of "inside-out" speaker is used as a woofer in the *Heathkit* AS-22 system.

4. *Flat plate instead of cone.* For years, engineers have experimented with every conceivable substance which could be used to make a vibrating piston. In almost every case, it

Fig. 1. Various ways of making cone-type speakers shallower. (A) Large-diameter voice coil. (B) Shallow magnet structure. (C) Inverted magnet structure. (D) Flat piston instead of cone.



turns out that a felted paper cone will do the same job, only better. (See "Hi-Fi Loudspeaker Cones" by C. L. McShane, February 1963 issue, ELECTRONICS WORLD.) However, there are a few recent commercial designs which achieve high-quality performance from flat plates instead of cones.

The *Jensen* 3-P/W1 looks from the front like a plain styrofoam disc mounted in a conventional speaker basket. But the cross-section in Fig. 1D shows that its internal construction is not so simple. The disc is driven at its edge by a second foam member which, in turn, is driven by the voice coil. This sophisticated "center plus edge" drive is required to make the foam disc act as a true piston throughout its operating range, which extends up to about 600 cps.

Another flat piston loudspeaker is the unique rectangular woofer used in three new systems marketed by *Audio Dynamics Corporation*. The largest of these is the Model ADC-18. While this does not qualify as a thin speaker system—it is actually 12½ inches deep—the distinctive styling of the enclosure makes it look much shallower than it really is.

Bi-Directional Speakers

Still a third design in which the voice coil drives a large flat plate instead of a cone is the "Bi-Phonic Coupler." In this design by Abraham B. Cohen, no enclosure is used—what appears to be the cabinet is actually the loudspeaker. The front panel is the low-frequency radiating surface and sound is projected both from the front and the rear of the system.

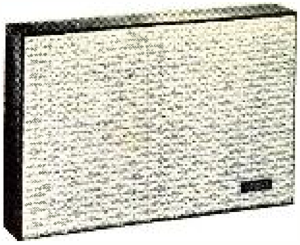
University is now marketing a new version of the "Bi-Phonic Coupler" which has been dubbed the "Mini" and has over-all dimensions of 18″ x 13⅜″ x 2″, making it the thinnest of the thin systems. Yet the low-frequency radiating area is about 180 square inches or comparable to a 12″ cone speaker.

We know (at least we have been told often enough) that a 12″ speaker cannot reproduce bass unless it is installed in a matching enclosure. How then does the coupler manage to reproduce music if its backwave simply exhausts into free air?

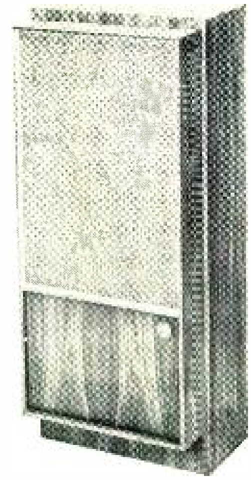
There are several reasons. First of all, nobody claims that this tiny speaker system can duplicate the bass reproduction of the larger enclosed systems. Second, the backwave does not actually radiate freely; there is an acoustic filter which helps prevent complete cancellation between the front and back of the radiating surface. Finally, loudspeakers behave quite differently in your home than they do in an anechoic chamber. If an unbaffled speaker happens to be positioned where it can excite a 50-cps standing wave, it will do so no matter what its free-air bass response might be.

The full-range electrostatic speakers made by *Quad* and *KLH* also radiate in both directions, although the size of these units (and the price) is considerably greater than the "Mini." The *KLH* "Model Nine" comes as a matched pair of what appear to be very expensive Shoji screens. Each unit is almost six feet high and two feet wide, yet the depth of the "Model Nine" is only 2⅞ inches.

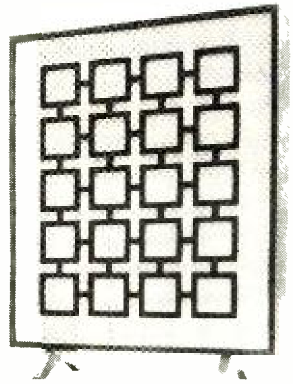
The reason for the very large radiating area of the *KLH* design is that the maximum diaphragm travel of a practical



Argos HFWB



(Above) ADC Model 18



(Right) Audax CA-70

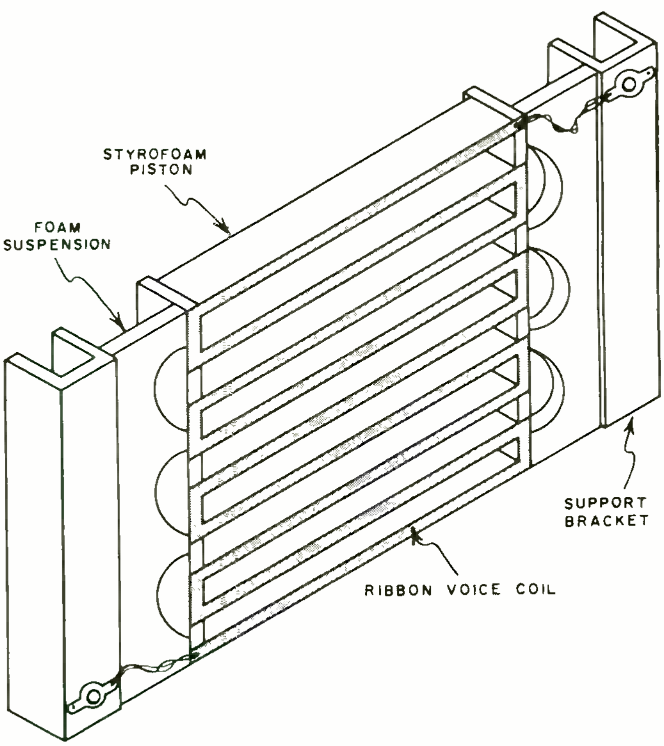
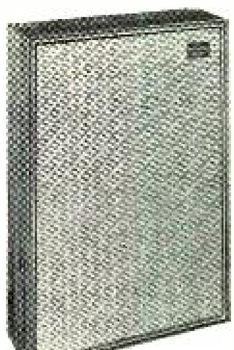


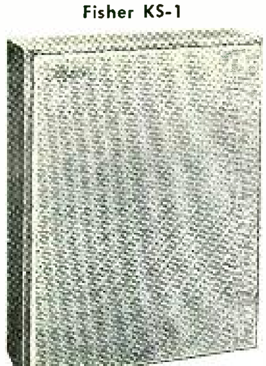
Fig. 2. The flat ribbon-type voice coil and the plastic diaphragm of the unique Orthophon loudspeaker (shown from rear).

Eico HFS6

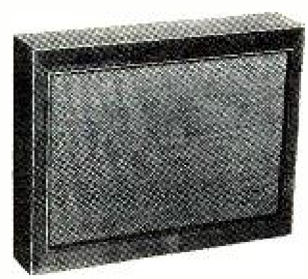
Electro-Voice 200



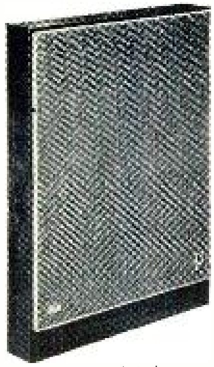
Fisher KS-1



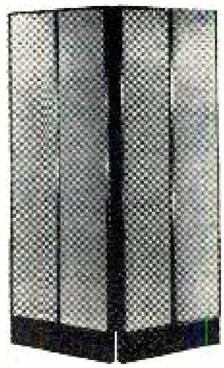
Heath AS-22



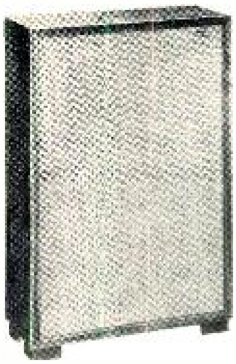
JBL Model 54



Jensen 3-P/2



KLH Model Nine



Knight 2250

Lafayette SK-240WX

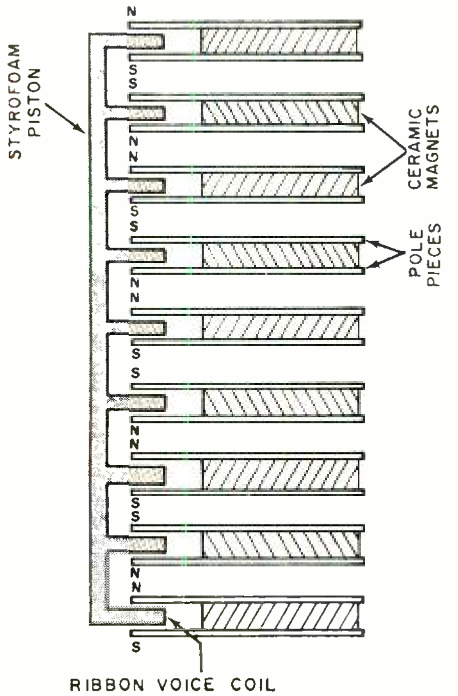


Fig. 3. Cross-sectional view through the Orthophon speaker.

electrostatic speaker is much less than the half-inch or more which can be realized from a cone-type speaker. Also, by making the diaphragm very large, air loading is maintained down into the bass range, reducing distortion and keeping efficiency at a reasonable level.

Experimental Designs

Bogen and Rich of Yonkers, N.Y. has been experimenting with a novel high-frequency transducer which has a flat voice coil fastened directly on a thin movable diaphragm. A series of small bar magnets are spaced on either side of the diaphragm in such a way that the magnetic field created is shallow and flat, rather than relatively deep and transverse, as in the conventional voice-coil gap. The idea is that the diaphragm is driven over almost all its surface, as is the electrostatic speaker. But in this instance, no high-voltage supply or step-up transformers are needed. It would seem that the big difficulty lies in getting a magnetic field strong enough to make the unit operate efficiently.

Another design which uses a flat distributed voice coil is the "Orthophon," originated in France. This is a modern-day version of the old *Blatthaller* speaker. The voice coil is serpentine in configuration, driving a carved-out styrofoam diaphragm (See Fig. 2). Fig. 3 shows a cross-section of the speaker. Again, the difficulty is in getting sufficient magnetic flux density in order to realize the theoretical benefits of the design.

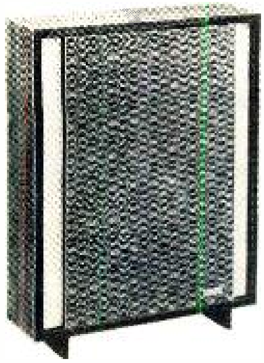
It should also be remembered that in transducers which use flat plates or diaphragms to reproduce the high-frequency range, directionality becomes a real problem. Successively smaller and smaller units must be used to reproduce higher and higher frequency ranges, or a number of individual cells must be mounted in a spherical array. A third possibility is to use an acoustic lens, but this would add enough depth to remove such a combination from the "thin speaker" class.

Conclusion

The concept of a "flat" speaker system is exciting, but there is a practical limit to how much of what Paul Klipsch calls "chargeable space" can be saved in this way. Systems which employ ducted enclosures can't be made much shallower than four or five inches, and therefore aren't quite as easy to hang as a picture. The really shallow systems, on the other hand, radiate in both directions and, unless they are set some distance out into the room, bass reproduction may suffer.

Nevertheless, for the serious music lover who has a real space problem, the new thin speaker systems offer the opportunity to enjoy high-fidelity reproduction without crowding the listener out of the room. ▲

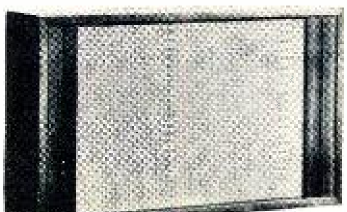
Paco L4



Radio Shack "Electrostat 5"

University "Mini"

Utah SH4-W



CATHODE-FOLLOWER NOMOGRAM

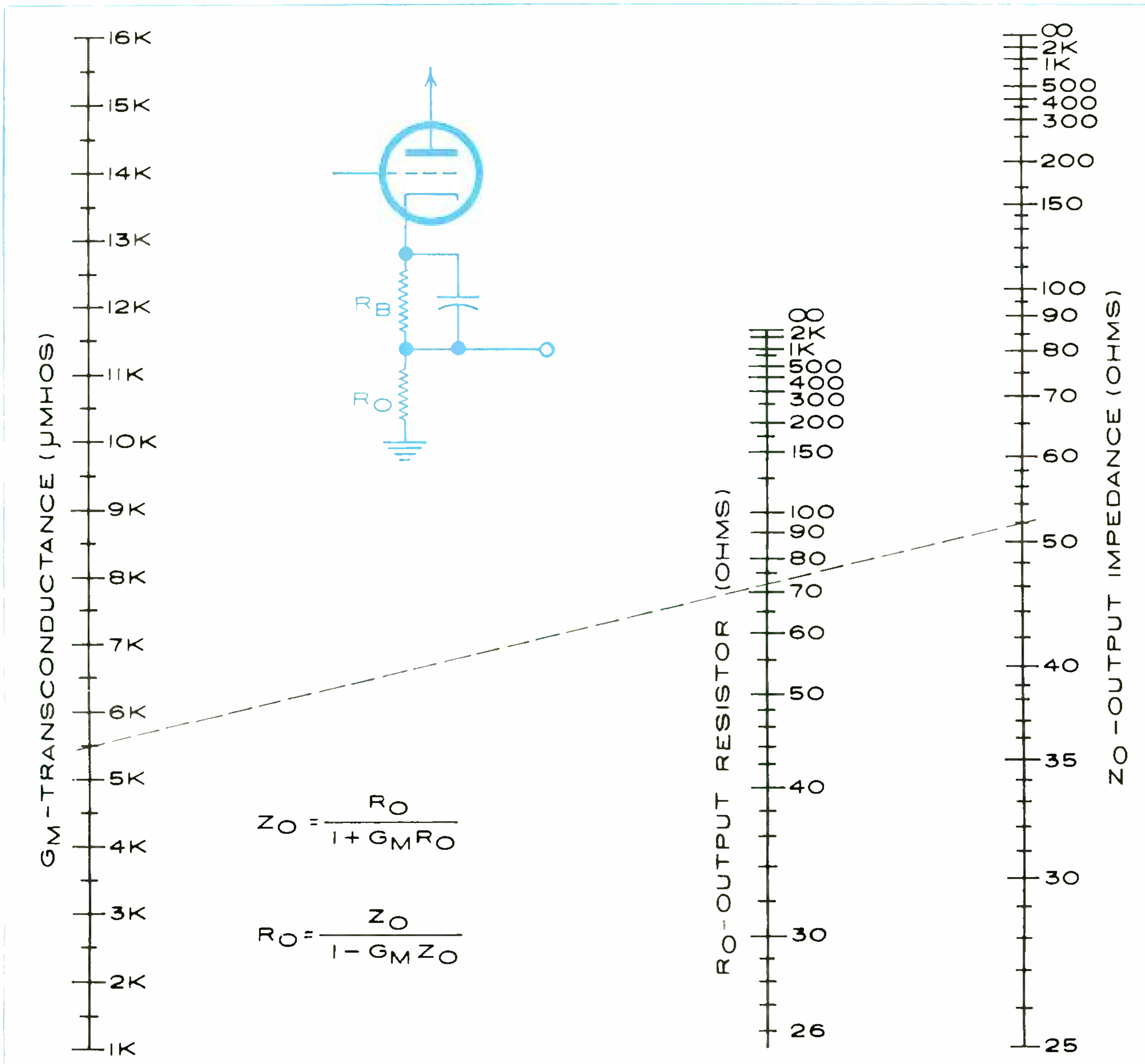


Chart permits the value of the cathode-load resistor to be selected to obtain various output impedances.

By A. L. TEUBNER

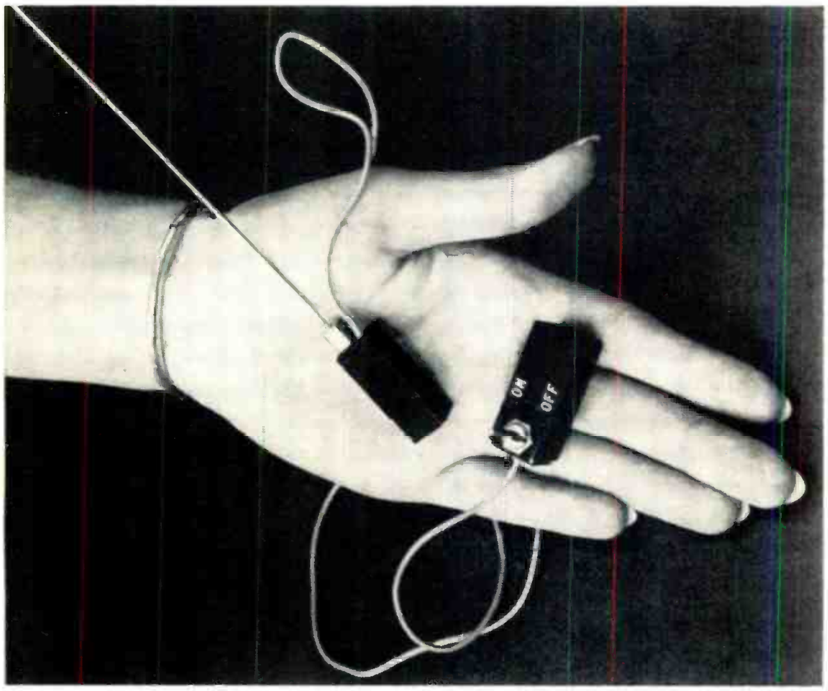
HERE is a nomogram that permits you to solve for the required load resistor for a cathode-follower which will produce any desired output impedance, using any vacuum tube with a transconductance between 1000 and 16,000 micromhos.

An example is already worked out on the nomogram. Assume that you want a cathode-follower to drive a 52-ohm coaxial line, using one section of a 12AT7. This tube has a transconductance of 5500 micromhos when it is biased at −2 volts and has 250 volts on its plate. To find the value of output resistor necessary, draw a line between 52 on the "Output Impedance" scale and 5.5 k on the "Transconductance" scale. The point where this line crosses the "Output Resistor" scale is the answer—in this case, about 73 ohms.

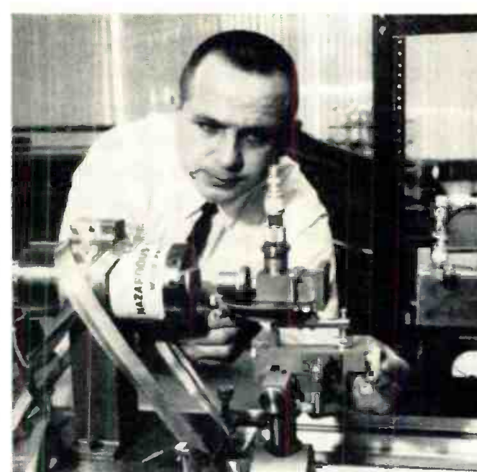
The value just found represents the *unbypassed* portion of the resistance between cathode and ground. If fixed bias is not available and cathode bias must be used, the total cathode resistance is determined in the usual way. For the example given, according to the tube manual the cathode resistor should be 200 ohms. Therefore, the bypassed resistor, R_B on the schematic drawn on the nomogram, will be 200 − 73 or 127 ohms. If you do not wish to use precision resistors, you can pick the nearest standard value and check the resulting output impedance by using the nomogram again.

You will notice that there are combinations of G_M and Z_O that do not give an answer because a line drawn between them passes above the top of the "R_O" scale. This simply means that it is impossible to obtain the desired output impedance using a tube with such a high transconductance, and another type must be chosen. ▲

RECENT DEVELOPMENTS in ELECTRONICS

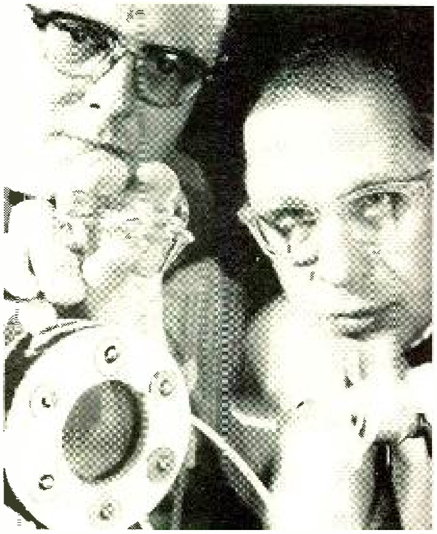


Subminiature Receiver. (Left) The tiny receiver shown here was built by Westinghouse Defense Center to demonstrate the use of molecular electronic (integrated circuit) functional blocks. Powered by a 6-volt battery, which is in the box with the on-off switch, the receiver has a range of about one mile when operated with a standard "walkie-talkie" transmitter. The operating frequency is between 25 and 30 mc. in the Citizens Radio band. The molecular electronic functional blocks used in the receiver are a radio-frequency amplifier, a mixer-oscillator, an intermediate-frequency amplifier, and an audio detector-amplifier stage. All these blocks are available from the company as standard catalogue items. Although the receiver was built with company funds, it is an outgrowth of molecular electronic work for U.S. Air Force.



Lasers in the Laboratory. A new internal means for controlling the coherent light beams emitted by solid-state lasers has been reported. The technique employs magnetic fields to tune, modulate, or pulse the light from crystal lasers as this light is being generated. Photo at near right shows RCA scientist adjusting focus of receiver that detects laser beam reflected by prism from generating equipment in foreground. At far right IBM engineer is converting ruby laser beam into an S-band microwave signal by the use of an optically coupled quartz crystal. This marks the first use of quartz or electro-optic materials in the microwave conversion process. Previous schemes have used either phototubes or photoconductive devices.... **Ultrasonic Thermometer.** (Below right) Sound waves far above the range of human hearing are used in this ultrasonic thermometer to take the ocean's temperature. This Westinghouse-developed device can pinpoint underwater temperatures at extreme depths to 0.05°F. The ultrasonic transducer uses a transistor circuit to drive a small aluminum disk at about 40 kc. Changes in temperature cause this vibrating frequency to change. Temperatures are measured by observing and counting the corresponding shift in frequency of the electrical oscillations produced by the underwater transducer.

Diesel-Oil Fuel Cell. (Near right) Diesel oil combined with air is used in a new laboratory fuel cell to generate electricity directly to power the motor at right. Pouring the commercial 18-cents-a-gallon fuel (simply purified) are G-E scientists who pioneered in the development of moderate-temperature cells using inexpensive hydrocarbon fuels. The new cell has been operated with a variety of other common liquid fuels as well as gaseous fuels such as propane and natural gas.... **Superconducting Solenoid.** (Far right) Another group of G-E scientists have demonstrated a magnetic coil with a field of more than 100,000 gauss. (The earth's magnetic field averages about ½ gauss.) The superconducting solenoid was wound with 600 feet of special niobium-tin conductor which carried currents of up to 266 amps. The coil, about 2 inches long and 2 inches in diameter, was wound on ⅓-inch diameter tubing. It was maintained at a temperature of around 1.8° Kelvin (which is approximately 456° below zero Fahrenheit).



"Silent Sentry" Security System. (Above) An electronic security system has been installed by Sylvania along the 3000-foot perimeter of a "Nike-Hercules" missile site near Offutt Air Force Base, Nebraska. The system, made up of 9 transmitting and 9 receiving units, produces an electromagnetic wave along the site's perimeter. When anyone breaks the field, an alarm is set off. **Millimeter-Wave Communications.** (Right) Sylvania is doing research in the use of millimeter waves for voice, private, high-capacity, and long-distance communications. The unit shown is a 70-gigacycle (70,000 mc.) transceiver recently installed at Buffalo.

REPLACEMENTS FOR

NON-STANDARD DOMESTIC TRANSISTORS

By JERRY EIMBINDER / Technical Director, D.A.T.A., Inc.

With less reference data available on these than on many foreign types, this comprehensive list of over 200 "maverick" transistors fills a serious gap.

THE PROBLEM of replacing transistors that do not carry standard, domestic type numbers, such as those used in receivers made in other countries, is well known. Transistor replacements in many receivers made on these shores, however, can be equally vexing. A recent article in this publication, "Domestic Replacements for Foreign Semiconductors," was devised to alleviate the problem both with receivers made abroad and with those assembled here but using foreign transistors. Here we deal with receivers of domestic manufacture which use transistors, most of them also made here, that do *not* have standard designations.

With our own standard system (type numbers assigned by the Joint Electron Devices Engineering Council of EIA, beginning with "2N") there is obviously no difficulty. Nor is there much trouble with some of the standard systems used abroad (such as the "2S" numbers used in Japan or the "0C" numbers used in Europe). Replacement listings for these types have appeared. A domestic unit that adheres only to a particular manufacturer's coding system can be much more of a problem.

Why do such irregularities exist? There are several, possible reasons for non-standard type numbers, sometimes known as "house numbers": The transistors may be specially selected from standard production types. For example, a matched audio pair for use in the common, class B push-pull output configuration might be so designated, rather than carry the original type number. Or else, the transistors may be "shrinkage" from premium industrial types. In this case, although they may not be suitable for the original purpose, the shortcomings they have would not impair performance in radios. Another possibility: they may be part of a run for use in a particular design, with the volume of units involved not justifying the assignment of an industry type number.

Sometimes the manufacturer anticipates that he will want to vary the specifications for the transistor somewhat in future production to meet various application needs. If he has registered a type number with accompanying specifications, he is not always free to do so. Finally, the non-standard designation may be that of the receiver manufacturer, who simply wishes to retain a captive replacement business.

Whatever the reasons, the difficulty exists. The information included here should go a long way to solving problems. ▲

ORIG. TYPE	REPLACE BY TYPE
ADMIRAL	
57D168	2N410
57D169	2N410
57D170	2N408
R-338	2N406
R-339	2N406
R-340	2N649
R-341	2N408
R-515	2N1527
R-516	2N1033
R-530	2N406
R-558	2N406
R-592	2N649
R-593	2N408
AIRLINE	
3434	2N410
3435	2N412
3504	2N406
3544	2N410
3600	2N408
E-241	2N217
SO-88	2N408
TS-739	2N408
TS-740	2N270
DuMONT	
R-2749M	2N408
EMERSON	
815020	2N412
815021	2N410
815022	2N406
815023	2N408
815024	2N408
815028	2N649
815029	2N649
815030	2N408
815031	2N649
815034	2N408
815036	2N412
815037	2N410
815038	2N408
815055	2N406
815056	2N406
815057	2N408
815065	2N412
815066	2N412
815068	2N410
815070	2N408
815103	2N410
815104	2N406
815105	2N406
E-044A	2N408
R-2749	2N408
GENERAL ELECTRIC	
4JX1A520	2N407
1524	2N649
IE-850	2N649
RS-1049	2N649
RS-1059	2N649
RS-1513	2N649
RS-1543	2N406
RS-1549	2N408
RS-1554	2N1527
RS-2352	2N408
RS-2354	2N408
RS-2366	2N406
RS-2367	2N406
RS-2373	2N406
RS-2374	2N406
RS-2375	2N408
RS-2677	2N406
RS-2683	2N1525
RS-2684	2N410
RS-2686	2N412
RS-2687	2N410
RS-2688	2N410
RS-2694	2N1527
RS-2695	2N1525
RS-2696	2N1525
RS-2697	2N406
RS-3275	2N406
RS-3276	2N408
RS-3277	2N1525
RS-3278	2N1525
RS-3279	2N1525
RS-3280	2N406
RS-3283	2N1525
RS-3284	2N408
RS-3286	2N1525
RS-3287	2N412
RS-3288	2N410
RS-3301	2N408
MAGNAVOX	
HJ-34A	2N270
HJ-70	2N370
MOTOROLA	
4315	2N407
4366	2N409
4367	2N409
4450	2N591
4562	2N408
4563	2N408
4564	2N408
4565	2N410
4567	2N410
MN-29	2N176
MN-53	2N591
MN-73	2N176
R-324	2N406
R-1273	2N408
R-1274	2N408
OLYMPIC	
GT-81R	2N405
GT-109	2N407
GT-760R	2N410
GT-761R	2N412
PHILCO	
T-1001	2N406
T-1005	2N408
T-1618	2N410
RCA	
3458	2N406
3577	2N301
3851	2N410
3852	2N408
REGENCY	
09390	2N109
09391	2N109
RIVERSIDE	
RS-684	2N412
RS-685	2N410
RS-686	2N406
RS-687	2N408
ROLAND	
R-67	2N405
SILVERTONE	
86452	2N408
86812	2N649
86822	2N649
86832	2N406
86842	2N406
R-428	2N408
S-95101	2N1526
S-95102	2N1524
S-95103	2N1524
S-95104	2N1526

(Continued on page 103)

TRANSISTORS FOR HI-FI
PANACEA OR PANDEMONIUM?

By D. R. von RECKLINGHAUSEN, A. W. LINDER, E. H. L. MASON / H. H. Scott, Inc.

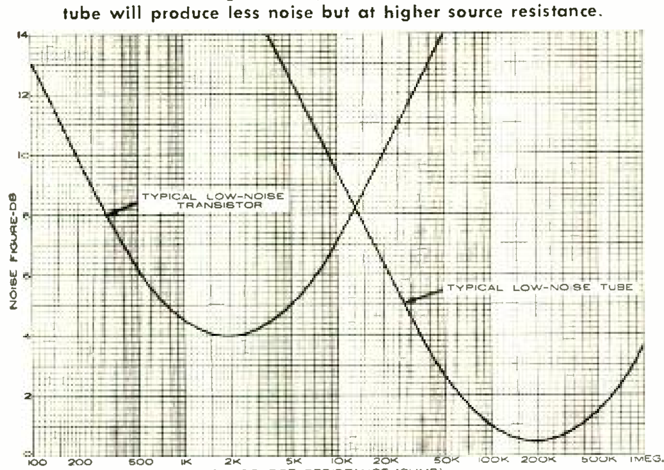
PART 1. Facts and Fallacies. What is the magic of "transistor sound" in high-fidelity amplifiers and what advantages do transistors really offer?

Editor's Note: There has been much heat but little light shed on the subject of transistors versus tubes for hi-fi amplifiers. Here is an authoritative, though perhaps controversial, look at the facts. Whether all manufacturers of high-quality transistor hi-fi equipment agree with these interpretations or not, this viewpoint is certainly worth considering.

SINCE the invention of the "wireless," the electronics industry has had to overcome many preconceived notions, half-truths, and fables. The advent of the transistor has given birth to even greater misconceptions.

That transistors are marvelous devices which have opened up vast new horizons cannot be disputed. Transistors make it possible for us to explore the outer reaches of space, provide us with new technical instruments heretofore impossible, and make available to the public highly mobile consumer products. But a transistor has limitations.

Fig. 1. Typical noise figures for transistor and tube. The lower the noise figure the quieter the circuit. Note that the tube will produce less noise but at higher source resistance.



Articles on transistor equipment and advertisements for these units often mention such features as "long life," "cooler running equipment," "better sound," the so-called "transistor sound," "quick warmup," and "small size." The words "no microphonics," "no hum," and "no noise" might also have been included. One might easily believe that the transistor was designed to cure all the ills of mankind and accomplishes this by a certain magic. What is the truth?

Advantages of Transistors

There will be no microphonics. It is certainly true that transistor equipment has much lower microphonics. Why? In a vacuum tube, the interior elements are a fraction of an inch long. They are usually suspended at two points and can act like the diaphragm in a microphone. Depending on individual construction, the resonant frequency of such a suspension is on the order of several hundred to several thousand cycles per second. Tube designers have taken particular care to minimize microphonics and have, in many cases, met with remarkable success. Yet they have not been able to completely eliminate all problems. So the tube remains a microphone, though fortunately a rather poor one. With the transistor, its elements are considerably smaller and generally fused together into one little block of material. The resonant frequencies of such a block are considerably higher and the active "diaphragm" area is a great deal smaller. In simple words, the transistor is a much poorer microphone, so a lot less microphonic output will be caused by mechanical shock, such as the turning of a rotary switch with a strong detent.

Quick warm-up. It is also true that transistor equipment warms up quickly. Transistors don't really warm up at all.

since they begin to operate as soon as voltage is applied. Here, one has to consider only the time constant of the power-supply filters, usually a fraction of a second. With tubes, 10 seconds are required for the tubes to reach 90% of their operating emission. On the other hand, this does not mean that transistor equipment becomes silent as soon as the power switch is turned off. The power-supply filter circuits have to discharge through the rest of the transistor circuitry and it may take a number of seconds before everything becomes completely silent.

Cooler operation. Transistor equipment does run cooler than tube equipment. There are no filaments to consume power. Transistors *have* to run cool to operate properly. By

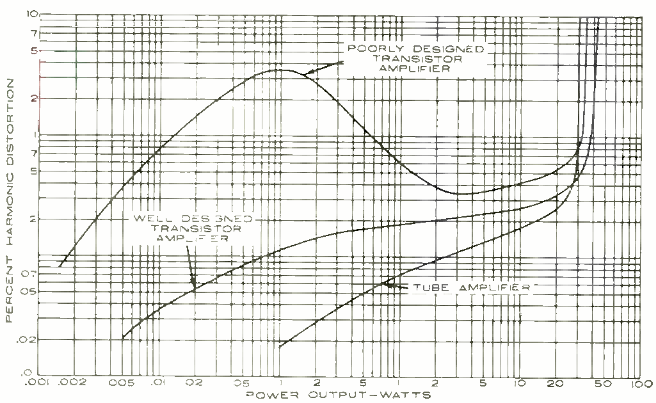


Fig. 2. Variation of 1-kc. harmonic distortion with power.

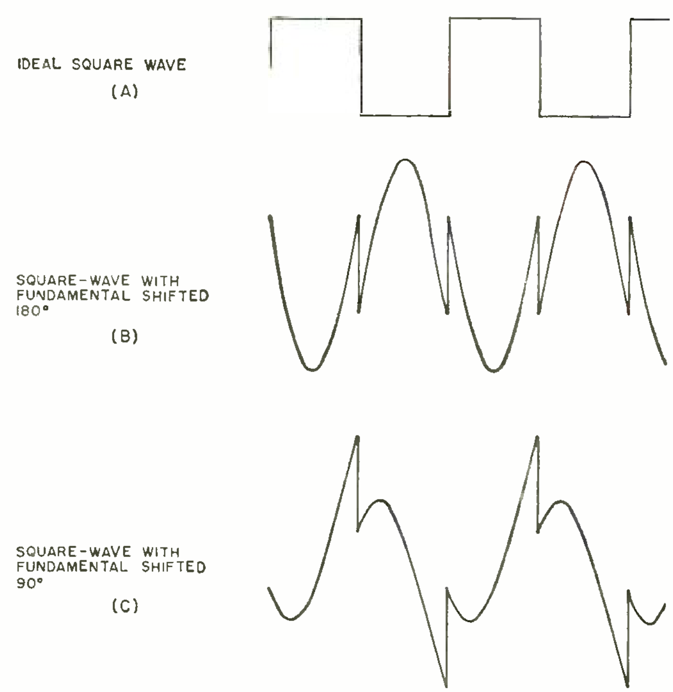


Fig. 3. All three waveforms shown produce identical sounds.

cool, it is meant that the instantaneous junction temperature of germanium transistors must never exceed the temperature of boiling water or one-and-one-half times that much with silicon devices. To insure this, case temperatures have to be lower, and, in most cases, will be comfortable to the touch. In addition, because the power output stages of transistor amplifiers are usually operated class B, transistors have very low power consumption at low listening levels

Transistors will have long life. Now this is a somewhat touchier point because it is very difficult to forecast transistor life at present. Occasionally, transistors exhibit a slow degradation in their characteristics which causes decreased gain and increased noise. Such units are readily spotted when checking the transistor equipment as a whole. Yet, transistors can fail fast when their ratings are exceeded even for a fraction of a second. So transistors can be said to have very long and very short life. When properly chosen and correctly used in electronic circuitry, transistors can be expected to have a service life that runs well into the tens of thousands of hours.

Some Controversial Issues

Transistor amplifiers will be relatively small. This is a more controversial point. Because transistors themselves are small, one would expect the transistor equipment as a whole to be smaller. This is not necessarily the case because the size of the over-all unit is determined primarily by the number and size of all the components and the ease of wiring of low-level circuitry. It is true that transistor equipment can be miniaturized—hearing aids which practically plug into the ear, power supply included, are a case in point. But, such miniaturized units usually have reduced low-frequency response and can hardly be considered "high fidelity." In high-fidelity circuitry, low-frequency response has to be maintained. This automatically requires the use of capacitors whose physical size is greater than the transistors. It is actually permissible temperature rise that dictates the size of a transistor power amplifier because adequate heat sinks have to be used if output transistors are not to exceed their ratings. In addition, the power supply has to be able to provide the necessary direct current at a power level higher than the audio output power. After all, output-circuit efficiency is less than 100%.

Transistor amplifiers can operate without any hum or noise whatsoever. Here again, the hearing aid is often used as an example. But this unit is battery-operated and any unit which is completely battery-operated will be free from power-line hum. However, whenever a power supply is connected to the a.c. power line, there will be residual hum. It may be miniscule but it is still there. In high-fidelity equipment, the major cause of hum is that caused by the power transformer's magnetic field. In tube equipment, this is of some concern, but can be minimized by proper wiring layout. In transistor equipment, such hum is of more consequence. The impedance level of transistors is much lower than in tube circuitry; therefore the power transformer has a greater effect on output hum. Again, this can be corrected, although somewhat less easily, by proper wiring. As a practical matter, it is really the wiring to the external equipment that determines the hum level in high-fidelity equipment.

By the same token, it can be said that there is no amplifying equipment which is truly hiss- or noise-free. Even a resistor on a bench at room temperature will produce a certain amount of noise. For example, a 3000-ohm resistor at room temperature will produce approximately 1 microvolt of hiss over a bandwidth of 20,000 cps. Amplifiers, be they tube or transistor, are not perfect. The noise figure indicates performance with regard to noise. If an amplifier has a noise figure of 6 db with a particular source impedance, its output noise voltage is 6 db higher than it would be if the amplifier produced no noise at all.

Referring to Fig. 1, where some typical noise figures are shown, it can be seen that a tube amplifier achieves its best noise figure when operated from a source impedance of around 200,000 ohms. This would make a tube amplifier best for high-impedance sources such as capacitive pickups and microphones. A transistor amplifier shows its best noise figure with a source impedance of around 2000 ohms, making it better for low-impedance sources such as dynamic microphones or magnetic pickups. Here, the transistor amplifier will actually be quieter than a tube amplifier.

Factors Directly Affecting Sound

The most widely talked about feature of good transistor amplifiers is that "they sound better." There seems to be some magic involved. Can such a magical spell be broken?

Here, it is necessary to analyze tube and transistor charac-

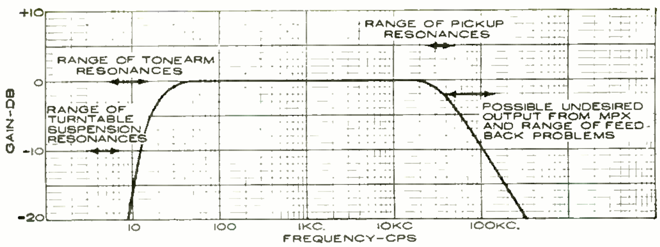


Fig. 4. With a frequency response such as this, there will be no problems from undesirable resonances and interference.

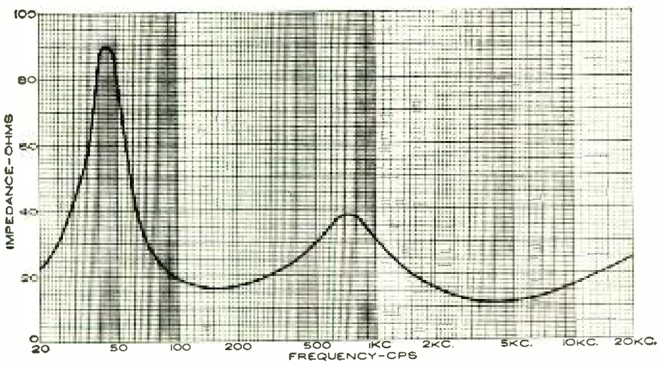


Fig. 5. Typical impedance curve for a "16-ohm" speaker system.

teristics and their effect on sound. In a preamplifier more transistor stages than tube sections are required. This is because transistors generally have lower gain and much wider tolerances in their characteristics. For this reason, more extensive feedback is used with transistor equipment than with tube units. But does this give better sound? Transistors have higher non-linearities than tubes. Therefore it is entirely possible that higher distortion can occur and perhaps does occur in certain preamplifier designs. Chances are that distortion is probably similar to that occurring in tube equipment. But this whole discussion may be purely academic since distortion is usually very low in any well-designed preamplifier circuit. The slight change in the type of distortion is certainly not a valid explanation for the "better" transistor sound.

In a well-designed transistor power amplifier, distortion at high operating levels is comparable to distortion in tube amplifiers. It is at low operating levels that the differences occur. With tube amplifiers, distortion decreases with reduced power. This is true because output tubes are usually operated in class AB with a substantial zero-signal plate current, and in low-distortion class A at low levels. Transistor power amplifiers are usually operated in class B because it is here that lowest distortion occurs. Class B means that only one-half of the output stage is conducting during each half of the cycle. If the output stage is not adjusted properly, then crossover from one stage to the other stage is not proper and distortion can occur. This distortion would be most noticeable at low listening levels. Fig. 2 illustrates this with measurements made at 1 kc. Distortion can be minimized by proper design but this, unfortunately, is not always done.

Up to this point, no proof has been offered that transistor amplifiers actually sound better.

Significance of Transient Response

One explanation for "transistor sound" is superior transient response. Transient response is important in the design of wide-range oscilloscopes or video amplifiers. Tube amplifiers that exhibit excellent transient response up into the hundreds of megacycles are available for commercial purposes but, at this time, we cannot say the same for transistors. At audio frequencies, achievable transient response is similar in both kinds of amplifiers. But does transient response really produce a better sound?

It is well to examine at this point what the ear can hear. Numerous reports in learned publications on psycho-acoustics have gone into this problem rather deeply. It has been found that the ear is amplitude-sensitive and can detect differences in frequency *vs* amplitude response as low as a couple of decibels. This is true for most of the audible range, but not for frequencies beyond the audible range. It was also found that the ear is only amplitude-sensitive and totally insensitive to phase.

In one of the classic experiments, pictures of square waves (such as in Fig. 3A) were drawn on sound film and played back to a number of listeners. Then the fundamental frequency of the square wave was shifted by 180 degrees, by 90 degrees, and also by some intermediate values. It will come as a surprise to many high-fidelity enthusiasts that the findings were that *the audible sound did not change at all.* Later concurring experiments showed the ear to be totally insensitive to phase in a steady signal.

Akin to phase shift is delay. To this, the ear is definitely sensitive. If certain portions of the frequency range are delayed excessively—for example, several seconds—this certainly can be heard when reproducing music. When the delay is relatively small, the difference becomes completely indistinct. For example, an echo can be perceived as an echo only when

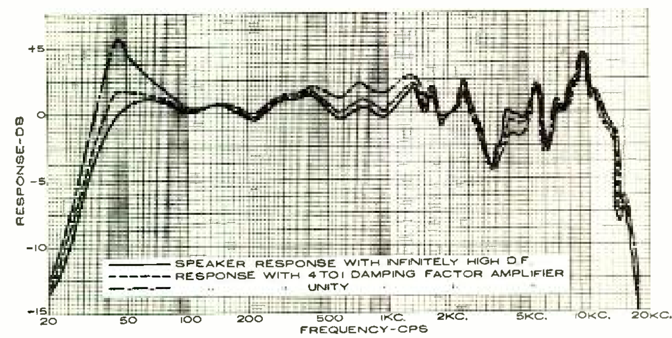


Fig. 6. Effect of unity amplifier damping factor on response. A definite peak has occurred at 45 cps and there is a slight increase in the response of the system between 500 and 1000 cps.

it occurs more than 10 milliseconds after the original sound. If it occurs at less than 10 milliseconds and is louder than the original sound, then only the echo will be heard. Additional experiments have been conducted with more sophisticated signals, *i.e.*, very short clicks. Here, no listener was found who could hear the two distinct clicks as separate clicks when they were less than one-quarter millisecond apart. One-quarter millisecond delay means 360 degrees of phase shift at 4 kc. or 1800 degrees phase shift at 20 kc. No respectable amplifier, even with a poor filter, will show that much phase shift.

Similar results have been found at low frequencies. Here again, the ear was found to be quite insensitive to delay and the lower the frequency the greater the tolerance to delay. Delay up to the tens of milliseconds was inaudible. Therefore, *any change in the appearance of a square wave used for testing of an amplifier does not indicate any change in listening characteristics of the amplifier.* Hence, any square-wave test of audio equipment is meaningless and superior square-wave response of an amplifier has very little bearing on the actual listening quality of the audio equipment.

Is Extended Frequency Response Desirable?

Since an audio amplifier is really used to reproduce music and speech, such an amplifier should be capable of reproducing all these signals with full power, and yet not be bothered by strong signals which can easily occur outside the 20 to 20,000 cps frequency range. Practically all the recorded music and speech components are contained in the range of 50–15,000 cps and none exceed 20–20,000 cps. For example, as Fig. 4 shows, a strong source of input signals below 20

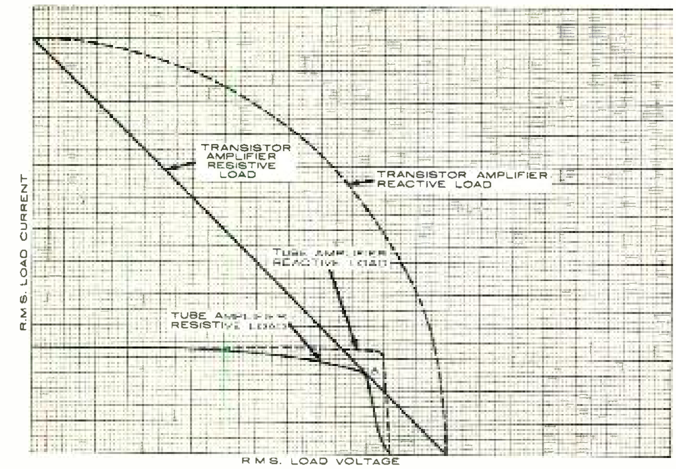


Fig. 7. Comparison between maximum available current vs maximum available voltage for tube and transistor output stages.

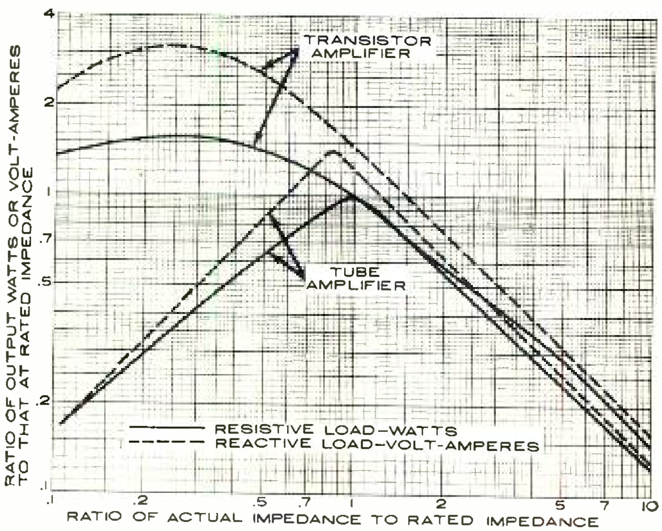


Fig. 8. Effect of load impedance on output power of amplifiers.

cps are phono pickups with their arm resonances or turntable suspension resonances. These signals can easily be of such a high value that they take a substantial amount of power-handling capability away from the amplifier.

High-frequency signals, such as distortion products magnified by pickup resonances while tracing high-volume recordings or the supersonic output of improperly constructed multiplex adapters, can easily degrade the power-handling capabilities of a power amplifier. Thus available power output for music is lowered. It should also be kept in mind that the power-handling capability of an amplifier beyond the extremes of its power bandwidth is considerably less than at the mid-audio band. Beyond the frequencies of the IHF power-bandwidth specification, power-handling capability for the same amount of distortion is reduced by 6 db or more per octave of frequency. 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.

Influence of Damping Factor on Sound

The damping factor of an amplifier is the ratio of the nominal load impedance to internal impedance of the amplifier. Users of high-fidelity equipment are accustomed to amplifiers with a relatively high damping factor, or relatively low internal impedance. When operating an amplifier with infinitely high damping factor into a loudspeaker impedance varying with frequency (as shown in Fig. 5), frequency response of the speaker system is as flat as designed. When operating the same loudspeaker from an amplifier with a lower damping factor (for example, 4), frequency response of the loudspeaker system due to amplifier impedance has changed but only by less than 2 db (as seen in Fig. 6). This is generally not audible and therefore need not be of particular concern since loudspeakers were not designed for infinite damping factors.

If the damping factor should be very low (for example, 1), the frequency response of the loudspeaker has definitely changed and bumps of 6 db have occurred. These are quite audible. Some transistor equipment has a damping factor of 1. By accepted practice, this is not desirable and certainly cannot explain the transistor sound.

"Transistor Sound"

When listening to a well-designed transistor amplifier at high levels and comparing it to a tube amplifier of identical rating, there is an audible difference. Why does such a transistor amplifier sound different from a tube unit?

As with anything in this world, there has to be a logical explanation. Most high-level and high-volume listening is done with loudspeakers, and one thing should be immediately realized—a "16-ohm" loudspeaker does not behave electrically the same as a 16-ohm resistance. A properly designed loudspeaker should normally have a minimum impedance throughout its frequency range of not more than about 25 percent under the rated impedance of 16 ohms, but its maximum impedance may be considerably higher than rated. Various effects, such as low-frequency cone resonances, port resonances, and crossover resonances, are seen in the impedance characteristics. The impedance curve of Fig. 5 is typical of a two-way loudspeaker system.

If an oscilloscope is connected across the loudspeaker terminals, it can be seen that occasionally the music peaks are clipped because the amplifier is driven into overload. This is not an unusual case and does not disturb listening greatly. Also, in observing the music waveforms on the oscilloscope under such conditions, the transistor amplifier has a higher clipping level than the tube amplifier. Only a small portion of this improvement in clipping level is found in measurements taken with a rated resistor load. Therefore, a different mechanism is at work.

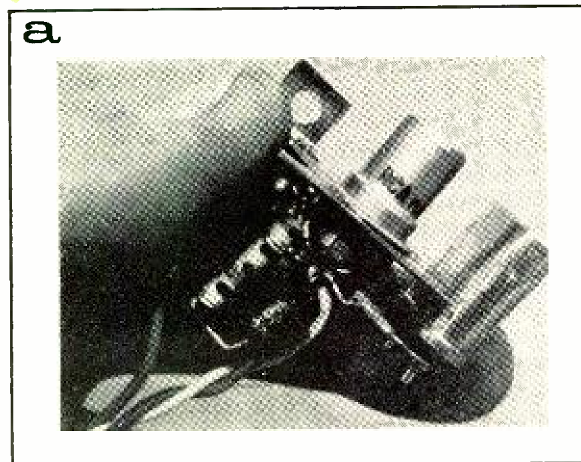
Here, we should examine the basic function of an output stage, be it tube or transistor. The output device acts as a variable resistance between the load impedance and the d.c. power supply. With proper control, it produces a sine-wave output with a sine-wave input. With a tube amplifier, maximum current that can be drawn by a load is normally limited to the plate current obtainable at zero bias voltage. With a transistor, no such current-limiting mechanism exists; maximum current is limited only by the internal impedance of the power supply and the saturation resistance of the transistor itself. Maximum available voltage is limited by the supply voltage in both tube and transistor circuits.

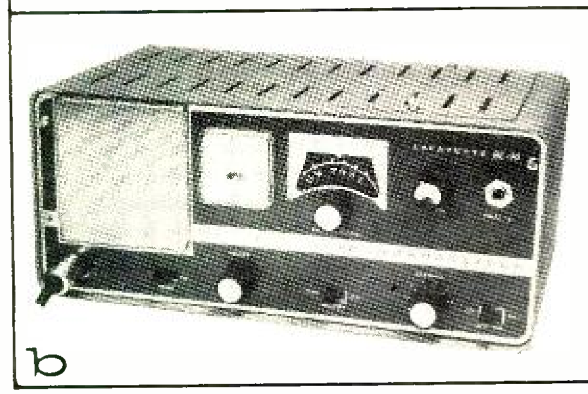
When this test is made with various load resistances, the solid curves of Fig. 7 are obtained. They show the maximum output current and the simultaneous maximum output voltage obtained from a tube and a transistor amplifier. Here, it can be seen that the tube curve shows a relatively sharp knee very similar to its plate characteristics, but inverted. Usually, at or near the knee the optimum load resistance results in maximum (and therefore rated) output power of a tube amplifier. With a transistor amplifier, this "curve" is a straight line whose slope is limited by the internal impedance of the power supply and the saturation resistance of the transistors. Transistor amplifiers are usually rated at point A, but the maximum possible output short-circuit current can be higher by a large factor. Similar tests can be made with purely reactive loads, and here the dashed lines of Fig. 7 are the result. (*Continued on page 84*)

NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

Description and operation of a new sideband receiver adapter along with a transceiver that employs a nuvistor front-end circuit.





THE big news in CB is sideband. Using single- or double-sideband techniques, at least three manufacturers have announced plans to market equipment that multiplies effective transmitter power without exceeding the FCC's legal limit of 5 watts to the final r.f. amplifier. In each case power intended for the conventional carrier (which bears no intelligence) is used instead for the sideband(s) where modulation actually resides. No details yet on specific transmitter circuitry, but we can describe this month the first commercial product on the market designed to adapt a receiver to SSB reception. It is *General Radiotelephone's* new SB receiver adapter unit.

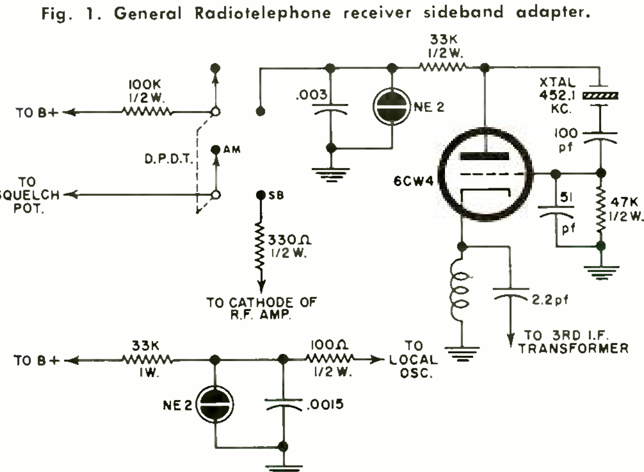
Lafayette's new HE-90 rig also includes some interesting circuitry worthy of our attention. It contains a nuvistor stage that calls for an unorthodox alignment procedure, not normally encountered in routine servicing.

(a) General Radiotelephone SB Adapter

This company's[1] approach to sideband reception is *via* its adapter installed in conventional CB equipment. The function of the device is to reverse some of the processes used in creating a sideband signal. Recall for a moment standard plate modulation. Audio mixes with r.f. in the final amplifier and three products emerge—the carrier; the upper sideband, which lies just above the 27-mc. carrier; and the lower sideband below it. If, for example, r.f. is precisely on 27 mc., a 1000-cycle tone would appear in two sidebands positioned at 26.999 mc. and 27.001 mc. Intelligence appears solely in sidebands and not the steady carrier. Once the carrier has developed sidebands it may be discarded.

In the sideband system, there is a carrier to create sidebands but it is balanced out at an early stage in the transmitter. And since two sidebands contain identical audio information, one may be filtered or phased out. A single sideband is fed to the final amplifier where it enjoys amplification ordinarily distributed among two sidebands and a carrier. Compared to conventional plate modulation, sideband operation is approximately four times more effective.

Fig. 1. General Radiotelephone receiver sideband adapter.



General Radiotelephone's adapter corrects the CB receiver's inability to detect sideband signals. As shown in the schematic (Fig. 1), it is a one-tube (nuvistor) oscillator, crystal-controlled on 452.1 kc. Oscillator energy serves to restore the missing carrier to the incoming sideband signal for detection into audio. As in the case of the transmitter, some carrier is required—only now the process is reversed. The oscillator output mixes with the sideband and the difference frequency is original audio.

The choice of 452.1 kc. for the oscillator is governed by the i.f. strip. In the firm's conventional CB equipment, 452.1 is the nominal center i.f. frequency. There is enough bandpass, however, in most 455-kc. transformers to permit the adapter to operate with other equipment.

Note in the schematic that the oscillator output is taken from the cathode of the tube and transferred to the 3rd i.f. transformer in the receiver. From this point it may mix with the sideband energy in the receiver's second detector. An example shows how audio is produced. Assume that a sideband signal (after conversion from 27 mc. down to i.f. frequency) occurs on 453.1 kc. The adapter injects 452.1 kc. and the difference in the detector is original 1-kc. audio.

Other notable features appear in the adapter schematic. Note the "AM-SB" switch near the top center. This selector reconnects the CB receiver's squelch potentiometer (squelch is ineffective on carrier-less sideband) into the cathode of the input r.f. amplifier. A means of manual r.f. gain control is thereby provided. With the high power gain of sideband, there is considerable risk of an incoming signal producing overload and audio distortion at the detector. Stated another way, the received signal may overmodulate the carrier from the adapter. The operator, however, (*Continued on page 72*)

The field engineer (at the left) is supervising the installation of a heavy but mobile antenna for a ground radar.

ELECTRONICS FIELD ENGINEERS AROUND THE WORLD

By CHARLES J. OLSON
Raytheon Electronic Services Operation

Frequently doing the impossible in installing and in maintaining electronics equipment for military services, government agencies, and industrial organizations, the Raytheon field engineer's role is demanding but exciting.

HAD Richard Harding Davis lived in the era of electronics, he might have written about field engineers instead of the military mercenaries he glamorized in his "Soldiers of Fortune." No tale of derring-do can equal the exploits of a field engineer in action. For more than two decades he has been doing the "impossible" in the most remote and inaccessible places of the world.

When radar made it possible to scan the horizons and immediately identify enemy aircraft, we knew we had a better answer to the menace of enemy attacks without warning. But radar is useless in the laboratories. It has to be installed, checked, and made to work on mountain peaks or on the frozen terrain of the arctic. Field engineers installed these radars and made them work, forming a line of surveillance against enemy attack.

When the atomic bomb was tested at the Nevada proving grounds in 1952, the Atomic Energy Commission informed the radio and television broadcasting networks that they would be permitted to broadcast an "open atomic detonation" in the third week of April. But they had only sixteen days to prepare for it; and it would require the installation of four mountain-to-mountain relays over a distance of 277 miles. Broadcast-station engineers installed the four microwave relays in record time. One of these was carried by helicopter to the top of Mount San Antonio and installed 8500 feet above sea level, beamed to the next relay 140 miles away. All four relays worked beautifully and permitted the public to view on their TV screens an actual atomic explosion.

The phenomenal growth and development of military and commercial aviation brought problems that became extremely critical. Surveys conducted among commercial and military pilots in the United States revealed an alarming increase in near-collisions in mid-air. Responsible aviation officials were aware of this menace and all realized that a more efficient air traffic control was needed.

It was felt that radar might provide a solution—a new kind of radar, more powerful and with improved scope displays and plotting devices—a long-range radar that would follow the flight of planes on the air routes.

It was the job of the field engineer to install such radars. He solved the problems of installation at the most remote and almost inaccessible locations. Installations have already been made at 52 locations in the United States for FAA, as well as at strategic locations from coast to coast for the Canadian Government. Air traffic control systems have even been erected on mountain peaks in the Swiss Alps.

In these installations, as well as installation of weather radar systems, missile tracking radars, and microwave relays for cross-country communications, field engineers had to overcome blizzards, sub-zero cold, and mountains of snow, as well as the opposite extremes of blistering desert heat and the humidity of tropical swamps. They have transported equipment by helicopters, "sno-cat" tractors, bulldozers, and even hand-drawn sleds. Camels in the desert, elephants and ox carts in India, burros in the Andes, dog sleds in the arctic—these are but a few of the means of local transportation used by field engineers throughout the world.

The work of the field engineer, however, is not limited to sophisticated electronic systems and complexes. Much of his time is devoted to a wide variety of other tasks, such as the adjustment of equipment in use, testing of equipment for new applications, supervision and assistance in overhaul and repair at military depots and industrial shops, training and supervision of operating and maintenance crews, and on-the-job training of personnel.

He may risk a limb or his life climbing an ice-covered mast to adjust a radar antenna on a fishing trawler in the dead of winter, or he may cruise along with cargo carriers checking the operation of echo-depth sounders. He may check and adjust a recently installed long-range sonar on a nuclear submarine, or he may test a high-speed bombing and navigation radar on a B-58 "Hustler." He may face unknown hazards in underground caves in field studies covering developments in subterranean communications.

New Uses for Existing Equipment

Perhaps the most intriguing and the most challenging tasks assigned to a field engineer is a new application of an existing electronic unit. When petroleum producing companies in Texas began to use underground caverns for the storage of crude petroleum, they were in need of some quick, yet reliable, method of measuring the capacities of these caves. A field engineer was dispatched to the scene. His assignment was to devise a means to measure the capacity of the cave electronically.

Having had considerable experience with echo-depth sounders for measurement of depths and distances between objects under water, he suspected that echo ranging could be used. He placed an electronic depth recorder on the ground near the opening of one of the caves, then attached a transducer to a shaft, hooking it up to the recorder with a long wire. He lowered the shaft into the cavern, slowly turning it around. The echoes from the cavern walls immediately activated the stylus which traced the measurements on the chart paper. By compensating for the different speed of sound through air as compared with water, he quickly converted the chart readings to measurements of distance in feet from the transducer to the cavern wall. As the shaft was turned the stylus marked the variations of distances from the transducer to the cavern walls, thus tracing the contour of the walls on the chart paper. By raising and lowering the shaft, the stylus markings indicated variations of the contours according to depth from the surface.

After several days of testing and experimentation, he originated a form for recording chart-paper measurements at various levels of the cave and then devised a formula whereby these recordings could be converted into cubic measurements of the cave in terms of gallons. The only modifications required to convert the marine echo-depth sounder into an instrument for measuring the capacity of an underground cave was the design of a special shaft for transducer mounting; essential gear for lowering, raising, and rotating the shaft; and a redesign of the chart paper to show distance measurements based upon the velocity of sound through air.

The City of New York needed a pipe line across the Narrows. This had to be sunk into a deep ditch at the bottom of the channel without disturbing the heavy traffic going in and out of the harbor. The construction company said, "yes." They were specialists in this kind of construction. With an ingenious system of feed rollers and inflated buoys, they were able to connect the pipe on shore, section by section, and feed the connected line into the harbor well below the traffic level, yet well above the bottom of the channel as it was floated on the buoys to the opposite shore. The ditch for the pipe was dredged out a short distance ahead of the end of the pipe line as it was fed into the water.

How does an electronics field engineer get involved in this kind of a construction job? He was called in to solve the problem of feeding this pre-connected pipe line across the channel exactly over the ditch so that it could be lowered into the ditch as soon as it reached the other shore. The use of chart measurements and surveying instruments in this case was too slow, laborious, and subject to error. Could it be done electronically?

The field engineer studied the problem and once again turned to the echo-depth sounder. With a small boat equipped with an electronic depth recorder, he preceded the pipe line as it was fed into the water. From the stylus markings on the chart paper he was able to indicate to the construction crew the exact position of each side of the ditch. It then became a simple matter of lowering the pipe line into its designated resting place at the bottom of the channel.

Requirements and Salary

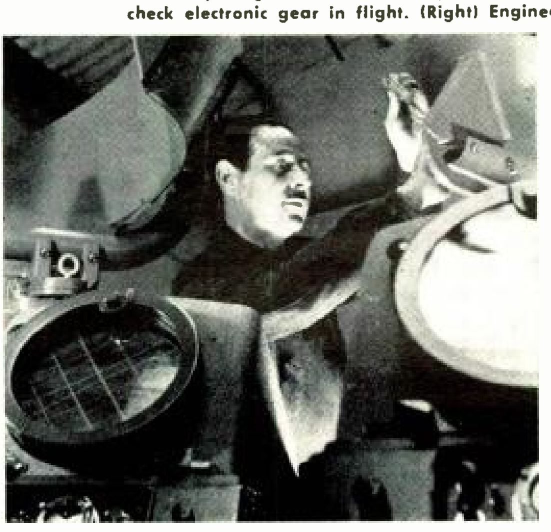
The requirements of a field engineer depend upon the particular assignment. As an engineer in charge of an assignment, he will have to have a Baccalaureate degree in electrical or electronic engineering or its equivalent. In many cases these men have Master's degrees. There *(Continued on page 71)*

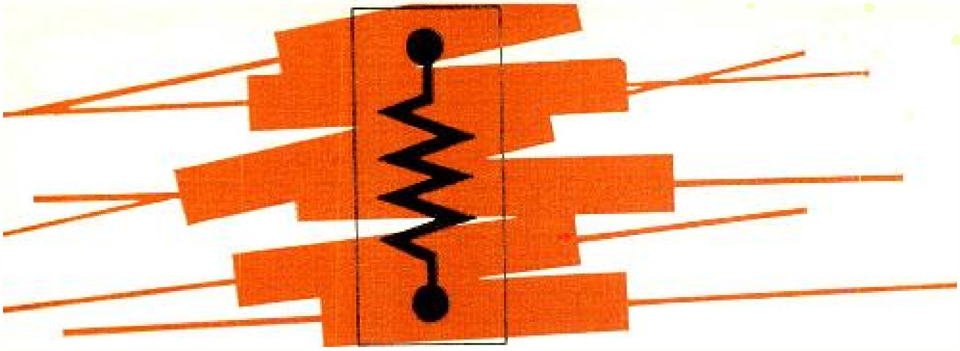
ABOUT THE COMPANY

Raytheon *established its field engineering staff in 1912 for the U.S. military and government services. This was essential since at the time military personnel was not capable of installing, operating, and servicing such complex electronic equipment as radar or other electronic devices. Through the years this engineering group has developed into one of the most comprehensive service organizations in the industry. Embracing the entire field of electronics, it now provides complete world-wide service for all electronic equipment from complex military weaponry to industrial automation and controls.*

These capabilities extend from systems planning, site surveys and maintenance, to engineering and product support, personnel training, technical writing, and special study projects. Raytheon's field engineering is a department of Electronic Services Operation and reports to the management of the company's Equipment Division.

(Left) Adjusting a marine radar to peak performance before installation. (Center) Field engineer boards B-58 to check electronic gear in flight. (Right) Engineers installing a marine radar antenna atop a ship's stub mast.





FIXED RESISTORS

By JOHN R. COLLINS

There is more to a fixed resistor than meets the eye. Here is a discussion of wire, composition, film, and tin-oxide resistors with their characteristics.

RESISTORS make up about 70 percent of the components in most electronic circuits. Although they are comparatively simple devices, it is not surprising to find that much research is directed towards perfecting them. New materials, processes, and configurations are being explored. A large part of the effort is devoted to improving reliability, and this has resulted in rugged units intended for missile and space use (Fig. 1). Emphasis on miniaturization for airborne and portable equipment has led to new vacuum-deposition techniques (Fig. 2). Without question, future electronic circuits will use more of such thin-film networks.

Although some of the latest devices are still used almost entirely for military and industrial apparatus, many are beginning to appear in some consumer products. Technicians, experimenters, and hobbyists now find a wider selection of moderately priced resistors from which to choose. A judicious choice of the right resistor for a critical application—for the first stage of a sensitive amplifier or for an r.f. circuit—can vastly improve circuit performance, while a mistake can prove costly. This is not a simple matter, since there is no *best* resistor, although certain types are better suited for particular circuit applications.

Technicians will find it easier to appreciate the operating characteristics of resistors if they know something about their design and construction. The principal classes are covered here in enough detail to provide a basis for selection.

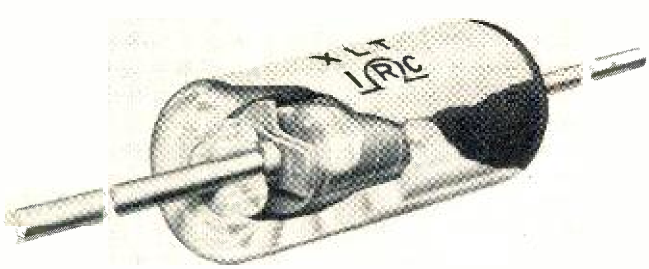
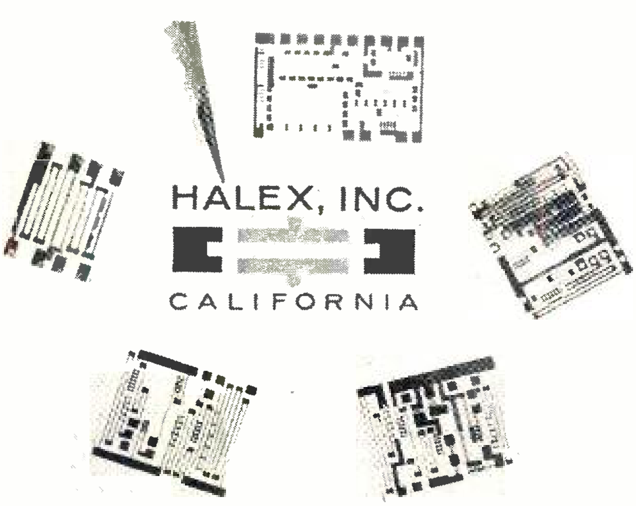


Fig. 1. Cutaway view of a typical glass-sealed precision resistor made by IRC for use in the "Minuteman" guided missile.

Fig. 2. Various types of resistor network combinations can be formed by vacuum deposition of a thin film on a substrate.



Wire Resistors

The earliest types of resistors were made by winding resistance wire on a suitable bobbin and applying some kind of insulating material such as enamel or varnish. Alloys of copper and nickel or nickel and chromium were used and proved generally satisfactory. Failures sometimes occurred because of different coefficients of expansion of the bobbin, the insulating material, and the terminals caused loose or broken wires, all resulting in failure of the component.

Many modern wire resistors use plastic bobbins instead of the rough ceramic forms, and the finished resistors are potted in the same kind of plastic. Then, there is no danger of strain when the wire becomes hot during use.

Resistance wire has also been much improved. The best type previously available had a resistivity of 750 ohms per circular mil foot, but a temperature coefficient of 150 parts per million (ppm) per degree centigrade. A little more than a decade ago, two new alloys were discovered: nickel-chromium-aluminum and nickel-chromium-aluminum-copper. They combine high resistivity with low temperature coefficient. Both are rated at 800 ohms/cmf at 20 ppm/°C.

It is not considered practical to draw wire of the required quality in sizes below ½ mil. This places a practical limit on the amount of resistance that can be obtained with a wire-wound resistor of convenient size. Thin wire is easily stretched in manufacturing if tension is irregular and this produces hot spots that may cause failure in use. If the wire is too loose, there is a great danger that shorted turns will change the over-all value.

Wire resistors intended for a.c. use are usually made with so-called non-inductive windings which are wound on flat forms in such a manner as to cancel out inductive reactance. Despite this precaution, all wire-wound resistors exhibit some reactance and are therefore unsuited for use at frequencies above a few megacycles.

Within a moderate range of resistance values, and for d.c. or low-frequency use, wire resistors are extremely reliable and capable of giving excellent service for extended periods under the most rugged and adverse environmental conditions.

Composition Resistors

The need for high value of resistance, especially in the grid circuits of vacuum tubes, led to the development of composition resistors. They are available in a wide range of values from about 1 ohm to hundreds of megohms. Being inexpensive and quite satisfactory for most uses, they are by far the most popular of all resistors for radio and electronic circuits.

The two basic types are slug and film composition resistors. In each case, the resistive element is a mixture of carbon particles and a resin. The proportions are varied, depending on the desired resistance range. For slug composition resistors, the paste is molded or pressed into a rod or bar to which leads are attached. The unit is then usually encapsulated in a plastic case.

Film composition resistors are made by applying the mixture in a thin film on a glass filament. The mixture is cured by heating, the glass is cut into lengths, and the resistors are finished by attaching leads and encapsulating for protection, as in the case of slug resistors.

Composition resistors are not manufactured to precise values, but are sorted and color coded according to their resistance after manufacture. Like all carbon resistors, composition resistors have a negative temperature characteristic. This means that their resistance decreases with an increase in temperature. Their resistance also decreases with frequency, a phenomenon which is attributed to the shunt capacitance existing between individual carbon particles in the mixture. The effect is greater for high resistance values, but is not as pronounced in film composition types (Fig. 3) since they contain fewer particles. Film types are thus a better choice for high-frequency use.

Instability is another problem with composition resistors. Their resistance can be permanently changed by overheating and is usually somewhat different after soldering into a circuit. In addition, carbon is very susceptible to oxidation and special precautions must be taken to prevent damage from this effect. Oxygen may be produced by electrolysis of any moisture on the surface of the resistive element, in the resin itself, or any other element of the resistor. The effect is greater at higher temperatures and this accounts for many of the failures in resistors of this kind.

A third problem with composition resistors is noise. This is measured by applying a d.c. voltage to the resistor and measuring the a.c. voltage noise that occurs. The net result is specified in microvolts of noise per d.c. volt applied and is abbreviated *microvolts per volt.* Since this ratio is usually high for composition resistors, they are not the best choice for the first stage of an amplifier where noise is the critical and sometimes limiting factor.

Carbon Film Resistors

Some of the problems associated with composition resistors, in particular their instability, can be attributed to the resin used to bind the carbon particles together. To overcome this difficulty, a class of resistors called deposited carbon, or pyrolytic carbon, was developed. They are formed by depositing a thin film of carbon on a ceramic core by burning a hydrocarbon gas such as methane. Where high resistance values are needed, some of the carbon is removed by cutting around the cylinder to leave a helical or spiral path for the current. By cutting a helical path in the cylinder of film, the resistance can be raised 3000 times. They are then hermetically sealed in a metal, glass, or ceramic enclosure that renders them relatively insensitive to ambient moisture.

Carbon film resistors are made to precise values that do not change in ordinary use. In this respect, they may be considered as substitutes for wire-wound resistors. They have the added advantage of being smaller, less expensive, and suitable for use at high frequencies. Their resistance range is also far greater and their temperature characteristic, while not as good as the best wire-wound, far exceeds those of composition resistors.

The greatest problem with carbon film resistors is to provide adequate protection from oxidation. Like all carbon resistors, they are affected by moisture. Special precautions are even more important for resistors of this kind, since a deterioration of the narrow spiral path might cause a catastrophic failure, whereas in a composition type, an equivalent fault might cause only a slight change in resistance. Even when all traces of moisture and humidity are adequately guarded

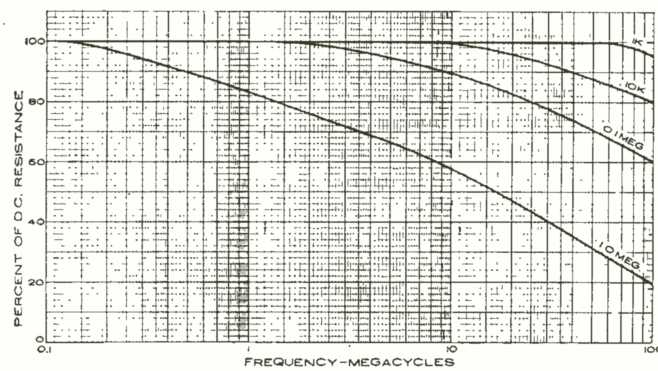


Fig. 3. Curve shows how resistance characteristic of typical carbon composition film resistors decreases with frequency.

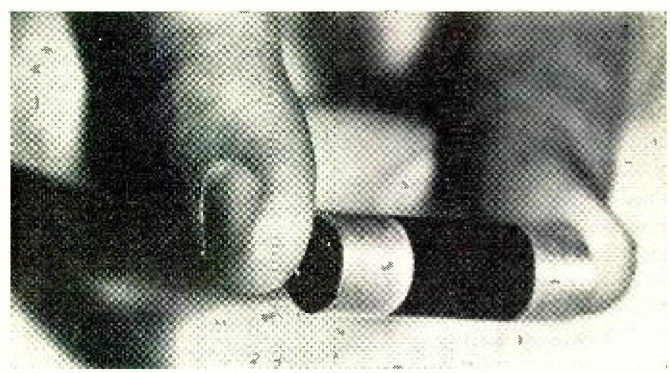
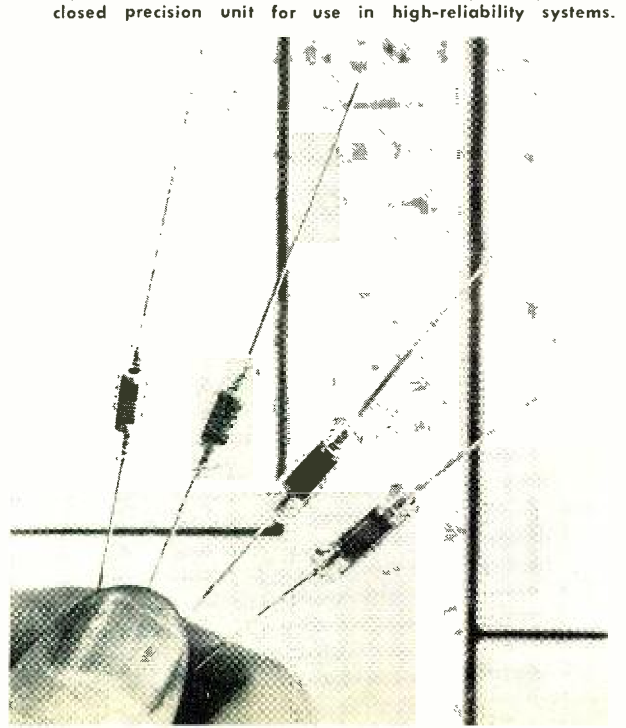


Fig. 4. Type H resistors, made by Corning Electronics Components Div., have low inductance at high frequencies. The H-31 shown above is rated at 5 watts d.c. or 7 watts a.c. in horizontal operation. Resistors are for use as circuit loaders.

Fig. 5. The NF-style resistor, made by Corning, is a glass enclosed precision unit for use in high-reliability systems.



against, a carbon film resistor may still fail because of migration of oxygen from the ceramic base material.

Metal Film Resistors

Probably most research today is directed towards the development of metal-film resistors. They have all the advantages of carbon-film resistors plus greater stability. They can be used under the most adverse environmental conditions and can be produced with practically zero temperature coefficient. These factors have made them especially favored for miniature power units, computers, missiles, aircraft instruments, and other circuits where reliability and weight are important.

Different results may be obtained by varying the kind of metal, the thickness of the film and the resistor geometry. One method of construction is illustrated in Fig. 1. This resistor, used in the "Minuteman" missile, is made by coating the ends of a ceramic core with a gold resinate that is fired to leave pure, metallic gold as the low-resistance terminal.

The core is then placed in an evacuated chamber and the resistance material—in this case a chromium alloy—is heated until it is caused to boil or evaporate. The vapor thus formed will deposit at a fairly rapid rate on nearby surfaces and will condense to form a thin, continuous film. Some manufacturers use a chemical process to produce thin films but, in either case, the films may vary from 20 to 25,000 angstroms thick.

The next step is to cut the film in a spiral to obtain the desired resistance value. Caps and leads are then attached and the unit sealed in glass for protection from air and moisture, since most metals are subject to oxidation.

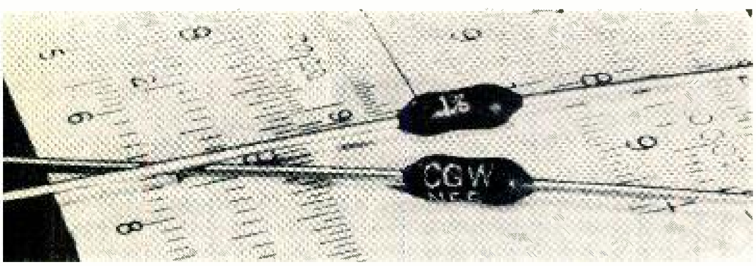


Fig. 6. The N-55 tenth-watt resistor is a metal oxide precision film unit, made by Corning, having weldable Dumet leads.

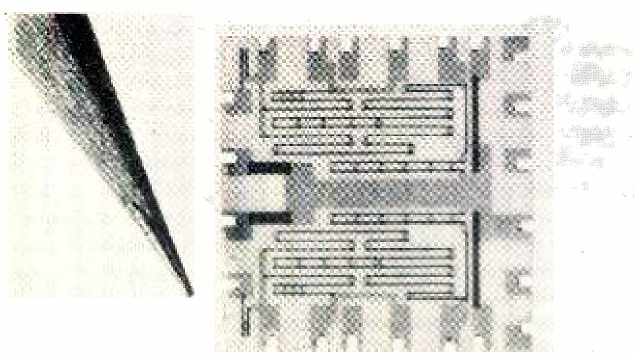
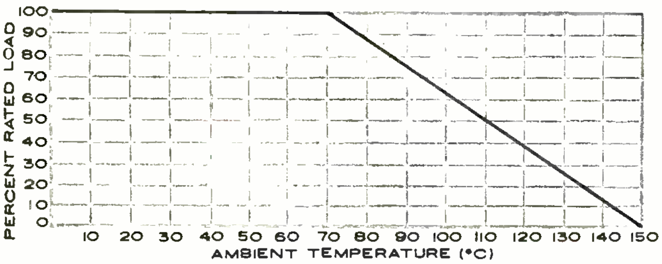


Fig. 7. A power amplifier can be made by depositing both active and passive components on a thin alumina substrate.

Fig. 8. A typical power derating curve shows that the allowable dissipation of a resistor decreases with temperature.



Thin-film resistors have a number of interesting properties that have spurred research. For example, thin metallic films exhibit electrical properties quite different from those of the bulk metal. Electrical resistance is usually much greater than would be predicted on the basis of the known specific resistance of the bulk metal. The resistivity of a thin film appears to be influenced not only by thickness and atomic mobility, but also by other factors such as zone structure and possibly traces of impurities difficult to control.

Bulk metals characteristically have a positive temperature coefficient. Thin metallic films however, may have either a positive, negative, or a zero temperature coefficient. Over a considerable range of resistance values it is possible to obtain thin-film resistors with temperature coefficients from +200 to −200 ppm/°C, and the desired value can be specified to within about 15 ppm/°C. The fact that temperature-resistance characteristic can be selected in this manner permits use of metallic film resistors to compensate for changes in capacitance in resonant or timing circuits.

Thin-film resistors are made with noise levels less than 0.1 microvolt per volt, even for high-resistance values. They are also excellent at high temperatures and some types can be used even at temperature extremes of 225° C.

Tin-Oxide Resistors

A special class of film resistors that resemble metal types in many respects are the tin-oxide resistors shown in Figs. 4, 5, and 6. They are made by passing continuous rods of optical grade glass at red heat temperature through a chamber containing fumes of stannous chloride. Oxidation of these fumes on the glass surface produces an oxide film that is molecularly bonded to the glass.

The hardness of the resulting oxide skin is superior to that of the glass base and is therefore extremely resistant to abrasion or scratching. The glass rod is a special formulation designed to exactly match the expansion characteristic of the tin-oxide film. The desired ohmic value is obtained by helixing in the usual manner.

Tin oxide is chemically stable and is not affected by the atmosphere or moisture. Coatings are placed on such resistors primarily to prevent electrical shorts rather than to protect them from the elements. Because of the inert nature of tin oxide, resistors of this kind can be used as dummy loads for transmitters with direct water cooling (Fig. 4).

The best types of tin-oxide resistors are used in advanced types of industrial and military equipment, including missiles (Fig. 5). Low-cost units are also available and are finding increasing use in the entertainment field as replacements for wire-wound power resistors and for high-frequency amplifier circuits where noise is critical (Fig. 6).

Tin-oxide resistors are made for a range of values from a few ohms to several megohms with power ratings from ⅛ watt to 6000 watts and can be used up to 225°C.

Planar Resistors

In modern electronics, resistive films are often applied to flat surfaces as shown in Fig. 2. In such cases, the resistance is usually expressed in ohms per square. Further designation is unnecessary since resistance per square centimeter is the same as resistance per square inch.

Halex, Inc. produces resistive films of nickel and chromium ranging from a few ohms per square to 500 ohms per square. For special purposes, they make films with resistivity to 4000 ohms per square, but these are extremely thin and are difficult to manufacture. The films are sealed with silicon oxide while they are still in the vacuum chamber and are therefore resistant to contamination or various types of atmospheric corrosion.

Resistors made in this way show little change with long exposure to high ambient temperatures. They are also able to withstand electrical (*Continued on page* 93)

LOW-PASS AUDIO FILTERS FOR INCREASED "TALK-POWER"

Test setup showing use of audio generator and v.t.v.m. to measure the operating characteristics of the author's filter.

Construction of a simple, low-cost device that will improve the performance of amateur phone transmitters.

By RICHARD A. GENAILLE

ONE of the keys to an outstanding AM radiotelephone signal for voice communications is the concentration of usable audio power in the transmitted sidebands. One occasionally hears a phone signal which, while its carrier indication on the receiver "S" meter is nothing spectacular, has a definite punch that makes for ease of copying even under severe interference conditions. This noticeable punch is audio punch or "talk-power" and is the result of this concentration of audio in the sidebands. If you haven't been complimented regularly by the various stations with which you communicate as to your signal's punch, it may be time for you to think about some of the improvements you might make to your transmitter audio system so as to rate some bouquets.

One such improvement that can be made without a great deal of effort or expense is the addition of a low-pass filter to eliminate the audio frequencies which contribute little or nothing to your transmitter's "talk-power."

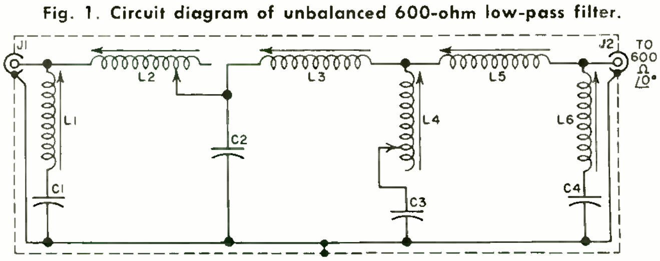
It is not within the scope of this article to discuss filters and filter theory since entire texts have been devoted to the subject. This article will, however, present certain basic facts concerning the use of filters in the audio portion of a ham transmitter and will describe the construction and application of an effective low-pass audio filter. The filter can be constructed from readily available components and will do an excellent job of eliminating undesirable frequencies from the audio portion of your transmitter. A simple method of adjusting the capacitance and inductance values to those required for correct filter operation will also be covered.

Speech Frequencies

Normal speech makes use of a wide band of audio frequencies; however, most of the *intelligibility* lies in the range from about 500 to 2500 cps with the greatest portion of speech *power* concentrated below 500 cps. By taking advantage of these speech characteristics one can obtain a surprising increase in the effectiveness of a radiotelephone transmitter. Since the frequencies below 500 cps modulate the transmitter most heavily, one must adjust the various transmitter audio-section controls so that overmodulation cannot occur when these low frequencies pass through the audio system. Such adjustment will make it necessary for the frequencies of greatest voice intelligibility to modulate the transmitter at some percentage below the ideal 100%. By eliminating frequencies below 500 cps, the amplitude of the frequencies above 500 cps may be raised considerably, resulting in a corresponding increase in transmitter effectiveness.

Reducing the low-frequency response of the transmitter audio system may be accomplished by using small values of coupling capacitors between resistance-coupled stages, preferably in the speech-amplifier circuit. If speech clipping is used in the transmitter it is considered good practice to cut low-frequency response before speech clipping or, if clipping is not used, to cut the response in the preamplifier stage. When speech clipping is used in the low-level audio stages of the modulation equipment, a low-pass filter must be used after

Fig. 1. Circuit diagram of unbalanced 600-ohm low-pass filter.



C1, C2, C3, C4—Mylar paper tubular capacitor, 600 v. ± 10%. (See Table 1 and text for values.)
J1, J2—Phono jack
L1, L3, L5, L6—15-60 mhy. horizontal linearity coil (J. W. Miller #6319. See Table 1 and text for adjustment data.)
L2, L4—60-130 mhy. horizontal linearity coil (J. W. Miller #6324. See Table 1 and text for adjustment data.)
1—12" x 2½" x 2¼" aluminum enclosure.

the clipping circuit to filter out the high-order harmonics generated by clipping action. These harmonics, which are the same as those generated by overmodulation, cause "splatter." As most operators realize, "splatter" is a highly undesirable and illegal transmitter output. Without speech clipping, the transmission of unwanted and practically useless higher audio frequencies results in a radiotelephone signal of excessive bandwidth. The use of a low-pass audio filter in this case helps to reduce the bandwidth occupied by the phone signal by eliminating the less desirable higher voice frequencies.

Filter-Network Design

Filters are essentially networks of capacitance and inductance arranged to provide attenuation bands or transmission bands as needed. The filter required for the purposes described previously should have relatively little attenuation below 2500 cps but high attenuation for all frequencies above 3000 cps. This low-pass filter would then have a transmission band extending from zero frequency to the frequency of cut off (2500 cps) and an attenuation band from the cut-off frequency to infinite frequency.

The low-pass filter to be described, and diagrammed in Fig. 1, is an unbalanced filter designed to operate between 600-ohm resistances and in the voice-frequency range. The filter passes all frequencies below 2000 cps with a maximum insertion loss of approximately 5 db. Frequencies above 2500 cps are attenuated by a minimum of over 20 db. as shown on the attenuation curve of Fig. 2.

The design characteristics are based on a cut-off frequency of 2500 cps and a frequency of infinite attenuation of 2600 cps. Table 1 provides information for the construction of low-pass filters with a cut-off frequency of either 2500 cps or 3000 cps, depending on the ultimate transmitter bandwidth desired.

Before describing the actual construction of the low-pass filter, a word may be in order concerning insertion loss.

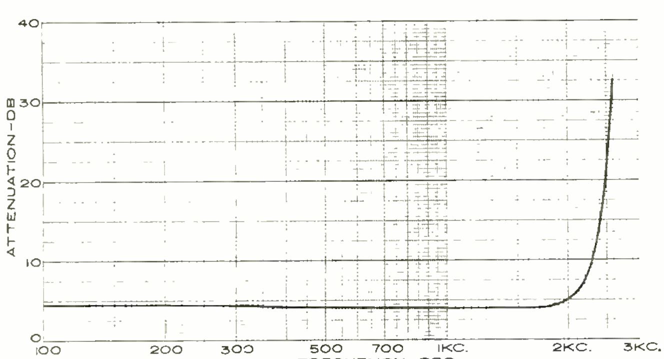


Fig. 2. Frequencies above 2500 cps are attenuated over 20 db.

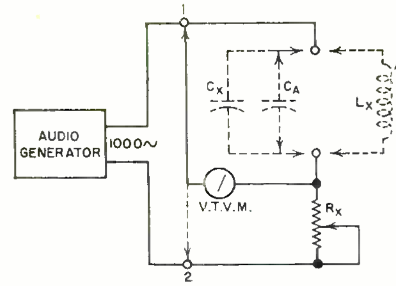


Fig. 3. Test circuit for adjustment of the L and C values.

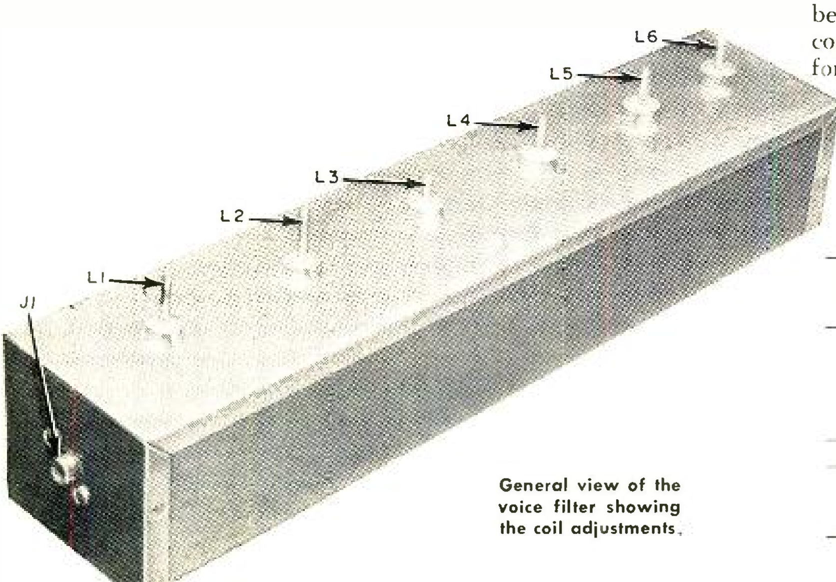
This loss is a substantially uniform attenuation provided to frequencies within the filter transmission band. Insertion loss varies with the kind of filter, the "Q" of the capacitors and inductor used, and the type of termination employed. In most cases the insertion loss may be considered as negligible.

Other than the adjustment of the capacitors and inductors, the construction of the low-pass audio filter is quite straightforward. The components are mounted in a standard 12" x 2¼" x 2¼" aluminum "Minibox," as shown in the photos. Single phono jacks are used for the input and output connections. The various coils for the filter may be mounted in their respective positions and adjusted prior to wiring. In order to provide for additional clearance between the coil forms and the filter case and to standardize the hole dimensions for coil mounting, the author made use of the 7/16" adapters and mounting clips for those coils normally arranged for 5/16" mounting holes. After the 7/16" phenolic adapters are positioned on the coil forms, the ¼" or so of excess phenolic coil form should be carefully trimmed off with a sharp hacksaw blade. The adapters and mounting clips are provided with the coils when purchased.

Component Adjustment

As is usually the case in the design of filter circuitry, the values of capacitance and inductance determined by formula never seem to come out such that standard fixed values of components may be used. It is necessary, therefore, to have some means of adjusting the capacitance and inductance values to those determined by formula, and shown in Table 1, in order to insure desired filter circuit performance.

If you have access to sophisticated laboratory equipment, the job is a snap. Adjustment of the coils and capacitors to the values required may be accomplished quite satisfactorily by using a sine-wave audio signal generator and vacuum-tube voltmeter in the simple test circuit diagrammed in Fig. 3. In this test circuit a source of audio voltage is connected across a simple voltage divider made up of a suitable variable resistance and the capacitor or inductor to be adjusted. The resistance value of the voltage-divider potentiometer should be slightly higher than reactance values, at 1000 cps, of the component to be adjusted. A suitable value of potentiometer for use in the adjustment of the inductors for either the



General view of the voice filter showing the coil adjustments.

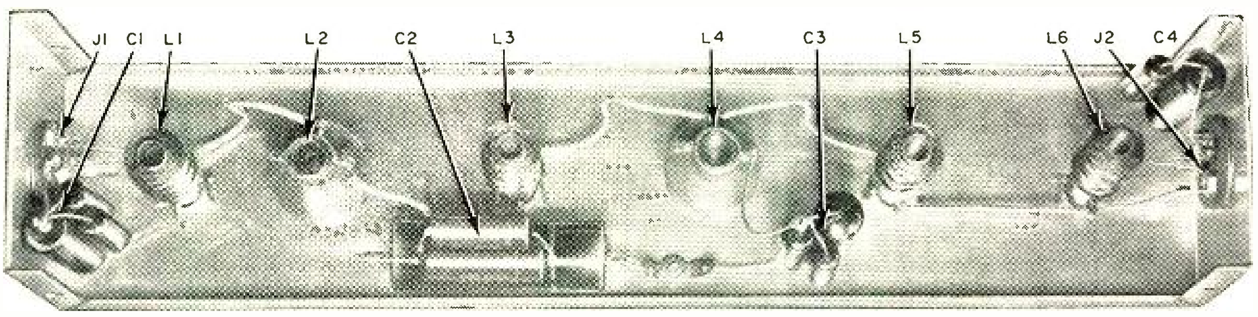
Table 1. Capacitance and inductance values required for two typical low-pass audio filters with cutoffs at 2500, 3000 cps.

Circuit Designation	Cut-off frequency: 2500 cps, Infinite attenuation @ 2600 cps — Inductance	Reactance @ 1000 cps (ohms)	Cut-off frequency: 3000 cps, Infinite attenuation @ 3100 cps — Inductance	Reactance @ 1000 cps (ohms)
L1, L6	40.8 mhy.	256	33.9 mhy.	213
L2	61.1 mhy.	384	50.9 mhy.	320
L3	48.7 mhy.	306	39.8 mhy.	250
L4	63.9 mhy.	401	59.2 mhy.	372
L5	33.4 mhy.	210	27.1 mhy.	170
	Capacitance		Capacitance	
C1, C4	.064 μf.	2504	.053 μf.	3004
C2	.212 μf.	751	.177 μf.	907
C3	.059 μf.	2722	.045 μf.	3571

2500- or 3000-cps cut-off frequency filter would be 500 ohms. A value of 4000 ohms would be satisfactory when adjusting capacitors having high reactance and 1000 ohms for the lower reactance values. The closer the over-all potentiometer resistance is to the component reactance value to be measured the less critical will be the potentiometer adjustment in the following test procedure.

To adjust the coils to their proper values, consult Table 1 for the reactance at 1000 cps for the particular coil to be adjusted. Assuming that coil $L1$ is to be adjusted to 40.8 mhy. for the 2500-cps filter, we would select a coil having this value of inductance within its range and connect it in the test circuit as coil L_X. If the coils have been mounted, use clip leads to connect the correct coil to the test circuit. The chart indicates that a 40.8-mhy. coil should have a reactance of about 256 ohms at 1000 cycles. Prior to application of the 1000-cps signal to the test circuit, adjust the voltage divider potentiometer to a value of 256 ohms or as close to this value as possible.

With the vacuum-tube voltmeter connected to test point #1 (across the coil being tested) and the audio signal generator set at 1000 cps, advance the output level control on the generator until approximately a half-scale reading is obtained on one of the lower a.c. voltage ranges. Use only sufficient audio-generator output in the test circuit to obtain a satisfactory reading on the v.t.v.m. The voltage reading across the coil should be noted and the test clip lead switched



Under-chassis view of filter showing parts placement. Required capacities are obtained by use of several paralleled capacitors.

to test point #2 (across the voltage-divider pot). If the voltage reading across the divider pot is not the same amplitude as the reading across the coil, adjust the coil slug a small amount at a time while checking the voltage back and forth across the coil and potentiometer until a slug adjustment is reached where the voltage readings obtained are equal.

At this point, the reactance of the coil at 1000 cps is approximately equal to the resistance setting of the potentiometer, or 256 ohms. The inductance of the coil, in turn, should be very close to 40.8 mhy. The coil can now be disconnected from the test circuit and installed in its correct position in the cabinet if it is not already mounted.

The inductance values for coils $L2$ and $L4$ in the 2500-cps filter are so close to the lowest extreme of the tuning range of the *Miller* #6324 coil that, in the author's case, it was impossible to actually tune these coils to the 61.1- and 63.9-mhy. values required. Apparently the minimum inductance of these coils is somewhat higher than 60 mhy. This situation coupled with the fact that, for the 3000-cps filter, the values of $L2$ and $L4$ are 50.9 mhy. and 59.2 mhy. respectively, resulted in the use of the tap provided on the #6324 coils. The largest section of these coils, which is the portion between the inner coil end (end closest to the coil form) and the tap, was used. Coil #6330, also manufactured by *J. W. Miller*, is slightly higher in cost and not as readily available, but may be used in positions $L2$ and $L4$ if desired. This coil is untapped but has a range of from 45 to 215 mhy.

The procedure just described for adjustment of the coils may be followed in adjusting the capacitance to the values indicated in Table 1 for the filter being constructed. In this case, since there is no variable adjustment of the capacitors, a basic capacitor value must be selected and, in place of making slug adjustments, small values of capacitance added across the basic capacitor (C_X) until equal voltage readings are obtained across capacitors C_A and C_X in parallel and the voltage divider potentiometer. Table 1 should be consulted for the correct potentiometer resistance setting for each circuit component checked. As an example of the way in which the total capacitance might be made up to obtain a particular reactance, capacitor $C2$ in the author's 2500-cps filter was obtained by paralleling .2-μf., .01-μf., and .0025-μf. capacitors. The test procedure described should be followed for adjusting each of the coils and capacitors to their respective values. It may be helpful to know that the values of the components can vary ±5% without severe reduction in filter performance.

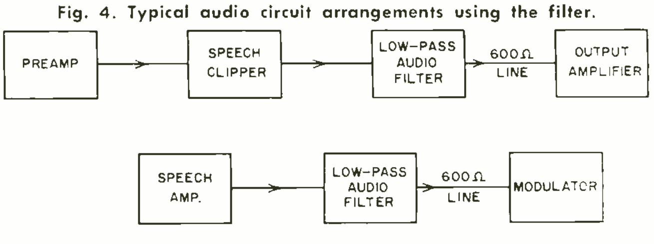
Wiring the filter is a simple job and may be accomplished in a very little time. If you wish you may check out the filter prior to installation by determining its attenuation curve. This can be done by feeding signal from the audio signal generator to the input side of the filter while the output side is connected to a 600-ohm termination. Audio voltage at various frequencies from approximately 200 to 3200 cps should be fed to the filter and for each discrete frequency setting of the generator measure the voltage at the input terminal and at the output terminal. For convenience, the v.t.v.m. db scale should be used. The difference between input and output readings can be plotted for each frequency and a curve obtained which should closely approximate the attenuation curve which is illustrated in Fig. 2.

Installation

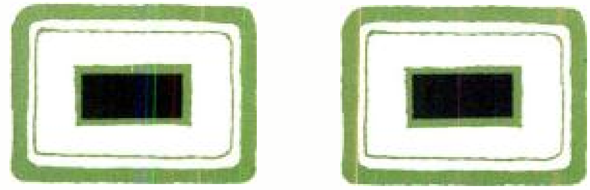
When the filter has been adjusted properly and is performing as expected, it may be installed in a suitable location, as shown in Fig. 4, bearing in mind that the filter is designed to work between 600-ohm resistive impedances. In practically all cases, the impedance in which the filter will terminate will have little or no reactive component and may, therefore, be considered as a pure resistance. If desired, one can arrange to install the filter as an integral part of the transmitter audio section with appropriate switching circuitry to cut the filter in or out of the audio system for "on-the-air" comparisons.

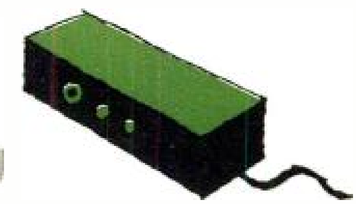
With the low-pass filter inserted into your phone transmitter as shown, you should soon be receiving compliments on the greater "punch" of your signals. ▲

Fig. 4. Typical audio circuit arrangements using the filter.



TAPE-SLIDE SYNCHRONIZER





Construction of a device using silicon controlled switch that automatically advances slide projector when it is triggered by a signal pre-recorded on taped commentary.

By CARL DAVID TODD / Head of Engineering, Modular Circuits Dept., Electronic Products Div., Hughes Aircraft Company

A TAPE-slide synchronizer is a very useful device which is employed to control a semi-automatic 35-mm. slide projector by means of a pre-recorded signal from a tape recorder. Also recorded on the same tape is the spoken commentary or description of the slides being viewed. Hence, a complete slide-film showing or presentation can be made with each slide being changed at exactly the right time in step with the recorded comments.

There are many cases where such a device would be useful. For example, have you noticed that the first time you show your friends a series of slides taken on your vacation, your spoken commentary is interesting and enthusiastic? However, after a number of showings, you begin to forget some of the details and lose a little interest. If you had recorded your commentary on tape in the first place and if the recording included a special signal that automatically advanced the slide-film projector at the right times, then the showing would be more professional and of greater interest.

The tape-slide synchronizer can also be useful in business or technical presentations involving a number of slides and a spoken commentary. Sometimes in such cases the person most qualified to deliver the talk or lecture might not be available at the time of the actual showing. By making a pre recorded talk on tape along with slide-changing trigger signals, the presentation can be made much more effective.

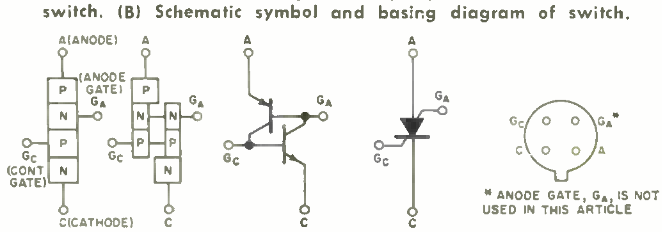


Fig. 1. (A) Transistor analog of the "p-n-p-n" silicon controlled switch. (B) Schematic symbol and basing diagram of switch.

Hence there are several cases in which it is desirable to have good synchronization between the slides and the tape-recorded narration. The tape-slide synchronizer to be described in this article performs this function in a very efficient manner, yet economically and simply. It may be added to any type of semi-automatic projector which has the provision for the use of a remote-control cable.

"P-N-P-N" Silicon Controlled Switch

Perhaps a few words should be said concerning the silicon controlled switch which is the heart of the triggering circuit of this unit. It is a four-layer *p-n-p-n* device with all four layers accessible by means of external leads. The device is essentially an *n-p-n* diffused-base transistor with a third junction added to form the *p-n-p-n* switch. The silicon controlled switch is considered to be equivalent to an *n-p-n* and a *p-n-p* transistor interconnected in a positive-feedback configuration. This is shown in Fig. 1.

The silicon controlled switch is actually just a miniature version of the silicon controlled rectifier and may be used in many of the same types of circuits. It is useful in such applications as triggering from a low-level signal or even when a moderate amount of trigger power is available as described in this article. It will be noted that, as compared to the three electrodes found on the normal silicon controlled rectifier, there are four electrodes in the silicon controlled switch, the other element being an additional gate. Since this gate is not used in the circuits to be described, its function will not be discussed here. The reader is referred to the *General Electric* "Transistor Manual" (6th Edition, 1962, Chap. 19) for further information pertaining to this particular type of interesting semiconductor device.

Basic Trigger Circuit

Fig. 2 illustrates the tape-slide synchronizer in its simplest form. It utilizes the 117-volt a.c. line as its supply source.

Relay *RL*1, which is used to advance the projector by providing switching action across the normal control terminals, is driven by the silicon controlled switch, *Q*1. With no signal applied to the input *J*1, the silicon controlled switch will be basically an open circuit in both the forward and reverse directions of the voltage, as developed across *R*4.

When a signal is present at *J*1 (as derived from the recorder speaker output), we have both a positive and a negative voltage alternately applied to the gate of *Q*1. When a positive voltage appears at the gate of *Q*1 at the same time as the anode is made positive with respect to the cathode, *Q*1 will fire. The resulting current will charge up capacitor *C*2 and close *RL*1. *C*2 retains a partial charge so as to keep *RL*1 closed on the half cycles in which *Q*1 is not conducting. For those half cycles when the anode is negatively biased with respect to the cathode, no current will flow irrespective of the voltage at the gate electrode. The purpose of *C*1 is to remove transients which might trigger the silicon controlled switch prematurely.

Note that resistors are used in each side of the line. *R*5 and *R*6 could be combined into a single resistor. However, it is better to use two equal resistors as shown in order that the maximum voltage appearing between any point in the circuit beyond the resistors and earth ground is little more than one-half of the line voltage. This is of particular importance since the miniature transformer *T*1 must isolate the circuit from the line in order to prevent undue amounts of hum and to prevent a potential shock hazard.

As a tone signal is applied to *J*1 from the tape-recorder output, we can cause *RL*1 to close. This will, in turn, cause the projector to advance. It is important that the tone be sustained for a long enough time to energize the relay and initiate the projector's advance mechanism. For most semi-automatic projectors, it is not necessary that the control signal be applied for the entire cycle time.

Normally, this synchronizer is used with a stereo tape recorder. Vocal narration is on one track while a control signal is recorded on the other track. It can also be used with a mono recorder as described later. With the stereo recorder, it will not be desirable to have the speaker on the control channel operating at the same time we are showing the slides. Under these conditions, plug in or connect a cable from *J*1 to the normal external speaker connection at the recorder, automatically disconnecting the internal speaker. Resistor *R*1 is then employed as a load in order to produce proper triggering action.

Using Power From the Projector

The circuit of Fig. 3 is representative of the input control system in many semi-automatic projectors. With such a circuit, it is possible to derive the power for operation of the tape-synchronizer directly from the projector with no additional connections to the 117-volt a.c. line. Note that when no switches are closed across the control line, *i.e.*, when the projector is at rest, then there is a voltage drop appearing across the two control terminals. The motor is in series with the 117-volt line. If current to be drawn is much smaller than the normal running motor current, then practically the entire 117 volts are available at the remote-control input terminals.

Fig. 4 illustrates an arrangement which utilizes this voltage to power the entire circuit. During the rest portions of the cycle, capacitor *C*2 is charged up to approximately the peak voltage appearing across resistor *R*4. With no gate signal applied to *Q*1, the silicon controlled switch will remain open-circuited and no current will flow through *RL*1. Now when the control signal is applied and the gate of *Q*1 becomes positively biased, *Q*1 will fire much like a thyratron. Since the anode voltage applied to *Q*1 is now d.c., because of rectifier diode *SR*1, a locking action will occur. It will not be necessary to repeat or continue the firing signal from the recorder each half-cycle of applied a.c. as in the previous circuit. *RL*1 will thus be held closed for a period of time determined by the *RC* time constant of *C*2 and the d.c. resistance of the relay.

When *RL*1 closes, the a.c. supply source for the circuit is removed. As *C*2 is now partially discharged, *RL*1 will open. However, there may be enough current still flowing through *Q*1 to cause the relay to remain locked for a brief time. But S3 in the projector (see Fig. 3) will normally have closed and remain closed for the remaining cycle time of the projector. Hence, *C*2 will have ample time to discharge so that *Q*1 will stop conducting and reset.

The circuit of Fig. 4 requires an additional diode (*SR*1) and the silicon controlled switch is no longer used as its own rectifier. But we do gain several advantages by using this

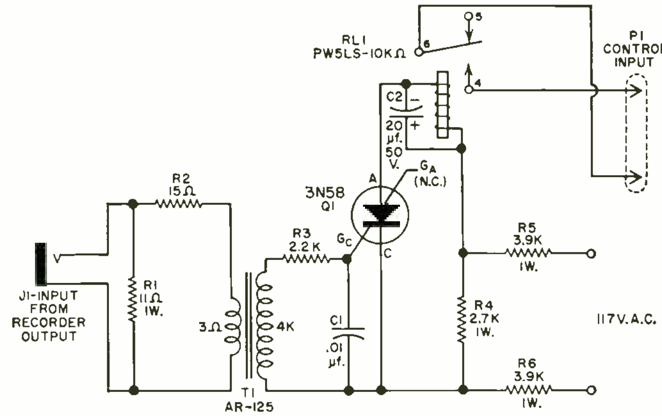


Fig. 2. The simplest form of the tape-slide synchronizer.

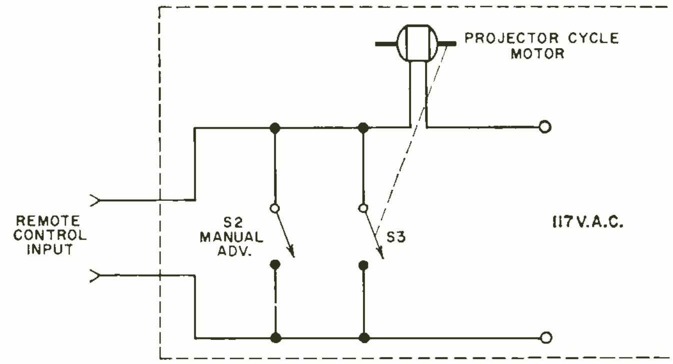
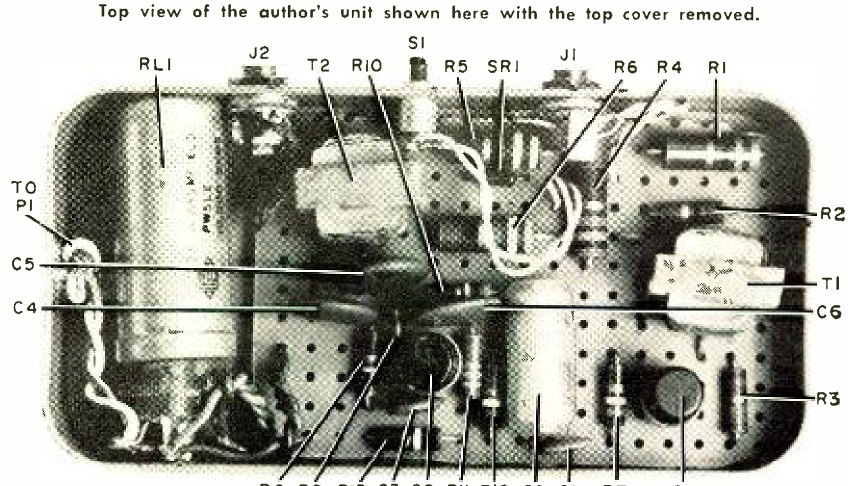


Fig. 3. Projector control circuit as used in many units.

Top view of the author's unit shown here with the top cover removed.



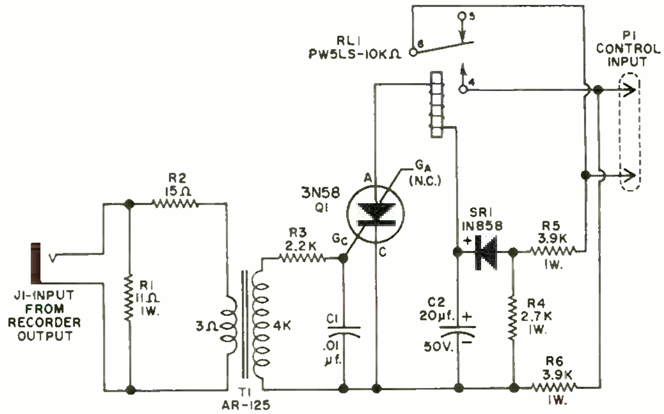


Fig. 4. Arrangement for using power from the slide projector.

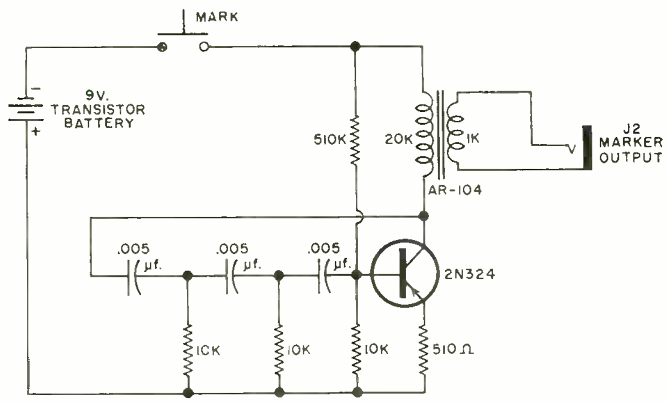


Fig. 5. Simple audio oscillator used to trigger synchronizer.

type of circuit over the one previously described. First, it is only necessary to connect one cable to the projector and one cable to the tape recorder. The synchronizer does not have to be plugged into the a.c. line. Also, the control burst length is no longer critical. Once the circuit is triggered, *RL1* will be automatically held for an adequate time to start the action of the slide projector.

Control Signals

With either of the circuits of Fig. 3 or Fig. 4 it is necessary to have some form of tone burst or marker control signal for the desired length of time and occurring at the exact time that the slide projector is to be advanced. Usually a short, high-pitched beep tone will be used although the frequency is by no means critical.

A tone may be recorded onto the control channel of the tape by whistling into the microphone for that particular channel. Usually a sustained whistle will be quite adequate or we could use a separate oscillator circuit as shown in Fig. 5. When we momentarily depress the button, a tone signal is generated that can be recorded on the tape. Later this signal will cause the slide to be changed.

It is possible to combine the tape-slide synchronizer trigger unit with the oscillator to be used in programming the narrated tapes. A convenient means of doing this is shown in Fig. 6. Here we have both the triggering circuit and a very convenient beep oscillator which derives its power from the same circuit as the relay. When relay *RL1* is closed then a voltage will be applied to the beep oscillator. This oscillator is designed to have a very low current drain yet produce an adequate signal at the output of transformer *T2*.

Note also that a switch S1 has been added so that we may manually advance the slide during the recording of the narration. If this method of slide advance is used during the recording session, then a beep tone will be automatically recorded onto the control channel tape track. The output available from *J2* is adequate to drive a high-level auxiliary input of the tape recorder. Should it be more desirable to use a microphone or other low-level input, it will be necessary to utilize an attenuator at the output of *T2*.

Construction Details

Construction of the synchronizer is straightforward and very simple. There is no really critical layout problem although it is advisable for the gate circuitry of *Q1* to be somewhat removed from the 117-volt a.c. line inputs and the control input going to the projector.

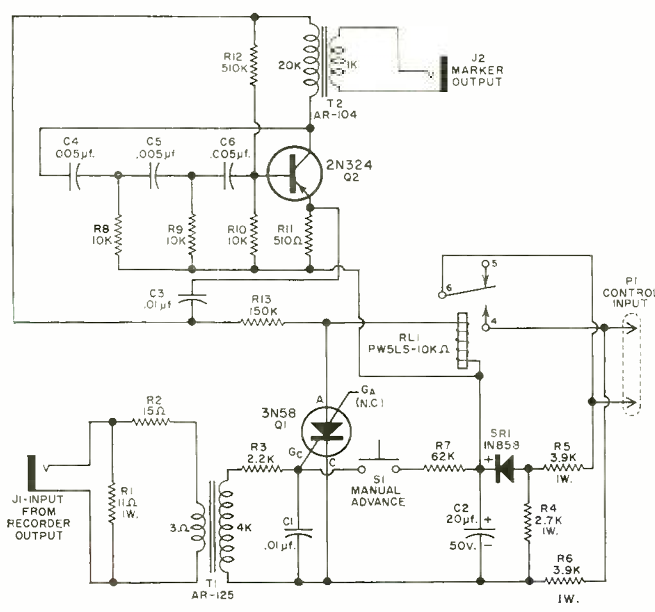
The package size and exact component configuration will be somewhat dependent upon what parts are actually used. As you will note, several alternates are suggested for some of the components. To achieve the small size and compactness of the author's unit requires components which are somewhat more expensive than most. The author had no difficulty in getting the complete circuit of Fig. 6 into a small plastic case 4½" x 2¼" x ⅞". A metal case may be used but special care must be taken to insure that none of the internal connections of the circuit, other than the low-side connections to *J1* and *J2*, touch the case. A shock hazard and severe grounding problems could result if this precaution is not taken.

You may include the entire synchronizer inside your projector. If this is elected to be done, then the spot chosen should be the coolest one possible.

Operation

One channel of the stereo tape recorder is adjusted in a normal manner with the microphone input to receive the vocal narration of the slides. The input to the other channel of the tape recorder is connected (*Continued on page 94*)

Fig. 6. Complete circuit diagram including marker oscillator.



R1—11 ohm, 1 w. res. ±5%
R2—15 ohm, ½ w. res. ±5%
R3—2200 ohm, ½ w. res. ±5%
R4—2700 ohm, 1 w. res. ±5%
R5,R6—3900 ohm, 1 w. res. ±5%
R7—62,000 ohm, 1 w. res. ±5%
R8,R9,R10—10,000 ohm, ½ w. res. ±5%
R11—510 ohm, ½ w. res. ±5%
R12—510,000 ohm, ½ w. res. ±5%
R13—150,000 ohm, ½ w. res. ±5%
Note: All resistors may be ±10% if desired and may be next nearest value.
C1,C3—.01 μf. ceramic capacitor
C2—20 μf., 50 v. elec. capacitor (Sprague TE-1305. Ordinary electrolytic may be used if size is not important)
C4,C5,C6—.005 μf. ceramic capacitor
S1—Miniature normally open push-button switch, momentary contact
P1—Plug to match control input on slide projector
J1,J2—Miniature phone jack
RL1—10,000 ohm relay (Potter & Brumfield PW5LS or equiv. Can use less expensive non-hermetically sealed plate relay, such as LM5-10,000)
SR1—Silicon diode, 100 p.i.v., 150 ma. (1N858 or equiv.)
T1—Input trans. 3 ohms: 4000 ohms (Argonne AR-125, Lafayette Radio. Can use speaker output trans. in reverse.)
T2—Driver trans. 20,000 ohms:1000 ohms (Argonne AR-104, Lafayette Radio, or any high-impedance trans.)
Q1—3N58 silicon controlled switch (G-E)
Q2—2N324 "p-n-p" audio transistor. (Any general-purpose audio type can be used.)

FREQUENCY MULTIPLICATION & DIVISION

By LOUIS E. FRENZEL, Jr. / McCollum Laboratories, Inc.

Techniques and circuits commonly found in such diverse units as frequency standards, counters, digital clocks, multiplex adapters, transmitters, and electronic organs.

ELECTRONICS technicians come into contact with a wide variety of electronic circuits; among them circuits which multiply and divide frequency. These circuits are used to obtain frequencies higher or lower than what is available from a single signal source and to produce synchronized wavetrains of harmonically related frequencies.

Frequency multipliers and dividers are used in many different types of electronic equipment. They are to be found in radio and TV transmitters, frequency standards, electronic organs, electronic counters, and in clocks for digital equipment. Of course, these are only a few examples. The versatility of these circuits makes them useful in many applications. Thus a survey of the most commonly used multiplier and divider circuits should be both helpful and interesting.

Frequency Multipliers

Frequency multipliers are most often found in radio transmitters. They are used to multiply the frequency of an oscillator to obtain a desired higher frequency. For example, a transmitter may use a frequency tripler stage to multiply a 7-mc. oscillator signal to 21 mc. A 7-mc. oscillator with a tripler stage is used in preference to a 21-mc. oscillator because oscillator circuits are less critical and more stable at the lower frequency.

A number of frequency multipliers are used in an FM mobile transmitter. A typical transmitter may use one tripler and three doubler stages to obtain a 156-mc. output signal from a 6.5-mc. oscillator ($6.5 \times 3 \times 2 \times 2 \times 2 = 156$).

Secondary frequency standards use frequency multipliers to obtain a number of accurate, harmonically related output signals. Fig. 1A shows such a unit. A tuning-fork oscillator generates an accurate 1-kc. signal. Two multiplier circuits, each of which multiplies by ten, are used to provide 10-kc. and 100-kc. outputs from the 1-kc. standard.

Most frequency multipliers work on the principle of harmonic generation. A harmonic is a signal whose frequency is an integral multiple of the frequency of another signal called the fundamental (*e.g.*, The fifth harmonic of 500 kc. is 2500 kc., and 3 mc. is the third harmonic of 1 mc.). The Fourier theory states that any non-sinusoidal signal is made up of a fundamental sine wave and a number of harmonic sine waves. A perfect square wave, for example, contains a fundamental sine wave and all odd harmonic sine waves. A 100-cps square wave contains a 100-cps sine wave and 300-, 500-, 700-, 900-, and 1100-cps sine waves. Other non-sinusoidal waveforms contain a fundamental sine wave to which is added various harmonics of different amplitudes and phases.

Frequency multiplication is accomplished by taking the sine-wave signal to be multiplied and distorting it so that the resulting distorted signal contains a harmonic equal in frequency to that of the desired higher frequency. A frequency-selective circuit is then used to pick out the desired frequency from the distorted signal. One way to multiply a sine-wave signal would be to shape it into a square wave and apply the square wave to a high-"Q" resonant circuit tuned to the desired odd-harmonic frequency.

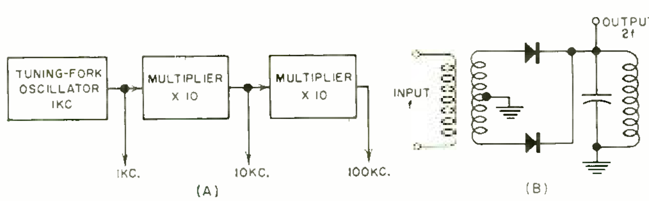


Fig. 1. (A) Multiplier frequency standard. (B) Simple doubler.

Multiplier Circuits

A simple frequency-multiplier circuit is shown in Fig. 1B. This circuit is often used as a frequency doubler. It will be recognized as the conventional full-wave power supply to which a tuned circuit has been added. The sine-wave signal to be multiplied is applied to the transformer primary and, through rectification by the diodes, is changed into a series of unidirectional pulses. This signal, which is rich in even harmonics, is applied to the tuned circuit which selects the second harmonic. The output is a sine wave whose frequency is twice that of the input. A number of these circuits can be cascaded to obtain higher frequencies which are multiples of two.

Almost any non-linear circuit that will distort a sine wave can be used to accomplish frequency multiplication. In addition to diodes, iron-core inductances which also have non-linear characteristics, have been used to produce harmonics. The harmonic generator with the greatest flexibility, however, is the non-linear amplifier. A class C amplifier has non-linear characteristics and most frequency multipliers are specially designed class C amplifiers.

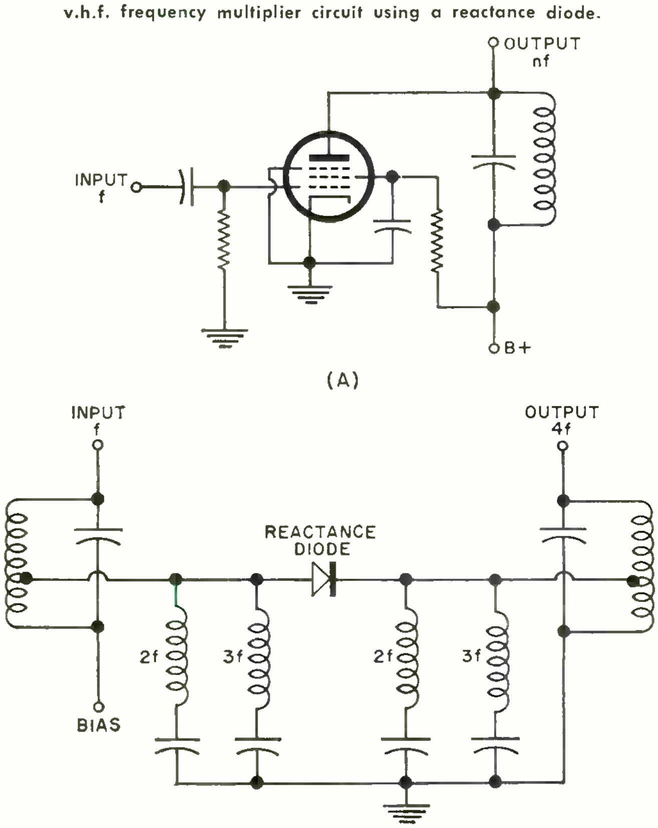
Fig. 2A shows a typical class C amplifier. Grid bias is adjusted so that the tube conducts for less than 180° of one input cycle. The signal appearing at the plate of the tube is a unidirectional pulse. This pulse is applied to a tuned circuit and causes the tuned circuit to be shock-excited at its resonant frequency. If the "Q" of the tuned circuit is high enough, the output of the amplifier will be a continuous sine wave.

The only difference between a class C amplifier and a frequency multiplier is in the tuned circuit. In the class C amplifier, the resonant circuit is tuned to the input frequency. In the frequency multiplier, the resonant circuit is tuned to the desired harmonic. The plate current pulse shock-excites this tuned circuit at the desired harmonic frequency. Another way of looking at this is to say that the pulse appearing at the plate of the tube, being non-sinusoidal, contains a number of harmonics. The exact number and amplitude of the harmonics contained in this pulse depends on the conduction angle of the class C stage. Generally, the smaller conduction angles produce more of the higher harmonics. Plate conduction angles as short as 60° are used to produce high-order harmonics. Class C amplifier frequency multipliers can provide satisfactory multiplications up to approximately 20. The greater the multiplication, however, the lower the efficiency and output power. In practice, the multiplication factor is usually kept below 10 for this reason.

Transistor class C amplifiers also make good frequency multipliers. They can be used to provide multiplications up to about 10 with good efficiency. Such frequency multipliers are found in a number of modern frequency standards, in Citizens Band transceivers, and in low-power telemetry transmitters that are employed for satellite and missile work.

Synchronized oscillators are also used as frequency multipliers. It is possible to synchronize an oscillator at its operating frequency by applying a synchronizing voltage at some sub-multiple frequency. The signal frequency to be multiplied is used as the synchronizing voltage, while the oscillator is designed to operate at a multiple frequency. While such a multiplier is generally unsatisfactory when phase, amplitude, and waveform stability requirements are critical, it can be used satisfactorily in many special applications.

Fig. 2. (A) A class C amplifier frequency multiplier. (B) A v.h.f. frequency multiplier circuit using a reactance diode.



Reactance Diodes

The most recent development in frequency multiplication techniques is the reactance diode or voltage-variable capacitor. This is the same device that is used in parametric amplifiers.

The reactance diode is essentially a non-linear capacitor and because of its non-linear characteristics, it is capable of generating harmonics. According to theory, an ideal non-linear capacitor should generate harmonics without loss. While such efficiency cannot be realized in practice, the reactance diodes available today have very high "Q's" and multiplier efficiencies as high as 80% have been obtained at certain frequencies and power levels.

The greatest use of these diodes as multipliers has been in the v.h.f. and u.h.f. ranges where frequency multiplication with conventional circuits is somewhat of a problem. Reactance-diode multipliers are presently being used at frequencies of 50 mc. to 1000 mc., but have also been used on frequencies above 1000 mc. with promising results.

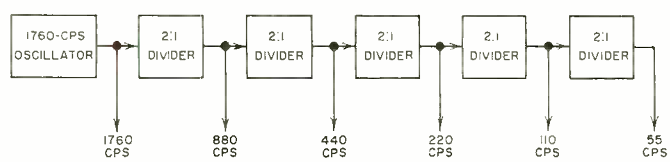


Fig. 3. Frequency divider circuit as used in electronic organ.

Fig. 2B shows a v.h.f. frequency quadrupler circuit using a reactance diode. The signal to be multiplied is applied to the input resonant circuit which is tuned to the input frequency (f). The output is taken from the output circuit which is tuned to four times the input frequency ($4f$). The series resonant circuits tuned to the second and third harmonics are used to eliminate these frequencies from the output and to maintain a good sinusoidal output signal. An external d.c. bias is applied to the reactance diode for proper operation. This circuit can have an efficiency of approximately 40% if the component "Q's" are high.

Frequency Dividers

Frequency multipliers produce output signals called harmonics while a frequency divider produces an output signal called a sub-harmonic. A sub-harmonic is a signal which is lower in frequency than the fundamental by some integral multiple (2, 3, 5, 10, etc.). For example, 10 kc. is the tenth sub-harmonic of 100 kc., or the 3rd sub-harmonic of 1200 cps is 400 cps.

Frequency dividers are used to produce signals which are lower in frequency than an available source and to produce synchronized, harmonically related wavetrains. They are to be found in many different types of electronic equipment.

A good way to show how a divider works is to give an example of its use in a piece of equipment. An electronic organ is a good example. An electronic organ will have a number of "A" keys, each producing a different frequency tone. These tone frequencies are related by a factor of two which means that they are spaced by an octave. Fig. 3 is a block diagram of a portion of a typical electronic organ.

The 1760-cps oscillator produces the highest octave "A" note. This 1760-cps signal is fed to a 2:1 divider whose output is 880 cps, or the next lower octave "A." Other 2:1 dividers are cascaded to obtain "A" tones of 440, 220, 110, and 55 cps.

Frequency dividers can be classified according to the type of output signal they produce—sinusoidal or pulse. The pulse type is the most widely used, but the sinusoidal type often finds application.

Sinusoidal frequency division can be accomplished by using a synchronized oscillator. The oscillator is designed to operate at the sub-multiple frequency desired. The signal to be divided is applied to this oscillator to synchronize the oscillator at the proper frequency. This kind of divider is referred to as a locked oscillator divider. Such a divider is relatively simple and can work over a wide frequency range. Its biggest disadvantage is that it will continue to yield an output even after the synchronizing signal is removed.

A simple locked oscillator sinusoidal divider is shown in Fig. 4A. This circuit consists of a pentagrid converter tube connected as a tuned-plate oscillator. The *LC* circuit is tuned to the desired sub-multiple frequency, f/n, where n is the number by which the circuit divides. The synchronizing signal (f) is applied to the first grid of the tube and the output is taken from the plate of the tube.

Another sinusoidal divider, using modulation and regeneration, is shown in block diagram form in Fig. 4B. This divider depends upon frequency multiplier circuits to make division possible. While it is a relatively complex circuit, its numerous advantages make it very useful where good, stable frequency division is needed.

Operation of this circuit is best described as follows. The signal (f) we wish to divide is applied to the modulator. This modulator is usually a pentagrid converter tube such as the 6BE6 or 6BA7. Also applied to the modulator is a signal whose frequency is $(f/n)(n\text{-}1)$, where n is the number by which we are dividing the input frequency. The output of the modulator consists of the two input signals and the sidebands which are the sum and difference of the two inputs. The modulator output circuit is tuned to the difference frequency f/n.

This f/n frequency is the desired output frequency. If the input signal were 100 kc. and we desire to divide by 10 ($n = 10$), the output frequency would be 100 kc./10 or 10 kc. This f/n signal is applied to a frequency multiplier. Diode or class C amplifier multipliers can be used. This multiplier is set to multiply by a factor of n-1. The output of the multiplier would be $(f/n)(n\text{-}1)$, and this is the signal that is applied to the modulator. This shows that the system has feedback. In the example above, (n-1) would be equal to 9. The output of the multiplier, (f/n) $(n\text{-}1)$, would be equal to 90 kc. The modulator output is the difference of the input signal and the feedback signal (100 kc. − 90 kc. = 10 kc.) and, therefore, the output f/n is 10 kc.

This circuit has numerous advantages, the most important of which is its ability to operate at frequencies of 1 mc. and higher. Most other frequency dividers, sine wave or pulse types, have an upper frequency limit below 1 mc. Other advantages include stability because of feedback, no output signal with input removed, and no off-frequency operation because of the numerous tuned circuits used. Its disadvantage is that it may not be self-starting, but this can usually be overcome by means of proper circuit design.

Multivibrator Dividers

There are many different kinds of recurrent-pulse frequency dividers. Since it is impossible to cover all of them, only the most commonly used types will be discussed here.

One of the most popular pulse-type dividers is the synchronized multivibrator. A free-running or astable multivibrator, like that shown in Fig. 5A, can be synchronized at its frequency by a higher or multiple frequency. The frequency of the multivibrator is determined by the values of *R* and *C* in the circuit. The multivibrator is designed so that its

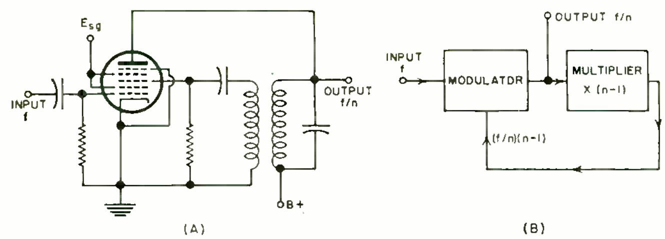


Fig. 4. (A) A locked oscillator sine-wave divider. (B) A sine-wave divider with modulation, multiplication, and feedback.

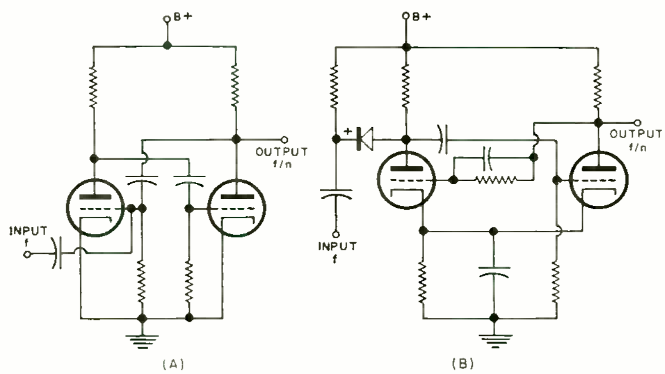


Fig. 5. (A) Astable (free-running) and (B) monostable MV dividers.

free-running frequency is slightly below the desired sub-harmonic frequency. When the frequency to be divided is applied to the circuit as a synchronizing or control signal, the multivibrator will run at exactly the sub-multiple frequency.

If the circuit of Fig. 5A were designed for a division by four, there would be one output pulse for every four input pulses. In other words, if the input frequency is 40 kc. the output frequency would be 10 kc.

Such frequency dividers are capable of stable frequency division up to 20. A single stage can even be used for division of over a thousand. When such large divisions are used, however, the output may not be exactly the desired sub-multiple frequency. It could be off by as much as 5%. When large divisions are desired in addition to good accuracy and stability, it is best to use a number of these divider stages cascaded, each having a small division such as 5 or 10.

The synchronized astable multivibrator divider can be used in almost any application where pulse repetition frequency must be divided. This divider is simple, easy to synchronize (with a sine wave as well as pulses), and has an output which can be easily shaped to fit the need. Its big disadvantage is that it will continue to produce an output when the input or synchronizing signal is removed. This condition is present in any synchronized oscillator type divider.

A monostable (one shot) multivibrator can also be used as a frequency divider. This multivibrator produces one output pulse for each input pulse as long as the duration of the output pulse is less than the spacing between input pulses. When the monostable multivibrator is producing an output pulse, it is considered to be in an unstable state because the pulse lasts for only a short time, after which the circuit turns off and remains off in a stable state until triggered again. The length of the output pulse depends upon the circuit time constant. By adjusting the output pulse length to something greater than the widths and spacings of several of the input pulses, frequency division can be accomplished. The multivibrator is insensitive to input pulses that occur during the time the circuit is in its unstable state. Because several input pulses occur during the time of the output pulse, the circuit divides. The output pulse duration must be adjusted to achieve the correct division factor.

Monostable dividers have two distinct advantages over the astable type. The division ratio is not sensitive to input pulse

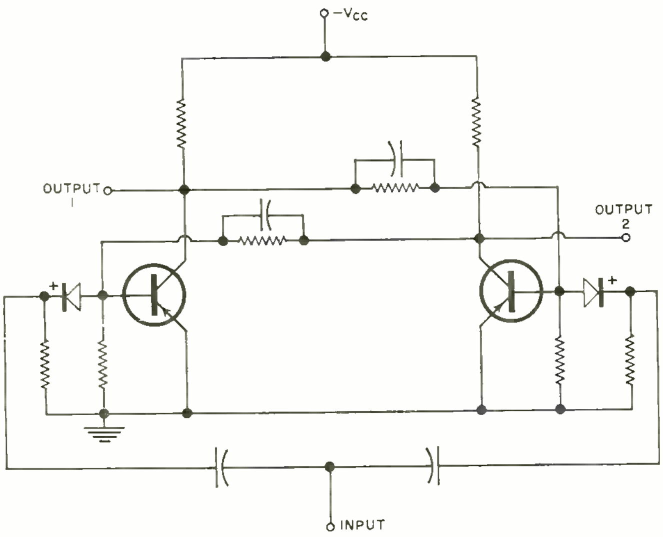


Fig. 6. A bistable (flip-flop) multivibrator divider circuit.

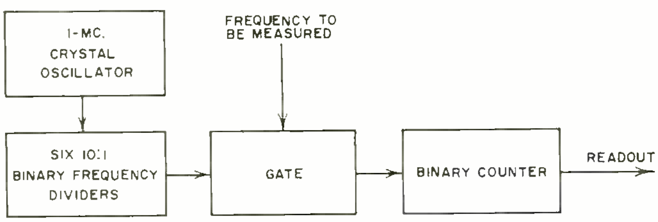


Fig. 7. A frequency measuring counter using binary circuits.

amplitude as it is in the astable divider, and when the input pulses are removed, the output disappears. A typical monostable divider is shown in Fig. 5B.

The binary or flip-flop circuit is another widely used divider. The flip-flop is a bistable multivibrator which contains two tubes or transistors. In operation, one of these tubes or transistors is conducting heavily while the other is cut off. By applying pulses to the circuit it is possible to reverse this condition. The conducting tube is cut off while the cut-off tube is brought into conduction. This transition between states takes place very rapidly, on the order of a microsecond or less, and causes a rectangular output pulse to be produced. The circuit will respond to input pulses of only one polarity, either positive or negative depending on the circuit arrangement. If negative pulses are needed, then one transition will take place for each negative input pulse. Because of this operation, the circuit will divide by 2. Fig. 6 shows a transistorized binary.

These circuits may be cascaded in any number to obtain any division ratio that is a multiple of two (2, 4, 8, 16, 32, 64, 128, etc.). The division ratio of a series of binaries can be found by evaluating 2^n where n is the number of binaries cascaded. For example, if three binaries were used, 2^n would be equal to 2^3 which is 8. The circuit would divide by 8.

Cascaded binary dividers can be used to divide by any whole number by simply using feedback. By introducing extra pulses at various points in the circuit by feedback, division by any whole number can be obtained. A very popular use of this feedback is in changing a four-binary 16:1 divider into a 10:1 divider. A binary divider that divides by ten is called a decade counter.

Counters and Dividers

A good example of the application of binary dividers is in a frequency counter. This device measures frequency very accurately by counting the number of cycles of the signal occurring during a precisely measured time interval, such as one second. The block diagram of such a device is shown in Fig. 7.

The signal from a stable and accurate 1-mc. crystal oscillator feeds six binary dividers, each of which divides by 10. The output is 1-cps pulses which control a gate circuit. The gate is held open for 1 second and the input signal frequency to be measured is passed through the gate. A counter section, consisting of decade binary-type counters, counts the number of cycles occurring during 1 second. The frequency is then read out in a convenient form.

While discussing frequency division, a word should be said regarding the term "counter." Many technicians and engineers use the terms "divider" and "counter" interchangeably, but it is not always correct to do so.

A "counter" is a device which will produce an output pulse for a set number of input pulses. The input pulses do not have to be continuously repetitive; they may be perfectly random. A decade counter, for example, will produce one output pulse for every ten random or repetitive input pulses.

From this definition of a counter, it is obvious that any counter is also a frequency divider and these terms may be used interchangeably in this respect. This holds true for all counter circuits for they all may be used as frequency dividers.

We cannot call all frequency dividers "counters," however. Some divider circuits, like the synchronized astable multivibrator, depend upon a continuously repetitive input signal for proper operation. It is easily seen that this circuit could not be used for counting since it produces an output signal whether or not a pulse or other synchronizing signal is present. No synchronized oscillator divider will count, therefore all dividers cannot be referred to as counters.

Other Types of Dividers

There are many other frequency divider circuits besides those described. For example, thyratrons and neon bulbs in synchronized relaxation oscillator circuits can be used. The phantastron and the blocking oscillator both make good dividers. The capacitor storage step counter, ring counter, and other counter circuits have also been used successfully. In addition, semiconductor technology has brought about many new divider and counter circuits. Circuits using unijunction transistors, trigistors, tunnel diodes, four-layer diodes, and others have been developed within the past few years.

Multipliers versus Dividers

Both frequency multipliers and dividers have their place in electronics. If a high-frequency signal is needed and a low-frequency signal source is available, naturally a multiplier will be used. A divider will be used to produce a lower frequency signal from a higher frequency source if required. However, when it comes to producing synchronized wave-trains of harmonically related signals, both multipliers and dividers can be used. Suppose we need synchronized signals of 100 kc., 50 kc., and 10 kc. We could use a 100-kc. oscillator with a 2:1 divider and a 5:1 divider. But a 10-kc. oscillator with a 1:5 multiplier and a doubler would also produce the same results. Which is better, the multiplier or the divider? While the exact choice depends heavily on the problems at hand, it can be said that dividers will usually be simpler and less expensive than multipliers. Dividers are also much more precise. Any small variation of the frequency or phase of a signal feeding a multiplier will be exaggerated in the output. This is particularly undesirable especially if close tolerances must be maintained. With a divider, however, a small input frequency or phase variation will be even smaller at the output.

Dividers also have the advantage of being quite suitable for both sine waves and pulses, while multipliers are generally suitable for sine waves only.

While dividers have a slight edge, multipliers still find many uses in electronics. Both dividers and multipliers are useful, and technicians will frequently encounter them both in electronic equipment. ▲

JOHN FRYE

Mac and Barney discuss permissible service-instrument error, component tolerances, and alignment techniques.

HOW MUCH ACCURACY?

"HOW YOU doing with that radio club theory class you're teaching, Barney?" Mac asked.

Barney, who never needed a second invitation to take a break from service work, laid his solder gun down on the bench quickly and squirmed around on his high stool until he was facing Mac, his employer.

"Guess I'm doing okay," he replied, "but that class is taking on a kind of funny complexion. It started out as a theory class to help novice hams get their general licenses, but several would-be radio and TV service technicians have turned up, and they ask altogether different questions than do the others."

"How do you mean?" Mac asked, lighting his pipe. "I'd think basic theory would be basic theory."

"Well, it is, in a way; but these service-oriented characters are interested in 'practical theory,' if you can excuse the expression."

"Maybe I could excuse it if I understood it. Talk plainer."

"Okay, I'll try. These jokers keep hounding me with questions about accuracy and tolerance: how accurate must a service meter be? How close should measured voltages be to those given in service literature? How much tolerance do you have in replacing a resistor or a capacitor of a certain specified value? Does an i.f. frequency have to be exactly on the nose? How about dial readings on a receiver? Are you justified in spending a lot of time making each station come in at precisely the proper dial reading?"

Mac grinned sympathetically. "Those questions are easy to ask and hard to answer. They belong in the same category with, 'Daddy, why don't the stars fall down?' or, 'Which is the best car?' or, 'I'm taking up photography; what camera should I buy?' Such questions are tough to handle because (a) they do not have simple, unqualified answers, or (b) an adequate explanation involves technical knowledge not available to the questioner."

"Yeah, but lots of people don't dig that," Barney replied. "A conscientious man who hesitates to give a snap answer because his broad experience lets him see possible exceptions just seems unsure or even ignorant. The cocksure character, unhampered by either deep knowledge or feeling of responsibility for his answers, deals an immediate reply right off the top and looks smart by comparison."

"Your observation is acute, but don't try to patent it," Mac advised. "Wise men have temporarily suffered by comparison with glib men ever since the Serpent fast-talked Eve. But I'm interested in how you fielded these questions about accuracy. I know the subject is of concern to many beginning technicians. Maybe if we kind of ran over the questions together we could add a certain calculated facility to your answers."

"I'm for that. To start off, I explained that most v.o.m.'s listed in electronic wholesale catalogues claimed d.c. accuracies from ½% to 3% of full-scale values and ¾% to 5% on a.c. Typical values were 2% on d.c. and 5% on a.c., and these are plenty good enough for radio and TV service work. Those higher accuracies are found in instruments designed to be used in lab work. As the accuracy increases, the price goes up rapidly; and spending the extra dough simply isn't justified in service work."

"I agree," Mac said, "but I hope you went on to explain *why* extreme accuracy is wasted in a service instrument."

"Oh sure. I pointed out you rarely questioned a voltage reading within 10% of the typical value given on a schematic. After all, why should you? Most resistors in a conventional set are of the plus-or-minus-10%-of-rated-resistance kind; furthermore, few technicians trouble to set the line voltage on the set being tested at exactly 117 volts, where it was when the typical voltages on the schematic were measured. With these unpredictable factors affecting the voltages being measured, using a super-accurate meter is kind of pointless. You don't use a telescopic sight on a shotgun. I got that point pretty well across, and then a wise guy wanted to know why I recommended 2% accuracy for d.c. measurements but only 5% accuracy for a.c. voltages."

"What did you tell him?"

"First off I explained I did not select those accuracies. They just happened to be the ones found in many v.o.m.'s designed for service work. An additional source of error in a.c. measurements was the instrument rectifier, and this explained the 2% *vs* 5% bit. However, I went on to say that you did not need as much accuracy in a.c. measurements in service work. When you put your a.c. meter on the line voltage, the rectifier plate voltage, or filament voltage in a radio or TV set, you are ordinarily checking more for the presence or absence of voltage than you are trying to measure the non-critical potential. It's usually a correct-or-nothing sort of deal. Since the other voltages are geared directly to the line voltage through transformer action or the action of a heavy-current voltage divider, and since the line voltage itself ordinarily varies more than 5%, a meter with 5% accuracy is perfectly adequate.

"The d.c. potentials in a receiver, embracing such things as plate, screen, grid bias, and a.v.c. voltages, are easily influenced by changes in the values of resistors, the leakage of capacitors, the current drawn by tubes, etc. Changes in these voltages, even comparatively small changes, frequently indicate a defective component; and the measurement of d.c. voltages is a highly useful troubleshooting technique. To be fully effective, though, this technique requires significant departures from typical voltage figures be attributable to other causes than meter inaccuracy. That's why the extra accuracy is needed for d.c. measurements."

"Actually the way a measurement is made has more to do with the validity of the reading than does the accuracy of the meter itself," Mac suggested. "The a.c. voltages, as you mentioned, are usually 'stiff' voltages unaffected by meter loading; so a 1000-ohms-per-volt meter is usually recommended for measuring them. The d.c. voltages, on the contrary, are quite often fed through high values of resistance; and any current drawn by the meter will lower such voltages substantially. That's why a v.t.v.m. is used to measure the typical d.c. voltages originally and why a high-resistance

v.t.v.m. should be used by the technician if at all possible—even though the claimed accuracy of the v.t.v.m. might not be quite as good as that of the technician's v.o.m. If the v.o.m. is used, it should have as high an ohms-per-volt rating as possible, and the increased loading should be taken into account in comparing the measured voltage with the typical voltage."

"If the technician uses a high-voltage scale on a 20,000-ohms-per-volt meter, he can come up with a pretty high resistance for his meter," Barney suggested; "but then the pointer is down on the bottom of the scale where the accuracy is not so hot.

"The main thing I tried to get across," he concluded, "was that the important deviation from typical readings was in percentage, not volts. A reading twenty volts off of the 300 volts supposed to be found on an output tube plate is not serious; but a reading only .1 volt off on the emitter of a transistor may well be a matter for concern. As I told them, it's where the deviation occurs that makes the difference. A half-inch extra length on an 80-meter half-wave antenna will have little effect on its performance, but an extra half-inch on Elizabeth Taylor's nose probably would have made a big difference in several lives."

"That should put your idea across," Mac said with a chuckle. "What did you tell 'em about the importance of precise i.f. frequencies?"

"I said it depended a lot on the receiver. There's not going to be any noticeable difference in performance if you align a little a.c.-d.c. receiver at 456 kc. or 457 kc. On the other hand, if you're working on a communications receiver that employs a crystal or mechanical filter, it's necessary the i.f.'s be aligned precisely on the nose for proper operation. It's also important in most dual- or triple-conversion receivers intended for single-sideband suppressed carrier reception that the i.f. frequencies be exactly the ones specified.

"This, of course, led right into the subject of dial-pointer accuracy. I argued that in small radios, many of which have a dial no bigger than a half-dollar, it matters little if the pointer is a little off on a particular station. It is much more important that the receiver tune the band of frequencies it is supposed to and that the r.f. and oscillator circuits track so sensitivity is uniform over the whole tuning range. With these little sets, you often have to choose between accurate dial tracking and uniform sensitivity. In such a case, go for sensitivity.

"The picture changes when you're working on a communications receiver. Here the receiver dial setting will be depended on to double-check the transmitter frequency or to rendezvous on a certain kilocycle for a schedule. Dial readings should be right on the nose."

"Sounds to me as though you answered most of the questions," Mac said, knocking the ashes from his pipe. "You undoubtedly added that in replacing parts it's a good idea to stick as close as you can to the original value and the original tolerance. Give the design engineer credit for having sound reasons for selecting the resistor or capacitor he did. You can, of course, safely substitute a higher wattage resistor or a higher voltage capacitor as long as the resistance and capacity values are the same."

"Ah, ah, ah!" Barney interrupted. "You don't really mean you can always change from a non-inductive carbon resistor to a higher-wattage inductive wire-wound resistor, nor that you can always substitute a polarized 450-volt electrolytic capacitor for a non-polarized 200-volt paper unit, do you? See what I mean about having to be so careful about giving advice to an uninformed person? Hey, what you grinning about?"

"I was just thinking you are only now beginning to appreciate what I went through those first few months after you came to work for me."

"I suppose that's right," Barney admitted. "How come it's so much easier to spot ignorance in others than it is in ourselves?"

"It's probably part and parcel of this subject we've been kicking around: tolerance," Mac suggested. "We're a lot more tolerant of our own shortcomings than we are of other people's. It's a good thing we are; otherwise we couldn't stand ourselves!" ▲

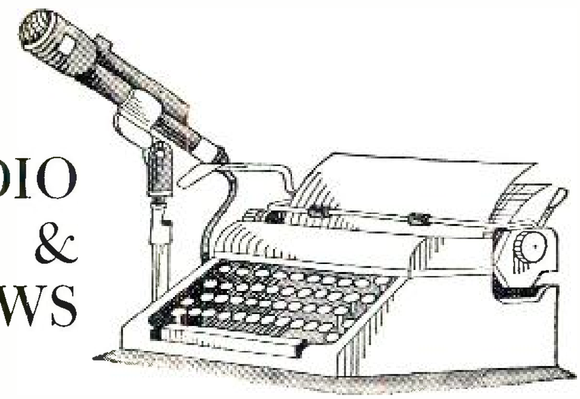
Hi-Fi Product Report

(*Continued from page* 24)

The meter power calibration was considerably in error. In general, the actual output on the 8-ohm tap was about 40% of the meter indication (*Editor's Note: According to the manufacturer, this is the result of using sine-wave signals for the measurements. In actual use with speech or music signals, the indications are relatively accurate providing meter-calibration instructions are followed.*)

Over-all, the amplifier seems to be well suited to high-quality p.a. applications. Its absolute performance through most of the frequency range of good p.a. speakers, is closely akin to that of high-fidelity amplifiers, and it has enough input and control flexibility for most p.a. installations.

The KN-3050 is available from *Allied Radio Corp.* for $129.50, in a black wrinkle cabinet. Plug-in low-impedance microphone transformers are $13.50 each. A three-channel remote microphone mixer, with a 50-foot cable, is $12.75. ▲



RADIO & TV NEWS

IT looks like the big push for color TV is getting up a head of steam and the wheels are beginning to turn. More stations are getting color gear while those stations already equipped are increasing their color programming hours. Meanwhile, set manufacturers are starting to increase the number of color models available and, in many cases, prices are going down.

Models range from the relatively low-priced table types to complete home entertainment centers usually incorporating AM-FM radio (with multiplex), and record and tape playback systems (in stereo) along with the color TV.

Prices appear to be going down as more color sets appear on the market. *Admiral* has introduced a 16-model color line including a 21-inch table type with a suggested list price of $399.95, representing a drop of $95 below the firm's current low-priced unit. *RCA* has introduced 21 color models ranging from $495 for a table model to $1700 for a home entertainment center. *Zenith* has announced 18 models of color sets with some models having price reductions of $50 over that of their predecessors. Their lowest-priced units are tagged at $499.95. *Sylvania* has six 21-inch models including three table types and three consoles. *Motorola* plans to introduce a line of color sets this summer using both a 21-inch round tube and a 23-inch rectangular tube.

Japanese Color

Although there has been no delivery to this country as yet, a couple of Japanese manufacturers are said to have some small-size color sets ready for field tests.

At the IEEE International Convention held in New York City this past March, *Toshiba* demonstrated a table model set that used a 16-inch rectangular shadow-mask type of color tube. *Sony* is said to be in the throes of designing several small-size color sets using a variation of the Lawrence tube. The smallest of these is said to be a fully transistorized portable using a 9-inch color tube.

Prices of these units have not been determined as yet, neither has service availability been discussed.

According to Japanese sources, there are two versions of the Lawrence tube being worked on. One is a single-gun type using conventional Lawrence tube techniques while the other is a 23-inch rectangular tube, using three guns, that claims to have over 300 footlamberts highlight brightness. (Typical shadow-mask highlight brightness is about 35-40 footlamberts.) The 23-inch, high highlight-brightness color tube was developed by the *Autometrics Division* of *Paramount Pictures.*

Other Color Tubes

Although several new approaches to color cathode-ray tubes have been developed during the past few years, it looks like none of them seem to be making commercial headway. *Philco's* "Apple" tube has not been heard from in many years. The *Goodman* tube made its appearance recently but is not in commercial form yet. *Paramount* is still working on its three-gun version of the Lawrence tube and hope to have a commercial version in the near future.

Over in Europe, the *Gabor* flat cathode-ray tube is still in the laboratory stage while the British are still working on the "Banana" tube. Outside of some laboratory testing, nothing further has been heard from *Harries* (Bermuda) on its sunflower-optics method of color reception.

Etched Circuit Boards

During the past few years, several companies have been threshing over the pro's and con's of printed circuit boards *vs* wired sets.

General Electric claims that in a recently completed field survey, with a pooled total of about 10,000 service calls, only two etched circuit boards had to be replaced. *G-E* pointed out that if a service technician were to make 40 service calls a week for 50 weeks, or a total of 2000 service calls a year, he would encounter a faulty etched circuit board once every two years.

As a result of this study, all *G-E* television sets sold to the public after June 1, 1963, will have a guarantee that any defect occurring in an etched board during the lifetime of the set will be repaired at no cost to the consumer. ▲

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	1AX2	.62		6AV6	.41		6S4	.52		12CU6	1.06
	1B3	.79		6AW8	.90		6SA7GT	.99		12CX6	.54
	1DN5	.55		6AX4	.66		6SH7	1.02		12D4	.69
	1G3	.79		6AX5	.74		6SJ7	.88		12DE8	.83
	1J3	.79		6BA5	.50		6SK7GT	.95		12DL8	.88
	1K3	.79		6BC5	.61		6SL7GT	.84		12DQ6	1.04
	1R5	.77		6BC8	1.04		6SN7	.65		12DS7	.84
	1S5	.75		6BE6	.55		6SQ7GT	.94		12DT5	.76
	1T4	.72		6BF5	.90		6T4	.99		12DT7	.79
	1U5	.65		6BF6	.44		6T8	.85		12DT8	.78
	1X2B	.82		6BG6	1.70		6U8	.83		12DW8	.89
	2AF4	.96		6BH8	.98		6V6GT	.54		12DZ6	.62
	3AL5	.46		6BJ6	.65		6W4	.61		12ED5	.62
	3AU6	.54		6BJ7	.79		6W6	.71		12EG6	.62
	3AV6	.42		6BK7	.85		6X4	.41		12EK6	.62
	3BC5	.63		6BL7	1.09		6X8	.80		12EL6	.50
	3BN6	.75		6BN6	.74		7A8	.68		12EZ6	.57
	3BU8	.78		6BQ6	1.12		7AU7	.65		12F8	.66
	3BY6	.58		6BQ7	1.00		7EY6	.75		12FA6	.79
	3BZ6	.56		6BU8	.70		7Y4	.69		12FM6	.50
	3CB6	.56		6BX7	1.11		8AU8	.90		12FR8	.97
	3CS6	.58		6BZ6	.55		8AW8	.93		12FX8	.90
	3DG4	.85		6BZ7	1.03		8BQ5	.60		12GC6	1.06
	3DK6	.60		6C4	.45		8CG7	.63		12J8	.84
	3DT6	.54		6CB6	.55		8CM7	.70		12K5	.75
	3GK5	.99		6CD6	1.51		8CN7	.97		12L6	.73
	3Q4	.63		6CG7	.61		8CS7	.74		12SF7	.69
	3S4	.75		6CG8	.80		8EB8	.94		12SK7GT	.95
	3V4	.63		6CL8	.79		8FQ7	.56		12SL7	.80
	4BQ7	1.01		6CM7	.69		9CL8	.79		12SN7	.67
	4CS6	.61		6CN7	.70		11CY7	.75		12SQ7GT	.91
	4DT6	.55		6CQ8	.92		12A4	.60		12U7	.62
	4GM6	.60		6CR6	.60		12AB5	.60		12V6	.63
	5AM8	.79		6CS6	.57		12AC6	.55		12W6	.71
	5AN8	.90		6CS7	.69		12AD6	.57		12X4	.47

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	5BK7	.86		6CY5	.70		12AF3	.73		18FW6	.49
	5BQ7	1.01		6CY7	.71		12AF6	.67		18FX6	.53
	5BR8	.83		6DA4	.68		12AJ6	.62		18FY6	.50
	5CG8	.81		6DE6	.61		12AL5	.47		19AU4	.87
	5CL8	.76		6DG6	.62		12AL8	.95		19BG6	1.39
	5CQ8	.84		6DJ8	1.21		12AQ5	.60		19EA8	.79
	5EA8	.80		6DK6	.59		12AT6	.50		19T8	.85
	5EU8	.80		6DN6	1.55		12AT7	.76		21EX6	1.49
	5J6	.72		6DQ6	1.10		12AU6	.51		25AX4	.70
	5T8	.86		6DT5	.81		12AU7	.61		25C5	.53
	5U4	.60		6DT6	.53		12AV6	.41		25CA5	.59
	5U8	.84		6DT8	.94		12AV7	.82		25CD6	1.52
	5V6	.56		6EA8	.79		12AX4	.67		25CU6	1.11
	5X8	.82		6EB5	.73		12AX7	.63		25DN6	1.42
	5Y3	.46		6EB8	.94		12AY7	1.44		25EH5	.55
	6AB4	.46		6EM5	.77		12AZ7	.86		25L6	.57
	6AC7	.96		6EM7	.82		12B4	.68		25W4	.68
	6AF4	1.01		6EU8	.79		12BD6	.50		32ET5	.55
	6AG5	.70		6EV5	.75		12BE6	.53		35C5	.51
	6AH4	.81		6EW6	.57		12BF6	.60		35L6	.60
	6AH6	1.10		6EY6	.75		12BH7	.77		35W4	.42
	6AK5	.95		6FG7	.69		12BK5	1.00		35Z5	.60
	6AL5	.47		6FV8	.79		12BL6	.56		36AM3	.36
	6AM8	.78		6GH8	.80		12BQ6	1.16		50B5	.69
	6AQ5	.53		6GK5	.61		12BR7	.74		50C5	.53
	6AS5	.60		6GK6	.79		12BV7	.76		50EH5	.55
	6AT6	.49		6GN8	.94		12BY7	.77		50L6	.61
	6AT8	.86		6H6	.58		12BZ7	.86		70L7	.97
	6AU4	.85		6J5GT	.51		12CN5	.56		117Z3	.85
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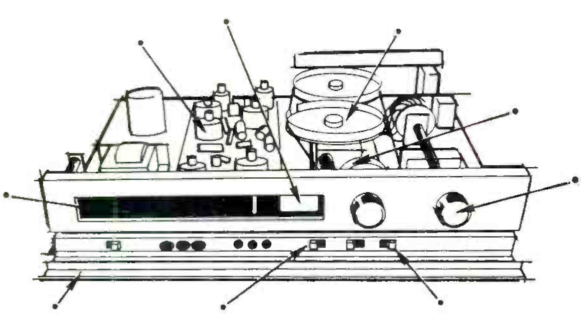

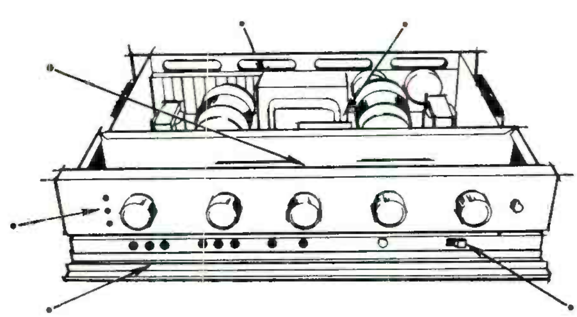

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Kit AJ-33, 14 lbs....no money down, $10 mo......... **$99.95**

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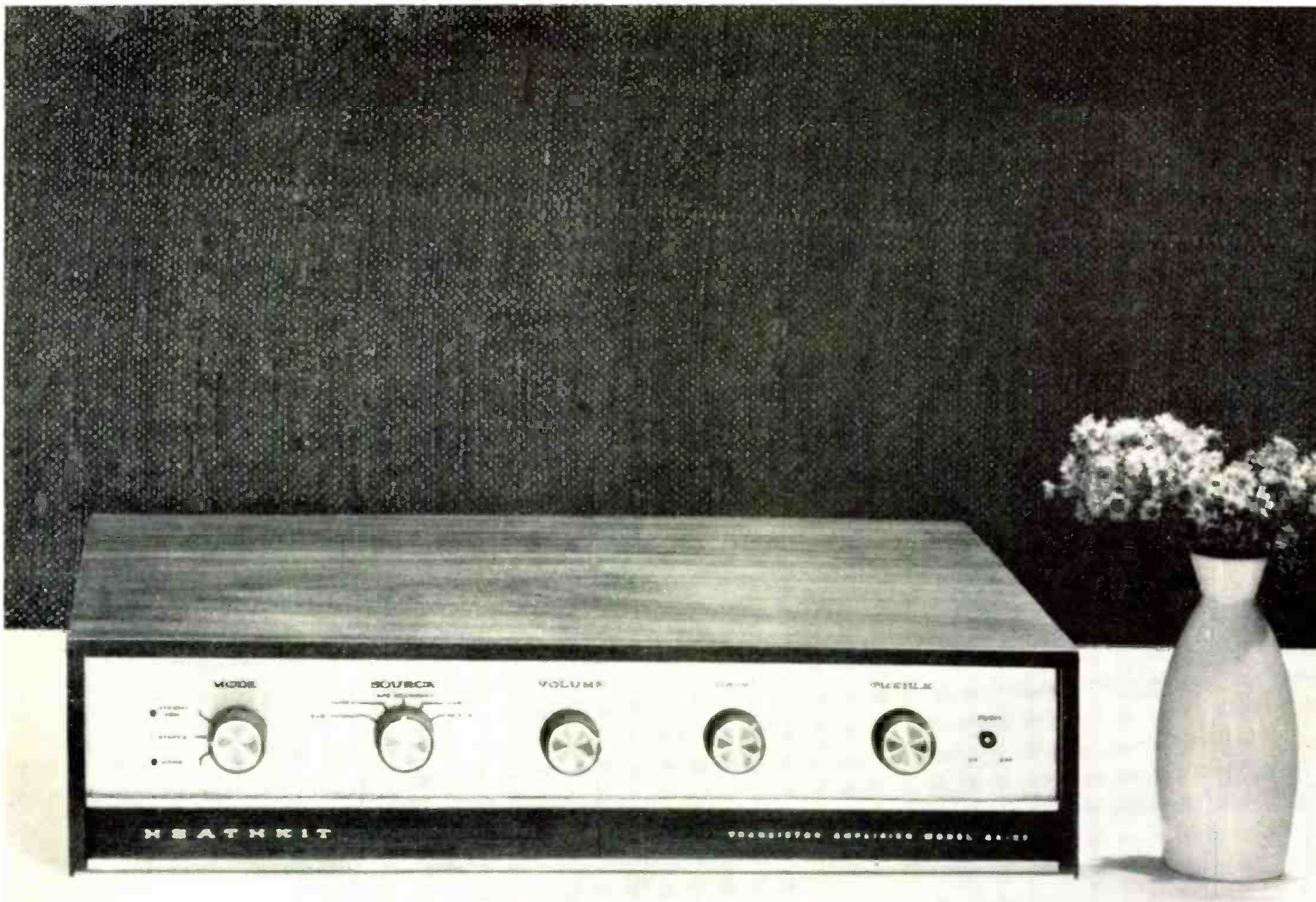

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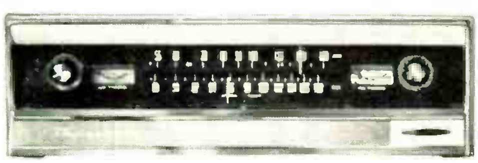
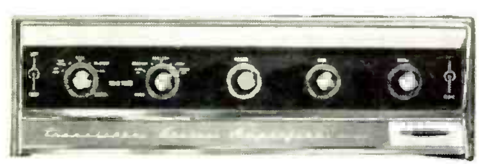
Deluxe "Matched" All-Transistor Stereo Twins





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• 25 transistors, 9 diodes • Automatic Stereo Indicator plus Automatic Switching to stereo • AFC and AGC • Stereo Phase Control • Filtered stereo tape recorder outputs.
Kit AJ-43, 18 lbs....no money down, $11 mo............................**$119.95**

AA-21 Stereo Amplifier

• 26 transistors, 10 diodes • 70 watts power at ±1 db from 13 to 25,000 cycles • Circuit board construction and encapsulated component modules for ease of assembly.
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Both units secondary controls are free from accidental changes because they are "out of the way" under the hinged lower front panels.

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FIELD-EFFECT TRANSISTOR

By PHILIP S. GREEN / Western Technical Products Co.

Description of a new semiconductor device that combines many advantages of tube and transistor.

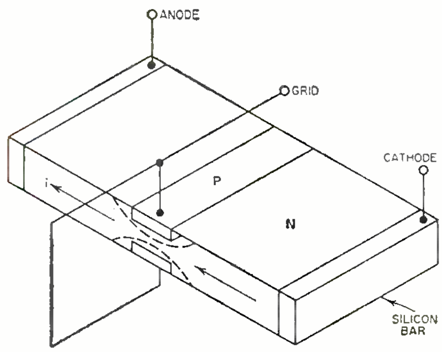


Fig. 1. Cathode-to-anode current is controlled by the space charge near the grid.

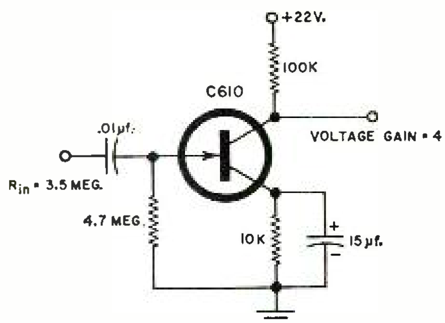


Fig. 2. A simple FET amplifier stage.

THE continued use of vacuum tubes in electronic circuits years after transistors became commonplace indicates that there are many things transistors just cannot do. The introduction of a new device, called the "field-effect transistor," may mark the end of vacuum tubes in some of these critical applications.

An indication of how the FET works is given by the names assigned to its three electrodes: the anode, cathode, and grid.

The FET is an amplifying semiconductor device with an input resistance of up to 100 megohms. It is much less noisy than conventional transistors, requires transistor-size supply voltages and, of course, has no filaments.

How It Works

The FET, as shown in Fig. 1, is basically a bar of *n*-type silicon with connections on both ends for the anode and cathode. On each side of the bar, in the middle, *p*-type impurities are introduced. These regions are connected together and form the grid. By applying to the grid a voltage which is negative with respect to the cathode, the two diodes formed by the *p*-*n* junction are reverse-biased. This causes a space charge region (dashed lines), through which no current can pass, to form on both sides of the bar. Increasing the grid bias chokes off more of the bar, and permits less current to flow from cathode to anode.

Since the grid-to-cathode circuit is a reverse-biased silicon diode, the input resistance can be quite high. This means that a small amount of power in the grid circuit can control a very large amount of power in the anode circuit.

The characteristic curves of the FET are almost identical to those of a pentode.

Some Applications

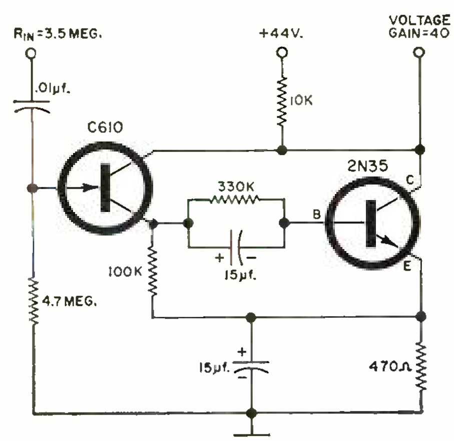
A simple FET amplifier is shown in Fig. 2. Even though the load resistor is quite large, the voltage gain is only four. This is the result of the low transconductance of the *Crystalonics* Type C610 device (this particular unit has a G_m of 100 micromhos). The best FET's have, to date, transconductances of only 1000 micromhos. Until this figure is improved, the best use of FET's can be made by combining them with transistors. In Fig. 3 a combination amplifier is shown which has a voltage gain of 40 and an input impedance of 3.5 megohms.

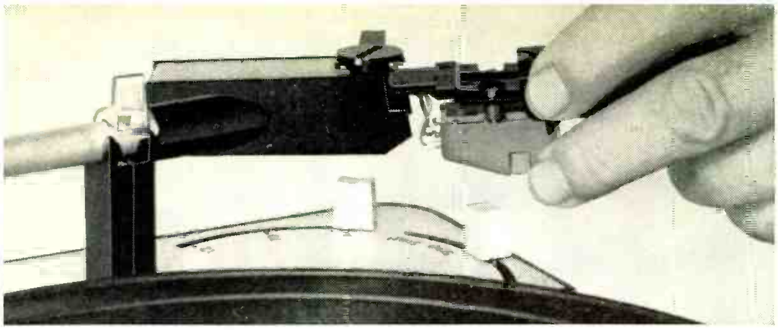
Other applications for these devices include low-level choppers, switches, tuned high-frequency amplifiers, and almost any other low-power transistor or vacuum-tube functions.

Some Drawbacks

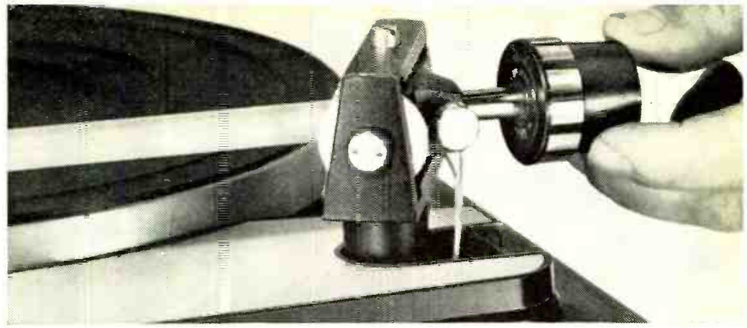
Several facets of the field-effect transistor have yet to be polished. As mentioned above, an increase in the transconductance would be very helpful, as would a decrease in the temperature

Fig. 3. Combination FET-transistor stage provides moderate gain and high input Z.

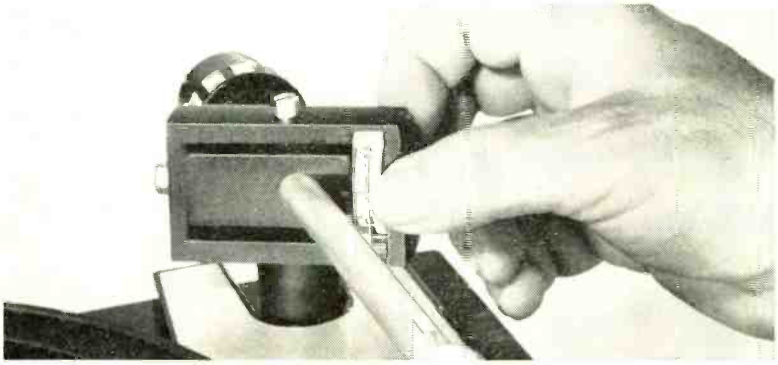




welcomes highest compliance cartridges for flawless tracking even at ½ gram or under



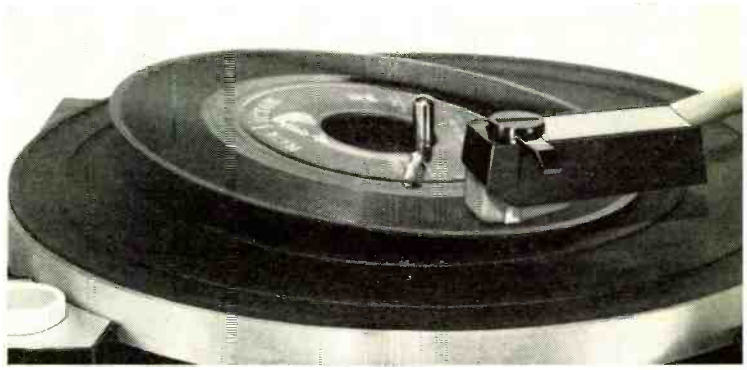
precise tonearm balance with rubber cushione fine-thread rotating counterweight



stylus force applied directly at pivot preserves perfect mass balance of tonearm

perfect pitch for the most critical ears with 6% variable range for all four speeds

superb over-all engineering permits tilt to almost 90° without spilling a note



"warped" and eccentric tracking dramatizes frictionless bearings, low tonearm mass

No wonder the new Dual 1009 Auto/Professional obsoletes every turntable and changer ever made...at any price!

Standards of performance once associated only with professional turntables and separate tonearms have now been matched or surpassed by a remarkable new record playing instrument . . . the Dual 1009 Auto/Professional by United Audio. Consider this achievement! A dynamically balanced automatic tonearm that *tracks below ½ gram, trips at zero* . . . resonance below 8 cps. A seven pound non-ferrous platter, machined to electronically-controlled tolerances, then dynamically balanced. A powerful high-torque motor that easily maintains speed accuracy with one record or ten . . . and resists line voltage variations even exceeding 10%. And, if you like, the Auto/Professional will shut off your amplifier after play! All this, plus strikingly handsome styling . . . and at $94.75, a most unprecedented value. Literature on request. United Audio·Dual, 12 W. 18th St., New York 11, N. Y.

UNITED AUDIO DUAL

sensitivity. Although the grid-to-cathode capacitance in most FET's now available is about 40 μμf., *Fairchild Semiconductor* has introduced the Type FSP-400 with an input capacitance of only 0.7 μμf. This will permit operation to much higher frequencies.

Except for the FSP-400 ($65.00) mentioned above and experimental models by *Texas Instruments* and others, most of the field-effect transistors now in production are manufactured by *Crystalonics, Inc.*, Cambridge, Mass. The variety of *Crystalonics* types now on the market is too great to permit a complete listing of them here. At the moment their prices range from $12.00 to over $70.00.

Also available are composite units—an FET and a conventional transistor in one case. These devices, priced from $50.00 to $74.00, have effective transconductance of up to 18,000 micromhos.

When full production gets under way, the easily manufactured FET's may very well sell for less than conventional transistors. ▲

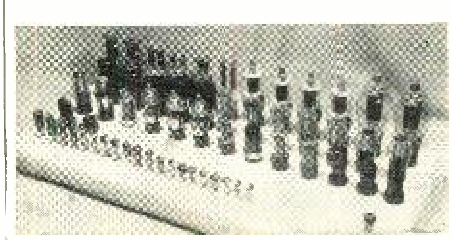
HANDY TUBE RACK

By R. A. GENAILLE

BY DIVERTING a slab of "Styrofoam" from its common household use as the base for a holiday centerpiece or by purchasing a new slab in the "five-and-dime" you can make an inexpensive, handy tube rack which will do an excellent job of storing all of those loose, unboxed tubes around the shack or shop. It will eliminate the storage of tubes in the usual cardboard carton where they are subject to jostling and subsequent damage. It will also simplify finding a particular tube in the batch.

The slab can be any convenient length or width depending upon how large a supply of loose tubes you have on hand. A suitable thickness is approximately two inches. Using a soft lead pencil, draw straight lines on the top surface of the slab with each line about two inches apart to serve as a guide for the placement of the tubes. Start at a convenient point on one of the guide lines and insert the tubes, base down of course, into the tube rack slab with a slight downward pressure and gentle side-to-side motion. Allow some separation between the tubes. The tube pins will ease gently down into the "Styrofoam" and make a clean indentation. Even octal base center posts and keyways will be inserted cleanly. The filament pins, keyways, and other guides can be marked with a touch of finger nail polish to permit rapid replacement of tubes in the "sockets." It may be found convenient to place all like base configurations in the same row, i.e., all 4 prong large in one row, all octal bases in another row.

Make up one of these handy tube racks. It will be one of the most useful accessories in your shop. ▲



Electronics Field Engineers

(*Continued from page 43*)

are, however, many men who can better be classified as technicians who are included in the area of "field engineering." They all have to be experienced men and have a thorough knowledge of the equipment or system on which they are working.

A candidate for field engineering need not have experience as a radio-TV technician, but such experience is an asset. Many of our field engineers are recruited from the military services. These men have been trained in the military service schools for work on electronic equipment. The more years he has served with the Army, Navy, or Air Force as an electronics technician, the better he is qualified. After joining the company these technicians are given special training for various field engineering assignments.

The basic qualifications in all cases are willingness to work and study hard, work overtime when needed, and have the originality and imagination which is so essential to the solution of difficult problems in installation and maintenance of electronic equipment.

The salary ranges from $6000 to $12,000 per year. For overseas work, there is a *per diem* allowance.

There is no limit on the length of time field engineers can stay out of the country on an assignment. These things are arranged according to individual engineers and according to assignment requirements.

There is no preference for either single or married men. The former are more flexible, the latter more reliable. Engineers are selected for their capabilities rather than their marital status. In regard to bringing families along, this depends upon length of assignment. Engineers prefer to leave their families at home if assignments do not exceed 3 to 6 months. For longer assignments, up to 1 year or more, they usually take their families with them.

Accommodations are usually provided by the customers at isolated and remote locations and they also assist in getting satisfactory living quarters even in populated areas.

An Unending Challenge

The life of a field engineer is an unending challenge. There are thousands of competent electronics field engineers serving the military, government agencies, and industrial organizations throughout the world. And yet, they represent but a very small fraction of the working population. They must have special qualifications and capabilities, including physical courage and stamina, an engineering education and experience, and the originality and imagination to innovate and improvise. ▲

New CB Circuits

(*Continued from page 41*)

may now reduce the received signal to satisfactory levels prior to the transceiver's detector stage.

Two neon bulbs are also added. As voltage regulators they stiffen the "B+" supply to the local oscillator and SB adapter to minimize frequency drifting. Error as small as 50 cps from nominal values can produce serious garbling.

It may sound odd, but the company recommends that sideband reception not be done on crystal control. Rather, the continuous-tuning dial of the receiver should be used to adjust the local oscillator frequency. The rationale is simple: CB receiving crystals within tolerance can be 1300 cycles off nominal. This is acceptable for normal AM, but nowhere nearly precise enough for sideband. Careful adjustment of the manual dial allows the operator to drop the sideband signal at a point on the i.f. curve for maximum intelligibility.

(b) Lafayette HE-90 Transceiver

Joining the brisk trend toward the nuvistor in v.h.f. circuitry, *Lafayette*[2] includes such a tube in the front end of the new HE-90 transceiver. It is a 6DS4, a high-mu triode whose low noise figure makes it a fine r.f. amplifier for weak-signal reception. The tube introduces an alignment technique fairly new to CB servicing. Despite high performance, the 6DS4 is a triode and thus displays enough grid-plate capacitance to create potential instability or self-oscillation. There is no screen grid to provide electrostatic shielding.

Visible in the circuit diagram (Fig. 2) is the scheme employed to counter the positive feedback route from plate to grid. It is largely in the form of neutralizing coil L_n; significantly different in operation from that of the more common neutralizing capacitor. The coil is preferable in this application since it permits the use of shorter leads around the tube socket.

The theory of operation is one of reactance cancellation. Positive feedback in the tube is due to capacitive reactance. The inductive reactance of the neutralizing coil, however, parallels this with an equal and opposite value and the net result is zero reactance.

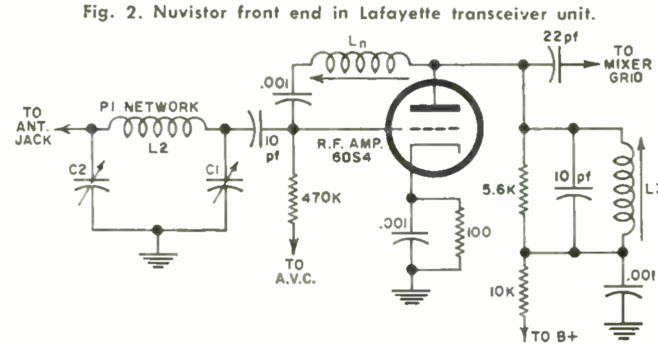
With this approach, a somewhat unconventional alignment technique is encountered in the HE-90. After all other receiver circuits have been tuned, "B+" to the nuvistor is removed (the 10,000-ohm plate-dropping resistor temporarily unsoldered). A strong 27-mc. signal is applied to the antenna terminals with a generator and the "S"-meter observed. There will be an output reading although the r.f. amplifier is now disabled. The input signal is traversing the tube *via* grid-plate capacitance. Coil L_n is now tuned for a *dip* in the "S"-meter. When the coil reaches 27-mc. resonance, a drop in indicated output signifies proper neutralization. This, of course, is contrary to usual alignment procedures, where most adjustments are intended to produce a peak reading.

"B+" may now be restored to the nuvistor and the receiver is ready for stable operation. ▲

REFERENCES

1. General Radiotelephone Co., 3501 W. Burbank Blvd., Burbank, Calif.
2. Lafayette Radio Electronics Corporation, 111 Jericho Turnpike, Syosset, N.Y.

Fig. 2. Nuvistor front end in Lafayette transceiver unit.



LAYING OUT PC BOARDS

By R. C. APPERSON, JR.

After laboring over a layout on paper, getting the very best component placement, and achieving a neat arrangement, the problem is to transfer the circuit to copper-clad board so that the resist may be applied.

Here is a simple trick to getting the exact layout transferred to the board. Using carbon paper (pencil type) and a ball-point pen, the circuit can be traced with ease to the copper-clad. The holes are marked in the pads and before the resist is painted on, drill all holes. Care must be taken that the paper does slip.

The author also found that a pattern tracing kit, of the type women use in transferring dress patterns to material, works very well. A tracing wheel is included which transfers the circuits to the copper-clad in dotted lines. If this method is used, drill all holes first, then trace the circuit since the dots for the holes are hard to identify among the circuitry. ▲

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for International Model 50 and Model 100 Citizens Band transceivers

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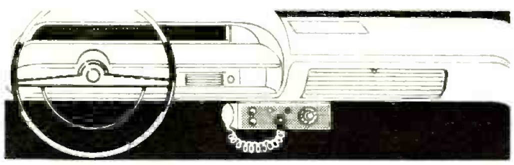

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Model RMO-9 . . . a deluxe unit with 9 transmit and 9 receive channels. Complete with channel switch, but less crystals $57.50

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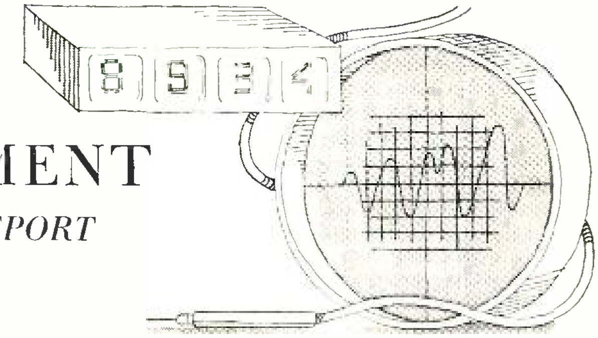
TEST EQUIPMENT

PRODUCT REPORT



Eico 902 Distortion Meter

For copy of manufacturer's brochure, circle No. 58 on coupon (page 15).

AN interesting new audio test instrument that can measure both harmonic and intermodulation distortion and includes a full-fledged audio v.t.v.m. is the *Eico* Model 902. This 3-in-1 meter is designed for audio research and development, as well as for in-production testing, quality control, and servicing of audio equipment.

The front-panel controls are conveniently grouped, with the v.t.v.m. and its controls at the left and the distortion-measuring circuits and their controls at the right. The 9-tube, 4-crystal-diode instrument is quite compact considering all the functions it performs. It measures only 8½" high by 12½" wide by 10" deep.

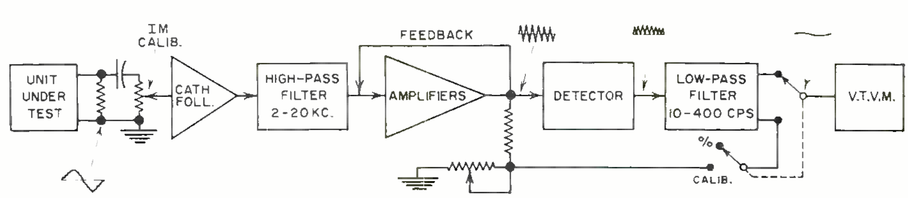
When used as an a.c. v.t.v.m., the unit has a maximum range of 300 volts with the lowest range of 10 mv. full scale. The input impedance is 2 megohms shunted by 15 pf. In addition to being calibrated in voltage and db, the same meter is used for reading distortion percentages. In this case the lowest and most sensitive range is 0.3 percent full scale for either harmonic or intermodulation distortion. A maximum of 30 percent IM or 100 percent harmonic distortion can be read directly.

For harmonic-distortion measurements, the 902 incorporates a continuously variable 20 to 20,000 cps three-range Wien-bridge rejection filter. A high-quality tuning capacitor using a 6:1 vernier makes it simple to adjust the null frequency accurately. The internal distortion is under 0.1 percent. In order to measure the harmonic distortion of a high-fidelity amplifier, a low-distortion audio oscillator is connected to the input of the amplifier under test, while the output is connected to the distortion meter. After nulling out the fundamental frequency, the meter will read the residual harmonics, hum, and noise.

For intermodulation-distortion measurements, the Model 902 produces its own test signals. These are the line frequency (60 cps) which is mixed with the output of a 7000-cps oscillator. The two signals are combined with a ratio of either 4 to 1 or 1 to 1. External audio signals can also be used for the IM test. Residual IM distortion of the instrument is about 0.05 percent.

When making this distortion measurement, the output of the unit is connected to the amplifier being tested; the output of the amplifier is then connected back to the test instrument. The 902 then amplifies the high-frequency signal and rejects the low-frequency signal (see diagram). If there is intermodulation distortion present, the h.f. carrier signal will have a low-frequency modulation envelope. The carrier is then detected and the detected signal is applied to a low-pass filter. This removes the carrier and passes only the low-frequency modulation envelope, representing the sum of the IM components. The latter is applied to the v.t.v.m. which reads directly in percent IM. Convenient terminals for an oscilloscope permit visual observation of the distortion being measured.

Two useful tables are included in the instruction manual. One, for harmonic distortion measurements, shows the output voltage across a wide range of loads for various output powers from 1 mw.



to 100 watts. The other, for IM measurements, shows the voltage across various loads for *equivalent* sine-wave powers from 1 mw. to 100 watts.

At the time of this writing, the Model 902 is available factory-wired only at a price of $250. ▲

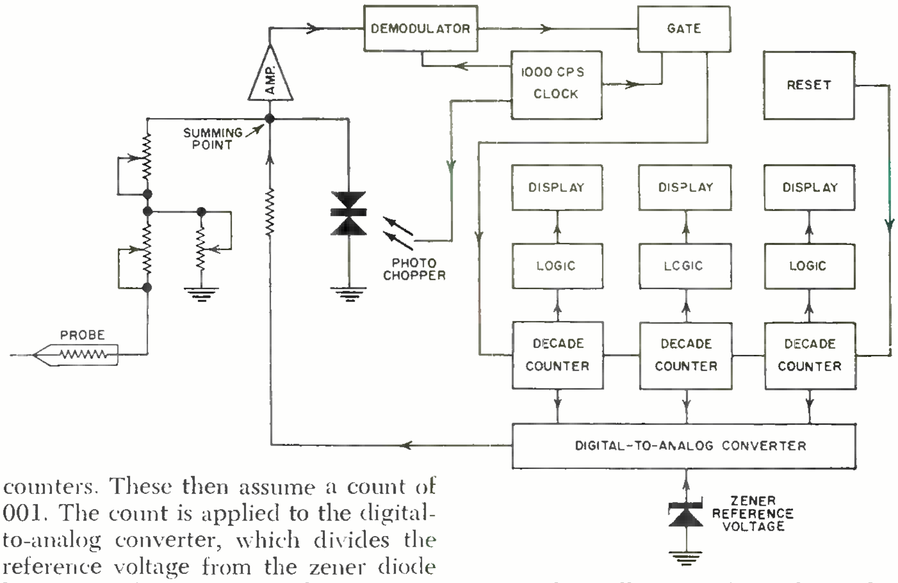
Dynascan III Digital Voltmeter

For copy of manufacturer's brochure, circle No. 59 on coupon (page 15).

THE digital voltmeter is coming into industrial use because it can be employed by unskilled personnel to take highly accurate voltage measurements. What is more, the instrument is usually able to supply digital output signals for use with printers or other computer-type equipment. Most DVM's are very elaborate and therefore are quite expensive; ranging in price from just below $1000 to much more. The *Dynascan* Model III DVM, by using somewhat simplified circuitry along with a 3-digit readout (rather than 4, 5, or more) is available for $399.50. The meter is designed for research and development, quality control, production testing, and other measurement applications.

The Model III uses all solid-state circuitry except for one nuvistor tube. It has four ranges: 0 to 1, 10, 100, and 1000 v.d.c. at an input impedance of 11 meg except for 1 meg on the lowest range. Accuracy of the meter is ±1 count, which is 1 part in a thousand or ±0.1 percent. Each of the three numerals in the readout is formed by means of a 7-bar numerical display. Depending on which of the bars is illuminated, the form of the number is displayed. A highly stable temperature-compensated zener diode is used to produce the reference voltage required.

Assume that all three decade counters have been reset to 000 and that the probe is connected to a source of voltage to be measured (see diagram). The d.c. voltage is attenuated and applied to a photo chopper whose resistance changes from very high to very low at the 1000-cps clock rate. Hence, the d.c. is chopped into an a.c. signal whose amplitude is directly proportional to the amount of d.c. This signal is then amplified and fed to the demodulator, which permits the gate to remain open and allows one clock pulse through to the



counters. These then assume a count of 001. The count is applied to the digital-to-analog converter, which divides the reference voltage from the zener diode by 1000 and feeds that to the summing point.

If the input voltage being measured and the output of the converter are not equal in amplitude and opposite in polarity, then the chopper continues to operate. This permits a second clock pulse to go through and the counters are now at a count of 002. The digital-to-analog converter then divides the reference supply to 1000/2 and feeds that to the summing point where a comparison is again made. This procedure continues until the output from the converter and the input being measured are equal. At this time, no further pulses are applied to the counters and they remain in a static condition.

The logic circuits interpret the condition of the counters and convert their setting to a 7-unit signal. This signal lights the proper lamp bulbs behind the proper bars in the numerical display. The pattern of light produced shows up as three illuminated numbers, thus forming the readout. The total number of counts in the counters is equal to the magnitude of the input voltage as measured in 1/1000 volt steps or counts. Once the circuits are balanced and a count has been recorded, all the counters are automatically reset and the entire procedure is repeated. Hence, the numerical information is displayed repeatedly. If the input voltage is constant, then the numbers displayed will remain the same. Otherwise, on the next counting sequence a different voltage will be indicated.

The time required for readout is proportional to voltage, with a maximum time of 1 second for the highest voltage. If the voltage being measured exceeds the setting of the range switch, then no reading is indicated.

The Model 111 is a fairly compact unit, measuring 5¼" high by 12¾" wide by 10½" deep. ▲

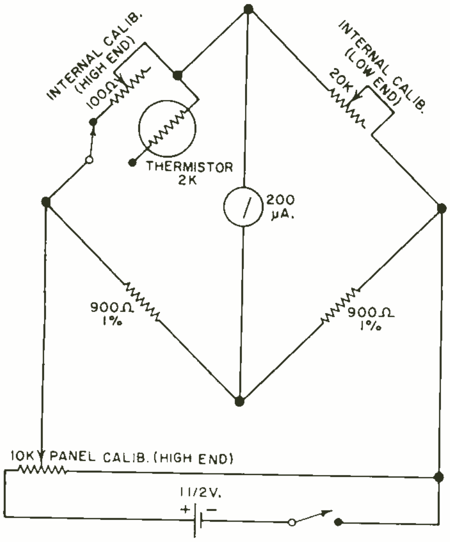
Seco 212 Electronic Thermometer

For copy of manufacturer's brochure, circle No. 60 on coupon (page 15)

A NEW electronic thermometer by *Seco Electronics* uses a thermistor probe in a bridge circuit to give accurate temperature readings. The Model 212 thermometer covers a temperature range from −20°C to 160°C in two scales with an accuracy of ±2%.

At low temperatures, the resistance of the thermistor is high and at high temperatures, resistance is low. For example, at room temperature, resistance is 2000 ohms, and at the maximum scale temperature (160°C) resistance drops to only 60 ohms. As the resistance of the thermistor changes, the bridge circuit (see figure) becomes unbalanced, causing more or less current to flow through the meter, deflecting it to indicate the temperature. The bridge is so designed as to result in linear scale on the indicating meter.

Four thermistor probe heads are available. The largest of these resembles an ordinary flathead screw while the smallest is about the size of a pinhead. The



handle of the probe is of high-temperature plastic so that complete isolation between the operator's hand and the sensing element is obtained. To take a reading, the probe can be attached to the component under test or it can be simply held in contact with the unit by hand.

The entire operating current for the instrument is supplied by a 1½-volt "D" cell. The current drain of about 1 ma. is so low that the battery life approaches its "shelf life."

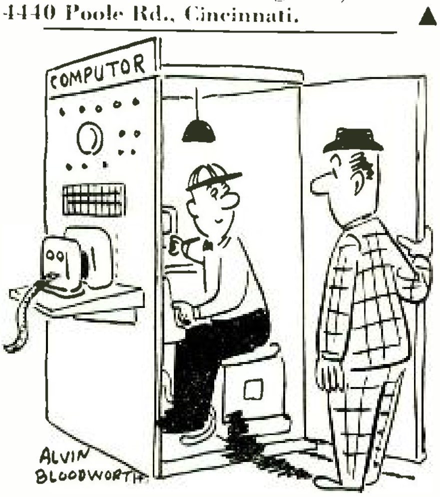
Each unit comes in a 4½" x 5½" x 7¾" Bakelite case with the thermistor probe attached by a 3-foot cord. Price is $79.50. ▲

CINCY STAG HAMFEST

THE 26th Annual Stag Hamfest, sponsored by the Greater Cincinnati Amateur Radio Association, will be held on Sunday, September 22nd at Strickers Grove on Compton Road, Mt. Healthy, Cincinnati. Coffee and doughnuts will be ready for early arrivals with continuous meal service beginning at 11:30. Hot dogs, snacks, and refreshments are included in the $3.00 gate fee.

There will be a ham gear swap shop, a lot of prizes, and a good time for all.

Complete information on this popular stag event can be obtained from Elmer H. Schubert, W8ALW, 3965 Harmar Ct., Cincinnati, or M. J. Marzigliano, K8YNT, 4440 Poole Rd., Cincinnati. ▲



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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!

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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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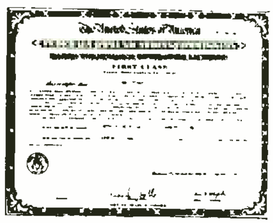

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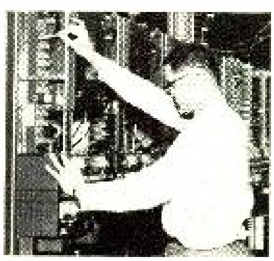

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Additions to Japanese Radio Listing

THANKS to J. P. Lane in Tokyo, we are able to provide our readers with additional listings and corrections for our "Directory of Importers and Manufacturers of Japanese Transistor Radios" which appeared originally on page 38 in our May issue.

According to Mr. Lane, the best source of information on all Japanese electronics equipment is the "1963 Japan Electronic Buyers Guide" which is available in the U.S. from Mr. Haruki Hirayama, Dempa Publications, Inc., Hudson Terminal Bldg., 30 Church St., New York 7, New York for $10.00 a copy.

Mr. Lane also suggests that, where possible, correspondence be addressed to the importer rather than the manufacturers in Japan, many of whom do not have facilities for handling English language communications.

He provides the following corrections to our listing:

Brand Name	Importer	Manufacturer
Alpha		Nippon Alpha Electric Co., Ltd. 6 Azabu Fujimi-cho Minato-ku, Tokyo, Japan
Channel Master		Sanyo Electric Co., Ltd. 18 Keihanhon-dori, 2-chome Moriguchi-shi, Osaka, Japan
Crown	Harpers International Inc. 315 Fifth Avenue New York 16, New York	Crown Radio Corp. 3 Higashikuron-cho Taito-ku, Tokyo, Japan
Eagle		Nippon Columbia Co., Ltd. 6 Shiba Tamura-cho, 6-chome Minato-ku, Tokyo, Japan
Fujiya		Fujiya Electric Co., Ltd. 6 Ginza-Nishi, 7-chome Chuo-ku, Tokyo, Japan
General		Yaou Electric Co., Ltd. 2776 Oi Sakashita-cho Shinagawa-ku, Tokyo, Japan
Hikari		Mitsuoka Electric Mfg. Co., Ltd. 536 Ebidani, Tondabayashi-shi Osaka, Japan
Koyo		Koyo Denki Co., Ltd. 6 Ginza-Higashi, 7-chome Chuo-ku, Tokyo, Japan
Matsushita		Matsushita Electric Co., Ltd. 1006 Kadoma, Kadoma-cho Kita-Kawachi-gun, Osaka, Japan
Nanaola		Nanao Radio Co., Ltd. 1050 Shimomeguro, 4-chome Meguro-ku, Tokyo, Japan
NEC		Nippon Electric Co., Ltd. 2 Shiba Mita, Shikoku-cho Minato-ku, Tokyo, Japan
NVC		Victor Co. of Japan, Ltd. 1-1 Nihonbashi Honcho Chuo-ku, Tokyo, Japan
Rincan		Kyowa Denki Kagaku Co., Ltd. 390 Nishi Osaki, 1-chome Shinagawa-ku, Tokyo, Japan
Sony		Sony Corp. 351 Kitashinagawa, 6-chome Shinagawa-ku, Tokyo, Japan
Standard		Standard Radio Corp. 11 Ebisu-minami, 1-chome Shibuya-ku, Tokyo, Japan
Toshiba		Tokyo Shibaura Electric Co., Ltd. 3 Ginza-Nishi, 4-chome Chuo-ku, Tokyo, Japan or: Hibiya Mitsui Bldg. 12 Yuraku-cho, 1-chome Chiyoda-ku, Tokyo, Japan
Yaekon		Yamada Electric Industrial Co., Ltd. 3 Shiba Shimbashi, 6-chome Minato-ku, Tokyo, Japan

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Transistors for Hi-Fi

(*Continued from page 40*)

All this may not mean very much to the average listener because, after all, he is interested in power or the volt-amperes which an amplifier can produce in his loudspeaker system. So for this purpose the curves of Fig. 7 have been replotted in Fig. 8 where load impedance and output are shown. It can be seen here that an impedance mismatch will cause a noticeable decrease in output power in a tube amplifier. In a transistor amplifier, an *increase* in load impedance will show a very similar effect as in a tube amplifier. However, a *decrease* in impedance actually results in an *increased* available output. Hence, the maximum available output power of a transistor amplifier is actually much higher than rated.

Why, then, are transistor amplifiers operated at this lower output point? Here, the transistor operates pretty much like a battery or the a.c. power line. There would be intolerable heating of the transistor (or the battery or the local power line) if matching were done. Matching occurs when the load impedance is equal to the source impedance. The automobile battery is nearly matched when the starter motor is operating in zero-degree weather and has very short life in continuous operation of this kind. Matching the local electric company's power-line generators would result in blown fuses. If one should try to match power transistors, it is most likely that a new matched set of transistors would be required after a few milliseconds.

The increased power available from a transistor amplifier under mismatch conditions is the first factor that might account for improved transistor sound. The second factor is that power transistors usually operate in class B circuitry and, consequently, the voltage variations of the power supply are larger than those encountered in a tube unit. Since the power-supply voltage at zero signal determines music-power output and since amplifiers are often rated for steady-state power output, the power output of a transistor amplifier under music conditions is considerably higher than a tube amplifier with its better regulated supply. A third factor of importance is that the distortion of a tube amplifier remains generally quite low up to very near its clipping point then distortion rises very rapidly beyond that point. It is at this low distortion point, just below clipping, that the tube amplifier is usually rated. A transistor amplifier usually has a rounder, more gradual distortion knee and higher power outputs are obtained when distortion is allowed to reach a few percent (as seen in Fig. 2).

In summary, there are three factors

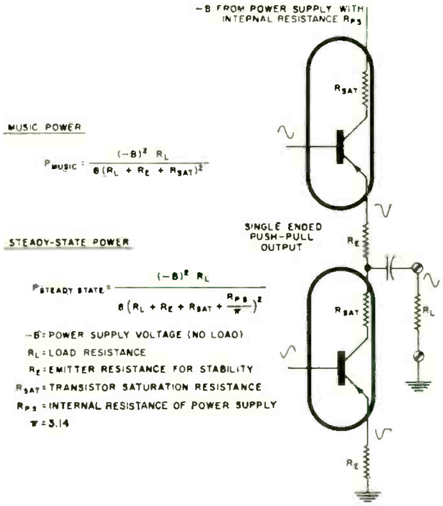
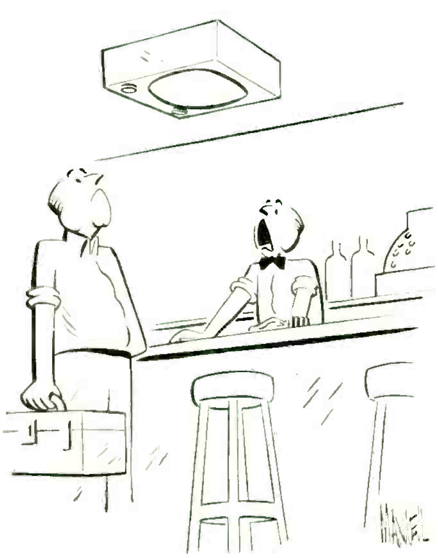


Fig. 9. Formulas for computing power output of single-ended push-pull output stage.

that permit a transistor amplifier to produce more available music power than a tube amplifier: *impedance mismatch, changes in power-supply voltage,* and *a rounder distortion knee.*

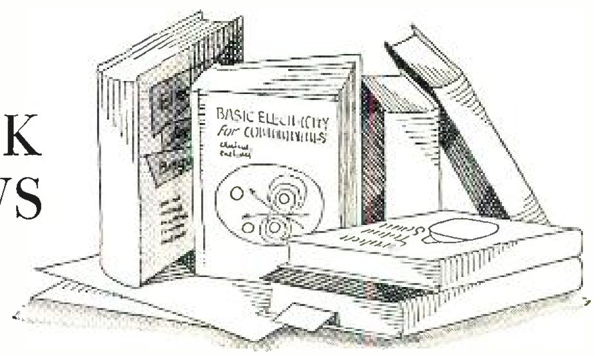
For those interested in calculating power output, a formula for steady-state power and another one for music power are given in Fig. 9. When distortion on peaks is allowed to reach several percent and when the loudspeaker impedance drops to 25 percent below its rated impedance, the music-power output of a transistor amplifier may well be more than 80 percent above its rated power, whereas for a tube amplifier it may be only 85 percent of rated. This over 2:1 difference in power output is certainly audible when listening at high levels. This is the real magic of transistor sound.

Next month we will discuss the output-transformer myth, the types of transistors to be used, and give a practical design for a transistor hi-fi power amplifier. *(Concluded next month)*



"You can imagine how certain customers will feel if it isn't working tonight!"

BOOK REVIEWS



"GENERAL ELECTRONICS CIRCUITS" by J. J. DeFrance. Published by *Holt, Rinehart and Winston, Inc.* 516 pages. Price $7.95.

Written by the head of the department of electrical technology at N.Y.C. Community College, this volume is designed for the engineering technician who wants and needs basic information on electronic circuitry. Prerequisite is a background in the principles of algebra, vector algebra, and basic trig plus a good foundation in d.c. and a.c. fundamentals and vacuum-tube and semiconductor characteristics.

There are 21 chapters in this volume covering power supplies, the decibel, various types of amplifiers, audio devices and special audio circuits, transistor voltage amplifiers, transistor equivalent circuits, transistor power amplifiers and drivers, sine-wave oscillators, pulse-wave generators, wave-shaping circuits, and switching circuits. Since this book was designed for classroom use, each chapter carries an extensive section on review questions and problems. This text is well illustrated by pertinent graphs, schematics, partial schematics, and photographs.

* * *

"ALL ABOUT HIGH FIDELITY & STEREO" edited and published by *Allied Radio Corporation.* 91 pages. Price 50 cents.

While the title may be a little too ambitious for a book of this size, there is an amazing amount of information for the non-technical music lover compressed into this little handbook.

The book explains the basics of high fidelity; mono and stereo sound; the functions of various individual hi-fi units; program sources; building your own equipment; transistorized audio equipment; speakers and speaker enclosures; and planning the home music system. A glossary gives clear definitions of hi-fi terms.

* * *

"BASIC INDUSTRIAL ELECTRONICS COURSE" by Alfred Haas. Published by *Gernsback Library, Inc.* 218 pages. Price $4.10.

This is a broad treatment of industrial electronics with emphasis on the practical rather than theoretical aspects of circuits and devices most often encountered in the industrial field.

The text is divided into 8 chapters covering the why and how of industrial electronics; transducers; the building blocks for electronic systems; automatic inspection, sorting, and counting; automatic machine control; electronic heating, welding, and machining; electronic safety devices; and power conversion and control.

The text is lavishly illustrated with line drawings, photographs, and schematics. Test questions are appended for either self checking or for classroom assignment.

* * *

"101 WAYS TO USE YOUR COLOR-TV TEST EQUIPMENT" by Robert G. Middleton. Published by *Howard W. Sams & Co., Inc.* 144 pages. Price $2.50.

This timely text is the ninth book in this publisher's "101 Ways" series and provides practical procedures and the use of test instruments in color-TV servicing.

One section of the book is devoted to an explanation of how to check the test equipment itself while the rest of the text deals with actual procedures to be followed in checking the various TV circuits and how to localize troubles, using standard color-TV instruments.

* * *

"HOW TO INSTALL AND REPAIR MARINE ELECTRONIC EQUIPMENT" by Elbert Robberson. Published by *John F. Rider Publisher, Inc.* 202 pages. Price $4.50.

This is a handy reference work dealing with all of the electronic equipment normally found on small boats. The book is divided into 18 chapters covering a definition of "small boat electronics," instrumentation and equipment, boat electrical systems, radiotelephone characteristics, powerboat antennas and grounds, sailboat antennas, radiotelephone installation and service, radiotelephone tuning, radio direction finder principles, RDF installation and calibration, echo sounders, automatic pilots, small-craft radar, loran, electrical interference suppression, galvanic corrosion and electrolysis, lightning protection, and consol/consolan.

Since the author is one of the "deans" of marine electronics and his experience dates back to the mid-1920's, there is little on this subject that Mr. Robberson has not encountered in actual practice.

The book is filled with practical advice, worthwhile servicing hints, and down-to-earth techniques for installing and maintaining all types of marine electronic gear.

° ° °

"WORLD RADIO-TV HANDBOOK" edited and published by *O. Lund Johansen, Ltd.* Denmark. Available in the U. S. from *Gilfer Associates*, Box 239, Park Ridge, N. J. $3.25.

This is the Seventeenth Annual edition of the SWL's "bible." Expanded to 246 pages, this edition contains over 250,000 facts about international radio broadcasting including call signs, exact location, frequencies, radiated power, transmitting hours, programming in English and other languages, announcing personnel, station ownership, mailing address, station slogan, and interval signals.

Technical data on television stations outside the U. S. is also included.

° ° °

"HOW TO DETECT & MEASURE RADIATION" by Harold S. Renné. Published by *Howard W. Sams & Co., Inc.* 156 pages. $3.95.

This is a basic text for science students, interested laymen, CB workers, and those wanting to keep up to date on what is going on in the field of nuclear power. In addition to discussing current applications in the field of power generation, instrumentation, medicine, agriculture, and industry, the text includes the equipment used to detect nuclear radiation and provides details on home-built counters of various types.

The author, formerly technical editor of this magazine, writes in a clear, easy-to-understand style which, along with the lavish illustrations, makes this book suitable for home use as well as formal classroom study.

° ° °

"PROFITABLE TELEVISION TROUBLESHOOTING" by Eugene A. Anthony. Published by *McGraw-Hill Book Company, Inc.* 407 pages. Price $7.25. Second Edition.

Since this guide first appeared over six years ago many changes have taken place in TV servicing including new types of circuits and components plus an upsurge in the popularity of color sets.

For these reasons each chapter of this new edition has been updated, a new chapter on remote controls added, and the color-TV treatment almost completely rewritten to conform to current practice.

Since this book is written by an experienced practitioner for the professional service technician, no time is wasted on frills and non-essential material. The text is well illustrated with photographs showing actual service procedures, picture-tube patterns, and equipment. Partial schematics are included where required to amplify the accompanying discussion.

* * *

"MATHEMATICAL TABLES AND FORMULAS" compiled by R. D. Carmichael & E. R. Smith. Published by *Dover Publications, Inc.* 269 pages. Price $1.00.

What a time-saver this book is for those who work with math—practicing engineers, students, or mathematicians. Here between two covers are standard log and trig tables, tables and formulas for use in algebra, elementary and analytic geometry, calculus, and all other areas of college math.

Powers, roots, reciprocals, natural logarithms, exponential and hyberbolic functions, ten-place logarithms of primes, graphs, integrals, list of infinite series—all this information and more has been packed into 269 pages of maximum usefulness. We predict most buyers will turn to this handbook with gratitude and great frequency.

* * *

"LASERS" by Bela A. Lengyel. Published by *John Wiley & Sons, Inc.* 120 pages. Price $6.95.

The generation of light by stimulated emission has captured the imagination of engineers everywhere giving rise to an almost unprecedented demand for more information on the subject.

This volume is a unified exposition of the principles of lasers in which the author presents the physics and technology of the generation of light by stimulated emission of radiation, at a level that can be grasped by scientists, students, engineers, the technically oriented administrator, and the intelligent layman.

The text material consists of an historical introduction, background material on radiation, a general description of lasers, analytical problems, solid-state lasers, fluid-state lasers, applications and developments. There is an extensive section devoted to a bibliography, tables, and an author and subject index to enable the reader to range farther afield if desired. ▲

CHASSIS DESIGN for LABS

By JAMES W. ESSEX

A new approach to wired units for experimentation and circuit study has advantages over special plug boards.

IN THE laboratories of today's educational institutions, there is a trend toward the use of components and circuits mounted on plug-boards for experimental work by students. These boards are supposed to overcome the drawbacks of the "old-fashioned" wired chassis, which were constructed without imagination and resulted in poor shop organization.

Here at the University of Waterloo, in Ontario, Canada, we began with the plug-board system in our student labs about six years ago, only to find that they did not live up to the expected savings in time and effort.

Fig. 1. A set of chassis for a single lab stacked on a storage shelf, ready to go.

With all components drawn from a central depot, the system required to maintain proper storage was discouraging. In addition, the plastic clips and plugs used for connections would loosen, with terminals becoming "open." Thus much student time in the labs was taken up with troubleshooting before desired tests could be run.

Some may argue that this troubleshooting experience has value. Nevertheless, the student is mainly there to take readings and make observations about a specific circuit, in order to learn the fundamentals of design and application. Troubleshooting eats into his limited time.

In 1960, a new approach was instituted using the "old" built-up chassis in such a way as to overcome its drawbacks. With components incorporated on each chassis, an immediate advantage was the elimination of huge, separate stores of resistors, capacitors, and other small parts. The new chassis are neat, simple, and easy to store. All chassis needed for a particular lab can be transported in a single trip, saving much set-up time; and returning them to storage is equally simple. A typical set of chassis stacked on a shelf, ready to go, is shown in Fig. 1.

A completed chassis for a class B, push-pull audio amplifier appears in Fig. 2. In addition to the schematic on the top plate, convenient jacks are installed to allow access to input and output connections as well as test points. Standard ¾" spacing is used to allow simple patch-cord connection into standard terminals on the laboratory's oscilloscopes and other instruments.

Individual plate current readings can be taken by removing the shorting bars in each of the plate leads and inserting a milliammeter. Total current can be read by removing the center shorting bar. Scope waveforms for each side of the push-pull circuit can be read without high-voltage problems by connecting across the cathode resistors. All components are mounted underneath, and the student can follow the actual wired circuit through the open bottom by turning the chassis over. A "window frame" construction is used. Note the bottom view of a chassis used for ex-

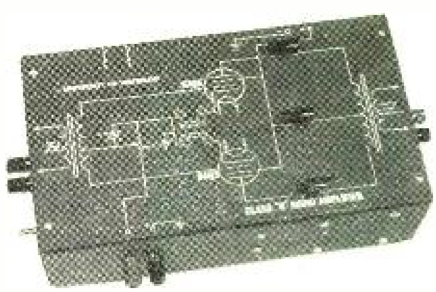
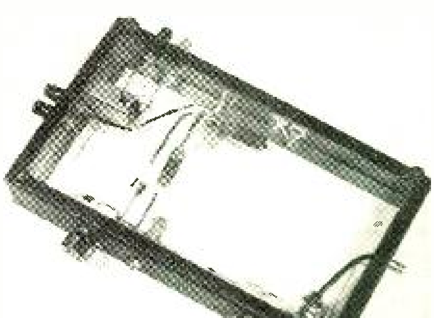


Fig. 2. Integral schematic and external connectors facilitate study of circuits.

Fig. 3. Open bottom of window-frame design renders circuit parts accessible.



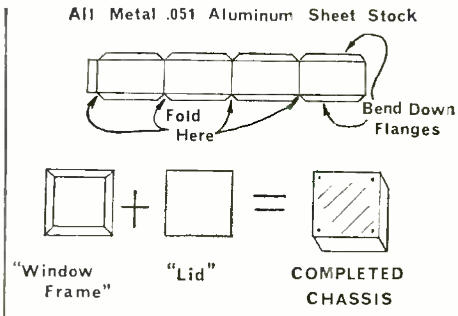


Fig. 4. Chassis fabrication is simple, involving only two pieces of metal, one of which is shaped into the main housing. The other is the top lid, cut to size.

periments with frequency conversion in Fig. 3. The top plate has been left off here.

The chassis frames are easily made from standard sheet metal stock. See Fig. 4. Several approaches were tried for getting the schematic drawings on the chassis tops. The solution chosen was one in which simple paper drawings are transcribed to a silk-screen master, then transferred to prepared metal plates used for the tops with good accuracy. After shopping around, we found a printing house that would make up the screens from our drawings.

The process is quick and inexpensive, compared to a laborious engraving process we had tried earlier. Little time is lost since the top plates are being prepared at the same time that the bottom chassis frames are being wired and tested. The tops are then fitted on and, after jacks are installed, the units are operational.

We can produce chassis of any dimensions, including odd sizes not normally available, comparable to commercially fabricated units. Because all units for any one lab are identical, assembly can be on a production-line basis for each model, which contributes to uniformity. In application, the chassis can be used over and over again with little attention or maintenance. But the many important advantages may be summarized as follows:

1. The need for lab demonstrators to "get the circuits going" is minimized, allowing more student time for dealing with the operational theory of the equipment. 2. Component breakage is eliminated, since parts are now integral to the chassis instead of being handled separately. 3. Convenient jacks enable speedier circuit checks. 4. Set-up and break-down time, previously required, is eliminated. 5. The integrated circuit schematic facilitates student correlation of the theoretical aspect of a design with the practical aspect.

With some intelligent reappraisal, the drawbacks of both the older type of wired chassis and the newer, popular plug boards have been overcome in a satisfactory design. ▲

Fixed Resistors
(*Continued from page 46*)

overloads without degradation. Temperature coefficients vary, becoming increasingly negative as the resistance per square value increases. This is because as the thickness decreases, the conductor begins to react more like a thin film and less like the bulk metal.

Thin film resistors deposited on substrate are often used in connection with deposited capacitors and semiconductors, to form complete circuits. Fig. 7 shows a power amplifier formed in this manner on a thin alumina substrate.

The amount of power that a resistor can handle is dependent not entirely on the resistor itself, but on how much heat can be transferred to the surrounding air. If the surrounding air is too hot, as might be the case in a hot climate or in an enclosed space, a derating factor must be applied. A typical derating curve is shown in Fig. 8. In this instance, the maximum ambient temperature for full-load operation is 70°C. The maximum no-load ambient temperature—the same as the maximum safe storage temperature—is 150° C. A straight line connecting these two points constitutes the derating curve.

By referring to the derating curve, it is possible to readily determine the percent of rated load at which a resistor can be operated for any given temperature. At 90°C for instance, a 1-watt resistor could be operated at about 75 percent of its rated load, or ¾ watt. At 110°C, the load should not exceed ½ watt.

It is possible for resistors to be damaged by high-voltage arcing, even when the power rating is not exceeded. This is especially true at high resistance values. A voltage rating is usually assigned to resistors in addition to its power rating to prevent use in circuits where excessive voltages may be encountered. Despite this precaution, resistors sometimes are subjected to high transient voltages which are not anticipated. These transient voltages may account for failures in apparently well-designed circuits. ▲

"All those in favor of having our next poker game in my office . . ."

Tape-Slide Synchronizer

(*Continued from page 52*)

to $J2$ to receive the marker-signal output. The control cable plug, $P1$, is plugged into the control cable input on the projector.

The slides are all loaded in place in a normal manner. As the narration is begun, it is recorded on the voice channel of the tape. Each time the slide is advanced by momentary depression of $S1$, a marker beep signal will be recorded on the control channel of the tape. The recording level should be relatively high for the control channel in order to eliminate noise that could prematurely trigger $Q1$ during playback.

When we are ready to play the narration and present the slides, the connection from the input of the tape recorder to $J2$ is removed. A connection is now made between the external speaker jack on the recorder and $J1$ on the synchronizer. This lead will carry the control signal that will trigger $Q1$. The control cable going from the synchronizer to the projector is connected as before.

During playback, the output of the recorder should be adjusted to give reliable triggering without excessive signals. This again tends to reduce possible noise problems. Each time a control beep is played by the recorder, the slide mechanism will be advanced one step. Thus we have a perfectly synchronized tape recorder and slide-projector combination.

Use with Mono Recorders

While the circuits described were designed primarily for use with a stereo (either two-track or four-track) recorder, they can be used with a single-channel mono recorder if the sound of the marker beep is not objectionable. In this case, resistor $R1$ is removed and the input at $J1$ is connected directly across the speaker output terminals of the recorder. It might be desirable to have the beep tone much higher in frequency in this case so that it would not be too audible. This can be done by reducing the values of $C4$, $C5$, and $C6$ in the oscillator circuit.

Since we now have only one channel for both control and narration, we must use a much higher amplitude for the beep tone. The lower amplitude signal for the narration will not be adequate for triggering, but when a strong beep signal is produced, the unit will be triggered and the slide will be advanced. It may be necessary to alter the value of $R2$ to obtain proper performance with some recorders. If the frequency of the beep tone is raised, it may also be necessary to change the $R3$-$C1$ time constant by using a smaller capacitor and/or resistor. ▲

ELECTRONIC CROSSWORDS

By N. F. LAVIGNE, JR.

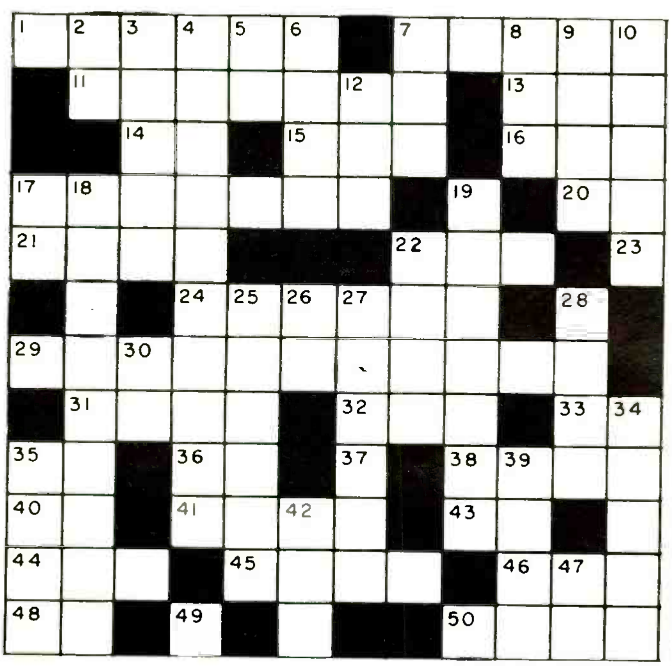
(*Answer on page* 102)

ACROSS

1. Counting system.
7. No. 1 Across is more so than the ordinary system.
11. Tube containing more than one grid.
13. Son-in-law of Mohammed.
14. Audio system for large areas (abbr.).
15. Tanned goatskin.
16. Two instrumentalists.
17. An inductor or capacitor is said to have done this when it causes a voltage to lead or lag current.
19. 500 (Roman numeral).
20. North Central state (abbr.).
21. Push- .... amplifier.
22. Tune transmitter I_p for this.
23. $I \times R =$
24. One type of computer.
29. Receiver characteristic.
31. To quote, as an authority.
32. That amount of gain after taking into account signal-to-noise ratio and any other deterring factors.
33. Close to (abbr.).
35. Crystal cut.
36. Chemical abbreviation.
37. 3.937×10^{-9} inch (abbr.).
38. On the bounding main.
40. Directional movement.
41. To choke up.
43. Abbreviation indicating operating points of a tube plotted on E_p -I_p graphs.
44. Lubricate.
45. Spanish "Bravos".
46. World War II Government agency.
48. Your family physician is one.
49. $E/R =$ ....
50. First movements upon awakening.

DOWN

2. Schematic abbreviation.
3. Kingdom between Tibet and India.
4. Causing refraction.
5. All of the resistance in the circuit (abbr.).
6. Device used to deflect in electro-magnetic CRT's.
7. Two on the color-code chart.
8. Attenuation device.
9. Founder of Troy.
10. Type of tube.
12. Accomplished the task.
17. Schematic notation for d.c. plate resistance.
18. An alloy formed below the melting point at a minimum temperature of transformation.
19. Another type of computer.
22. Symbolically, the Holy Spirit.
25. Art of decorating metal by incising and filling with a black alloy.
26. In that spot.
27. Number of lines of printed matter.
28. Unit of force.
30. Chemical abbreviation.
34. Passive detecting system.
35. Smallest part of an element capable of existing alone.
39. Type of waveguide coupling.
42. Not new.
47. 3.1416.



NEW PRODUCTS & LITERATURE

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 15.

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

FIELD-STRENGTH METER

1 **Sadelco, Inc.** has released a new and improved version of its TV and FM field-strength meter as the Model FS-1-B. Battery powered and completely portable, the instrument

weighs only 3 pounds and measures 8¼" x 4½" x 3". The unit covers TV channels 2-6, FM 88-108 mc., and TV channels 7-13 in three ranges. Input impedance is 75 ohms. The lowest calibrated division is 20 μv. with readable deflection obtained with 10 μv. Accuracy is $\pm$ 1.75 db or better.

The amplifying and metering circuits are thermistor controlled to maintain instrument accuracy between +32 and +85 degrees F. Two 9-volt transistor-radio-type batteries power the unit. The circuit uses 8 transistors, 5 diodes, and 2 thermistors.

STRETCH CABLE

2 **National Radio Company, Inc.** announces a new addition to its line of stretch cable which is now available with an outer covering of silicon rubber or extruded pure rubber. Because of their rubber outer casing, these cables are especially suited for use under high humidity conditions or in chemically contaminated environments.

The cables have a capability of 300% stretch from relaxed position and will maintain complete conductivity under any degree of tension.

TRANSISTOR IGNITION SYSTEM

3 **Motorola Inc.'s** Automotive Products Division has introduced a transistor ignition system which is said to give breaker point life many times that of conventional systems, provide easier cold-weather starting, and improve high-speed performance.

Designed to be used on any automotive, marine, or stationary engines having battery ignition, the new ignition system is available in four models to accomodate 12-volt negative or positive or 6-volt negative or positive ground electrical systems.

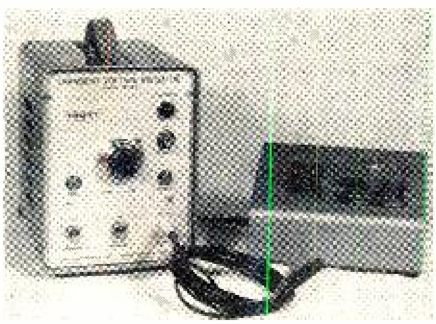
The system is supplied as a kit which includes a transistor amplifier, a special ignition coil, a ballast resistor, installation cables, assorted hardware, and special distributor cam lubricant.

TWIN DIODES

4 **Workman Electronic Products, Inc.** has developed twin diodes, Models S3AL5 and S6AL5, to replace conventional tubes 3AL5, 6AL5, and 12AL5. The new units are priced lower than the tubes. There are no filaments to burn out and, according to the manufacturer, video circuits will have more detail, audio circuits better fidelity, and sync circuits increased locking range.

TRANSIENT-VOLTAGE COUNTER

5 **Trott Electronics, Inc.** is now offering a transient-voltage counter, the Model TR741EC. The unit consists of a counter, relay, battery, and other electronic components housed in an aluminum enclosure measuring 7¼" x 4½" x 4½" and weighing 3 pounds. Counting speed is 10 counts per second while the counting range is four



digits (0-9999). The instrument is operated from a 22½-volt "B" battery.

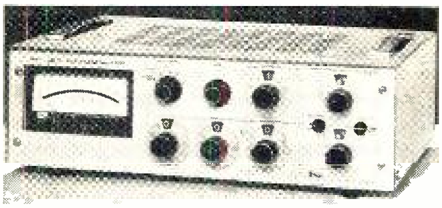
The counter is used in conjunction with the firm's TR741B transient-voltage indicator to read out the number of transient voltage occurrences during a given period of time. The counter alone may be used for pulse height comparison of a series of pulse or peak voltages.

SCOPE RECORDING CAMERA

6 **Beattie-Coleman, Inc.** is offering a new model oscilloscope recording camera, the "K-5 Oscillotron". The new instrument offers two object-to-image ratios: 1:0.9 and 1:0.7. It also features variable focus, vertical or horizontal format, flat-field f/1.9 lens, and a new and lighter die-cast aluminum construction. It has a standard **Polaroid** back. Direct binocular viewing of the CRT while recording is possible. The camera is designed to fit any standard 5" oscilloscope.

HIGH-SPEED PICOAMMETER

7 **Keithley Instruments** has recently introduced its Model 417 picoammeter which is said to provide a tenfold increase in response speed over comparable instruments. The unit incorporates all solid-state circuitry with the exception of one electrometer tube. It offers wide range and sensitivity from 10^{-13} ampere full scale to 3 x 10^{-5} ampere, zero drift of less than one percent in 8



hours, and calibrated current suppression to 1000 times full scale. Accuracy is within 3%. A 3-volt, 1-ma. output for recorders is available for full-scale signals on any range.

The unit is housed in a 5½" x 19¼" x 13½" enclosure for standard rack mounting. A conversion kit is available for bench mounting. Power requirements are 105-125 volts or 210-250 volts, 50-1000 cps, 20 watts.

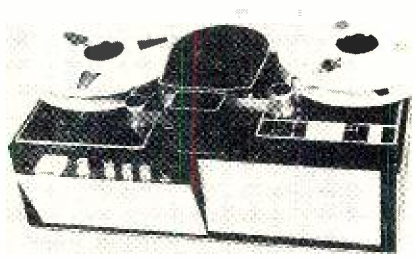
NUMERICAL READOUT TUBE

8 **Amperex Electronic Corp.** has introduced the first practical biquinary numerical indicator tube as the type ZM1032. The new component is designed for readout applications in digital voltmeters, cash registers, calculating machines, computers, and counters.

Construction of the biquinary tube differs considerably from ordinary decade indicator tubes. The ZM 1032 has two separate anodes and is divided internally into two vertical compartments by a shield electrode. The rear compartment contains one anode and the figures 0-2-4-6-8. The front compartment contains the other anode and the figures 1-3-5-7-9. With this tube only seven transistors are needed in the driver circuitry instead of the usual 10. In addition to cost savings per decade, the simplified circuitry possible with the biquinary tube is said to have significant effect on system reliability.

CCTV TAPE RECORDER

9 **Machtronics, Inc.** has developed a portable CCTV tape recorder which it is marketing as the MVR-10. The unit which weighs 65 pounds and measures 24⅞" x 10⅜" x 13 7/32" accepts composite video signals from any image orthicon or vidicon source. The sync may be industrial or EIA standard. The video signal is placed on the tape by the helical scan method,



using 180° tape wrap and two long-life, high-output video heads.

The instrument will handle 10½" reels and operates at 7.5 ips; providing 96 minutes of recorded material. Power requirements are 117 volts, 60 cycles.

400-CYCLE TRANSFORMERS

10 **Magnetic Circuit Elements, Inc.** is offering a new line of standard 400-cycle transformers with bi-directional application flexibilty. The new units have a center-tapped primary and two

identical secondaries and can be used in step-down applications or in the reverse direction for converter applications.

The new line comes in seven different sizes with power ratings ranging from 2.4 to 215 volt/amperes. Engineered primarily for missile-space applications, the 71 electrically different parts are available off-the-shelf in an encapsulated MIL-727A Grade V package.

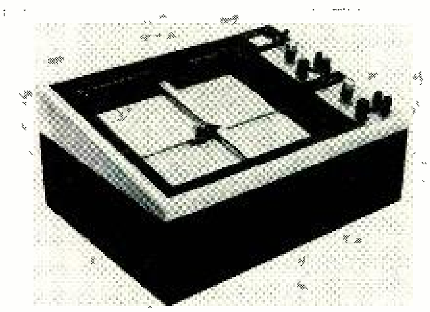
SOLDERING IRON INDICATOR

11 **Electronic Ideas, Inc.** is now offering a pencil-type soldering iron with a built-in light indicator. The indicator lamp, built into the handle, gauges tip temperature and wattage. The lamp burns brightly on 50 watts and dimly on 40 watts An added safety advantage is being able to tell when the iron is hot (when the lamp is lit) thus preventing serious burns.

The "Sidco" Model KC 1200B is made of special heat-stabilized nylon. A self-adjusting spring socket holds tips in perfect contact. The handles are in blue with a 6-foot long gray cord

X-Y RECORDER

12 **Houston Instrument Corporation** is marketing a new X-Y recorder which is moderately priced for instruments of this type. The HR-96T features 1 mv./in. 10 v./in. sensitivity, 100,000-ohm constant input impedance, switch-



selectable stepped input attenuators, X-axis time sweep, 0.25% accuracy, electric pen lift, and snap-on pen assembly.

The recorder takes 8½" x 11" and 11" x 16½" chart papers and is available in either 115-volt, 50-60 cps or 230-volt, 50-60 cps versions.

SECONDARY FREQUENCY STANDARD

13 **Eltec Laboratories, Inc.** is marketing the Model 700 "Zero-Beat," a three-in-one instrument which serves as a secondary frequency standard, a 5-kc. FM deviation standard, and provides signal generator output. Frequency range is 25-470 mc. and ambient temperature range is from −10 to +130 degrees F. Operation is on 117 volts a.c., 6/12-volt inverter, or auxiliary generator from 95 to 130 volts. Power input is 50 watts.

The instrument measures 18⅞" x 11⅛" x 6¼" and weighs 21 pounds. Accuracy is .0002% as primary standard in field service and .00003% secondary standard under lab conditions. There are six front-panel controls and four output terminals plus external modulation input and common ground terminals.

CRT TESTER & REJUVENATOR

14 **Eico Electronic Instrument Co. Inc.** is now offering a portable CRT tester & rejuvenator in a luggage-type wood carrying case with an accessory compartment that houses a line cord and universal multi-socket cable that accomodates any CRT, black-and-white or color.

The Model 632 incorporates a transformer-operated 1000-volt d.c. supply for repairing CRT defects, a 150-volt negative d.c. supply with pot which provides continuously variable grid cut-off voltage to indicate contrast range of the CRT, plus a 25-watt rheostat and a three-range filament voltage selector for filament voltages in the 0-5, 5-10, and 10-15 volt ranges.

A panel switch selects the red, green, and blue guns of color CRT's for individual testing as for black-and-white tubes. A 4½" three-color "Good-?-Bad" meter and a neon lamp are used as indicators.

ELECTRONIC THICKNESS TESTER

15 **Twin City Testing Corporation** is introducing the "Permascope", an instrument which permits very accurate measurement of any non-magnetic coating thickness on a magnetic base.

This electronic thickness tester features a transistorized amplifier and a built-in rechargeable power pack, which makes it independent of outside power. The instrument can also be used with an a.c. outlet without damaging the batteries.

The unit is portable, weighs less than 16 pounds, and can be used in temperatures ranging from −20 to +150 degrees F. A built-in power check is provided.

THERMOELECTRIC DEMONSTRATOR

16 **Westinghouse Semiconductor Division** has developed a thermoelectric educational unit which comes with a matched direct-current power supply. The unit, type W830, demonstrates the principles of thermoelectric cooling (Peltier effect) and generation (Seebeck effect). It is designed for use in college engineering courses, industrial research laboratories, electronic and electrical school programs, and prep school programs in advanced physics.

All components are mounted on an engraved aluminum panel and the unit is housed in a walnut case measuring 8½" x 4" x 3". Power requirements are from 0 to 1 volt a.c. at 5 amps, 0 to 115 volts a.c. at 1 amp., and 0 to 1 volt filtered d.c. at 20 amps.

PORTABLE 100-KV V.T.V.M.

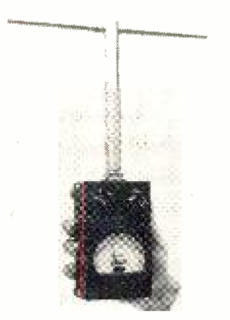
17 **Jennings Radio Manufacturing Corp.** has announced a new transistorized, battery-operated voltmeter designed for highly accurate measurements of a.c., pulse, and r.f. voltages up to 100 kv. Frequency response is flat from 20 cps to over 50 mc. Accuracy is ± 3% full-scale for all ranges.

Vacuum capacitive voltage dividers, which are carefully shielded to prevent r.f. pickup and erroneous readings, reduce the voltage to be measured to a value permitting convenient and accurate metering as well as visual operation.

The instrument is powered by five batteries and has direct-reading linear voltage ranges of 2.5, 5, 10, 25, and 50 kv. (50 kv. across each divider, 100 kv. across both dividers). Loading capacitance is less than 5 pf.

MAGNETIC FIELD SURVEYOR

18 **Instrument Systems Corp.** is offering a compact, self-contained, portable magnetic field surveyor, Model 507, which utilizes a precision Hall effect generator as its sensor. The instrument detects direction and measures the strength of d.c. magnetic fields in gauss. Readings of earth's magnetism or lower can be readily observed. Zero centering permits polarity determination.



Dimensions are 3" wide x 5¼" high x 2⅛" deep. Weight is 2 pounds. Meter ranges are 1-0-1, 5-0-5, and 20-0-20 gauss. Accuracy is ± 5% from 0-10 gauss and ± 10% from 10 to 20 gauss.

FRAME-GRID TUBE

19 **Amperex Electronic Corporation** is in production on the first instant-heating harp cathode tube to utilize a frame grid and to achieve relatively high power at u.h.f. frequencies with fast warm-up time.

Designed for use in continuous and intermittent vehicular communications equipment, the 8408 features a power output of 6 watts at 500 mc. with an instant-heating warm-up time of under 0.5 sec. The tube is a push-pull tetrode designed for use as an r.f. amplifier or frequency multiplier in transistorized vehicular transmitters. It is internally neutralized for frequencies up to 500 mc. and operates on a heater voltage of 1.1 volts. Amplification factor is 26 and transconductance 700 μmhos per unit.

STRIP CHART RECORDER

20 **Amprobe Instrument Corporation** has added a new high-voltage model to its miniature strip chart recorder line. The Model PAV8600 records in three voltage ranges: 0-150, 0-300, and 0-600 volts a.c. It makes a permanent record on pressure-sensitive strip-chart paper that loads like film in a camera. The stylus is inkless and is not affected by heat, moisture, or cold. With the chart paper removed, the instrument can be used as a direct-reading meter.

The recorder measures 6 9/16" x 3⅜" x 1 11/16" and weighs only 20 ounces.

HI-FI—AUDIO PRODUCTS

"SPHERICAL-SOUND" SYSTEM

21 **Murray-Carson Corporation** has developed a new cavity generator spherical-sound system which provides 360-degree propagation from a compact point source. The frequency range of the "Camille" series is 30-17,000 cps and the system is designed to handle 8 watts of program material. The cabinets measure 11" x 8" x 4¼" and come in harvest maple, limed oak, and oiled walnut finishes. Impedance is 8 ohms in the standard cabinets but other impedances are available on request.

The enclosure is designed to be mounted on shelf, table, wall, or floor. The unit weighs 5 pounds.

INDUCTION PICKUP COIL

22 **Fargo Company** is now offering a subminiature pickup coil which has been especially designed for use with transistorized recording, amplifying, and radio transmitting equipment.

The Type F-105 coil makes it possible to use transistorized battery-operated tape recorders, as well as transistorized amplifiers, dictating machines, and pocket portable radio transmitters, for pickup of phone conversations. Measuring only ⅜" x ⅜" x ⅝", the pickup may be held in place by pressure-sensitive tape. The unit will operate with a remote pickup cable up to 100 feet in length. It may also be used with a.c.-operated recorders having high-impedance input by the addition of a standard 100-ohm matching transformer.

STEREO TAPE RECORDER

23 **Freeman Electronics** is in production on a three-speed, high-fidelity, self-contained stereo tape recorder, the Model 600.

The instrument offers any combination of four-track and two-track stereo and/or mono record and playback, sound-with-sound, and sound-on-sound. It has built-in power amplifiers and ex-

tended-range stereo speakers. The amplifiers will drive up to ten external speakers from stereo jacks.

The power supply is transistorized thus making the over-all weight of the unit 44 pounds. The recorder measures 19" high x 17½" wide which permits the cover to be closed when playing reels up to 7".

The Model 600 features automatic shut-off, five stereo jacks, hysteresis-synchronous motor, cathode-follower preamp outputs, stereo/multiplex recording, dual illuminated vu meters, wow and flutter .15% @ 7.5 ips, 3-digit tape index, and optional vertical or horizontal operation.

SMALL-SIZE SPEAKER SYSTEM

24 **KLH Research and Development Corp.** is currently marketing a new compact speaker system, the Model Fourteen. The system uses two compliant full-range speakers whose diameter is only 3" and maximum excursion ⅜". The excursion is controlled by the high ratio of magnet power to cone lightness. There is no crossover network.

Incorporated is a passive electronic network which reshapes the power output of any conventional amplifier to match the low-frequency power requirements of the speakers. The new speaker system measures 18" x 14" x 3¾" deep.

FM MODULATION MONITOR

25 **McMartin Industries, Inc.** has received type-approval on its new TBM 3500 FM modulation monitor which operates in conjunction with the firm's TBM 3000 frequency monitor to provide a complete basic station monitor as required by the FCC.

The new unit is accurate within ± ½ db from

50 to 75,000 cps and is capable of monitoring all modulation, including FM stereo and SCA multiplex. The peak flasher is extremely fast, responding to pulses with duration as short as 10 msec. Distortion is less than 0.5%.

STEREO AMPLIFIER KIT

26 **Fisher Radio Corporation** has added a dual-channel basic stereo amplifier, the K-1000, to its line of "Stratakits." Music power rating is 150 watts IHF standard with both channels driven. The r.m.s. power rating, both channels driven, is 130 watts (65 watts per channel). However, each channel will deliver at least 75 watts at well under 1.0% distortion, according to the manufacturer.

The major components come pre-mounted on an extra-heavy-gauge steel chassis. Wires are pre-cut for every stage and complete instructions for assembly are included. Frequency response is 20-20,000 cps ± .5 db and ± 1 db from 8-48,000 cps. The assembled kit measures 15⅛" wide x 7¾" high x 12" deep. It weighs 70 pounds.

COMBINATION MAGNETIC HEAD

27 **The Nortronics Company, Inc.** is offering a new series of compact magnetic heads which combine the record/play and erase functions in one miniature assembly. Case size is 0.490" high, 0.575" wide, and 0.580" deep.

The complete line of these space-saving, cost-cutting heads includes 4-track and 2-track stereo record/play and erase combinations; 4-track, 2-track, and full-track mono record/play and erase combinations; as well as heads with custom configurations for specialized applications. Heads in the new series feature lamination construction with quartz gaps, precision polished all-metal face, and are offered with either hyperbolic or cylindrical face contours.

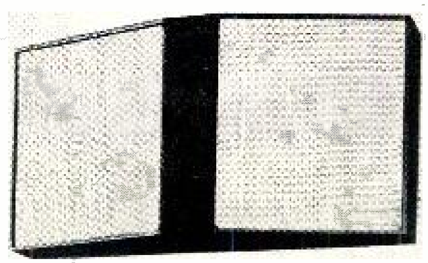
INTEGRATED STEREO AMP/PREAMP

28 **Dynaco, Inc.** is now offering its first integrated stereo preamplifier and power amplifier as the Model SCA-35. Available in either kit or factory-assembled versions, the new unit provides a full 17½ watts of continuous power for each channel over the 20-20,000 cps spectrum. A patented output transformer design is utilized for improved performance.

By IHF music-power ratings, this is a 45-watt amplifier. All necessary control functions are available on a simple front panel. The factory-assembled etched circuits reduce kit construction time to 8 hours. The unit provides adequate gain for all magnetic cartridges and tape heads. Provision is made for stereo headphones or third-speaker output. A specially designed bandpass filter eliminates rumble and scratch.

WALL-MOUNTED SPEAKER SYSTEM

29 **Utah Electronics Corporation** is now offering a wide-angle, high-power, wall-mounted speaker system as the TP88. Utilizing tapered faces for wide-angle dispersion, the new system provides coverage of long, narrow rooms.



Although only 4" deep in the center, the system will handle 15 watts of peak audio power. Two 8" speakers of thin basket construction are prewired to a screw-type terminal board for ease of installation. The unit is available in blonde, walnut, and mahogany finishes and comes complete with all mounting hardware. Over-all size is 10" high x 20" wide.

SHALLOW SPEAKER SYSTEM

30 **Jensen Manufacturing Company** has recently introduced a five-speaker, four-way sound system which is housed in a cabinet measuring 16" high x 25½" wide x 8½" deep. The TF-4 incorporates a high-compliance, long-travel "Flexair" woofer, a special 8" midrange, two 3½" tweeters, and an E-10 "Sono Dome" ultra-tweeter.

Frequency range of the system is 25 cps to beyond audibility. Crossovers are at 600, 4000, and 9000 cps. Speaker power rating is 25 watts and impedance is 8 ohms. Currently the system is offered in walnut and unfinished versions.

TAPE TRANSPORT

31 **KS Instrument Company** has just introduced the "500" tape transport which measures 19" wide x 10½" high x 7" deep and is designed to be operated in any plane.

The transport is available at speeds of 1⅞, 3.75, 7.5, 15, 30, 60 ips in any consecutive combinations. Response at 7.5 ips is 50-15,000 cps ± 2 db. Features included in the basic unit are automatic tape lifter, digital tape counter, electrostatic tape cleaner, input-output jack, automatic tape stop for tape break or end of reel, secondary flywheel on hysteresis motor, electrodynamic braking and tensioning memory system, two speeds (3.75 & 7.5 ips), ball-bearing drive mountings, and fail-safe and totally interlocked electronic controls.

A variety of optional features and accessories for use with the basic transport are available.

TAPE-TRANSPORT MOTORS

32 Western Gear Corporation's Electro Products Division has developed a new synchronous motor for tape transport fast-reversing capstan drives, the Model 3741HP1. The new motor is only one-third the size of its conventional hysteresis motor counterpart, it starts and reverses in half the time, provides two to three times the damping, has only one-fifth as much jitter, and requires no extra cooling.

The unit operates on 60-cycle, 117-volt a.c. with a speed of 1200 rpm. Torques of 75 oz.-inch starting, 70 oz.-inch pull-in, and 130 oz.-inch pull-out are specified. The motor is 4" long and has a diameter of 4⅝".

CB-HAM-COMMUNICATIONS

MOBILE FACSIMILE SYSTEM

33 Radcom-Westrex division of Litton Industries has developed a high-speed mobile facsimile system which can transmit photographs or other copy up to 4¼" x 3¼" in 4¼ minutes half-way around the world.

The AN/GXC-4 system consists of a transmitter, which is designed to be carried in a jeep, truck, light aircraft, or helicopter, and a recorder which can be located anywhere in the range of the radio set being used for transmission. Each unit weighs about 100 pounds and measures approximately 16" x 16" x 20". Signal carrier is 2400 cps and scanning resolution is 300 lines per inch. The system operates from 117-volt, 60-cycle a.c.

MARINE RADIOTELEPHONE

34 Aeronautical Electronics, Inc. has announced the availability of a new v.h.f. FM marine radiotelephone, the "Aerotron Sea-Line". The unit provides static-free FM communications on four crystal-controlled channels (156.8 mc. for calling and safety, 156.3 mc. for ship-to-ship, 15645 mc. for marinas, yacht club, and shore facilities and 157.3/161.9 mc. for marine radiotelephone service).

The radiotelephone requries no ground-plate,

the tuning is unaffected by fresh or salt water, and needs only a small coaxial whip antenna for peak performance.

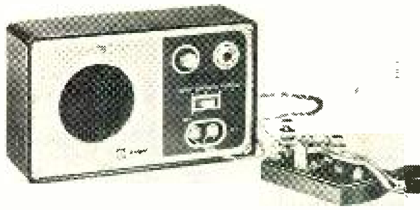
23-CHANNEL SELECTOR SWITCH

35 Kavin Engineering Company is marketing an electrically symmetrical 23-channel selector switch which is designed to be easily mounted on any tunable-receive CB transceiver. Minimum circuit upset is achieved by d.p.switching, completely symmetrical construction, and low capacitance design.

The switch will accommodate crystals on hand as well as permitting other crystals and dial markers to be added as the sockets are filled. The switch comes complete with dial, mounting hardware, and instructions, but without crystals.

CODE PRACTICE OSCILLATOR

36 Knight Electronics Corporation is marketing a two-transistor, battery-powered code practice oscillator in kit form as the Model LC-1. Either audible tone or a code flasher can be used for monitoring practice sessions. A built-in speaker provides sufficient volume for group



practice while a handy phone jack permits the use of high-impedance headphones for private monitoring. The key has the "feel" of on-the-air operation.

The unit measures 2" x 6¼" x 3¾" and weighs only 2¾ pounds. The kit comes complete with key, battery, all parts, and instructions for assembling the device.

MULTI-TONE GENERATOR

37 Westlab, Inc. has developed a multi-tone generator that is self-powered and transistorized. The Model SP-101 produces three widely different call tones for a wide range of signal applications such as a siren tone for air-raid or emergency alarm, a steady tone for "all-clear" signalling and a fire-alarm pulse tone.

The unit operates instantly when activated and is adaptable to any switching device such as varisters, program clocks, auto-call, and fire-alarm pull boxes. It can be used with p.a., voice-warning, or paging systems. The unit weighs 10 ounces and measures 1⅝" x 2⅝" x 6¾". It operates from 117-volt, 50-60-cps power sources.

MANUFACTURERS' LITERATURE

CERAMICS SELECTOR CHART

38 Cornell-Dubilier Electronics Division is offering copies of its "Ceramics Selector," a 17" x 22" wall chart designed to assist engineers in selecting ceramic capacitors for commercial, industrial, military, and high-reliability applications.

General purpose, temperature-compensating, and feedthrough capacitors are the three major classes covered by the chart. Twenty different ceramic capacitor types are listed with line drawings and dimensions.

THE "TELSTAR" STORY

39 Bell Telephone Laboratories has published an elaborate, 72-page illustrated color booklet which contains ten semitechnical articles about the engineering that went into the "Telstar" project: the communications equipment in the satellite, the Andover ground station, and the satellite launch operations.

The material originally appeared in the April 1963 issue of the Bell Laboratories "Record."

OSCILLOGRAPH RECORDERS

40 Clevite Corporation is offering copies of its 16-page, three-color illustrated brochure "New Concepts in Recording," which describes oscillograph recording systems for military, industrial, and scientific applications.

The brochure covers significant developments of the past two years, contains a series of applications to show where direct writing recorders can best be applied, and describes the actual equipment in some detail.

SPEAKER/TURNTABLE DATA

41 Acoustic Research, Inc. is offering a 12-page booklet covering its acoustic suspension loudspeakers and turntables. The firm's AR-3, AR-2, AR-2a, AR3t and AR-3st speakers are pictured and described and details are provided on the 33½ and 45 rpm turntable.

TRANSFORMER DATA

42 United Transformer Corp. has announced publication of two new 1963-64 catalogues on iron-core components. Volume 1 which runs 52 pages covers transformers, inductors, and "Magamps." Volume 2 deals with electric wave filters, high-"Q" coils, and inductors in 24 pages.

All of the catalogue items, as listed are available for immediate delivery.

The company's capability for producing custom-built components is also discussed.

TRANSISTORIZED INDICATOR LIGHTS

43 **Dialight Corporation** has published a 10-page, two-color catalogue which discusses the principles, design, and construction of its STI-series subminiature transistorized indicators lights. Two general classes of lights are covered: units for connection to power at 90 volts or more and units for low voltage circuits of 6 volts or more.

One section of catalogue L-166B is devoted to an application form which outlines conditions and requirements of transistorized lights.

TUBE PROCUREMENT DIRECTORY

44 **Corvair Electronics, Inc.** is offering copies of its 8-page "Electronic Tube Procurement Directory" which lists more than 2500 of the most popular types. Prices for various quantity breaks are stated. All standard brands are covered in this integrated listing. Types include special purpose, phototubes, transmitting, counter, telephony, miniatures, subminiatures, ignitrons, klystrons, magnetrons, rectifiers, strobes, thyratrons, sockets, industrial CRT, and receiving tubes.

SILICON CONTROLLED RECTIFIERS

45 **National Electronics Inc.** has issued two four-page data sheets covering its 16- and 25-ampere series of silicon controlled rectifiers. Included on the data sheets are maximum ratings, characteristics at maximum ratings, outline drawings of the units, and graphs of various performance characteristics.

COMPUTER PRODUCT DATA

46 **Ampex Corporation** has released an 8-page catalogue covering its complete line of computer products. Included in the two-color publication are cores, arrays, stacks, tape transports, read-write electronics, and tape. Applications, features, advantages, and specifications are listed.

PHOTO CREDITS

Page	Credit
22	Audio Dynamics Corporation
24	Allied Radio Corporation
31 (Fig. 2), 32 (Fig. 3)	Orthophon
41 (top)	General Radiotelephone
41 (bottom)	Lafayette Radio Electronics Corp.
43	Raytheon Co.
44 (Fig. 1)	International Resistance Corp.
44 (Fig. 2), 46 (Fig. 7)	Holex, Inc.
45, 46 (Fig. 6)	Corning Electronics Components Div.
51	Hughes Aircraft Company
74	Eico Electronic Instrument Co.
75	Dynascan Corporation
76	Seco Electronics
91	University of Waterloo (Ont.)

Answer to Electronic Crosswords

(Appearing on page 95)

B	I	N	A	R	Y		R	A	P	I	D
	P	E	N	T	O	D	E		A	L	I
		P	A		K	I	D		D	U	O
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	C	I	T	E		N	E	T		N	R
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O	I	L		O	L	E	S		O	P	A
M	D		I		D			S	T	I	R

Replacements for Domestic Transistors

(Continued from page 36)

ORIG. TYPE	REPLACE BY TYPE
S-95106	2N1524
S-95201	2N406
S-95202	2N649
S-95203	2N408
S-95206	2N406
S-95207	2N408
T-45	2N408
T-46	2N412
T-47	2N410
T-48	2N410
T-50	2N217
T-59	2N410
T-60	2N410
T-61	2N408
T-72	2N408
T-74	2N406
T-76	2N649
T-77	2N217
T-81	2N408
T-82	2N408
T-83	2N406
T-84	2N406
SONY	
A-122	2N372
B-51	2N408
C-73	2N412
C-75	2N410
C-76	2N410
D-63	2N649
D-65	2N406
D-66	2N406
SYLVANIA	
T-50631	2N408
T-50944	2N410
TRUETONE	
SC-43	2N410
SC-44	2N410
SC-45	2N217
SC-46	2N410
VIKING	
M-351	2N1177
R-424	2N1177
R-425	2N1178
WESTINGHOUSE	
003H03	2N408
011H01	2N412
012H01	2N410
297V003	2N408
297V011	2N412
297V012	2N410
3500	2N408
3504	2N406
10036	2N408
10037	2N408
10038	2N408
10039	2N408
R-289	2N406
R-290	2N406
R-291	2N408
R-608	2N406
ZENITH	
12144	2N370
12146	2N408
12147	2N270
12148	2N371
12149	2N372
12152	2N407
12161	2N632
12162	2N411
12163	2N544
12164	2N362
12165	2N409
12166	2N409
12173	2N409
12178	2N544
12180	2N1425
121120	2N406
121145	2N412
121151	2N408
121152	2N406
121153	2N410
121154	2N410
121161	2N407
121162	2N412
121164	2N408
121179	2N1527
121180	2N1425
121181	2N1525
121185	2N1525
R-16	2N408
R-258	2N412
R-497	2N406
R-579	2N410

 CIRCLE NO. 125 ON READER SERVICE PAGE

FAMOUS BC-645 TRANSCEIVER

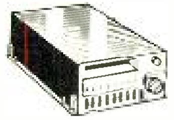
BRAND NEW! 15 Tubes 435 to 500 MC

Can be modified for 2-way communication, voice or code, on ham band 420-450 mc, citizens radio 460-470 mc, fixed and mobile 450-460 mc, television experimental 470-500 mc, 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton. Shipping weight 25 lbs. **SPECIAL!** . . . **$19.50**

PE-101C Dynamotor, 12/24V input **$7.95**
UHF Antenna Assembly **2.45**
Complete Set of 10 Plugs **5.50**
Control Box **2.25**

SPECIAL "PACKAGE" OFFER
BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW While Stocks Last **$29.50**

ARC-3 RECEIVER!



Complete with All Tubes Exc. Used **$21.50**
Like NEW **$33.50**

Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 preselected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.
110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested **19.95**

ARC-3 TRANSMITTER

Companion unit for above tunes 100 to 156 MC on any 8 pre-selected channels, 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used . . . . .Only **$18.95**
Like new condition **$28.50**
ARC-3 PUSHBUTTON CONTROL BOX **$5.95**

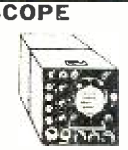
ASB-5 'SCOPE INDICATOR

BRAND NEW, including all tubes, **together with 5BP1 'Scope Tube.** Originally used in Navy Aircraft RADAR equipment. Easily converted for AC operation.
VALUE $250.00!
OUR LOW PRICE **$16.95**

LORAN APN/4 OSCILLOSCOPE

Easily converted for use on radio-TV service bench. LIKE NEW! Supplied with 5" Scope, type 5CPI only **$14.95**

APN-12 3-INCH SCOPE

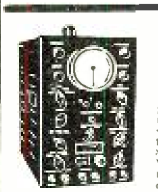


Has vertical and horizontal sweep with focus and intensity controls, coaxial antenna changeover motor. Complete with 11 tubes and 3JP1 CR Tube. For 115 V, 400 cycle AC and 24 V DC. Circuit diagram included. **LIKE NEW** . . **$14.95**

BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. **BRAND NEW, OUR LOW PRICE** . . . **$12.88**

TS-100AP 'SCOPE



EXC. USED (worth $750)
OUR LOW PRICE **$39.50**
Brand New $69.50

Can be used with linear sweep or general purpose test scope. Cable included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.

LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 Kc to 20,000 Kc With Calibration book
Complete, Like New **$69.50**

DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A 28V 7A	575V .16A 540V .25A	2.95	4.45
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-36	28V 1.4A	220V .080A	1.95	2.95
DM-37	25.5V 9.2A	625V .225A	2.95	4.22
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
PE-86	28V 1.25A	250V .050A	2.75	3.85

DM-37 DYNAMOTOR, Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

IMPORTERS—EXPORTERS of ELECTRONIC EQUIPMENT

We specialize in the export of military surplus electronic equipment:

- **All at LOWEST PREVAILING PRICES.**
- **In addition to items shown on this page, we have in stock or can obtain for export customers, military electronic equipment made for World War II, Korean War, and later.**

Many thousands of items in our huge warehouse.

- **IF YOU DON'T SEE WHAT YOU WANT HERE, WRITE US YOUR NEEDS. LET US QUOTE ON ANY GOV'T SURPLUS ELECTRONIC EQUIPMENT YOU SEE ADVERTISED ANYWHERE. INQUIRIES WELCOMED.**
- **All packing and shipping is made directly from our own warehouse in NYC to give you substantial savings in handling costs!**

LORAN APN-4

FINE QUALITY NAVIGATIONAL EQUIPMENT

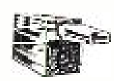
Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes. Exc. Used. **$69.50**

NEW! APN-4A Receiver-Indicator as above, changed to operate same as APN4-B for improved performance . . . . .NEW **$88.50**
Shock Mount for above **$2.95**

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC. OUTPUT: 115 V AC, 800 cycles. Like New **$22.50**

12-Volt Inverter Power Supply for above APN-4. Like New. P.U.R.
We carry a complete line of spare parts for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR



Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition **$79.50**
Used, with all parts, less tubes, crystal and visor . . . . Special **$29.50**

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. Like New **$22.50**

12-V. Power Supply for APN-9, like New P.U.R.
Shock Mount for above **$2.95**
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC.	$12.95	$14.95
BC-454	Receiver 3-6 Mc.	12.45	17.95
BC-455	Receiver 6-9 Mc.	11.50	13.95
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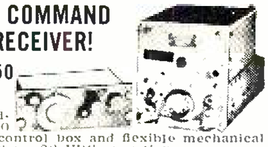

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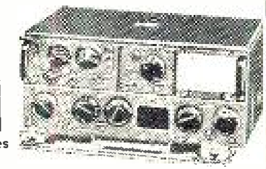
11 CHANNELS
200-1500 Kc
2 to 18.1 Mc



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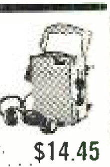

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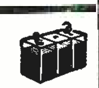

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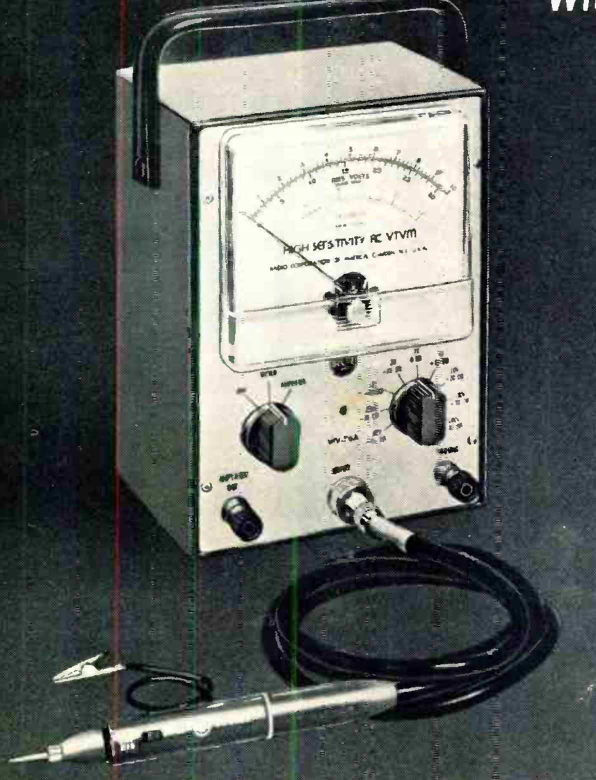

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Measures AC Voltages .0002-Volt to 500 Volts
Doubles as a Preamplifier

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- Large power-supply filter minimizes hum.
- Compact, lightweight, portable.

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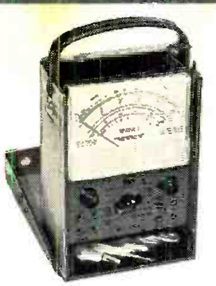

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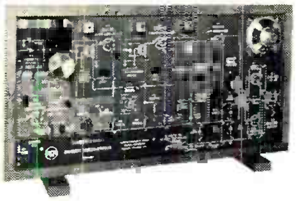

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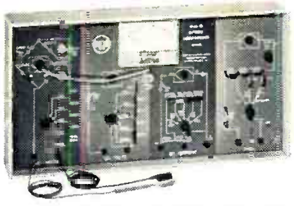

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