# Electronics World

JANUARY, 1966
50 CENTS

## A PROVEN TRANSISTOR IGNITION SYSTEM
## V.H.F.: MARINE RADIO'S NEW HORIZON
## RADIOLOGICAL SURVEY METERS

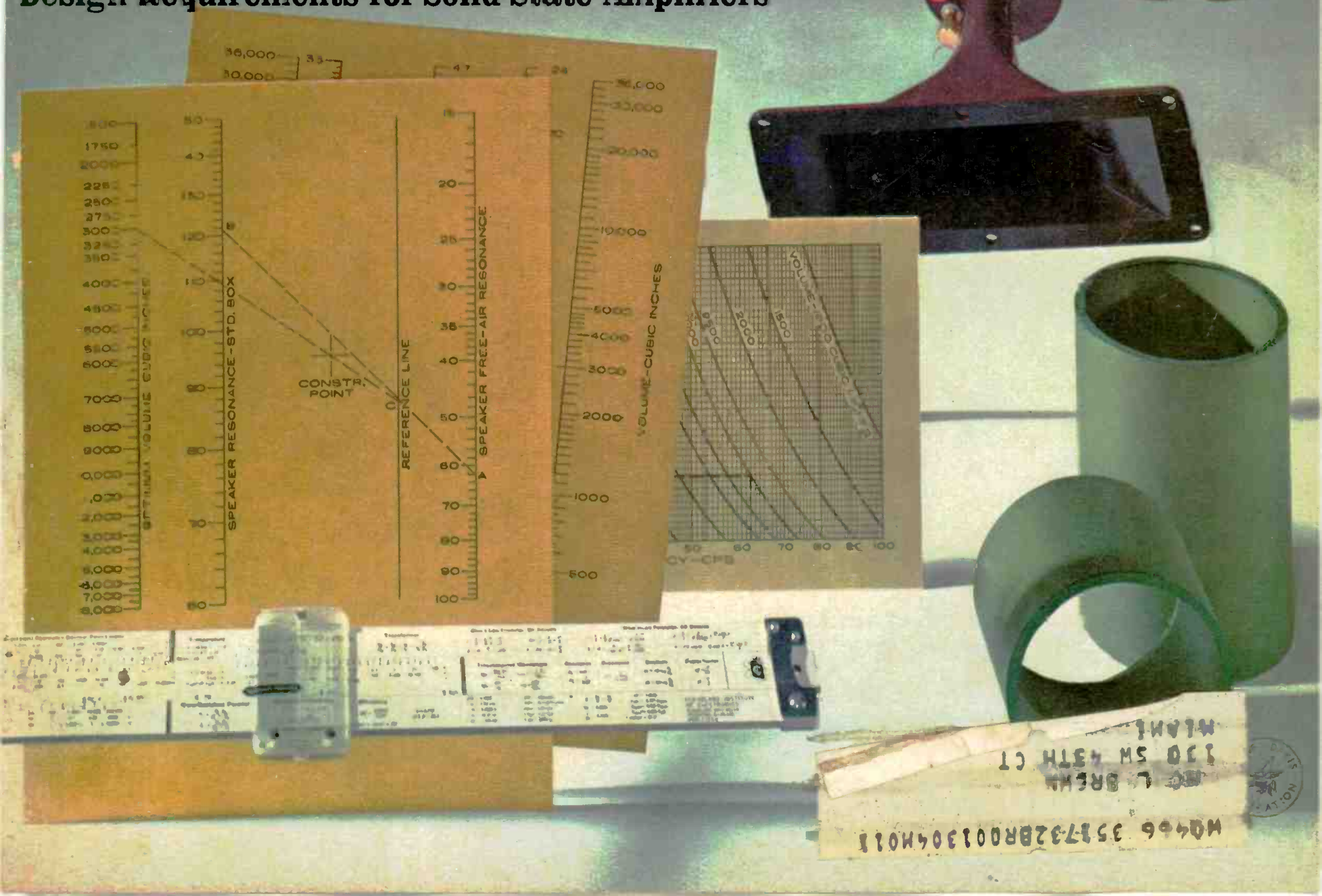
### SPECIAL HI-FI FEATURES

COVER STORY

## DESIGNING HI-FI SPEAKER ENCLOSURES

**Performance Characteristics of all Solid-State Amplifiers, Tuners, and Receivers**

**Design Requirements for Solid-State Amplifiers**



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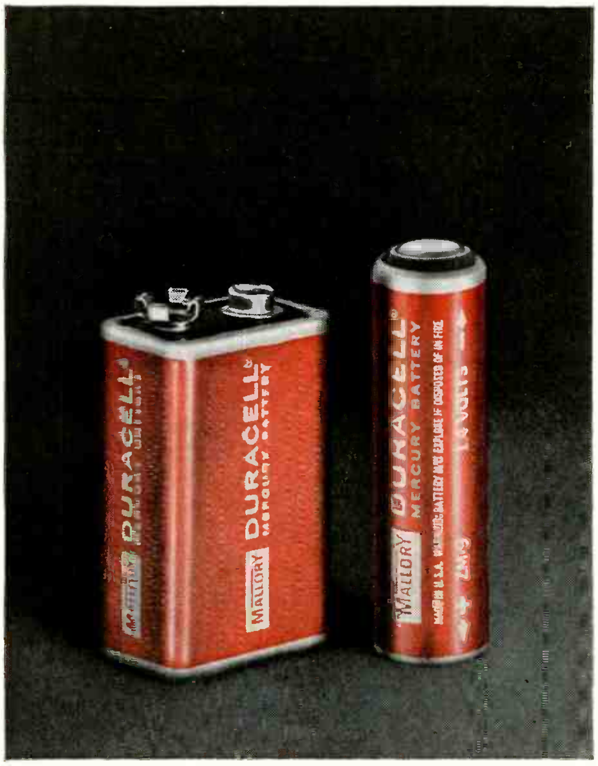
CIRCLE NO. 117 ON READER SERVICE CARD

# MALLORY Tips for Technicians

## Why New Duracell® Mercury Batteries last even longer in transistor radios

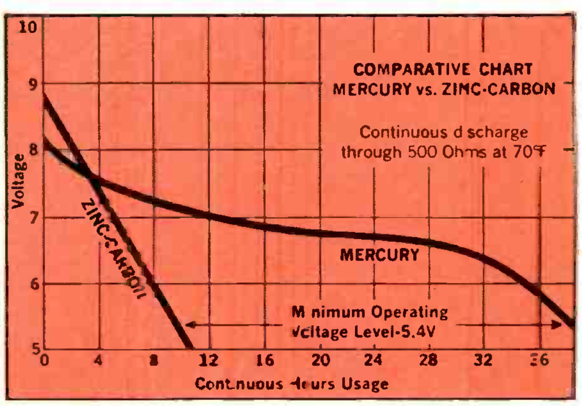



The best way to explain why mercury batteries are *better* is to compare a typical transistor radio with a standard 2 cell flashlight. The vast majority of flashlights use zinc-carbon batteries. The bulb draws about ½ ampere. And the flashlight is used only a minute or two at a time. Therefore the zinc-carbon battery does a reasonably adequate job.

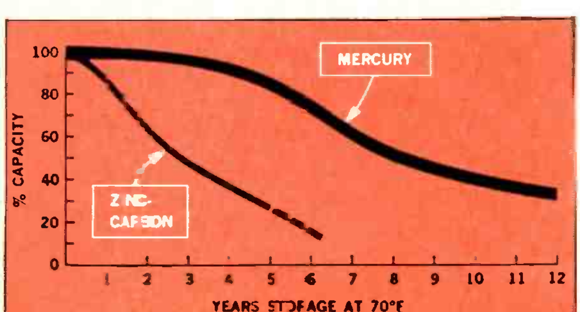
But a typical transistor radio draws only 10 *milliamperes* . . . (the flashlight draws *50 times* as much current). And the radio is used for hours on end. What's needed here is a battery which supplies power in small doses over a very long period of time. There *is* such a battery and it was invented by Mallory. Over the years, it has been improved so much we've given it a new name . . . the DURACELL Mercury Battery. The DURACELL crams *more useable power* into *less volume* than *any other battery system* available. Strangely enough, you'd expect to pay more, but it is actually more economical.

Want proof? Okay, the new TR146X is the 9 volt size that fits most transistor radios. It will run a typical transistor radio at *least* 37 hours. The zinc-carbon equivalent goes for only 9 hours, or less than ¼ as long. (We're talking about top-quality domestic zinc-carbon's here . . . not cheap imports with *very* short life.)

What does this mean to the pocketbook? The zinc-carbon costs 69c while the TR146X $1.95 . . . but don't let that fool you. Divide 69c by 9 and you'll see that it costs you 7.67c per hour to use the zinc-carbon. Now divide $1.95 by 37 and you'll see that it comes to only 5.27c! That's a bargain! In the penlight size, the ZM9 DURACELL gives 4.8 times more *life* for only 3.8 times more money . . . another bargain.




Forget the money! Think of performance. Mercury battery voltage stays *constant* while the zinc-carbon fades fast. This means that B+ voltage stays where it belongs for *days longer* rather than dropping into the distortion range.




Forget the money! Forget the performance! Think of storage life. Zinc-carbon batteries die in a few months *whether they are used* or not. Mercury batteries can sit around for 2 or 3 *years* and still provide instant power.

There's more, too . . . *dependability.* The same dependability and safety that makes the heart pacer possible.

If you need *more proof,* try a new DURACELL Mercury Battery in *your* radio or any electronic gadget . . . you can get 'em at your Mallory Distributor. Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.


CIRCLE NO. 104 ON READER SERVICE CARD


OUR COVER symbolizes the lead article in this month's issue "Designing a Ducted-Port Bass-Reflex Enclosure." Some of the important nomograms and charts used in the design of an optimum-volume enclosure are shown. A pair of Jensen speakers, one of which is to be used as a woofer and the other as a tweeter, a couple of lengths of cardboard tubing for enclosure tuning, and a CIE sliderule for some of the design calculations also appear in the photo. For details, refer to page 25. Photograph by Ernest Silva Inc.

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# Electronics World

JANUARY 1966 VOL. 75, No. 1

# CONTENTS



## MONTHLY FEATURES



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# COMING NEXT MONTH


## Special Feature Articles:

**Video Tape Recorder for Home Use**—An experimental design, using the longitudinal-track method, has produced a useful picture at 72 ips with a frequency response to about 1.5 megacycles. The author describes in detail the various steps leading up to the final design. **The SCR Revolution**—Like the transistor, the silicon controlled rectifier is one of the industry's "glamour" components. With sales topping an estimated $40 million by the end of this year, J. E. Mungenast of General Electric outlines SCR applications as a static switch, series motor feedback speed control, full-wave bilateral switch control, and inverter-chopper control.

**DESIGNING AN ALL-CHANNEL TV ANTENNA**
*Paul Mayes describes the evolution of the single downlead, all-channel "log-periodic" antenna which covers both v.h.f. and u.h.f.*

**NON-DESTRUCTIVE TESTING**
*The first article of a two-part series covers magnetic, liquid penetrants, x-ray, fluoroscopic-TV, gamma-ray, and neutron radiographic methods of non-destructive testing.*

**NANOSECOND PULSES: TECHNIQUES & APPLICATIONS**
*Donald Lancaster outlines some of the important uses for these ultra-short pulses in the fields of electro-optics, measurements, and circuit analysis. He also covers details on how such pulses are generated and applied.*

**SUPER-SENSITIVE COMMUNICATIONS SYSTEMS**
*Design trends in space-age receivers, using phase-lock techniques, are detailed in this comprehensive article by Jim Kyle These new circuits are setting records for range-to-power efficiency.*

**LINE-OPERATED TRANSISTOR TV SETS: EMERSON**
*This is the third in a series of circuit analyses. The Emerson Model 11PO4A, 11-inch portable is discussed.*

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


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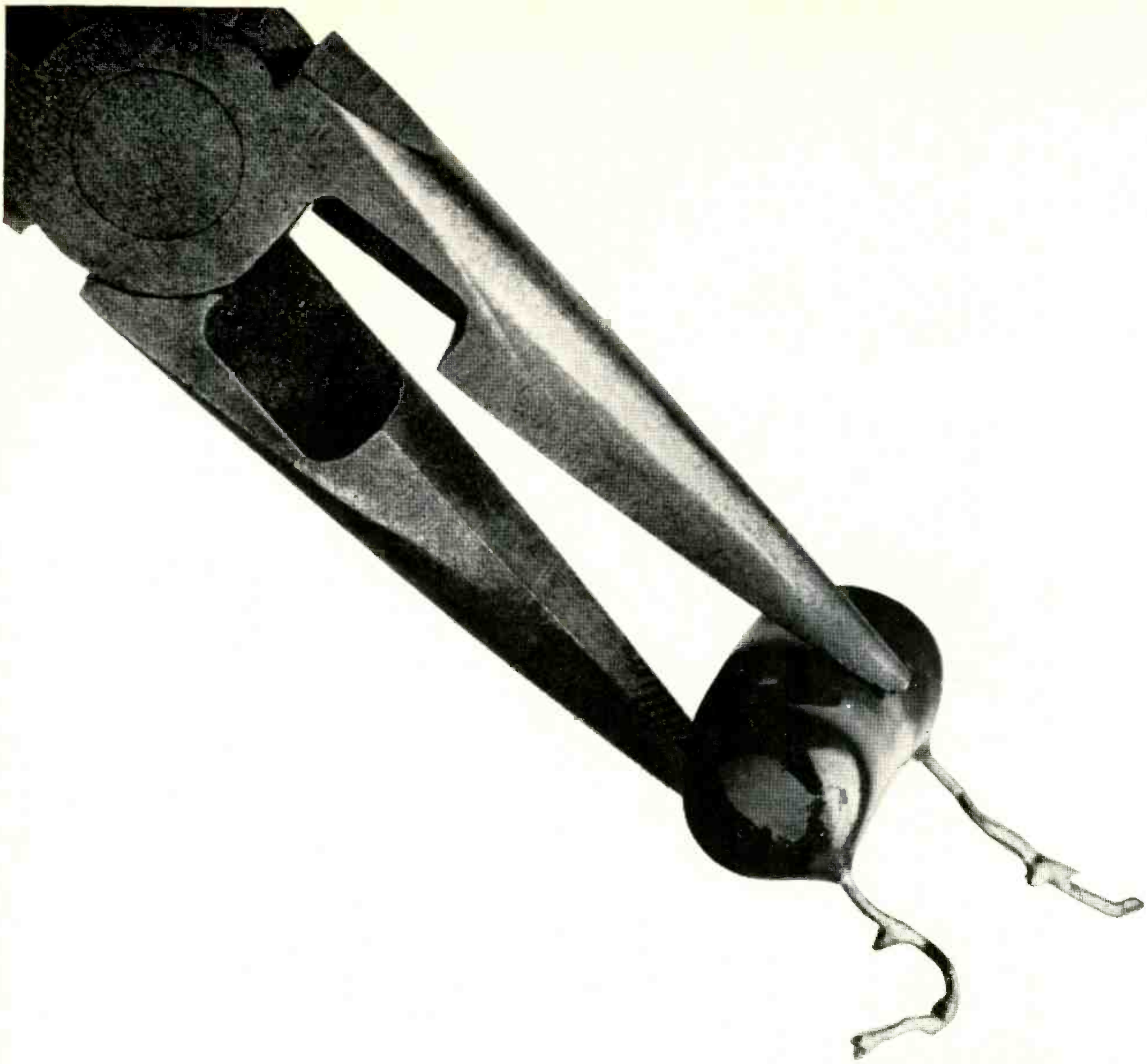

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**CIRCLE NO. 123 ON READER SERVICE CARD**

# For the record

WM. A. STOCKLIN, EDITOR

## AIRPORT TO THE MOON

WE do not have too many opportunities to get down to Cape Kennedy but when we do we are truly amazed at the changes that come about from year to year. We have just returned from a trip there as a guest of NASA and *Bendix Radio*, where for the first time we were able to see the progress being made in our Apollo program.

The Cape, some 12 miles in length, has 41 launching pads of which 21 are presently in use. The greater part of this complex is under the direction of the Air Force but will continue to be used by NASA. In addition, NASA has built its own facility, the John F. Kennedy Space Center, on adjacent Merritt Island. It consists of 87,000 acres, under NASA's direct jurisdiction, for the assembly, check-out, and launch of the Apollo/Saturn V space vehicle and check-out of our present Gemini complex.

Although communications and telemetry antennas were visible, for the most part, we saw very little electronic equipment. We were fascinated, however, by the tremendous construction program now nearing completion—a program of a size and complexity almost beyond comprehension. Already erected is the Vehicle Assembly Building, the world's largest in terms of volume. (See photographs on page 94.) It has three times the volume of the Empire State Building and if the Merchandise Mart (Chicago) and the Pentagon (Washington) were combined, they would be lost within this structure. It permits the vertical construction of four Apollo/Saturn V space vehicles simultaneously—each 445 feet, 9 inches high. To accommodate these, four overhanging doors move up almost the entire height of the building—500 feet. This structure which also houses the electronic launching equipment, is located some three miles from the launching pads.

One of the two pads presently under construction is almost complete and a third is yet to be built. Each concrete and firebrick pad will accommodate dozens of offices and rooms for massive computers and electronic equipment.

These facilities are extraordinary in themselves; yet NASA has gone a step further. Each Apollo/Saturn V assembly will be constructed in the Vehicle Assembly building on a movable platform known as the Mobile Launcher. It is 135 feet wide and 160 feet long. Mounted at one end of its 2-story platform base will be a 380-foot steel tower to support and house equipment. The combined weight of tower, space vehicle, and Mobile Launcher is 10.6 million pounds. It is expected that each Apollo/Saturn V assembly will take three months to construct and test.

After completion, a Crawler-Transporter will lift the entire assembly—the Mobile Launcher, 380-foot tower, and the Apollo/Saturn V rocket and satellite—and transport them 3 miles to the launch site at a speed of 1 mile per hour. Not only is the lifting of such a mass beyond anything accomplished to date, but the almost 50-story height must be moved with no more than one foot deviation from direct vertical position in the uppermost section—even though at one point it must climb a 5% grade. Automatic leveling devices are used. The roadbed of solid concrete is 10 feet deep and at certain points has a depth of 19 feet. Engineers estimate that even this roadbed will sink about three inches when the full load (8000 tons) is carried across it.

The project is nearing completion and progress has been extremely satisfactory with only one serious problem still to be solved—a problem that seems almost insurmountable.

The Crawler-Transporter consists of a platform about the size of a baseball diamond which fits directly under the Mobile Launcher. It is self-propelled, equipped with a hydraulic steering system and four double-tracked caterpillar-type traction units driven by electric motors. Several months ago when it was tested with a limited load, the roller bearings simply pulverized. At the time of our visit NASA had no comment. Whether it was the fault of the individual bearings or of the basic design concept is impossible to determine at this time. Not until NASA officials have reported their findings will this be known. We have a feeling, though, that the basic design is at fault and rumors are that none of the roller bearing manufacturers in this country wish to be involved.

Will the problem be solved or is the principle of lifting such a tremendous load beyond present capabilities? The answer to this question will be a prime factor in the progress of our Apollo program. The entire philosophy of assembling the rockets within an enclosure and moving them three miles to the launch pad depends on whether or not the Crawler-Transporter will work. If it doesn't, NASA will most likely have to resort to final assembly directly on the pad. At least for the moment, it seems a lot easier for us to get to the moon than it is to get the rocket and satellite assembly to the launch pad. ▲

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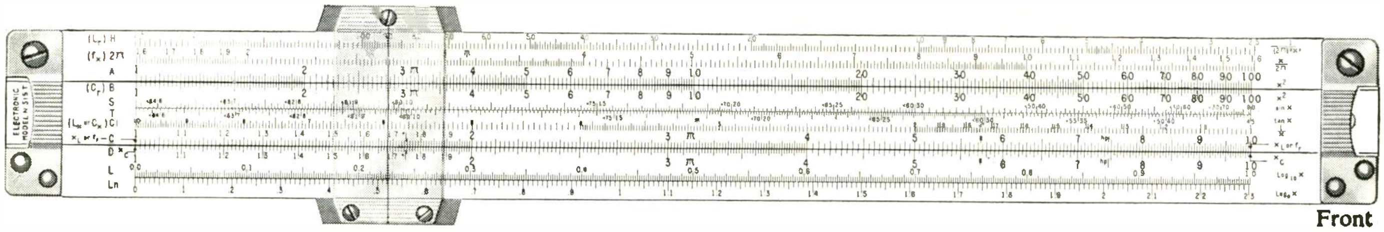
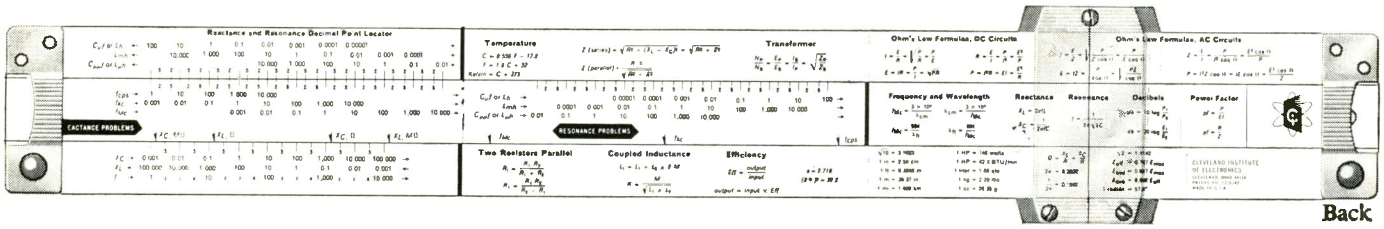


Front



Back

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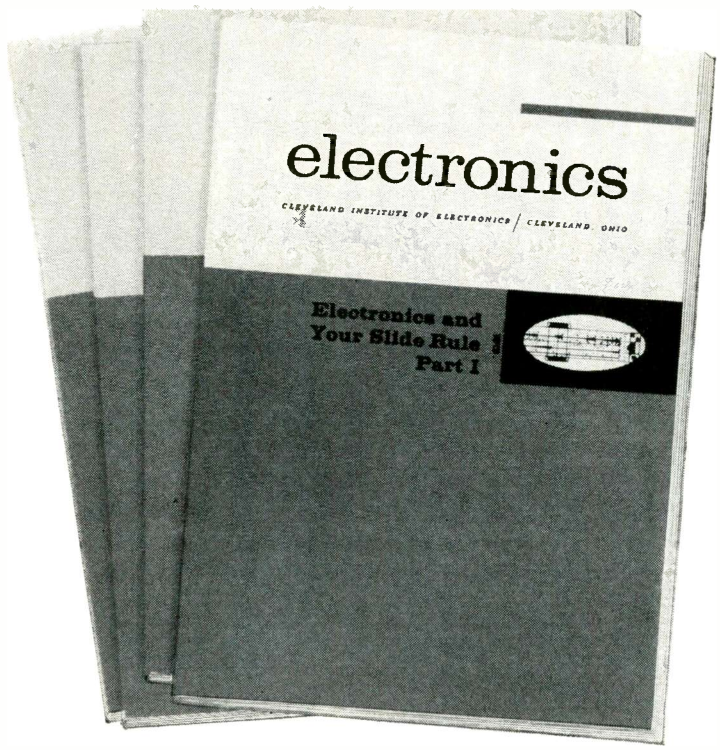


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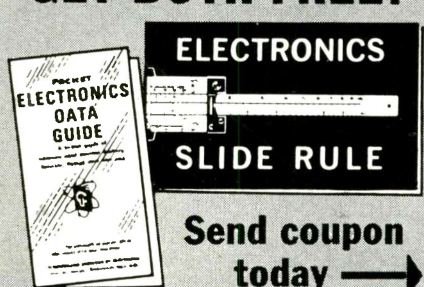


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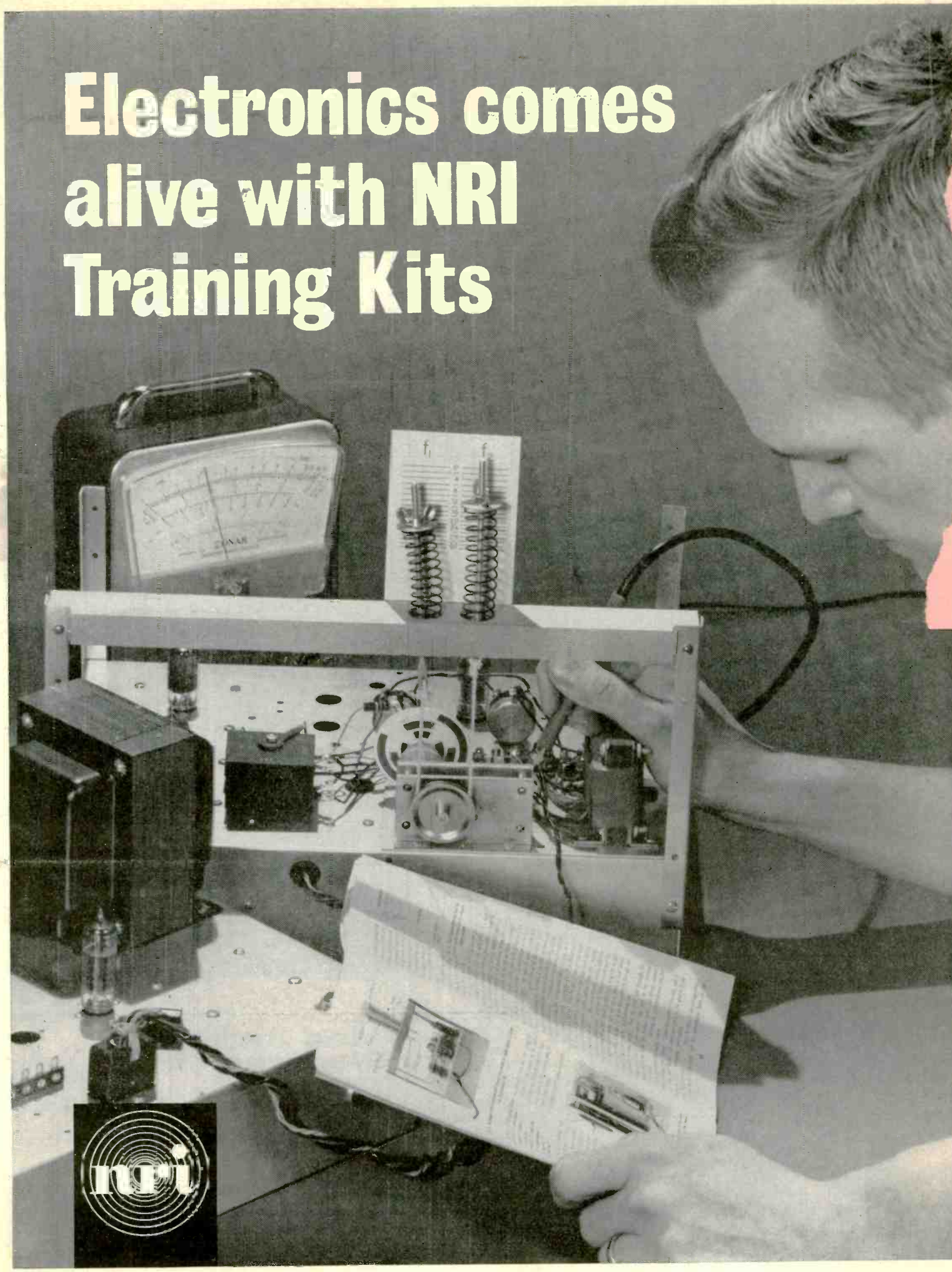
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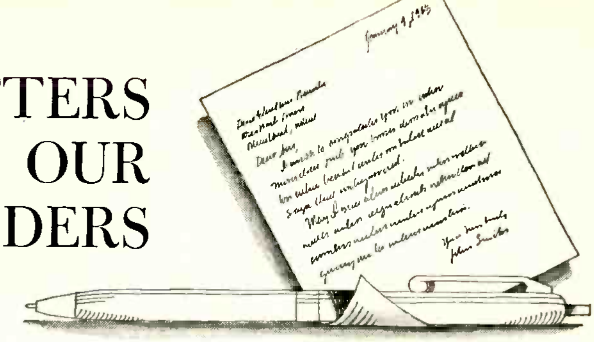
# LETTERS FROM OUR READERS



### SHIELDED TWIN-LEAD

To the Editors:

I read your article entitled "New Shielded Twin-Lead for Color TV & U.H.F." in the October issue of ELECTRONICS WORLD. I recently bought a color TV, which picks up the ignition noise from my neighbor's car engine. I've called several electronics companies, and no one stocks the wire described in your article. Even the local factory service company has never heard of the wire.

It would be greatly appreciated if you would let me know where I may purchase the shielded twin-lead wire.

STEVEN D. YETMAN
Norfolk, Va.

*Because this cable, which is manufactured by* Belden, *is brand-new, it may not yet be available at all the company's distributors. However, it should be available very soon. We would suggest that you write directly to the manufacturer for the name of the nearest distributor handling the new shielded twin-lead. The address is* Belden Manufacturing Company, *P. O. Box 5070A, Chicago, Illinois 60680.—Editors.*

° ° °

### CIRCUIT MODIFICATIONS

To the Editors:

Could you recommend the necessary circuit changes to make the SSB converter described in your October, 1965 issue adaptable to a receiver with a 1681-kc. i.f. frequency? The receiver is the *Heathkit* Model HR-10.

JAMES PORTER
Cherry Hill, N.J.

*This letter typifies a good many requests we get on some of our construction projects. We are sorry that we do not have the facilities for redesigning and testing out the many modifications of some of our projects that individual readers might like to have us try for them. In the case of this converter, not only would the crystals have to be changed but also the various filter circuits that are used. If such changes were made, other problems might crop up due to the higher i.f. frequency.*

*Therefore, all we can say is that the unit as designed was intended for operation with receivers having the more conventional lower intermediate frequencies, and we do not recommend its use with receivers having other i.f.'s unless the reader has the knowledge and the willingness to experiment with the circuit on his own.—Editors.*

° ° °

### VIDEO TAPE-RECORDER KIT

To the Editors:

We are pleased to inform you that we have a fine stock of *Wesgrove* video recorders in both assembled and kit form available for immediate delivery.

The price of an assembled unit is $550, while kits sell for $450.

HAL COX, Pres.
Hal Cox, Inc.
800 Bay Street
San Francisco, Calif.

*Our November editorial quoted somewhat different prices for the* Wesgrove *video recorders. Because of some later improvements and import duties on the kit version (this recorder is made in England), the prices quoted in the above letter should be considered as more accurate than those mentioned in the editorial.*

*In addition to the above West Coast source in this country, the* Wesgrove *recorder is also available from* P.A.F. Enterprises, *32 East 22nd Street, Bayonne, New Jersey 07002. Prices are $450 for the kit and $650 wired by special order.—Editors.*

° ° °

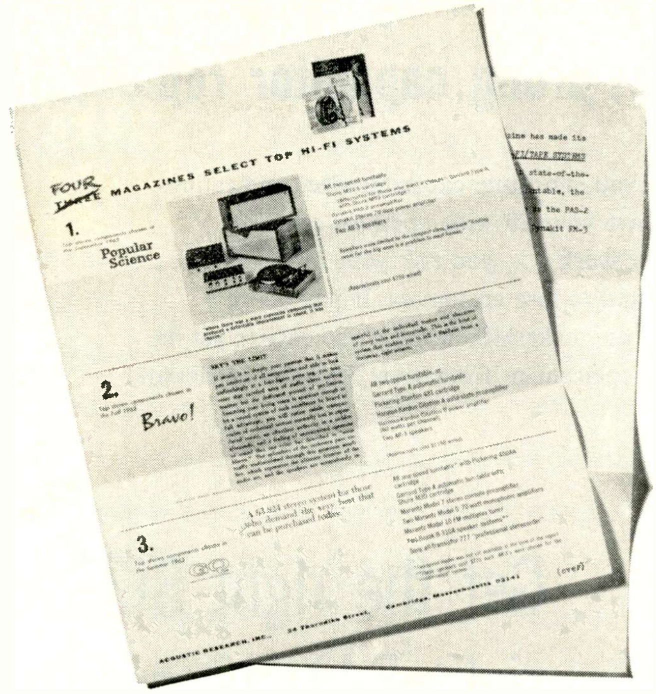
### OUR DECEMBER COVER

To the Editors:

Your December, 1965 cover is very striking. However, what you show as a normal color-bar pattern does not look like anything I have ever seen on a properly operating color-TV set. There is either something wrong with the TV receiver used to take this picture or with your printing process. Which is it?

GEORGE L. PARKER
Detroit, Mich.

*The receiver used for the color-bar pattern was in excellent working order, and the colors displayed were far more vivid and of somewhat different hue than those shown. Unfortunately, however, the villain in this case was our own printing process which was not able to*




# This is a survey *(available for the asking)* of the hi-fi equipment recommendations of four magazines.

These four lists of equipment choices, from stereo cartridge to speakers, were compiled independently by each of four national magazines — **Gentlemen's Quarterly,** a men's clothing magazine for the carriage trade; **Bravo!,** a concert program "wrapper" with a circulation of almost a million; **Popular Science,** the leading high-circulation science magazine; and **Hi-Fi/Tape Systems,** a hi-fi annual.

# AR-3 speakers were the top choice of three of the four.

The fourth magazine, **Gentlemen's Quarterly,** chose speakers costing $770 each for its most expensive stereo system; AR-3's were relegated to the "middle-range" ($1,273) system.

# The AR turntable was the top choice of all four.

The AR turntable is $78 including arm, oiled walnut base, and transparent dust cover. The AR-3 is $203 — $225, depending on finish (other speaker models from $51). AR's catalog is available on request.

**ACOUSTIC RESEARCH, INC.,** ***24 Thorndike Street, Cambridge, Massachusetts 02141***

*duplicate the colors faithfully. As a matter of fact, the chromaticity diagram shown at the top of the cover clearly demonstrates that the color gamut of a color-TV system (refer to triangle) exceeds that of modern three-color printing-process techniques.*

*The colors in the normal color-bar pattern should be, from left to right, (1) yellow-orange, (2) orange, (3) bright red, (4) magenta, (5) reddish-blue, (6) blue, (7) greenish-blue, (8) cyan, (9) bluish-green, and (10) green.—Editors.*

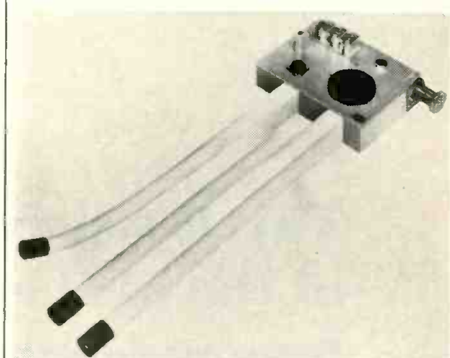
* * *

### MORE "PROBLEM BRACES"

To the Editors:

I noted with interest the "problem brace" that one of your readers presented in a past issue and its ingenious packing case shown in a subsequent "Letters" column.

I think the case could easily be used for our high-resolution, tri-channel



servo-potentiometer, announced on last April Fool's Day by our British associate, *Standard Telephones and Cables, Ltd.*

Thomas C. Flynn, Mgr.
Technical Public Relations
International Telephone & Telegraph Corp.
New York, N.Y.

* * *

### REVERSE-POLARITY DIODES

To the Editors:

I have a number of stud-mounted silicon diodes that have standard "1N" numbers on them except that the letter "R" appears at the end of the type number. Does this letter mean anything? Must these diodes be insulated from their heat sinks?

I would certainly appreciate any information you can pass along on this particular matter.

Robert Morgan
Hampton, Virginia

*Most standard silicon rectifier diodes have their cathodes connected to their cases and studs. The cathode is the positive output terminal of the diode in a rectifier circuit. If this voltage is to be maintained above chassis ground, it is necessary to insulate the diode case and stud from the chassis. If the diode uses the chassis as a heat sink, a pair of mica washers can be used for insulation. If the diode is mounted on a separate heat* *sink, the diode must either be insulated from the heat sink or the heat sink itself must be insulated from the chassis. On the other hand, if the positive output is at ground potential, it is not necessary to insulate.*

*Many diodes are available with their anodes connected to their cases and studs. These are "reversed" diodes and they carry the letter "R." When these diodes are used in a rectifier circuit in which the anode is connected to ground, insulation is not required. If the anode must not be grounded, insulation must be used.—Editors.*

* * *

### RESISTANCE SOLDERING

To the Editors:

The "Letters from Our Readers" are always most interesting. Keep them coming.

From time to time, there is occasionally one that takes me back many years in the "electronics" field, when it wasn't what it is today. Your article in July on "Resistance Soldering" by D. A. Reid reminds me of the time in 1918—48 years ago—when I built this type of equipment for localizing heat in soldering-welding and also for the welding of small high-voltage, low-amperage radio storage-battery plates and terminals, which I designed and constructed in the early days of radio, around 1922-1926. You will find that Harold P. Manly, ten years later, in his book "Auto and Radio Battery Care and Repair" (1928) utilized the carbon "burning" method and illustrated its use for storage-battery work.

ALFRED A. ADAMS
San Francisco, Calif.

* * *

### REMOTE CONTROL SYSTEM

To the Editors:

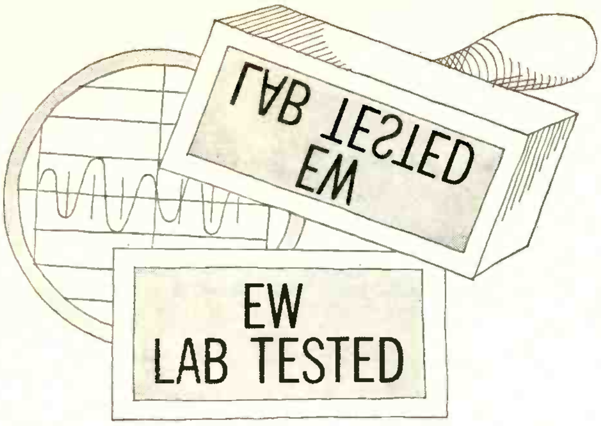
Please thank several of your readers for calling attention to the error in Fig. 2 on p. 93 of your October issue. This mistake occurred in my article "Remote Control System."

The two upper d.c. supplies should get their a.c. power from the drop across *R*4 so that their output to "Line" will be superimposed on the a.c. drop across resistors *R*2 and *R*3.

Fig. 2 should be corrected by disconnecting the junction of *C*5 and *C*7 from the junction of *C*1, *C*3, and *R*2 and connecting it instead to the junction of resistors *R*3 and *R*4.

I made the error in copying my original drawing in simpler form for the article, and I missed it in checking the galley proofs which you so carefully sent me. My apologies to your readers. Unceasing vigilance seems certainly to be the price of accuracy.

D. H. ROGERS
Mgr., Distrib. Prod. Engin.
Jerrold Electronics Corp.
Hatboro, Pa. ▲




# HI-FI PRODUCT REPORT

*TESTED BY HIRSCH-HOUCK LABS*

**Sony TC-250-A Tape Deck/Preamp**
**Empire Model 9000 Speaker System**

## Sony TC-250-A Tape Deck/Preamp

*For copy of manufacturer's brochure, circle No. 33 on Reader Service Card.*

THE *Sony* TC-250-A is one of the few tape machines selling for less than $200 that we have found to be capable of true high-fidelity performance. It is a compact unit, with a two-speed (7½ and 3¾ ips) transport and completely transistorized recording and playback electronics. Since it is designed to operate with a component high-fidelity system, it comes mounted on an attractively finished wooden base. The base is removable for built-in installations, which may be made with the deck in a vertical or horizontal position. The TC-250-A measures approximately 14¼" wide by 11⅜" deep by 6¼" high. It does *not* have its own power amplifiers and speakers.

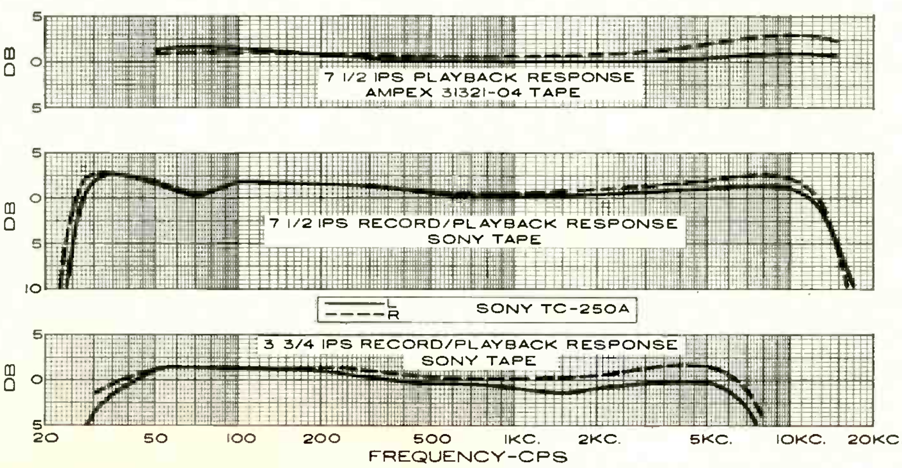
The operating controls have been reduced to a minimum, both in number and in simplicity of use. It has only a push-on, push-off power switch (illuminated when on) and a single-function selector knob visible in normal operation. The function selector has positions for "Rewind," "Stop," "Forward," "Pause," and "Fast Forward" operation. The "Pause" position, falling between "Fast Forward" and "Forward," helps to insure that the tape is stopped before making an abrupt speed change. If reasonable care is used, there is little danger of tape spillage or breakage. The tape drive shuts off automatically when the tape has run out.

The machine has an index counter and a pair of vu meters, which are illuminated in red when recording. The meters read both recording and playback levels and are designed so that the maximum recording level is approximately 12 db below tape saturation (with *Sony* tape). This assures the user of low distortion in his recordings, even if the meter occasionally swings into the "red" region. The meters have a fast response and appear to be nearly critically damped, with negligible overshoot.

As with studio-type decks, this machine has no playback level controls. A tape recorded at "0 vu" plays back at about the same level, which is nominally 0.77 volt at the low-impedance line outputs. The volume and tone controls of the associated high-fidelity system perform the necessary control functions.

Under a hinged cover are two microphone jacks (accepting miniature phone plugs) for use with low-impedance microphones capable of working into 600-ohm loads. A suitable microphone is the *Sony* F-96L (not furnished). The two recording level controls and a red recording safety interlock button are also under the cover. The button must be pressed before putting the tape into motion for the recording mode. It releases when the tape is stopped, unless going into the "Pause" mode. The high-level inputs and outputs are reached through a cut-out in the rear of the wooden base.

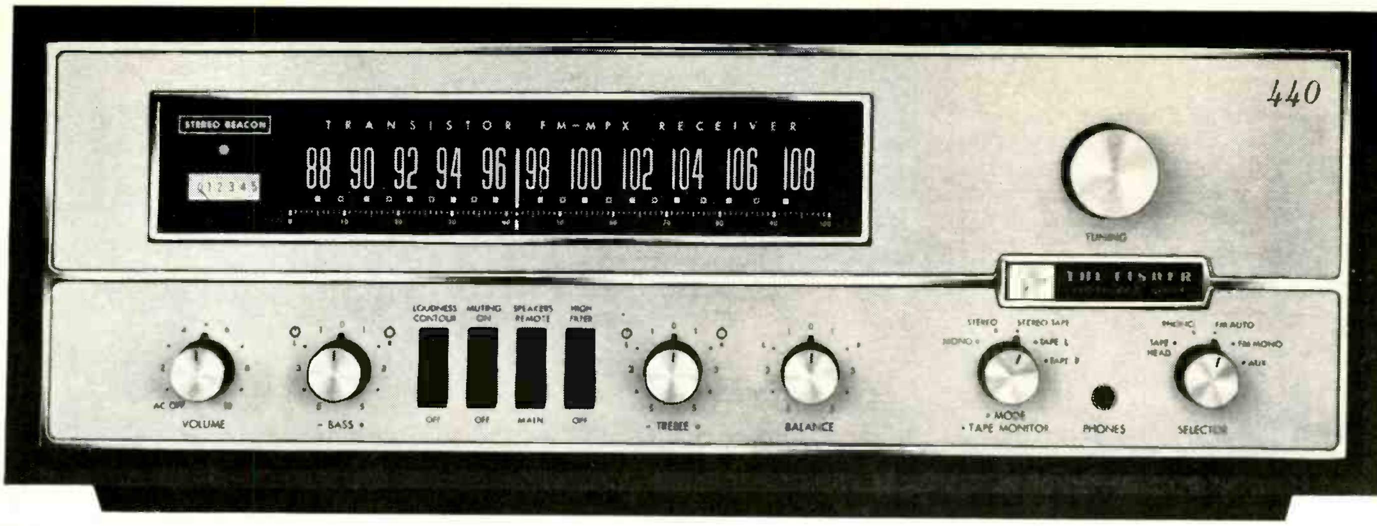
For making four-track mono recordings, each recording level control has an "off" position at its counterclockwise limit which shuts off the bias and erase current to that channel so that the channel may be recorded independently without erasing the other channel.




We measured the 7½-ips playback response with the *Ampex* 31321-04 four-track alignment tape. It proved to be within ±1 db from 50 to 15,000 cps. The over-all recording/playback frequency response at 7½ ips was within ±2.5 db from 25 to 14,000 cps, using the reel of *Sony* tape supplied with the recorder. At 3¾ ips, it was within ±1.5 db from 30 to 7000 cps.

The wow and flutter at 7½ ips were 0.03% and 0.09% respectively, comparing

*(Continued on page 22)*




# A Fisher receiver is greater than the sum of its components.

Fisher has always maintained that an all-in-one receiver can equal or surpass the performance of separate components of similar circuitry. And at far lower cost.

The most recent and eloquent proof of this is the new 440-T, the first all-solid-state stereo receiver of Fisher quality under $330.

On a single chassis occupying only 16¾ inches of shelf space and only 11 inches front to back, the 440-T incorporates a sensitive FM-stereo tuner with automatic mono-stereo switching, an extremely versatile stereo control-preamplifier, and a heavy-duty stereo amplifier. All transistorized, all with Fisher reliability.

By eliminating duplication of parts and circuits, such as extra power supplies and the low-impedance circuitry usually associated with connecting cables, the 440-T actually has a *plus* factor of reliability over separate components. Obviously, fewer parts mean fewer trouble spots. But that isn't all. Hum and noise are more easily reduced to imperceptible levels. And critical preamplifier and power circuits operate at their electrical best. Elimination of other unnecessary parts, such as extra chassis, jacks, knobs, etc., clearly means a considerable cost saving.

In the 440-T, Fisher engineering has also achieved a new degree of reliability in transistorized components. Conservatively rated silicon output transistors permit higher undistorted power and long, trouble-free operation. Damaging heat has been designed out. The receiver can be operated at full power, hour after hour, without harm. You can even short the speaker leads without causing damage. Adjustments and alignments have been practically eliminated, so that the 440-T will operate as perfectly after two years as on the first day.

In spite of its technical sophistication (just look at the specs!), the 440-T is so simple to operate that even your wife will enjoy using it from the very first day. Masses and messes of wire are gone; you simply connect a pair of fine speakers and turn on the music.

It is this total approach to integrated design that makes the 440-T more than just the sum of a tuner, an amplifier and a control center. And that is why it is an unprecedented buy at $329.50. (Cabinet, $24.95.)

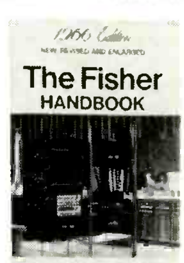
### Features and Specifications

*Tuner Section:*
4-gang transistor front end; 4 IF stages; 3 limiters; STEREO BEACON*; automatic stereo switching; sensitivity, 2.0 μv (IHF); stereo separation, 35 db; S/N (100% mod.), 68 db; selectivity, 50 db; capture ratio, 2.2 db.

*Amplifier Section:*
Silicon output transistors; short circuit protection; speaker selector switch (main or aux.); front-panel headphone jack; music power (IHF), 4 ohms, 70 watts; harmonic and IM distortion, 0.8%; frequency response (overall), 20-22,000 cps ± 1.5 db; hum and noise, 80 db; input sensitivity, phono magnetic (low), 4.5 mv; stereo separation, phono magnetic, 50 db.

Size: 16¾" wide x 5⅛" high x 12⅜" deep (including knobs and heat sink).
Weight: 21 pounds.

*PATENT PENDING




031

**FREE! $2.00 VALUE!** Send for your free copy of the new 1966 edition of *The Fisher Handbook.* This revised and enlarged version of the famous Fisher high fidelity reference guide is a magnificent 80-page book. Detailed information on all Fisher components is included.

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## The Fisher 440-T



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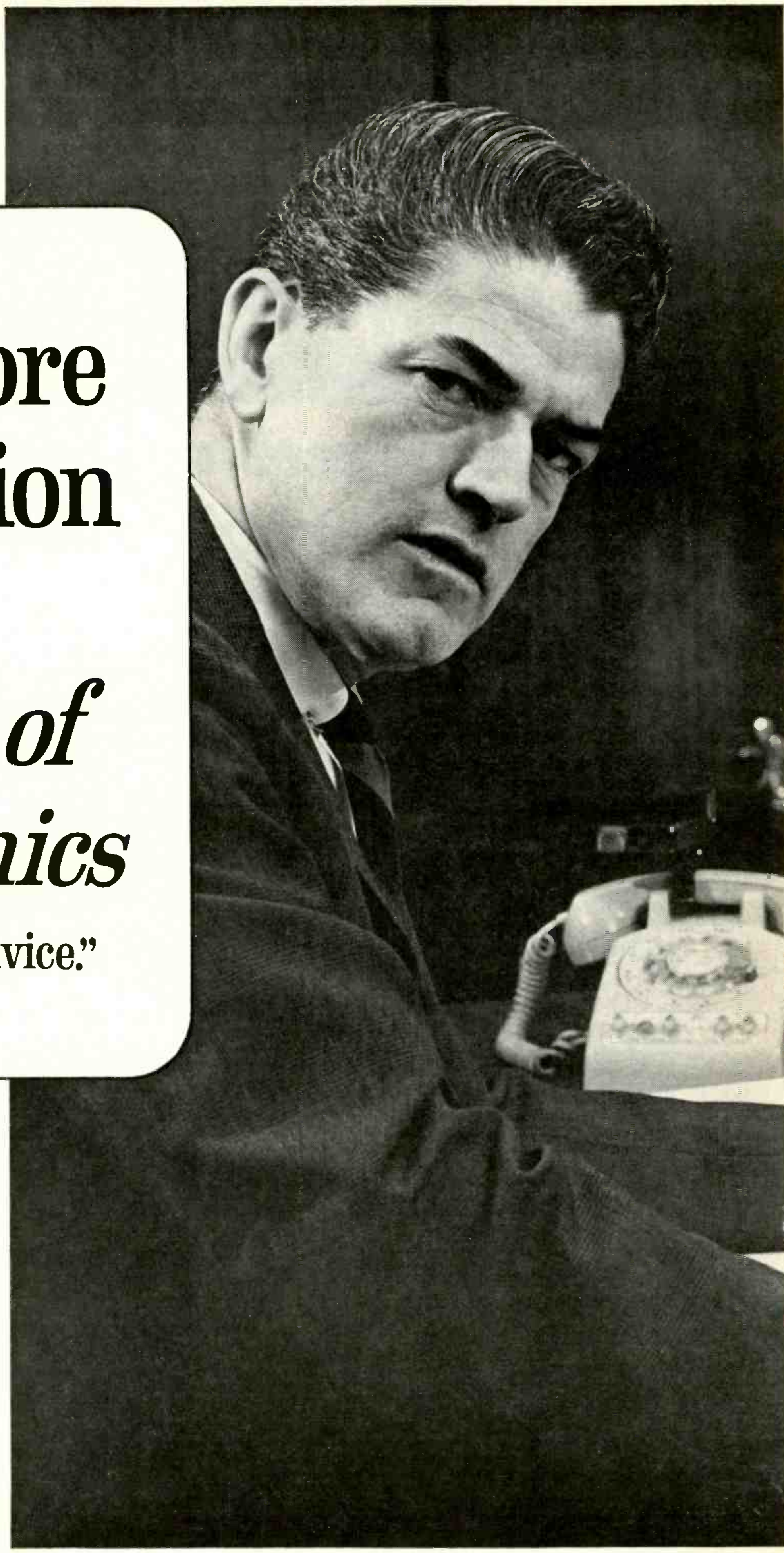
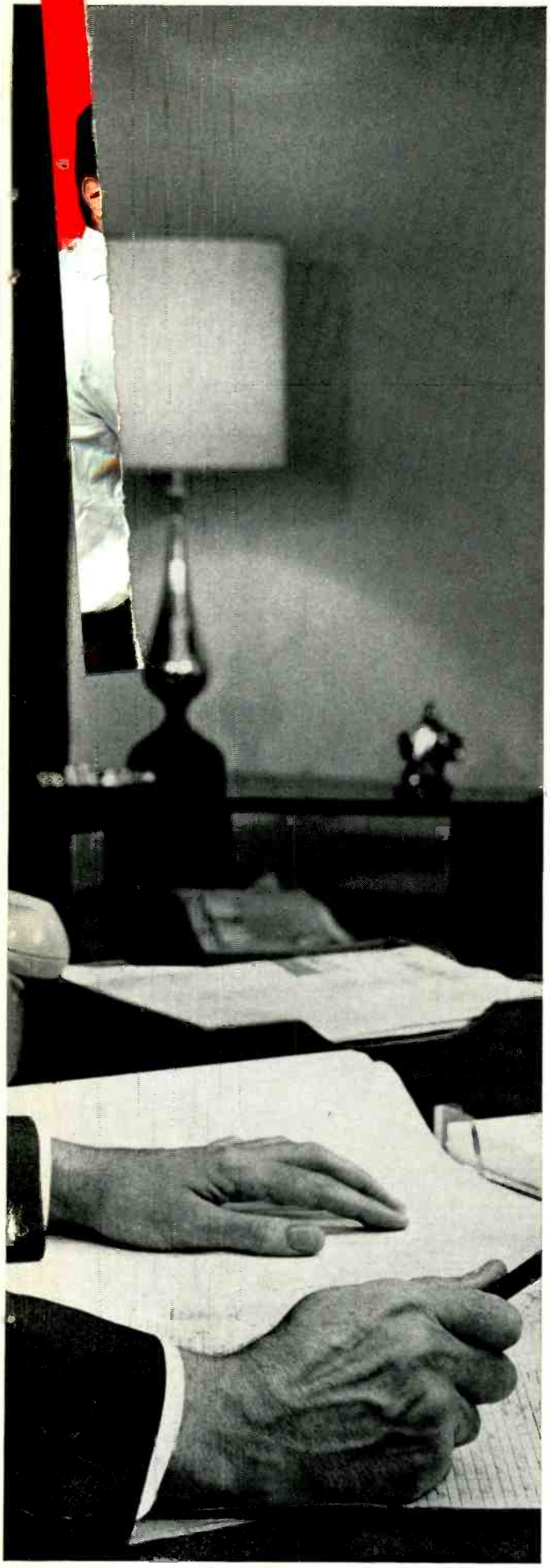
“Get more education or *get out of electronics* ...that’s my advice.”





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favorably with some of the most expensive tape recorders we have tested, and much better than the rated 0.19%. The signal-to-noise ratio was 45 db, referred to the "0 vu" recording level. Since this level can be exceeded considerably without reaching 3% distortion (the usual criterion for establishing a reference level for S/N ratings), the manufacturer's rating of 50 db seems perfectly reasonable.

The tape speeds were slightly fast, amounting to a timing error of about 30 seconds in 30 minutes of playing time. Only 50 millivolts was needed at the high-level inputs for a 0-vu recording level. The corresponding line output was 0.73 volt at 7½ ips and 0.63 volt at 3¾ ips. At the fast tape speeds, 1200 feet of tape were handled in 150 seconds.

This tape deck/preamp played commercially recorded tapes with excellent fidelity. Its own recordings were virtually indistinguishable from the original program. In all sonic respects, this modestly priced machine proved to be the equal of other recorders costing several times as much. Our chief criticism of its tape handling was the sudden tug and subsequent bounce imparted to the tape by the takeup reel every time it went into normal motion. However, we experienced no stretching or breaking difficulties with 1-mil or 1.5-mil tape.

Selling at $149.50, the *Sony* TC-250-A represents a top value for anyone wishing to add a tape recording facility to his music system at reasonable cost. ▲

## Empire Model 9000 Speaker System

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

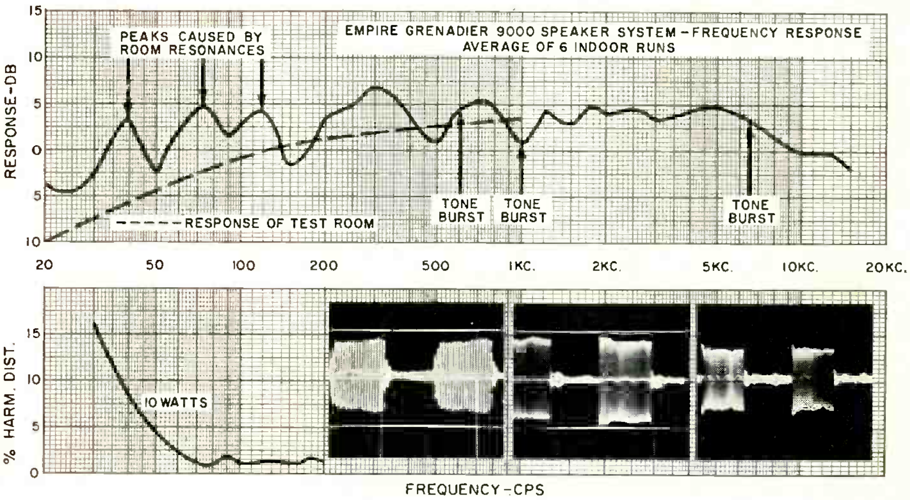
THE *Empire* Model 9000 "Royal Grenadier" speaker system differs from other designs in its use of a cylindrical column enclosure. It is a three-way system, of 8 ohms nominal impedance, with its woofer mounted face down near the bottom of the enclosure. The column is partially filled with sound-absorbent material to damp internal resonances.

The woofer is front-loaded by a tapered plug in the base of the column and radiates over a 360-degree angle through a slot surrounding the base. The manufacturer's literature describes this as a front-leaded horn. The bass driver has a 15″ cone, a 4″ diameter voice coil, and a very heavy ceramic magnet structure.

The middle and high frequencies are handled by two small dome radiators in a separate, isolated housing on the side of the column. The housing is a die casting, with its openings forming acoustic lenses for wide dispersion. The crossover networks are built in, and there are no level adjustments for the middle- and high-frequency speakers. The system terminals are concealed from view underneath the pedestal.

The Model 9000 is handsomely styled as a seven-sided column, in satin-finish walnut. It stands 29″ high, with a 20″ diameter circular walnut top. It is also available with a marble top. In its all-wood version, it weighs 85 pounds,

(*Continued on page* 78)



# FINCO COLOR-VE-LOG ANTENNAS

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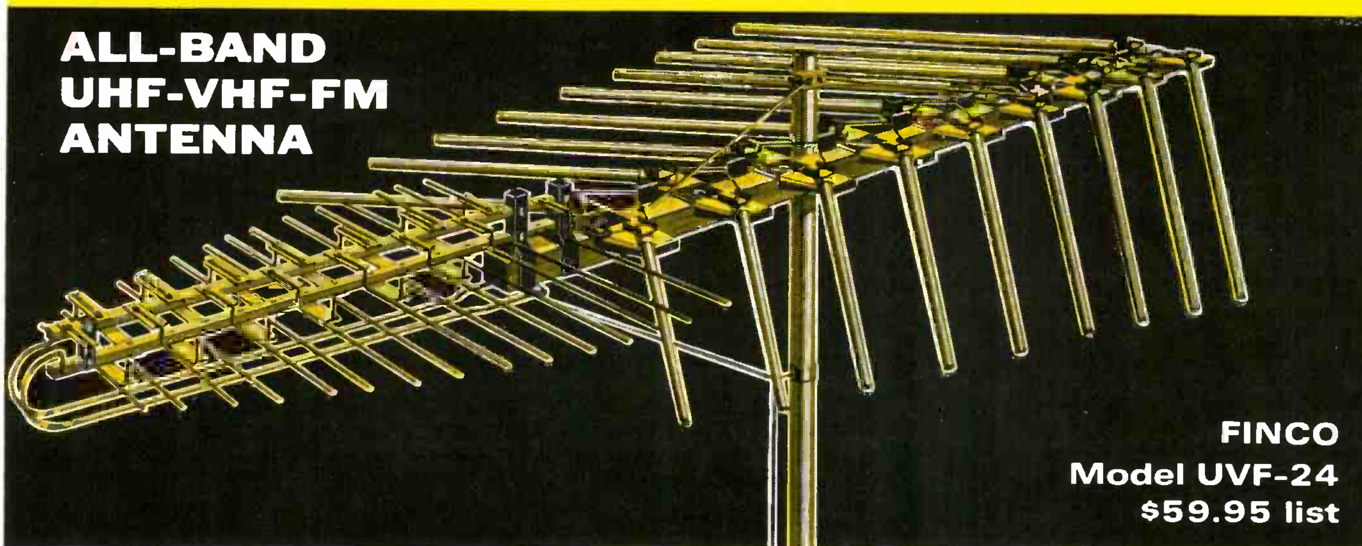


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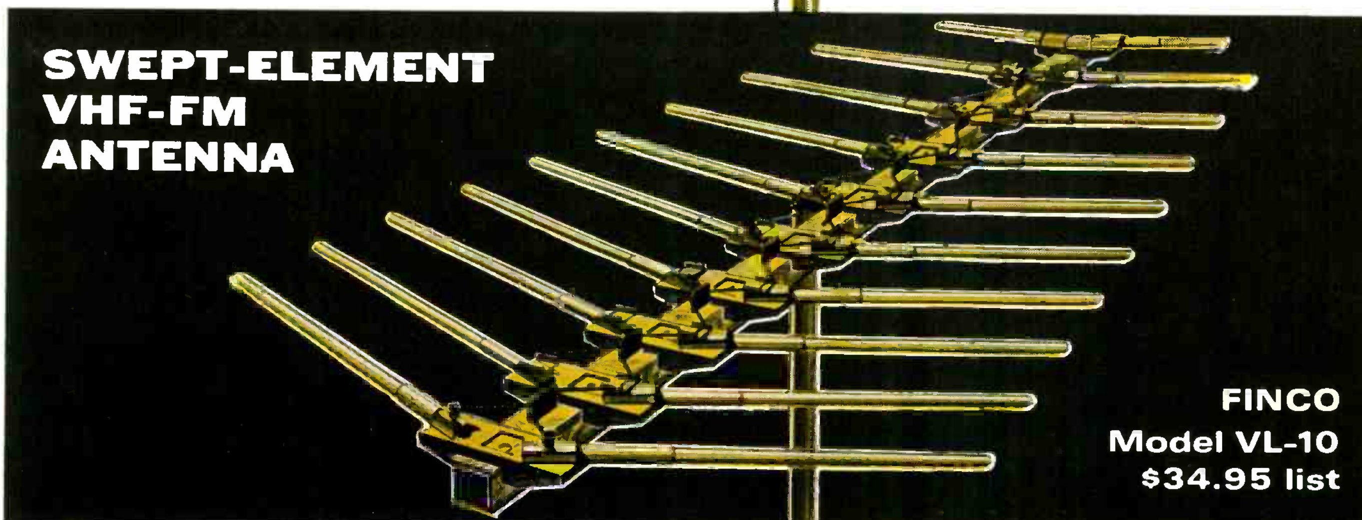


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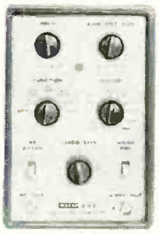
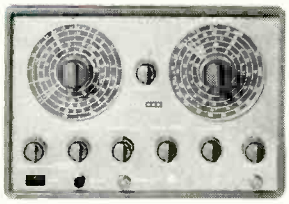
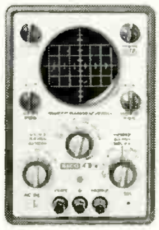


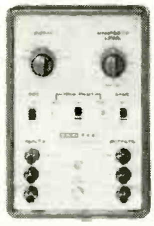
New Model 380 Solid State NTSC Color Generator generates exact NTSC color signals individually and all required dot-bar patterns. Super-compact, 4 pounds light, instant operation. **$159.95 wired only.**



Model 369 Sweep/Marker Generator for easiest, fastest visual alignment of color or B&W TV and FM RF and IF circuits. Five sweep ranges from 3-220mc. Four marker ranges from 2-225mc. Crystal marker oscillator. Post injection of markers. **$89.95 kit, $139.95 wired.**



New Model 435 Direct-Coupled Wideband Scope. Top-quality DC-4.5mc scope with 3" flat-face CRT. Zener calibrator: Outperforms 5" scopes three times its size. Facilitates on-location color TV and other servicing. **$99.95 kit, $149.95 wired.**



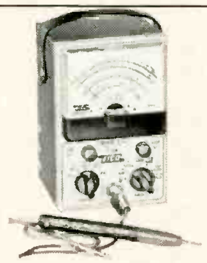
New Model 342 FM Multiplex Signal Generator. Design lab quality. Both composite audio and FM RF outputs. Inputs for stereo audio source for store demonstrations, critical A/B listening tests. **$149.95 wired.**

New Model 1030 Regulated Power Supply. Speeds troubleshooting, design work, production line testing, electronics teaching. Variable bias and plate sources regulated to 1/3 of 1%: 0-150V @ 2ma; 0-400V @ up to 150ma. Ripple less than 3mv rms. Unregulated fil. volts of 6.3V & 12.6V, @3A. Switchable, monitoring milliammeter and voltmeter. **$59.95 kit, $99.95 wired.**

New Model 378 Audio Generator. Near-distortionless sine wave generator (<0.1% 20-20,000c) providing fast, convenient switch-selection of frequencies from 1c to 110kc (1c steps 1c-100c, 10c steps 100c-1kc, 100c steps 1kc-10kc, 1kc steps 10kc-110kc), 8-pos. 10db/step output attenuator & fine attenuator. Output meter (4½" 200ua) with 8 voltage ranges & db scale. $49.95 **kit, $69.95 wired.**

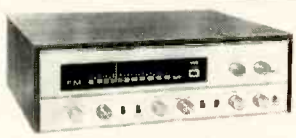
New Model 965 FaradOhm Bridge/Analyzer. "Unusually versatile" — Electronics World. 9-range, low-voltage capacitance-resistance bridge safely measures even 1-volt electrolytics. Metered bridge balance, leakage test voltage (6 DC VTVM ranges 1.5-500V), leakage current (11 DC VTAM ranges 0.15ua-15ma). DC VTVM & VTAM externally usable. **$129.95 wired.**

Model 460 Wideband Direct-Coupled 5" Oscilloscope. DC-4.5mc for color and B&W TV service and lab use. Push-pull DC vertical amp., bal. or unbal. input. Automatic sync limiter and amp. **$89.95 kit, $129.50 wired.**



Model 232 Peak-to-Peak VTVM. A must for color or B&W TV and industrial use. 7-non-skip ranges on all 4 functions. With Uni-Probe.® **$29.95 kit, $49.95 wired.**

New Model 779 Sentinel 23 CB Transceiver. 23-channel frequency synthesizer provides crystal-controlled transmit and receive on all 23 channels. No additional crystals to buy ever! Features include dual conversion, illuminated S/RF meter, adjustable squelch and noise limiter, TVI filter, 117VAC and 12VDC transistorized dual power supply. Also serves as 3.5 watt P.A. system. **$169.95 wired.**



New Model 3566 All Solid-State Automatic FM MPX Stereo Tuner/Amplifier. "Very satisfactory product, very attractive price"—Audio Magazine. No tubes, not even nuvistors. Delivers 112 watts IHF total to 4 ohms, 75 watts to 8 ohms. Completely pre-wired and pre-aligned RF, IF and MPX circuitry, plus plug-in transistor sockets. **$219.95 kit (optional walnut cabinet $14.95), $325.00 wired including walnut cabinet.** UL approved.

New Model 753 The one and only SSB/AM/CW Tri-Band Transceiver Kit. "The best ham transceiver buy for 1966"—Radio TV Experimenter Magazine. 200 watts PEP on 80, 40 and 20 meters. Receiver offset tuning, built-in VOX, high level dynamic ALC. Unequaled performance, features and appearance. Sensationally priced at **$179.95 kit, $299.95 wired.**

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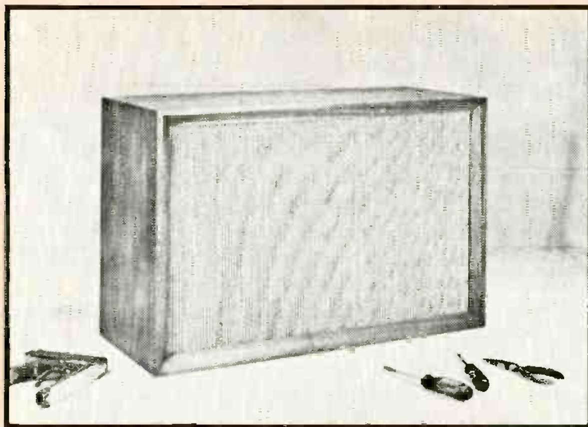
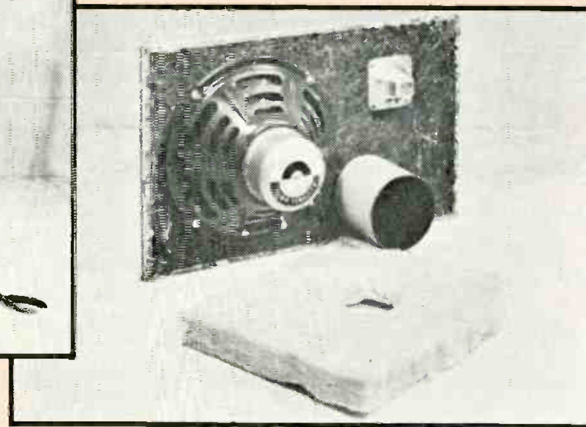
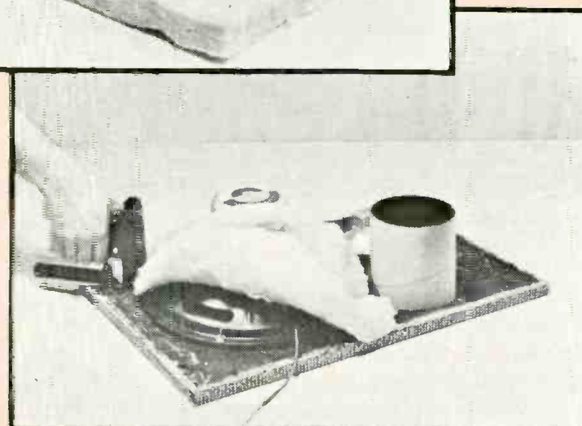


A high-fidelity speaker system of optimum volume that has been constructed using the data obtained from nomograms.

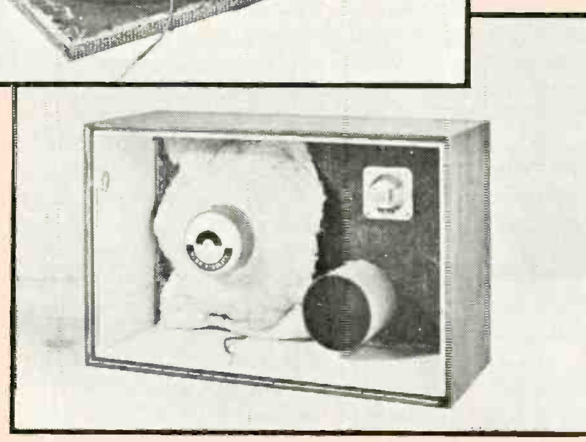


The 12-inch woofer is shown here mounted on ¾-inch composition board front panel along with cone tweeter and the duct.



A thickness of fiberglass is stapled to board for damping.

# DESIGNING A DUCTED-PORT BASS-REFLEX ENCLOSURE



Inside view of enclosure shown before back cover is put on.

By JAMES F. NOVAK/Senior Engineer, Jensen Mfg. Div./The Muter Co.

**There is an optimum volume for best transient performance and maximum efficiency. A number of nomograms are given to allow designer and constructor to achieve this volume.**

ONE of the most important, yet often least understood, parts of a loudspeaker system is the loudspeaker enclosure. The enclosure—often called a baffle, cabinet, or just plain box—determines to a large extent the low-frequency performance of a loudspeaker system and, in many cases, governs it.

Enclosures may be divided into five main types: 1. flat baffle, 2. open-back cabinet, 3. completely enclosed cabinet, 4. horn-loaded, and 5. bass-reflex.

These five types can be further subdivided into as many as five additional variations on each type. The purpose of this article is to select one type of enclosure that will be simple to construct, require no mathematics to design, and yet give satisfactory performance with a large variety of loudspeakers. Nomograms are given which will enable the constructor to de-

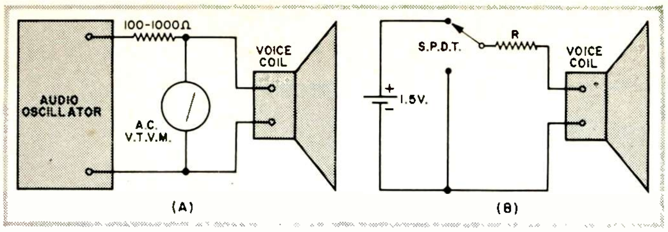



Fig. 1. Hookup for checking speaker resonance and damping.

sign a suitable enclosure for any given loudspeaker with a reasonable assurance of obtaining an optimum design.

### Types of Enclosures

Obviously, no single type of enclosure will give utopian performance with all types of loudspeakers. When one considers all of the cost, complexity, and performance trade-off's, however, one type of enclosure does stand out above all others. This is the bass-reflex. It may be useful to discuss briefly the reasons for not choosing one of the others.

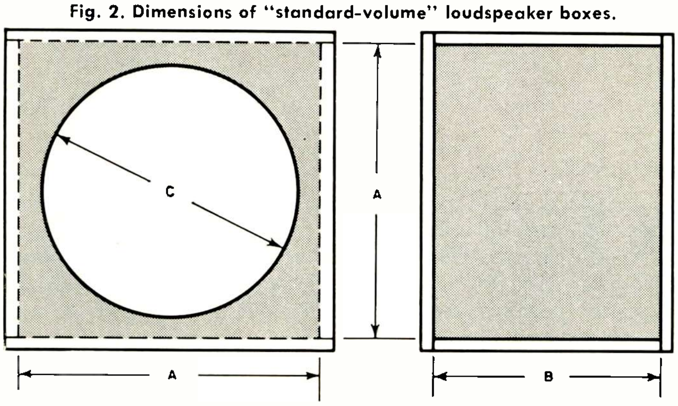
The main factor that determines the low-frequency cut-off of most loudspeaker systems is a resonance frequency of some kind, *i.e.*, either the resonance of the loudspeaker itself, its resonance in the enclosure, or a new resonance created by the presence of the enclosure.

The flat baffle and open-back cabinet are not very useful for high-fidelity applications. A loudspeaker radiates sound energy from both sides of the cone. These two sound fields are out of phase with each other, *i.e.*, when the front of the cone radiates a high-pressure wave, the back is radiating a low-pressure wave. These two waves tend to cancel each other when they are not isolated and this effect becomes more pronounced as the frequency becomes lower.

This problem can be minimized by making the baffle larger but this has its shortcomings. In order to obtain acceptable performance to say, 40 cps, the length of one side must be at least a half wavelength long at that frequency or 14 feet. Of course, the flat baffle can be folded back on itself such as in the open-back cabinet, but the structure will still be quite ungainly. It is for this reason that baffles of this type are rarely found in present-day high-fidelity practice.

An obvious solution to this cancellation problem is to completely enclose the back of the loudspeaker so that the sound field from the back of the loudspeaker diaphragm cannot be radiated. One major difficulty with this type of enclosure is that the "air cushion" within the box stiffens the moving parts of the loudspeaker and increases the resonance. The low-frequency cut-off of simple baffles and enclosures is determined

Fig. 2. Dimensions of "standard-volume" loudspeaker boxes.




| SPEAKER SIZE (IN.) | DIM. A (IN.) | DIM. B (IN.) | DIM. C (IN.) | V (CU. FT.) |
|---|---|---|---|---|
| 8 | 10 | 8 5/8 | 6 3/4 | 0.5 |
| 10 | 14 1/4 | 8 1/2 | 8 3/4 | 1.0 |
| 12 | 14 1/4 | 8 1/2 | 10 1/2 | 1.0 |
| 15 | 20 | 8 5/8 | 13 1/4 | 2.0 |

primarily by the resonance frequency of the speaker when in the baffle or enclosure. The resonance of a speaker in a closed box is determined by the volume of the box. Large cabinets will increase the resonance to a lesser degree than will small cabinets. Generally speaking, it will be necessary to use cabinet volumes of at least 3 cubic feet for 8-inch loudspeakers, 8 cubic feet for 12-inch loudspeakers, and 15 cubic feet for 15-inch loudspeakers. Small bookshelf-type enclosures require the use of rather specially designed loudspeakers having high mass and very low stiffness (high elasticity or compliance) in order to obtain fairly low resonance frequencies.

Horn-type loudspeakers are usually impractical to design readily because they require a complete knowledge of the mechanical constants of the speaker, such as mass, stiffness, flux density, etc. This type of data is seldom available outside of the speaker manufacturer's engineering department. Even if complete loudspeaker data is available, the design calculations are quite complicated and the cabinetry even more so.

From a constructional standpoint, the bass-reflex enclosure is hardly more complicated than the simple closed box. It is, in fact, exactly the same as a closed box except that there is an opening, usually on the front of the enclosure. This opening allows the sound from the rear of the loudspeaker to come around to the front. But, unlike the flat baffle or open-back cabinet, cancellation does not take place. Because the opening, called a port, has mass and the volume of the enclosure has compliance, a tuned circuit is created which shifts the phase of the sound waves so that they reinforce those from the front of the cone over a fairly wide frequency range. The enclosure/speaker combination now becomes a system of two tuned circuits. These two tuned circuits are closely coupled together. The result is that the original speaker resonance frequency disappears completely and is replaced by two other resonance frequencies, one above and one below the original speaker resonance.

The sound waves radiated from the port and speaker are opposite in phase at the lowest resonance frequency and, therefore, cause a significant cancellation in net output. At the original speaker free-air resonance, however, the sound waves from port and speaker are 90° out-of-phase. Because the cone amplitude and therefore radiation at this frequency is greatly reduced, the total amount of energy radiated is essentially a function of the acoustic properties of the port.

At the upper resonance, the port and cone radiation are in phase, resulting in an increase in total sound radiation.

### Optimum Enclosure Size

A careful study of bass-reflex operation from a theoretical standpoint reveals a complexity far greater than the extremely simple construction would indicate. A number of generally unknown facts come to light concerning low-frequency extension and optimum transient response.

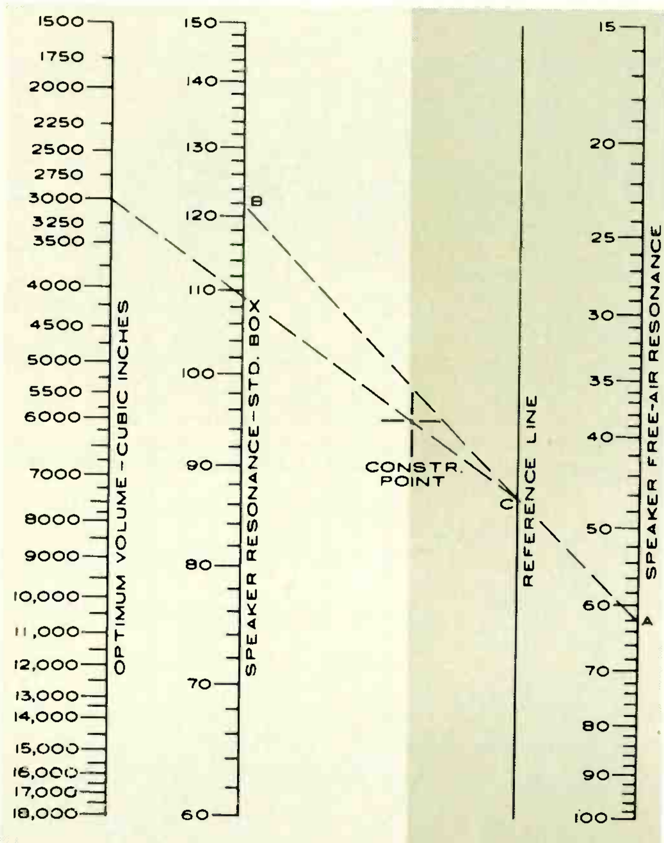
1. *A bass-reflex enclosure can be too large.* After a certain maximum volume is reached, further volume increases result in "boomy" bass rather than an appreciable extension of low-frequency response. This is particularly true when a speaker with a small magnet is used. It is best to use a completely closed cabinet in this case.

2. *A bass-reflex enclosure can also be too small.* A common assumption is that the enclosure can be made much smaller by using a duct behind the port. While the use of a duct allows one to tune the enclosure to very low frequencies when volumes are small, it is the ratio of enclosure air stiffness to speaker stiffness that determines the low-frequency cut-off. As the enclosure volume is made smaller, the enclosure stiffness increases and so does the cut-off frequency. This will remain true regardless of how the enclosure is tuned. A false "boomy" bass will generally result and the enclosure may as well be left closed. In some cases a better sounding bass will result if the back of the speaker enclosure is removed.

3. Only one condition of cabinet tuning and damping will

result in optimum transient response, *i.e.*, freedom from hangover or boom. Because a speaker in a bass-reflex forms a closely coupled system of two tuned circuits, the system will tend to decay with two frequencies. The achievement of optimum transient response demands that the system decay with one frequency and with a specified time constant. In order to make the system decay in one frequency, the enclosure volume and port combination must be tuned to the free-air resonance of the speaker. A specified decay can be achieved by adding acoustic resistance, in the form of damping material, to the enclosure. The proper amount of damping material can be determined by means of a test method described later.

A nagging question in the design stage of any enclosure of this type is "How large shall it be?" It was pointed out earlier that the enclosure can be too large or too small for proper bass-reflex action. This implies that an *optimum volume* exists and indeed it does. This optimum volume does not de-




◄ Fig. 4. Optimum-volume nomogram for use with 10-inch and 12-inch loudspeakers. Standard box here is one cubic ft.

pend upon the size of the speaker nor its resonant frequency *per se* but rather on the ratio of enclosure air stiffness to the speaker cone suspension stiffness. This optimum ratio is 1.44 or, looking at it another way, the speaker resonant frequency in the enclosure before porting should be 1.56 times the free-air resonance of the speaker. This size enclosure, when properly tuned, yields at the same time the most extended low-frequency response and a transient response with subjectively unnoticeable hangover, assuming sufficient damping exists. Compared to the entirely closed cabinet, the half-power point (3 db down) occurs at 0.7 times the closed cabinet speaker resonance for an extension of one-half octave.

## Designing the Enclosure

In order to proceed with the actual design work, it is necessary to know the stiffness of the cone suspension. Since speaker manufacturers are notorious for not having this information readily available, it is necessary to derive this by measuring the speaker resonance in free air and in a "standard volume." A properly calibrated audio oscillator, a simple a.c. vacuum-tube voltmeter, and a 100- to 1000-ohm resistor are

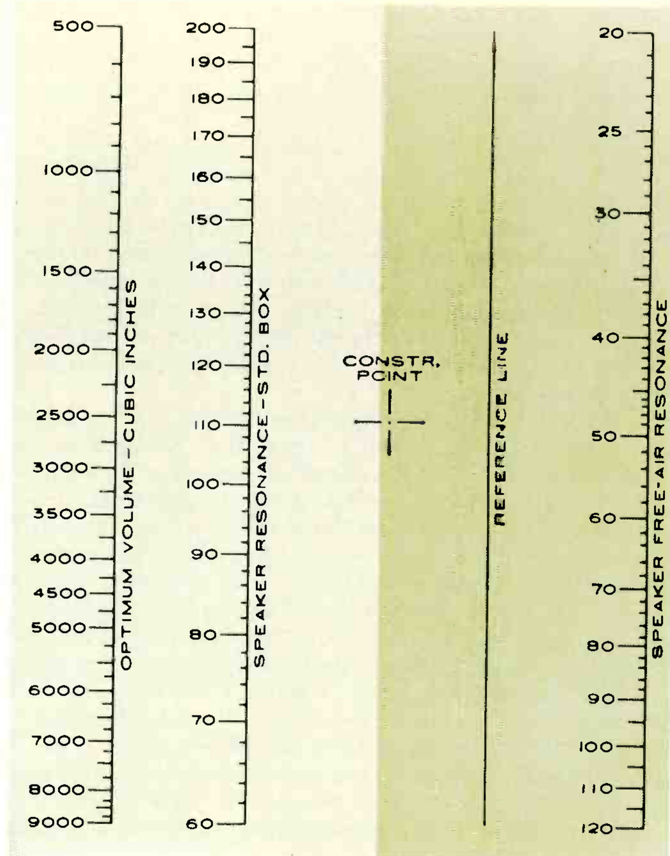
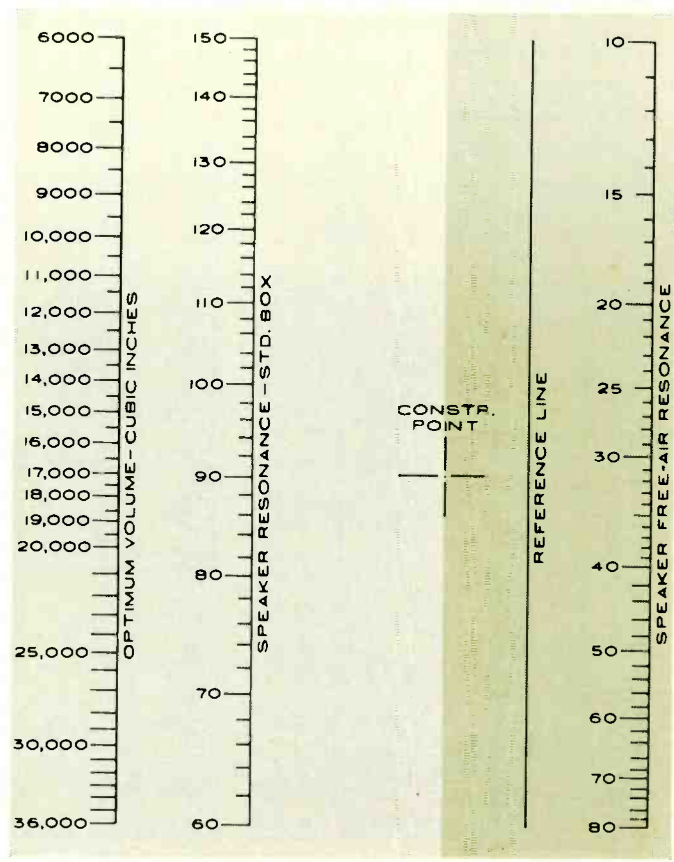



Fig. 3. Optimum-volume nomogram for use with 8-inch loudspeakers. Standard box in this particular case is one-half cu. ft.

Fig. 5. Optimum-volume nomogram for use with 15-inch loudspeakers. Standard box size in this case is two cubic ft.



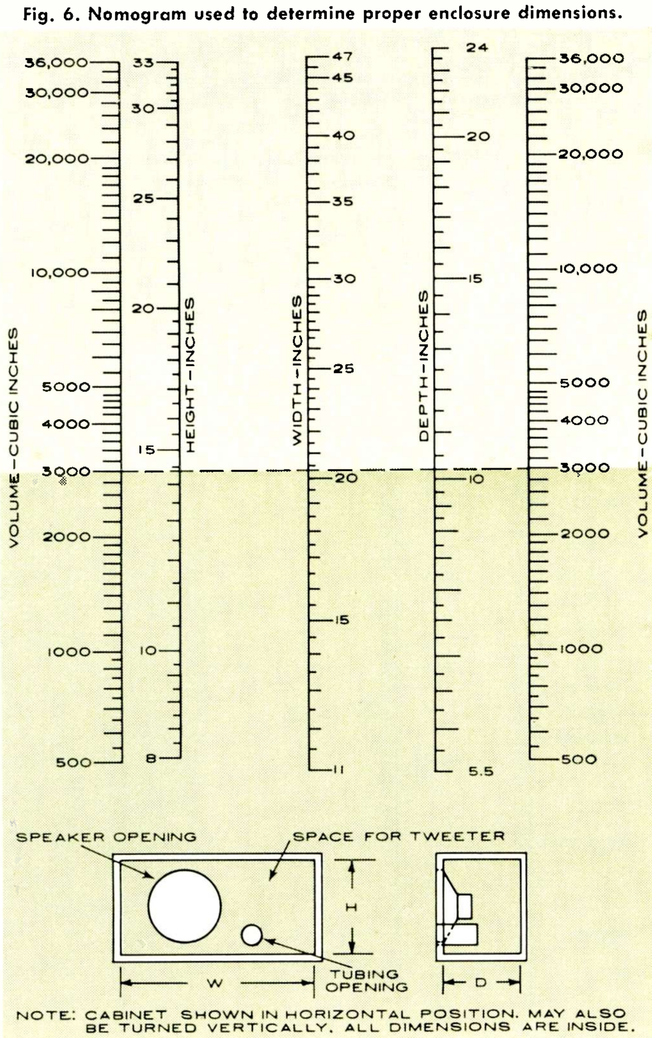
required. Although this value is not at all critical, the higher values will give more sharply defined readings. Use the largest value consistent with the oscillator output voltage and voltmeter sensitivity. Fig. 1A shows how these elements are connected.

The "standard volume" is nothing more than a small plywood box of known volume. Fig. 2 shows the constructional details of boxes for 8-inch, 10-inch and 12-inch, and 15-inch speakers. Although a single volume could have been used for all loudspeaker sizes, three separate volumes were chosen in the interest of economy. This box must be thoroughly sealed with caulking compound or putty to prevent leaks. Note: All measurements will be made with the speaker mounted on the *outside* of the box. All six sides should, therefore, be permanently assembled.

The first step after selecting a loudspeaker and constructing the appropriate "standard volume" is to measure resonant frequencies. Hook up the unbaffled speaker as shown in Fig. 1A. The speaker should be held in the air away from any large objects and the audio oscillator slowly swept through the low-frequency end of the audio range so that it passes through the speaker's resonant frequency. The voltmeter connected across the voice coil terminals will show a large rise in voltage at this frequency. The frequency corresponding to maximum voltmeter reading is the resonant frequency of the speaker.

After noting the free-air resonant frequency, place the speaker face down over the hole in the "standard box." A slight amount of hand pressure should be applied to the rear of the speaker to help get a good seal between speaker gasket and the box. The speaker resonant frequency is again determined as before. The resonant frequency determined this time

**Fig. 6. Nomogram used to determine proper enclosure dimensions.**



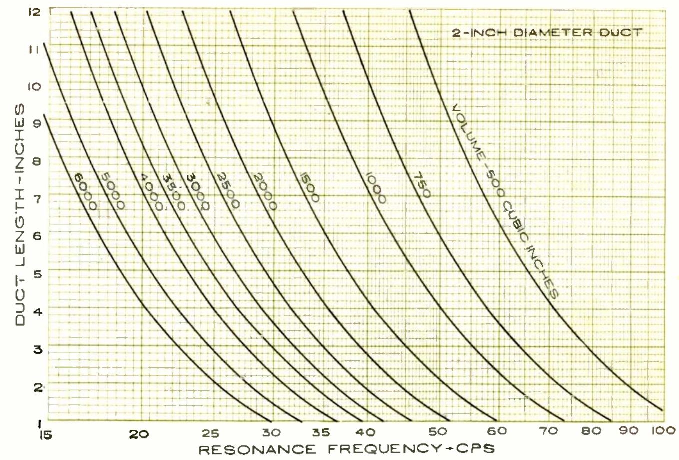




**Fig. 7. Duct lengths for various free-air resonance frequencies using 2-in. tubing. Note: duct length measured from cabinet front.**

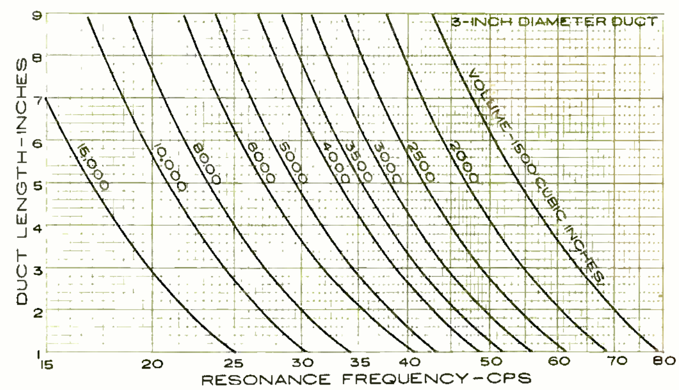



**Fig. 8. Duct lengths for various free-air resonance frequencies using 3-in. tubing. Duct length is measured from cabinet front.**

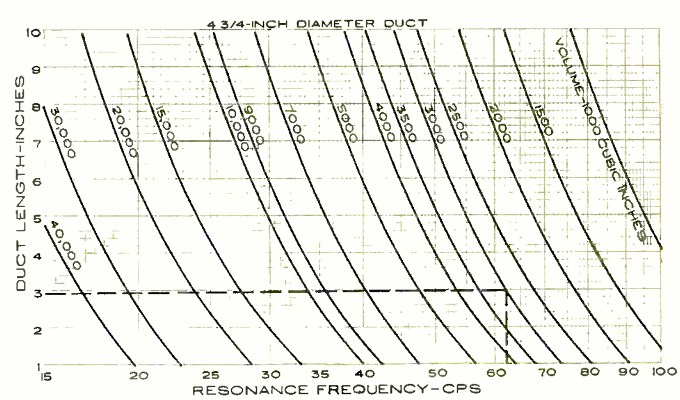



**Fig. 9. Duct lengths for various free-air resonance frequencies using 4¾" tubing. Duct length is measured from cabinet front.**

will be higher than the free-air resonance. It is quite possible for this frequency to be two to four times the free-air resonance.

The proper nomograms of Figs. 3, 4, or 5 can now be used to determine the proper enclosure volume. The following example will clarify the technique.

Assume an enclosure is to be built for a 12-inch loudspeaker with the following resonant frequencies: free-air resonant frequency, 62; resonant frequency in "standard box," 121 cps.

Using the nomogram of Fig. 4, draw a straight line between Point A, the speaker free-air resonance and Point B, the speaker resonance with the "standard box." From the intersection of this line and the reference line, Point C, draw another straight line through the construction point until it intersects with the optimum-volume line. The number read (3000 cubic inches) is the proper volume for this loudspeaker.

Unless the reader has reasons for making the enclosure conform to a special shape, the (*Continued on page* 76)

# Capacitance Measuring Nomogram

Description of test circuit that may be employed to check large number of electrolytic capacitors rapidly. Useful for incoming inspection of these components.

By MAX H. APPLEBAUM
Warwick Electronics Inc., Pacific Mercury Div.

THIS capacitance tester will find its maximum usefulness when applied to incoming inspection testing of electrolytics, especially in plants engaged in the manufacture of consumer electronic products. In this instance, a large quantity of capacitors is checked out on an AQL (acceptance quality level, a statistical procedure) basis to determine the acceptability of a shipment. The test can be made quickly at a minimum of cost since no particular skill is required of the operator. It will also have equal value to technicians and hobbyists who cannot afford the more expensive capacitance bridges normally used for this test.

Fig. 1A shows the basic circuit of the tester. An a.c. voltage, equal to the product of the nominal rated a.c. ripple current and the approximate reactance resulting from the sum of the reactances of the capacitors at 60 cps is applied to the circuit. (In most cases approximately 30 volts r.m.s. may be used. Slightly higher voltage may be used for large values of capacitance.) $E_{D.C.}$ is a polarizing potential equal to the rated d.c. working voltage of the unknown capacitor ($C_X$). This potential is applied across $C_X$ through the series resistor $R$ to prevent $C_X$ from being shorted by the d.c. supply. $R$ should have a value of about 20 times the reactance of $C_X$ at 60 cps. The limiting factor in determining the maximum value of $R$ is the capacitor charging time which should be short for rapid testing. The following chart shows some suggested values of resistance for various ranges of capacitance:

| Cx | R |
|---|---|
| 1-10 μf. | 10,000 ohms |
| 10-100 μf. | 1000 ohms |
| 100-1000 μf. | 100 ohms |
| 1000-10,000 μf. | 10 ohms |

$C_K$ is a capacitor of known value and should be close to the value of $C_X$ for more accurate results. By taking the ratio of the two capacitors and setting it equal to the inverse ratio of the a.c. voltages appearing across them, we arrive at an equation from which $C_X$ can be calculated. $C_X/C_K = E_K/E_X$. The task of calculating $C_X$ can be done quickly and conveniently by using the nomogram of Fig. 2. The method of using this nomogram can best be described by the following example:

Find the value of an unknown electrolytic ($C_X$) measured in the test fixture of Fig. 3 when the known capacitor ($C_K$) is 10 μf. and the a.c. voltages measured are 9 volts across the known capacitor ($E_K$) and 11 volts across the unknown ($E_X$). The solution is obtained in two steps. (1) Align a straightedge from 9 on the $E_K$ scale to 11 on the $E_X$ scale, and (2) align a straightedge from 10 on the $C_K$ scale and the point where the straightedge crossed (Continued on page 64)

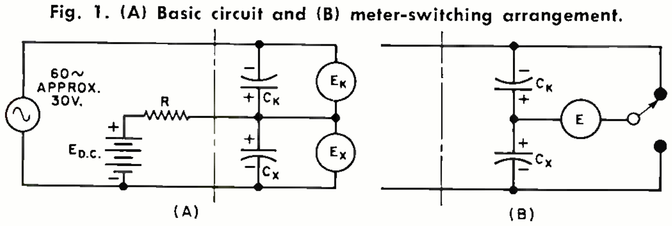



Fig. 1. (A) Basic circuit and (B) meter-switching arrangement.

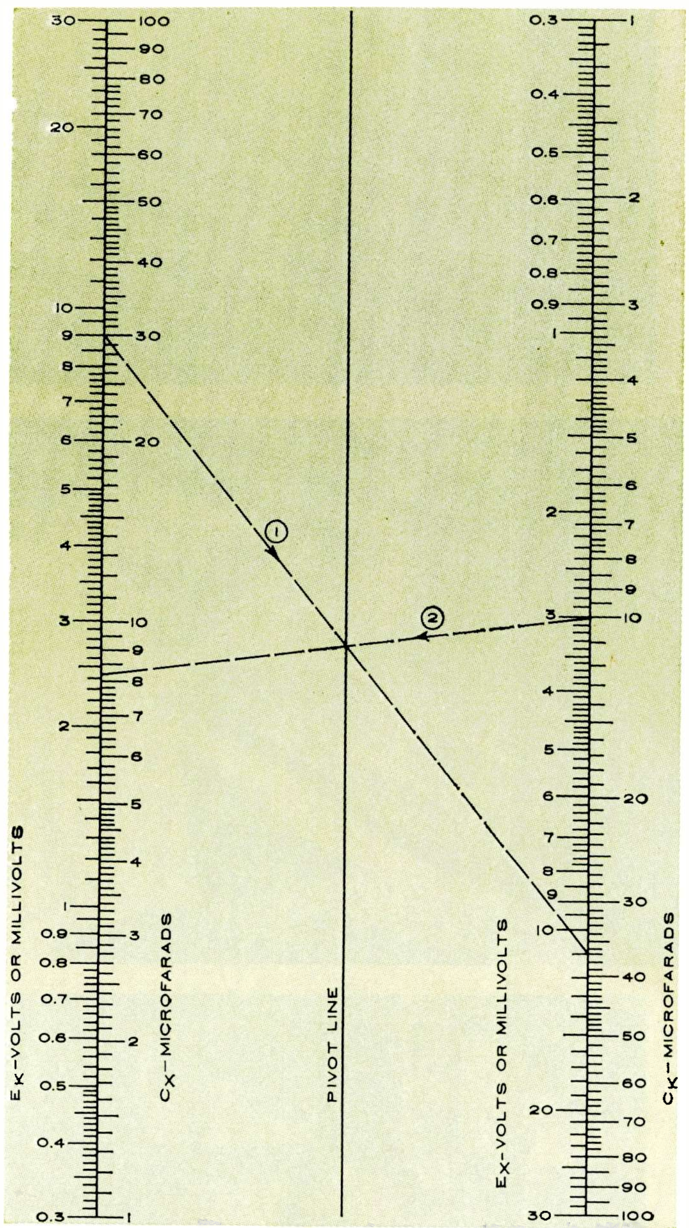
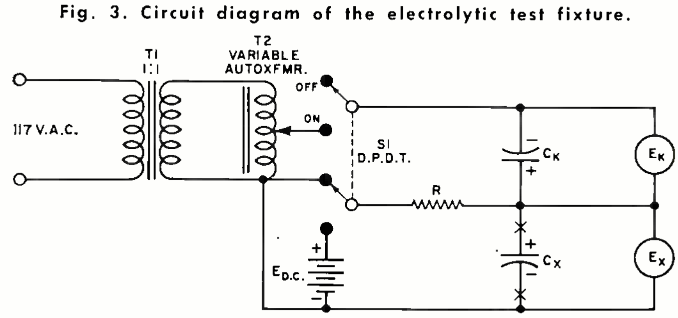
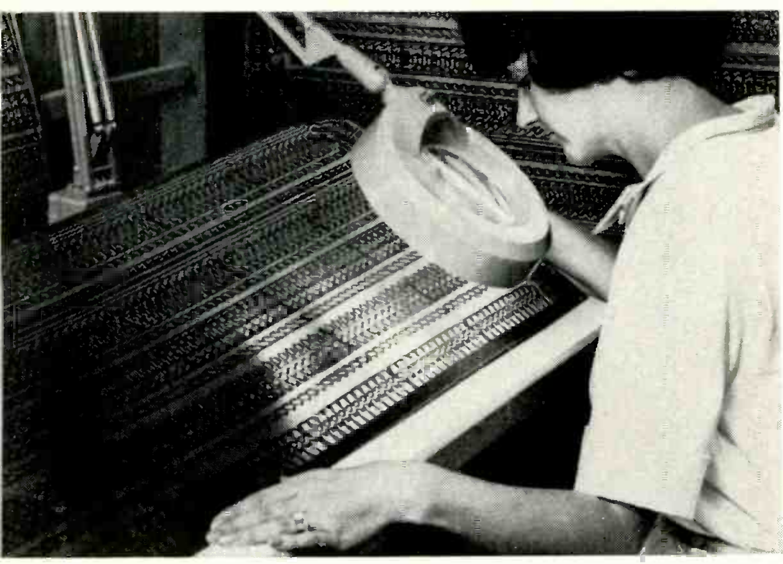



Fig. 2. Nomogram used to determine unknown capacitor value.

Fig. 3. Circuit diagram of the electrolytic test fixture.



# RECENT DEVELOPMENTS IN ELECTRONICS

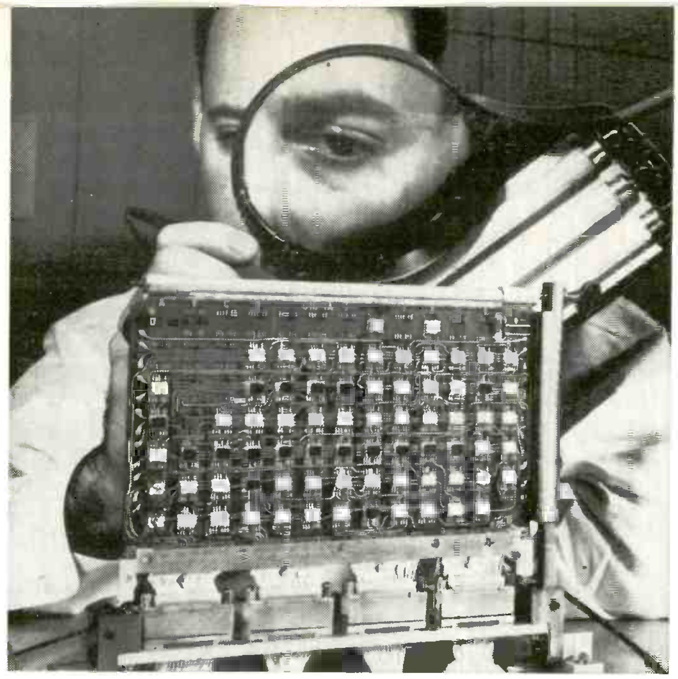


**Traveling-Wave Tubes for Space.** (Above) The TWT, of the type shown here, has racked up more than 30,000 operational hours in outer space aboard four successful spacecraft. It is also scheduled for launch on at least eight future space shots, including the Apollo man-on-the-moon vehicle. The unique metal-and-ceramic TWT, designed and built by Hughes Aircraft Company's microwave tube division, was used in the transmitter of Mariner 4 that sent photos of Mars back to earth. Similar tubes were launched aboard Syncom 2 (July, 1963), Syncom 3 (August, 1964), and Early Bird (April, 1965) communications satellites. A major advantage of the metal-ceramic construction is that the tube can withstand severe launch shocks; the tube has passed tests at the 200G level. The TWT's vary slightly in size and weight according to power requirements. For example, the Mariner 4 tube is 9 inches long and weighs 13 ounces. It was designed to last 20,000 hours but other such tubes have a 40,000 to 90,000 hour lifespan. Inside the TWT's housing, a high-intensity electron beam transfers its energy to a helical coil causing a weak microwave signal entering coil to be amplified.

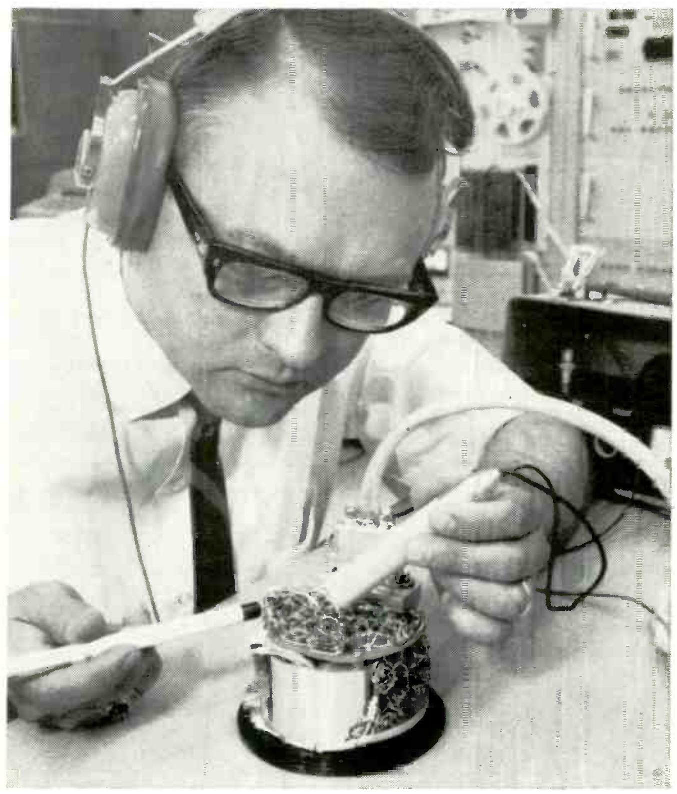
**Largest Printed Circuit.** (Center) A technician at Litton Industries' Advanced Circuitry division is shown here inspecting the largest known printed circuit board in production. Copper circuits are etched on both sides of the 1/16-inch-thick phenolic board, which is nearly four feet long. The particular board shown is intended for use in an electronic organ.

**Millimeter-Wave TV Signal.** (Left) The entire radio-frequency channel of a television station has been superimposed on a millimeter-wave signal by means of a new semiconductor device called an injection modulator. It is believed to be the first time the total spectrum of a TV station—including both carriers and modulation—has been impressed on a millimeter beam by a semiconductor device. The signal was transmitted by an experimental millimeter-wave communications system to demonstrate the capabilities of the new injection modulator. Development of the new device was carried out by GT&E Laboratories under contracts from the U.S. Army Electronics Command, Fort Monmouth, N.J. The TV set on the right shows the detected TV signal before it is impressed and transmitted over the millimeter-wave beam. The TV set on the left shows the detected TV signal after transmission over the beam. In the laboratory demonstration, an 83-mc. signal containing video and sync pulses was applied to the injection device to modulate a 70,000-mc. carrier. The resulting amplitude-modulated millimeter-wave signal was transmitted, detected, and displayed on TV set.

**Integrated Circuits for Computers.** (Right) Electronic components for a miniaturized computer, which weighs less than 200 pounds and occupies only four cubic feet of space, are shown being tested here by a Sylvania engineer. The computer will perform the large-scale, high-speed computations of conventional data-processing equipment using approximately 3500 tiny integrated circuit packages. Each package contains the equivalent of 24 components, such as resistors, transistors, diodes, and capacitors. The completed boards are mounted on a processor which can operate simultaneously with up to eight peripheral devices including tapes, punches, and memories.

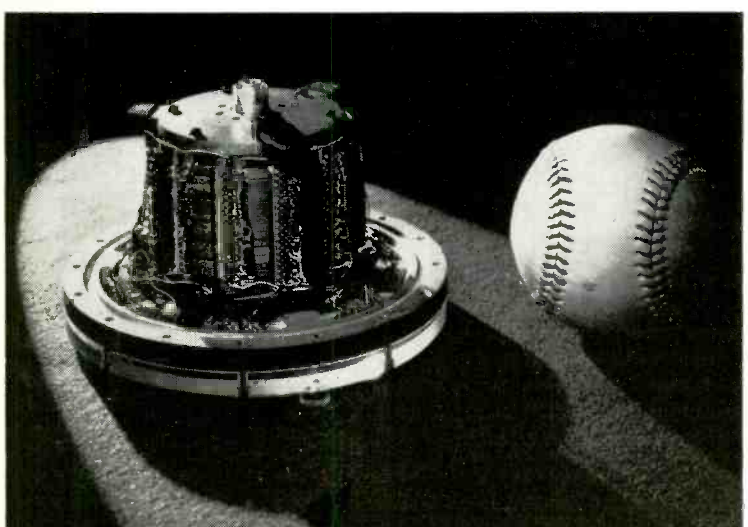


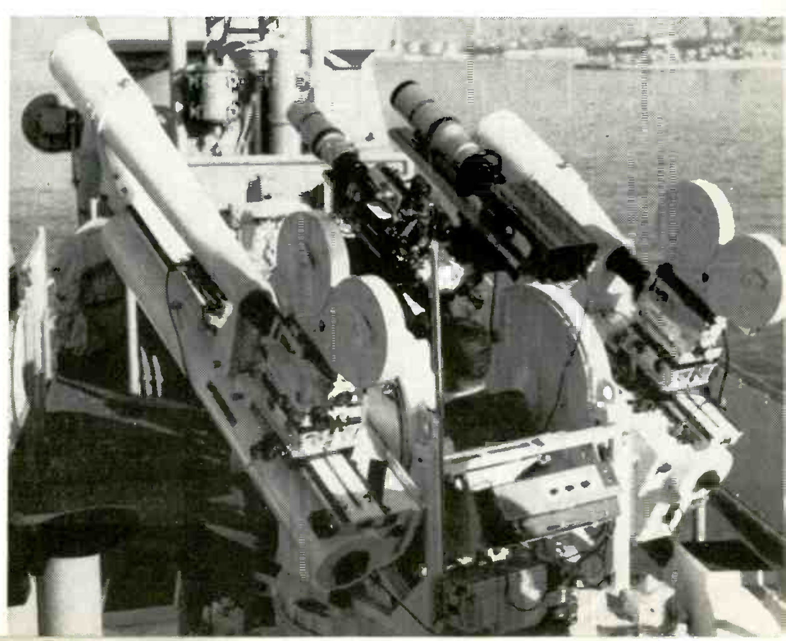
**R.f. Probe Tests Integrated Circuits.** (Center) A portable, self-contained troubleshooting device that detects latent defects in electronic equipment, particularly integrated circuits, is shown being used here. A non-metallic rod (in the user's right hand) taps the various components while the instrument's probe picks up any noise generated. The probe is actually a broad-band, tuned radio frequency amplifier that detects and measures noise in the 20 to 30 mc. range. Once the operator has studied the noise levels and compared them with the normal levels for well-functioning equipment, he zeroes in on the faulty component or circuitry by reducing amplifier gain and varying pick-up position. The unit has been built by Honeywell's Minneapolis Aeronautical Division.



**Compact Computer Memory.** (Below left) This baseball-size experimental computer memory—one of the most compact ever developed—has been designed to store data for rocket and missile guidance systems. The miniature device holds four times more data than other memories of its kind but is seven times smaller. Developed by IBM engineers for aerospace use, the memory unit has only one moving part and can hold 600,000 separate bits of data. The moving part is a small cylinder on which data is stored magnetically. The drum can spin at up to 12,000 rpm.

**CCTV Missile-Firing Monitor.** (Below right) Closed-Circuit TV is being used more and more today at the Naval Missile Center's Photographic Department at Point Mugu, Calif., particularly in testing and evaluating missile launches. The CCTV recording system, employing video tape recorders, augments film camera coverage. The illustration shows a TV-equipped tracking mount recently installed aboard a destroyer for a coming operation. Two film cameras are installed on the outboard sides of the mount, while the TV cameras are at the center. CCTV is particularly important because it records data for real-time (as it occurs) viewing as well as for later reference and review.





# Solid-State Hi-Fi Equipment Directory

COVERING only solid-state audio components, this directory lists the electrical characteristics, physical dimensions, and prices of 108 separate items including preamplifiers, power amplifiers, integrated amplifiers (combining preamplifier and power amplifier), tuners, and receivers (combining tuner, preamp, and power amplifier sections).

With the exception of tuners and receivers that may use a vacuum tube in their front end, all devices covered in this listing are fully transistorized. *All are stereo unless noted.*

All information supplied in this directory was in reply to requests made of each manufacturer. Several companies that also manufacture solid-state components (*RCA* for example) are not listed as unfortunately we could not get the specifications on their equipment. ▲

## Solid-State Preamplifiers

| Model | Rated output (v.) | THD @ 1 v. output, 1 kc. (%) | IM @ 1 v. output (%) | Freq. response @ 1-v. output (cps) | Input sensitivity for rated output: Phono mag. (mv.) | Phono ceramic (mv.) | Tape head (mv.) | High level (v.) | Headphone jack impedance (ohms) | Tape output jack | Tape monitor switch | Rumble/scratch filter controls | Physical size (inches): W | H | D | Assembled price ($) | Kit price ($) | Cabinet ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACOUSTECH, INC., 139 Main St., Cambridge, Mass. 02142 | | | | | | | | | | | | | | | | | |
| IV[a] | 2 | — | .09 | — | 10 | — | — | .5 | 600, up | yes | — | — | 15¾ | 4 | 8 | — | 149.00 | inc. |
| | CM LABORATORIES, 575 Hope St., Stamford, Conn. | | | | | | | | | | | | | | | | | |
| CC-1 | 2 | .1 | .1 | 2-100 k | 3 | — | 6 | .25 | none | yes | yes | scr. | 15¾ | 5½ | 12 | 315.00 | — | 21.00 |
| | HADLEY LABS., 115 Spring Street, Claremont, Calif. | | | | | | | | | | | | | | | | | |
| 621 | 3 | .05 | .05 | 20-20 k | 3 | — | 3 | .3 | none | yes | yes | none | 15 | 4½ | 8 | 359.00 | — | inc. |
| | LANSING, JAMES B., SOUND, INC., 3249 Casitas Ave., Los Angeles 39, Calif. | | | | | | | | | | | | | | | | | |
| SG520 | 3 | .15 | .05 | 20-20 k | 6 | — | 5 | .3 | 8, up | yes | yes | yes | 15½ | 6½ | 13½ | 450.00 | — | 15.00 |
| | MARANTZ CO., INC., 25-14 Broadway, Long Island City, N.Y. 11106 | | | | | | | | | | | | | | | | | |
| 7T | 10 | .05 | .15 | 20-20 k | .6 | — | 1.2 | .075 | any | yes | yes | yes | 15⅜ | 5¾ | 7 | 295.00 | — | 24.00 |
| | McINTOSH LABORATORY INC., 2 Chambers St., Binghamton, N.Y. | | | | | | | | | | | | | | | | | |
| C-24 | 2.5 | .1 | .1 | 20-20 k | 2 | — | 2 | .2 | 4, 8, 16 | yes | yes | yes | 16 | 5⅞ | 11 | 249.00 | — | — |

All information supplied by manufacturer. Measurements were requested at 117-v.a.c. line. Distortion and frequency response taken with high-level input.
[a]Model VI same as Model IV except 200-ohm output, stepped controls, and costs $249.00, factory assembled.

## Solid-State Power Amplifiers

| Model | IHF music power (w./chan.) | Continuous power (w./chan.) | THD @ rated power, 1 kc. (%) | THD @ 1 w. (%) | IM @ rated power (%) | IM @ 1 w. (%) | Power bandwidth (cps) | Freq. response @ 1 w. (cps) | Input sensitivity (v.) | Output impedance (ohms) | Damping factor | Physical size (inches): W | H | D | Assembled price ($) | Kit price ($) | Cabinet ($) | Center channel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACOUSTECH, INC., 139 Main St., Cambridge, Mass. 02142 | | | | | | | | | | | | | | | | | |
| 1-A | — | 80 | .45 | — | .25 | .1 | — | 5-50 k | — | 4, 8, 16 | 150 | 15¾ | 5 | 12 | 395.00 | — | inc. | — |
| III | — | 50 | .45 | — | .25 | .1 | — | 5-50 k | — | 4, 8, 16 | 150 | 15¾ | 5 | 8 | 274.00 | 199.00 | inc. | — |
| XI | — | 35 | .45 | — | .25 | .1 | — | 5-50 k | — | 4, 8, 16 | 150 | 15¾ | 5 | 10 | — | 129.50 | inc. | — |
| | ALTEC LANSING, 1515 South Manchester Ave., Anaheim, Calif. 92803 | | | | | | | | | | | | | | | | | |
| 351B[a] | 50 | 40 | 1.5 | — | — | — | — | 20-20 k | .45 | 4, 8, 16, 125, 70-v. | 7.5 | 9¾ | 5 | 9¼ | 252.00 | — | — | — |
| | CM LABORATORIES, 575 Hope St., Stamford, Conn. | | | | | | | | | | | | | | | | | |
| 35D | — | 35 | .25 | .25 | .25 | .25 | 20-20 k | 1-100 k | .65 | 4, 8, 16 | 200 | 10⅛ | 6⅛ | 12¼ | 285.00 | — | — | — |
| 35MRM[a] | — | 50 | .5 | .5 | .5 | .5 | 20-20 k | 1-100 k | .65 | 4, 8, 16 70-v. | 200 | 19 | 5¼ | 13 | 237.00 | — | — | — |
| | DYNACO INC., 3912 Powelton Ave., Philadelphia, Pa. 19104 | | | | | | | | | | | | | | | | | |
| 60/60 | 60 | 60 | .5 | .1 | .5 | .1 | 8-65 k | 10-100 k | 1.5 | 8 | 20 | 13 | 4 | 10 | 200.00 | 150.00 | inc. | yes |
| | HADLEY LABS., 115 Spring Street, Claremont, Calif. | | | | | | | | | | | | | | | | | |
| 622 | 80 | 40 | .5 | .1 | .8 | .2 | 2-35 k | 3-50 k | 1.1 | 4-20 | 250 | 12½ | 4¾ | 10⅞ | 359.00 | — | — | — |
| | LANSING, JAMES B., SOUND, INC., 3249 Casitas Ave., Los Angeles 39, Calif. | | | | | | | | | | | | | | | | | |
| SE 401 | — | 40 | .25 | — | .5 | — | 10-30 k | — | 1 | 4-16 | [b] | 15¼ | 4⅝ | 6⅝ | 231.00 | — | — | no |
| SE 400 | — | 40 | .25 | — | .5 | — | 10-30 k | — | 1 | 4-16 | [b] | 15¼ | 4⅝ | 6⅝ | 261.00 | — | inc. | no |
| | MATTES ELECTRONICS INC., 4937 West Fullerton Ave., Chicago, Illinois 60639 | | | | | | | | | | | | | | | | | |
| SSP 200 | 160 | 100 | .5 | .5 | .07 | .4 | 7-20 k | 1.5-30 k | 1 | 4, 8, 16 | 250 | 14¼ | 8 | 5¼ | 375.00 | — | inc. | no |
| | SCHOBER ORGAN CORP., 43 West 61st Street, New York 23, N.Y. | | | | | | | | | | | | | | | | | |
| TR-2[a] | 50 | 40 | .22 | .1 | 1.4 | .9 | 20-20 k | 9-40 k | .055 | 4-16 | — | 5½ | 7½ | 11¼ | — | 69.95 | inc. | no |

All information supplied by manufacturer. Measurements were requested at 117-v.a.c., 8-ohm loads, both channels driven.
[a]All are stereo units except Altec Lansing 351B, CM Labs. 35MRM, and Schober TR-2. [b]Controlled to match specific loudspeaker.

# Solid-State Integrated Amplifiers

| Model | IHF music power (w./chan.) | Continuous power (w./chan.) | THD @ rated power, 1 kc. (%) | THD @ 1 w. (%) | IM @ rated power (%) | IM @ 1 w. (%) | Power bandwidth (cps) | Freq. response @ 1 w. (cps) | Output impedance (ohms) | Damping factor | Center channel output | Input sensitivity for rated output: Phono mag. (mv.) | Phono ceramic (mv.) | Tape head (mv.) | High level (v.) | Headphone jack imp. (ohms) | Tape output jack | Tape monitor switch | Rumble/scratch filter controls | Physical size (inches): W | H | D | Assembled price ($) | Kit price ($) | Cabinet ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ACOUSTECH INC., 139 Main St., Cambridge, Mass. 02142** | | | | | | | | | | | | | | | | | | | | | | | | | |
| V | — | 45 | .45 | — | .25 | .1 | — | — | — | — | — | 2.5 | 10 | — | .5 | — | — | — | — | 15¾ | 5 | 8 | 349.00 | — | inc. |
| VII | — | 30 | .45 | — | .25 | .1 | — | — | — | — | — | 2.5 | — | — | .5 | — | — | — | — | 15¾ | 5 | 8 | 219.00 | — | inc. |
| **ALTEC LANSING, 1515 S. Manchester Ave., Anaheim, Calif. 92803** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 360 B | 35 | 30 | 1.5 | — | — | — | — | 20-20 k | 4, 8, 16 | 10 | yes | 4 | 200 | 1.9 | .4 | 4-16 | yes | yes | yes | 15 | 5½ | 11⅜ | 389.00 | — | — |
| **BOGEN COMMUNICATIONS, P.O. Box 500, Paramus, N.J. 07652** | | | | | | | | | | | | | | | | | | | | | | | | | |
| AT-600 | 30 | 25 | .6 | .4 | .5 | .3 | 20-20 k | 25-50 k | 4, 8, 16 | 40 | no | 2.5 | — | 2 | .2 | 4, 8, 16 | yes | yes | no | 15 | 4⅝ | 10 | 199.95 | — | 27.95 |
| AT-400 | 20 | 15 | 1 | .6 | .8 | .5 | 20-15 k | 15-30 k | 4, 8, 16 | 35 | no | 2.5 | — | 2.5 | .2 | 4, 8, 16 | yes | yes | no | 15 | 3⅝ | 9½ | 139.95 | — | 19.95 |
| **CM LABS, 575 Hope St., Stamford, Conn.** | | | | | | | | | | | | | | | | | | | | | | | | | |
| CC-50S | — | 50 | .5 | .1 | .5 | .5 | 20-20 k | 5-60 k | 4, 8, 16 | 200 | no | 3 | — | 6 | .25 | 4-hi | yes | yes | yes | 17 | 6 | 13 | 387.00 | — | — |
| **ELECTRO-VOICE, INC., Buchanan, Mich. 49107** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1144 | 25 | 18 | 1.5 | .5 | — | — | — | 20-30 k | 4-16 | 35 | no | 4.5 | — | — | .09 | 4-16 | yes | yes | no | 8¼ | 3⅜ | 10¼ | 124.50 | — | inc. |
| **FISHER RADIO CORP., 21-21 44th Dr., Long Island City 1, N.Y.** | | | | | | | | | | | | | | | | | | | | | | | | | |
| TX-300 | 50 | 36 | .5 | — | .4 | — | 12-50 k | 20-25 k | 4, 8, 16 | 20 | no | 2.8 | — | 1.8 | .2 | 4-16 | yes | yes | yes | 15⅛ | 4 13/16 | 11⅞ | 329.50 | — | — |
| TX-200 | 45 | 35 | .5 | — | .4 | — | 12-50 k | 20-22 k | 4, 8, 16 | 20 | no | 4 | — | 2.6 | .28 | 4-16 | yes | yes | yes | 15⅛ | 4 13/16 | 11⅞ | 279.50 | — | — |
| **GROMMES, PREC. ELECTRONICS, INC., 9101 King St., Franklin Park, Illinois** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3000 | 60 | 50 | .25 | .15 | .5 | .2 | 30-20 k | 10-100 k | 4, 8, 16 | 35 | yes | 1 | — | 3 | .2 | 4-16 | yes | yes | yes | 15 | 6½ | 13¼ | 299.50 | — | — |
| C-41 | 25 | 20 | .3 | .25 | .5 | .25 | 30-20 k | 10-100 k | 4, 8, 16 | 30 | no | 1 | — | 3 | .15 | 4-16 | yes | no | yes | 15 | 4⅞ | 11 | 179.95 | — | — |
| **HARMAN-KARDON, INC., Plainview, Long Island, N.Y.** | | | | | | | | | | | | | | | | | | | | | | | | | |
| SA 2000 | 18 | 16 | 1 | .1 | 1 | .2 | 9-24 k | 8-25 k | 4-16 | 10 | no | 2 | 100 | — | .25 | any | — | yes | yes | 14 | 4¼ | 8½ | 159.00 | — | 24.95 |
| **HEATH CO., Benton Harbor, Mich. 49023** | | | | | | | | | | | | | | | | | | | | | | | | | |
| AA-22 | 33 | 20 | .3 | .3 | 1 | 1 | 15-30 k | 15-30 k | 4-16 | 20 | no | 6 | — | — | .25 | — | yes | no | no | 15 | 3 3/16 | 11⅜ | — | 99.95 | inc. |
| AA-21D | 50 | 35 | .5 | .5 | 1 | 1 | 13-25 k | 13-25 k | 4-16 | — | no | 3 | — | 2 | .25 | — | yes | yes | no | 15½ | 5¼ | 14 | — | 137.00 | 6.95<br>12.95 |
| AA-14 | 15 | 10 | .5 | .5 | 1 | 1 | 15-50 k | 10-60 k | 4-16 | — | no | 4 | — | — | .3 | low | no | no | no | 12 | 3¼ | 9¾ | — | 59.95 | 3.50<br>7.95 |
| **KENWOOD ELECTRONICS, INC., 3700 S. Broadway Pl., Los Angeles, Calif. 90007** | | | | | | | | | | | | | | | | | | | | | | | | | |
| TK-400 | 40 | 32 | 1 | — | — | — | — | — | 4-16 | 20 | — | 1.5 | — | 1.5 | .1 | — | — | yes | — | — | — | — | 174.95 | — | — |
| **KLH RESEARCH AND DEV. CORP., 30 Cross St., Cambridge, Mass. 02139** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | 50 | 35 | 2 | .5 | 1.5 | .5 | 30-20 k | 20-20 k | 4-16 | 6 | no | 5 | — | — | 1 | 4-16 | yes | yes | scr. | 11¾ | 4½ | 10½ | 219.95 | — | — |
| **KNIGHT, ALLIED RADIO CORP., 100 N. Western Ave., Chicago, Illinois 60680** | | | | | | | | | | | | | | | | | | | | | | | | | |
| KN-999A | 60 | 35 | 1 | .25 | 1.5 | .5 | 20-30 k | 15-40-k | 4, 8, 16 | 40 | — | 4 | — | 4.5 | .25 | 4-25 | yes | no | yes | 13⅞ | 4½ | 12¾ | 199.95 | — | 14.95 |
| KN-966 | 33 | 20 | 1 | .25 | 1.6 | .7 | 30-20 k | 20-30 k | 4, 8, 16 | 30 | — | 4 | — | 4.5 | .25 | 4-25 | yes | no | yes | 13⅞ | 4½ | 12¾ | 119.95 | — | 14.95 |
| **KNIGHT-KIT, ALLIED RADIO CORP., 100 N. Western Ave., Chicago, Illinois 60680** | | | | | | | | | | | | | | | | | | | | | | | | | |
| KG-895 | 60 | 40 | .5 | .5 | 1 | .7 | 20-20 k | 18-30 k | 4, 8, 16 | 11 | — | 2.5 | — | 2 | .25 | low | yes | yes | yes | 16¾ | 5 | 15 | — | 149.95 | 19.95 |
| KG-870 | 35 | 28 | .5 | .3 | 1 | .7 | 25-18 k | 20-25 k | 8, 16 | 17.5 | — | 3 | — | 2 | 1 | low | yes | yes | yes | 13 | 2¾ | 11 | 149.95 | 99.50 | 12.95 |
| KG-854 | 27 | 17 | 1 | .5 | 1.5 | .8 | 25-20 k | 20-25 k | 8, 16 | 17 | — | 3 | — | 2.5 | .5 | low | yes | no | yes | 13 | 2¾ | 11 | — | 79.95 | 12.95 |
| KG-320 | 16 | 10 | 1 | .7 | 1.5 | .8 | — | 25-18 k | 8, 16 | — | — | 3 | — | 2.5 | .4 | low | yes | no | no | 10 | 2¾ | 8½ | — | 59.95 | 9.95 |
| **LAFAYETTE RADIO ELECTRONICS CORP., 111 Jericho Tpke., Syosset, L.I., N.Y. 11791** | | | | | | | | | | | | | | | | | | | | | | | | | |
| LA-340 | 20 | 12 | 1 | .5 | — | — | 70-27 k | 30-20 k | 4, 8, 16 | — | no | 2 | 80 | 2.5 | .25 | 8 | yes | no | no | 11¾ | 3¾ | 10½ | 79.95 | — | inc. |
| LA-243 | 25 | 20 | .7 | .3 | — | — | 50-25 k | 20-20 k | 4, 8, 16 | — | no | 1.4 | 120 | 2.7 | .85 | 8 | yes | no | yes | 13 5/16 | 4⅞ | 10¾ | 119.95 | — | inc. |
| **LANSING, JAMES B., SOUND, INC., 3249 Casitas Ave., Los Angeles 39, Calif.** | | | | | | | | | | | | | | | | | | | | | | | | | |
| SA 600 | — | 40 | .25 | — | .5 | — | 10-30 k | — | 4-16 | — | no | 5 | — | 5 | .25 | 8, up | yes | yes | no | 16⅛ | 5¼ | 13½ | 345.00 | — | 15.00 |
| **LEAK, ERCONA CORP., 432 Park Ave. S., New York, N.Y. 10016** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Stereo 30 | 15 | 8 | .1 | .1 | — | — | — | 30-20 k | 4, 8, 16 | 60 | — | 3.5 | 3.5 | 3 | .1 | no | yes | yes | yes | 13 | 4¼ | 9 | 249.50 | — | inc. |
| **OLSON ELECTRONICS, INC., 260 S. Forge St., Akron, Ohio 44308** | | | | | | | | | | | | | | | | | | | | | | | | | |
| AM-280 | 30 | 22 | .1 | .56 | 1 | .62 | 50-20 k | 20-20 k | 4, 8, 16 | 20 | no | 2.5 | 100 | 3 | .12 | 4, 8 | yes | yes | yes | 14¼ | 4¼ | 10 | 109.98 | — | inc. |
| AM-272 | 7.5 | 5 | 3 | 1.8 | 2.8 | 1.5 | — | 40-20 k | 4, 8, 16 | — | no | — | 160 | — | .16 | — | — | — | — | 10⅜ | 2¾ | 6¾ | 34.98 | — | inc. |
| **PILOT RADIO INC., 100 Electra Lane, East Station, Yonkers 4, N.Y.** | | | | | | | | | | | | | | | | | | | | | | | | | |
| A700 | 35 | — | .5 | .5 | — | — | 15-50 k | 15-50 k | 4-16 | — | yes | 2.8 | — | 1.2 | — | 180 | yes | yes | yes | — | — | — | 229.95 | — | — |
| A300 | 20 | — | .5 | .5 | — | — | 15-40 k | 15-40 k | 4-16 | — | no | 2.5 | — | 1.2 | .18 | 180 | yes | yes | yes | — | — | — | 179.95 | — | — |
| **H. H. SCOTT INC., 111 Powder Mill Rd., Maynard, Mass. 01754** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 299T | 22½ | 18 | .8 | .5 | 2 | .5 | 25-20 k | 18-25 k | 4, 8, 16 | 20 | no | 5.9 | — | no | .5 | low | yes | yes | scr. | 15 5/16 | 4 13/16 | 12¼ | 199.95 | — | 13.95 |
| 260 | 50 | 40 | .8 | .5 | 2 | .5 | 20-20 k | 15-30 k | 4, 8, 16 | 20 | yes | 3 | — | 2 | .5 | low | yes | yes | yes | 15 5/16 | 4 13/16 | 12¼ | 279.95 | — | 13.95 |
| **SHERWOOD ELECTRONIC LABS INC., 4300 N. California Ave., Chicago, Illinois 60618** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9900 | 45 | 36 | .3 | .15 | 1 | .15 | 12-35 k | 8-100 k | 4-16 | 30 | — | 1.8 | — | 1 | .25 | 40 | yes | yes | scr. | 14 | 4 | 10½ | 229.50 | — | 7.50 |
| 9500 | 25 | 15 | .3 | .15 | 1 | .15 | 12-35 k | 8-100 k | 4-16 | 25 | — | 1.8 | — | 1 | .25 | 40 | yes | yes | scr. | 14 | 4 | 10½ | 179.50 | — | 7.50 |
| 9000A | 80 | 60 | .25 | .1 | .5 | .1 | 12-25 k | 8-100 k | 4-16 | 40 | — | 1.8 | — | 1 | .25 | 40 | yes | yes | yes | 14 | 4 | 12½ | 309.50 | — | 8.50 |
| **V-M CORP., P.O. Box 659, Benton Harbor, Mich. 49023** | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1485 | 37.5 | 15 | 5 | 1.5 | — | — | — | 20-20 k | 8 | — | no | 5 | 100 | — | .7 | none | yes | no | no | 13⅝ | 5¼ | 10¾ | 99.50 | — | inc. |

All information supplied by manufacturer. All stereo units. Measurements were requested at 117-v.a.c., 8-ohm loads, both channels driven. Distortion and frequency response taken with high-level input.

# Solid-State Receivers

| MODEL | With AM | IHF usable sens. (μv.) | IHF capture ratio (db) | IHF selectivity (db)[a] | Tuner THD (400 cps) @ rated output (%) | Tuner freq. response @ rated output (cps) | Drift (kc) | Stereo switching | Front end | Interstation muting | SCA or noise filter | AFC | IHF music power (w./chan.) | Continuous power (w./chan.) | THD @ rated power (1 kc.) (%) | THD @ 1 w. (1 kc.) (%) | IM @ rated power (%) | IM @ 1 w. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ALTEC LANSING, 1515 South Manchester Ave., Anaheim, California 92803** | | | | | | | | | | | | | | | | | | |
| 711A | no | 2.2 | 2.5 | — | .15 | 20-20 k | — | auto | trans. | — | SCA | no | 25 | — | .5 | — | — | — |
| **BOGEN COMMUNICATIONS, P.O. Box 500, Paramus, N.J. 07652** | | | | | | | | | | | | | | | | | | |
| RT-4000 | no | 2.5 | 3 | 35 | .7 | 30-15 k | 10 | auto | trans. | no | both | yes | 20 | 15 | 1 | .6 | .8 | .5 |
| RT-8000 | yes | 2.3 | 2.8 | 35 | .7 | 30-15 k | 10 | auto | trans. | no | both | yes | 35 | 27½ | .6 | .4 | .5 | .3 |
| **EICO ELECTRONIC INSTRUMENT CO. INC., 131-01 39th Ave., Flushing, N.Y. 11352** | | | | | | | | | | | | | | | | | | |
| 3566 | no | 2 | 4.5 | 40 | .5 | 20-15 k | — | auto | trans. | yes | both | yes | 37½ | 25 | .5 | .3 | 1 | .3 |
| **ELECTRO-VOICE, INC., Buchanan, Michigan 49107** | | | | | | | | | | | | | | | | | | |
| 1177[b] | no | 2 | 2.5 | — | 1.5 | 20-20 k | 20 | auto | trans. | no | both | yes | 25 | 18 | 1.5 | .5 | — | — |
| **FISHER RADIO CORP., 21-21 44th Dr., Long Island City 1, N.Y.** | | | | | | | | | | | | | | | | | | |
| 600-T | no | 1.8 | 2 | 55 | .4 | 20-15 k | 10 | auto | tube | yes | — | no | 60 | 45 | .5 | — | .5 | — |
| 440-T | no | 2 | 2.2 | 50 | .5 | 20-15 k | 10 | auto | trans. | yes | — | no | 35 | 30 | .8 | — | 1 | — |
| **HARMAN-KARDON, INC., Plainview, Long Island, N.Y.** | | | | | | | | | | | | | | | | | | |
| SR 900 | no | 1.8 | 2.5 | — | .5 | 10-20 k | 1 | auto | trans. | yes | SCA | no | 50 | 40 | .5 | .1 | 1 | .1 |
| SR 600 | no | 1.9 | 2.5 | — | .5 | 10-20 k | 1 | auto | trans. | no | SCA | no | 40 | 34 | 1 | .1 | 1 | .1 |
| SR 400 | yes | 2.9 | 4 | — | 1 | 10-20 k | 1 | auto | trans. | no | SCA | no | 30 | 26 | 1 | .1 | 1 | .1 |
| SR 300 | no | 2.9 | 4 | — | 1 | 10-20 k | 1 | auto | trans. | no | SCA | no | 30 | 26 | 1 | .1 | 1 | .1 |
| **HEATH CO., Benton Harbor, Michigan 49023** | | | | | | | | | | | | | | | | | | |
| AR-13A | yes | 2 | 3 | — | 1 | 20-20 k | — | auto | trans. | yes | both | yes | 33 | 20 | .3 | .3 | 1 | 1 |
| AR-14 | no | 5 | 3 | — | 1 | 20-15 k | — | man. | trans. | no | SCA | yes | 15 | 10 | .5 | .5 | 1 | 1 |
| **KENWOOD ELECTRONICS INC., 3700 S. Broadway Pl., Los Angeles, California 90007** | | | | | | | | | | | | | | | | | | |
| TK-80 | no | 1.8 | 2 | 20 | 1 | 20-20 k | 10 | auto | nuvistor | yes | both | yes | 40 | 32 | .9 | .15 | 2 | .3 |
| TK-60 | yes | 2.5 | 2 | 10 | 1 | 20-20 k | 10 | auto | trans. | no | both | no | 25 | 20 | .9 | .2 | 2 | .3 |
| TK-50 | no | 2.5 | 2 | 10 | 1 | 20-20 k | 10 | auto | trans. | no | both | no | 25 | 20 | .9 | .2 | 2 | .3 |
| **KNIGHT, ALLIED RADIO CORP., 100 N. Western Ave., Chicago, Illinois 60680** | | | | | | | | | | | | | | | | | | |
| KN-376 | yes | 3 | 3 | — | .5 | 20-20 k | 25 | auto | trans. | no | no | yes | 35 | 20 | .5 | .25 | 1.6 | .7 |
| **KNIGHT-KIT, ALLIED RADIO CORP., 100 N. Western Ave., Chicago, Illinois 60680** | | | | | | | | | | | | | | | | | | |
| KG-964 | yes | 2.5 | 8 | — | 1 | 20-20 k | — | auto | trans. | no | both | yes | 32 | 18 | 1 | 1 | 1.5 | 1 |
| **OLSON ELECTRONICS, INC., 260 S. Forge St., Akron, Ohio 44308** | | | | | | | | | | | | | | | | | | |
| RA-727 | no | 1 | 3 | — | .9 | 20-20 k | neg. | auto | trans. | no | SCA | yes | 22 | 15.5 | .5 | .25 | .6 | .3 |
| **PILOT RADIO INC., 100 Electra Lane, East Station, Yonkers 4, N.Y.** | | | | | | | | | | | | | | | | | | |
| R 1100 | — | 2 | 1.5 | — | .3 | 20-15 k | 20 | auto | trans. | yes | both | no | 60 | — | .5 | .5 | — | — |
| R 700 | — | 3 | 3 | — | .4 | 20-15 k | 20 | auto | trans. | no | both | no | 35 | — | .5 | .5 | — | — |
| RA 300 | — | 3.5 | 4 | — | .4 | 20-15 k | 20 | auto | trans. | no | both | no | 20 | — | .5 | .5 | — | — |
| R 300 | — | 3.5 | 3 | — | .4 | 20-15 k | 20 | auto | trans. | no | both | no | 20 | — | .5 | .5 | — | — |
| **H. H. SCOTT INC., 111 Powder Mill Rd., Maynard, Mass. 01754** | | | | | | | | | | | | | | | | | | |
| 388 | yes | 1.9 | 4 | 45 | .8 | c | 20 | auto | FET (FM) trans. (AM) | no | both | no | 40 | 30 | .8 | .25 | 2 | .5 |
| 348 | no | 1.9 | 4 | 45 | .8 | c | 20 | auto | nuvistor | yes | both | no | 50 | 40 | .8 | .25 | 2 | .5 |
| 344 B | no | 2.2 | 4 | 45 | .8 | c | 20 | auto | nuvistor | no | both | no | 32.5 | 25 | .8 | .25 | 2 | .5 |
| 342 | no | 2.7 | 6 | 40 | .8 | c | 20 | auto | FET trans. | no | both | no | 22.5 | 18 | .8 | .25 | 2 | .5 |
| **SHERWOOD ELECTRONIC LABS., INC., 4300 N. California Ave., Chicago, Illinois 60618** | | | | | | | | | | | | | | | | | | |
| S-8800 | no | 1.6 | 2.4 | — | .3 | 20-15 k | 10 | auto | trans. | yes | both | no | 50 | 40 | .3 | .1 | 1 | .1 |
| **V-M CORP., P.O. Box 659, Benton Harbor, Michigan 49023** | | | | | | | | | | | | | | | | | | |
| 1488 | yes | 5 | — | — | — | 20-20 k | 100 | auto | trans. | no | both | yes | — | — | 3 | 1.5 | — | — |
| 1484 | yes | 1.8 | — | — | — | — | 100 | auto | trans. | no | both | yes | 37.5 | 15 | 3 | 1.5 | — | — |

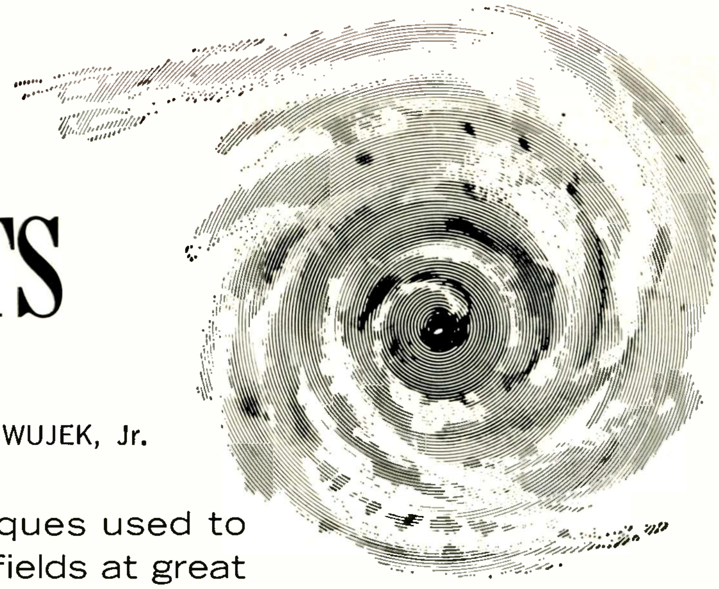
All information supplied by manufacturer. All stereo units. All have tuning meters except Heath AR-14 and V-M 1488. All have stereo indicator lights. Measurements were requested at 117-v.a.c. line with 8-ohm loads, both channels driven. All tuner measurements are in reference to FM section only.

| Power bandwidth (cps) | Freq. resp. @ 1 w. (cps) | Output impedance (ohms) | Damping factor | Center channel output | Input sensitivity for rated output: Phono mag. (mv.) | Phono ceramic (mv.) | Tape head (mv.) | High level (v.) | Headphone jack impedance (ohms) | Tape output jack | Tape monitor switch | Rumble/scratch filter controls | Physical size (inches): W | H | D | Assembled price ($) | Kit price ($) | Cabinet ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 10-100 k | 4-16 | 50 | yes | 5 | — | 2.2 | .5 | 4-16 | yes | yes | rum. | 16 3/8 | 5 3/8 | 12 1/16 | 378.00 | — | — |
| 20-15 k | 15-30 k | 4, 8, 16 | 35 | no | 3 | — | 3 | .2 | 4-16 | yes | yes | no | 16 | 4 5/8 | 14 | 279.95 | — | 29.95 |
| 20-15 k | 15-30 k | 4, 8, 16 | 40 | no | 2.5* | — | 2.5 | .2 | 4-16 | yes | yes | no | 16 | 4 5/8 | 14 | 319.95 | — | 29.95 |
| 8-60 k | 5-60 k | 4, 8, 16 | 13.2 | no | 3 | — | — | .18 | any | yes | yes | no | 17 1/4 | 5 3/4 | 13 1/4 | 325.00 | 219.95 | 14.95 |
| — | 20-30 k | 4-16 | 35 | no | 4.5 | — | — | .09 | 4-16 | yes | yes | no | 15 3/4 | 3 7/8 | 10 1/4 | 280.00 | — | — |
| 20-25 k | 12-35 k | 4, 8, 16 | 20 | no | 2.8 | — | 1.8 | .21 | 4-16 | yes | yes | yes | 16 3/4 | 5 1/8 | 11 7/8 | 459.50 | — | — |
| 20-20 k | 20-35 k | 4, 8, 16 | 22 | no | 4.2 | — | 3.5 | .23 | 4-16 | yes | yes | scr. | 16 3/4 | 5 1/8 | 11 | 329.50 | — | — |
| 3-75 k | 2-100 k | 4-16 | — | no | 1.5 | 100 | 1.5 | .15 | any | yes | yes | yes | 16 1/4 | 5 | 11 3/4 | 429.00 | — | 29.95 |
| 6-50 k | 5-60 k | 4-16 | — | no | 1.5 | 100 | 1.5 | .15 | any | yes | yes | yes | 16 1/4 | 5 | 11 3/4 | 349.00 | — | 29.95 |
| 9-24 k | 8-25 k | 4-16 | — | no | 2 | 100 | — | .25 | any | yes | yes | — | 14 1/2 | 4 1/2 | 11 1/2 | 289.00 | — | 29.95 |
| 9-24 K | 8-25 k | 4-16 | — | no | 2 | 100 | — | .25 | any | yes | yes | — | 14 1/2 | 4 1/2 | 9 3/4 | 259.00 | — | 29.95 |
| 15-30 k | 15-30 k | 4-16 | 20 | no | 6 | — | — | .25 | — | yes | no | no | 17 | 5 1/2 | 14 3/4 | — | 184.00 | — |
| 15-50 k | 10-60 k | 4-16 | — | no | 4 | — | — | .3 | low | yes | no | no | 15 1/4 | 3 7/8 | 12 | — | 99.95 | 10.95 4.95 |
| 25-25 k | 20-60 k | 4-16 | 20 | yes | 1.5 | 20 | 1.5 | .1 | 4-16 | yes | yes | no | 17 3/4 | 5 13/16 | 14 | 289.95 | — | — |
| 30-25 k | 20-70 k | 4-16 | 20 | yes | 2 | 25 | 2 | .1 | 4-16 | yes | yes | yes | 17 3/4 | 5 13/16 | 14 | 239.95 | — | — |
| 30-25 K | 20-70 k | 4-16 | 20 | yes | 2 | 25 | 2 | .1 | 4-16 | yes | yes | no | 16 1/2 | 5 13/16 | 14 | 219.95 | — | — |
| 30-20 K | 20-30 k | 4, 8, 16 | 30 | — | 4 | — | 4.5 | .25 | 4-25 | yes | no | yes | 16 3/4 | 5 | 13 | 269.95 | — | 22.75 |
| 25-20 k | 20-50 k | 4, 8, 16 | 17 | — | 3 | — | 2.5 | .5 | 4-16 | yes | no | yes | 16 3/4 | 5 | 15 | — | 189.95 | 19.95 |
| 50-20 k | 30-30 k | 4-16 | — | no | 4 | 300 | 4 | .3 | 4-8 | yes | no | no | 9 1/2 | 5 1/4 | 12 1/2 | 187.99 | — | — |
| 6-40 k | 15-40 k | 4-16 | — | yes | 2.9 | — | 1.3 | .21 | 330 | yes | yes | yes | 14 1/8 | 5 3/4 | 17 | 449.95 | — | — |
| 15-50 k | 15-40 K | 4-16 | — | no | 2.8 | — | 1.2 | .19 | 180 | yes | yes | yes | 13 5/8 | 5 3/4 | 17 | 399.95 | — | — |
| 15-40 k | 15-40 k | 4-16 | — | no | 2.5 | — | 1.2 | .18 | 180 | yes | yes | no | 13 1/2 | 5 3/4 | 17 | 339.95 | — | — |
| 15-40 k | 15-40 K | 4-16 | — | no | 2.5 | — | 1.2 | .18 | 180 | yes | yes | no | 12 5/8 | 5 3/4 | 17 | 299.95 | — | — |
| 20-20 k | 15-30 k | 4, 8, 16 | 20 | yes | 3 | — | 2 | .5 | low | yes | yes | rum. noise | 18 1/4 | 6 1/4 | 11 1/4 | 499.95 | — | 29.95 |
| 20-20 k | 15-30 k | 4, 8, 16 | 20 | yes | 3 | — | 2 | .5 | low | yes | yes | noise | 18 1/4 | 6 1/4 | 11 1/4 | 479.95 | — | 29.95 |
| 20-20 k | 15-30 k | 4, 8, 16 | 20 | yes | 3 | — | 2 | .5 | low | yes | yes | noise | 15 9/16 | 4 15/16 | 12 1/2 | 374.95 | — | 13.95 |
| 20-20 k | 18-25 k | 4, 8, 16 | 20 | no | 5 | — | — | .5 | low | yes | yes | noise | 15 9/16 | 4 15/16 | 12 1/2 | 299.95 | — | 13.95 |
| 12-35 k | 8-100 k | 4-16 | 30 | no | 1.8 | — | 1 | .2 | 40 | yes | yes | scr. | 16 1/2 | 4 1/2 | 14 | 359.50 | — | 9.00 |
| — | 40-20 k | 8 | — | no | 100 | 100 | 600 | .6 | — | yes | no | no | 13 1/2 | 5 1/4 | 11 3/4 | 159.95 | — | — |
| — | 40-20 k | 8 | — | no | — | 100 | 600 | .6 | — | yes | no | no | 15 5/8 | 5 5/16 | 13 1/4 | 199.95 | — | — |

[a]Taken at ±200 kc. [b]Model 1156 same as 1177 with AM added. [c]In excess of FCC limit.

*(Continued on page 84)*

# MAGNETIC MEASUREMENTS IN SPACE



By JOSEPH H. WUJEK, Jr.

Description of some of the techniques used to measure extremely weak magnetic fields at great distances from Earth and close to distant planets.

THE measurement of magnetic fields has always been of interest to space scientists. Because the motion of charged particles is influenced by magnetic fields, the strength and direction of these fields are of primary interest. Other space phenomena such as the aurora or "northern lights," radio-wave propagation, and the solar plasma or solar winds are also affected by magnetic fields. Magnetic "storms" or variations in the field strength cause changes in the behavior of these phenomena. The presence or absence of magnetic fields in the region about distant planets supplies some information as to the planet's composition. Clearly, if we are to better understand our environment, we must chart the magnetic fields about the earth as well as deep space.

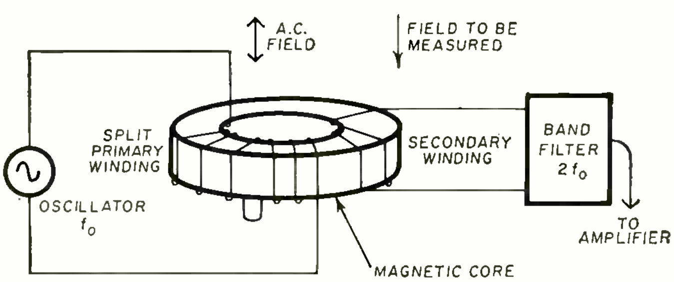
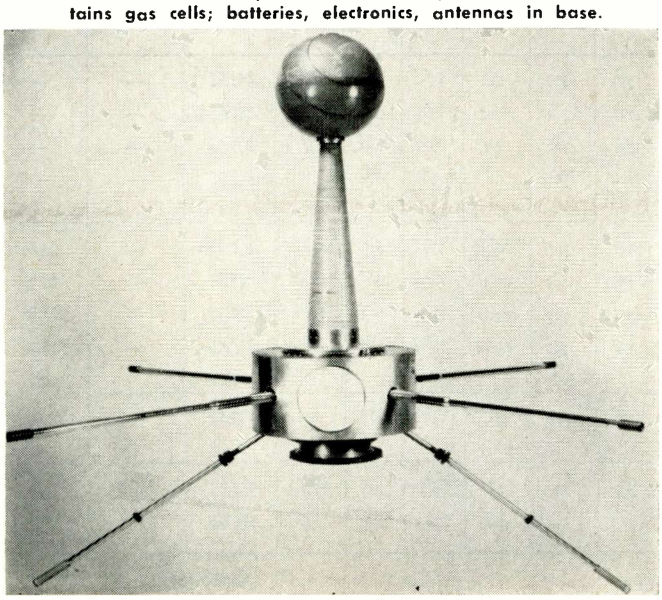



**Fig. 1. Basic fluxgate magnetometer arrangement is shown.**



**Complete payload of dual-gas-cell rubidium-vapor magnetometer used in Explorer 10 satellite. Spherical head contains gas cells; batteries, electronics, antennas in base.**

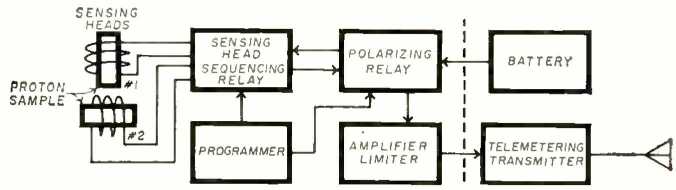


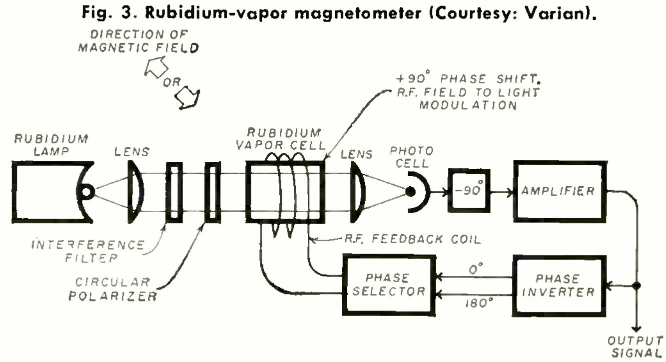

**Fig. 2. Proton-precession magnetometer (Courtesy: Varian).**

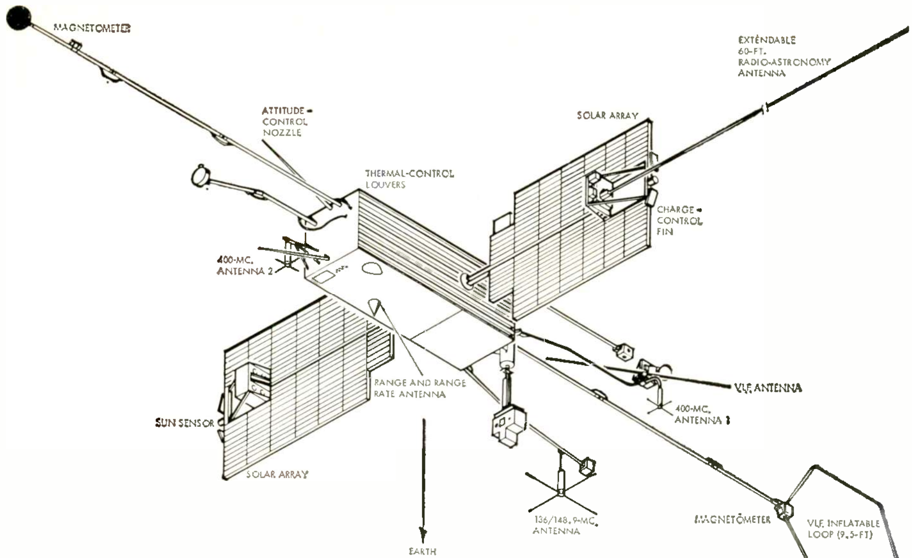
## Problems of Space Measurements

Scientists have long had instruments to measure magnetic fields in the laboratory, so one might assume that these instruments might be adapted for space use. Indeed, for some applications, modified laboratory instruments can be used in space applications. These modifications are directed toward reducing weight and volume; decreasing power consumption; and insuring reliable operation with shock, vibration, and wide variations in temperature. But the measurement of magnetic fields in space encounters problems not ordinarily met in the general laboratory situation.

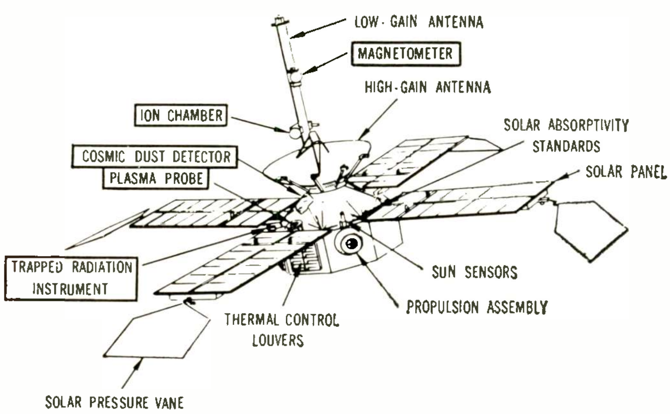
The magnetic field of the earth at the earth's surface is typically about 0.5 gauss or 50,000 $\gamma$. ($\gamma$, or *gamma*, is a unit of magnetic field intensity. One *gamma* = 1/100,000 gauss.) As a rocket, satellite, or space probe moves away from the earth, the strength of the earth's magnetic field diminishes rapidly. In deep space the fields encountered may be on the order of 1 to 100 $\gamma$. The instruments must, therefore, have sensitivities which are 500 to 50,000 times better than required for ordinary earth-based measurements. Moreover, the instruments must be capable of detecting changes of only several *gamma*. A broad dynamic range is usually also required in order that the instruments do not saturate at high

**Fig. 3. Rubidium-vapor magnetometer (Courtesy: Varian).**






**A recent scientific satellite, carrying no less than 20 experiments, is our polar Orbiting Geophysical Observatory (OGO-2), launched in October. This satellite carries two magnetometers located at the ends of 22-foot booms so as to be far removed from magnetic or electrical influence of the spacecraft body.**




**Mariner/Mars spacecraft showing some of scientific experiments.**

field levels. Of course, several instrument systems could be used in parallel, each having a different range of sensitivity. But the availability of telemetry channels as well as the added weight, increased power drain, and circuit complexity often rule out this approach.

Added to the difficulties already mentioned are the problems of *interference* and *calibration*. *Interference* as used here refers to the presence of magnetic fields from the spacecraft itself. Magnetic materials present in the spacecraft perturb the environmental field and, in the case of deep-space probes, the spacecraft's field may be much stronger than the fields of deep space. And since an electrical current has a magnetic field associated with it, electrical and electronic equipment on board the spacecraft also contribute to the interference problem.

Complete solutions to interference problems cannot be obtained, but the effects can be minimized. Placing the measurement sensors far from the spacecraft body aids in reducing interference from the spacecraft. This can be accomplished by placing the sensors on booms which are folded during launch and are deployed after injection into orbit. Keeping the use of magnetic materials to a minimum and shielding electrical equipment also reduces noise. The use of coaxial cables and shielded wires is also included in these measures. Even with these techniques, a noise field of 100 $\gamma$ at one foot from the spacecraft is probably the practical limit.

*Calibration* at low field levels is difficult because of the presence of the earth's field. Special *zero-field* rooms have been constructed so as to buck out this field. These rooms are built by winding huge coils along three mutually perpendicular axes. Generally, one coil has pole faces in the vertical axis, while two coils in the horizontal axes are placed at right angles to each other. By carefully adjusting current through each of these electromagnets, most of the earth's field is effectively bucked out at or near the center of the space between them. Locating the room far from man-made interference (power stations, etc.) allows the "field-free" region to be reduced to fractions of one *gamma*.

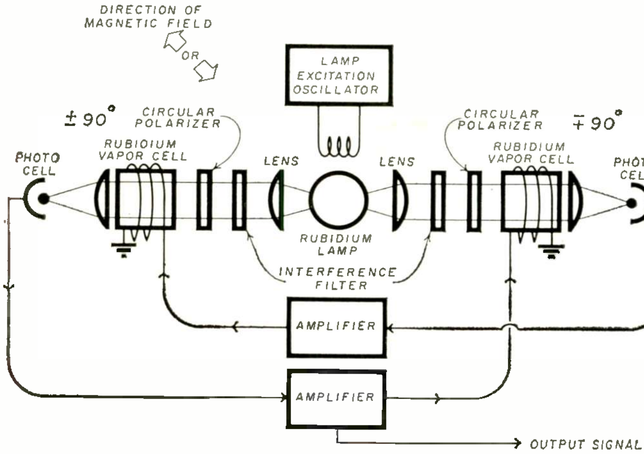
## Magnetometers

The *transducers* which convert the magnetic field intensity to a quantity which is more readily measurable are called *magnetometers*. We shall describe three general types of magnetometers which are commonly used in spacecraft applications: (1) search coil; (2) fluxgate; and (3) atomic.

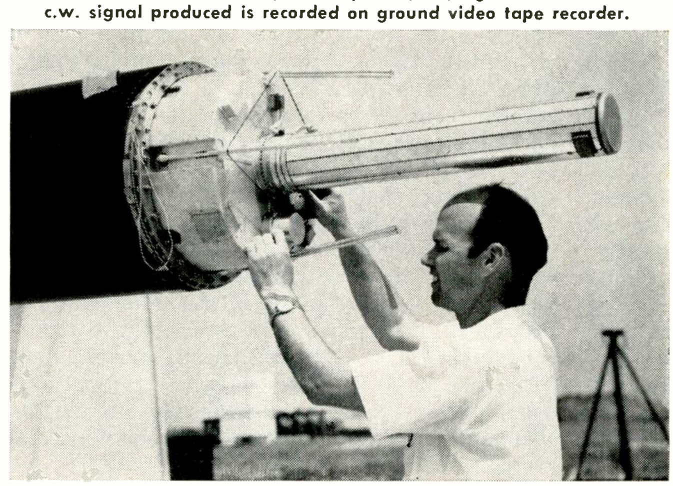
The search-coil magnetometer (SCM) works on the generator principle which is familiar to all of us. If a coil of wire is rotated in a magnetic field, then a voltage will be induced in the coil. The magnitude of the induced voltage is dependent upon: (*a*) the instantaneous magnetic field strength; (*b*) the speed at which the coil passes through the field; (*c*) the angle at which the magnetic field "cuts" the coil; (*d*) the number of turns in the coil winding; and (*e*) losses in the system.

The conditions described occur (*Continued on page* 92)

**Fig. 4. Satellite rubidium magnetometer (Courtesy: Varian).**




**General-purpose single-cell rubidium-vapor magnetometer being mounted on rocket. Principles of optical pumping were used. The c.w. signal produced is recorded on ground video tape recorder.**



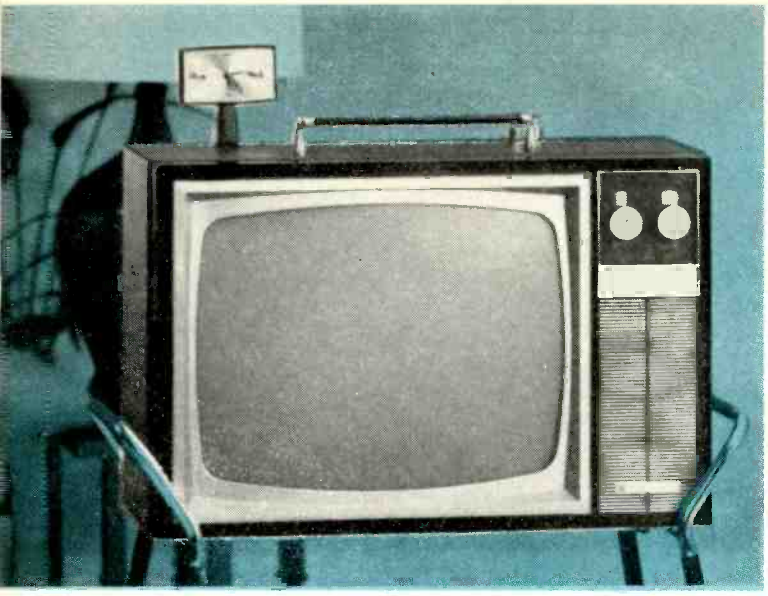


Fig. 1. The transistorized 19-inch black-and-white TV set, the Model 19T33, is part of the Sylvania line for 1966.

# Line-Operated Transistor TV Sets: *Sylvania*

By WALTER H. BUCHSBAUM

Second in a series of articles covering unique circuit details on line-operated, large-screen transistor TV sets. This second article covers the 19-inch Sylvania set using the AO1-2 chassis.

THE *Sylvania* product line contains both a 12-inch and a 19-inch transistorized monochrome TV set, with very similar circuits. The 19-inch model, chassis AO1-2, is distinguished by the relatively small number of components it uses. In addition to the u.h.f. and v.h.f. tuner, only 19 transistors, 13 diodes, and one vacuum tube, the 1B3 high-voltage rectifier, are used.

With the picture tube itself as the largest component, the remainder of the set is relatively compact and uses a power transformer, a full-wave diode rectifier for the main "B+" voltages, and the usual interlocks and circuit breakers. The power supply provides +38, +34, +32, and +12 volts. In addition, a half-wave rectifier and an *RC* filter are used to provide the +135 volts used for picture tube and video amplifier circuits. In over-all dimensions and weight, the 19-in. transistor TV set, shown in Fig. 1, is not very different from its vacuum-tube counterpart but the reliability and the low power consumption due to the use of transistors are expected to make this receiver more trouble-free than a vacuum-tube set.

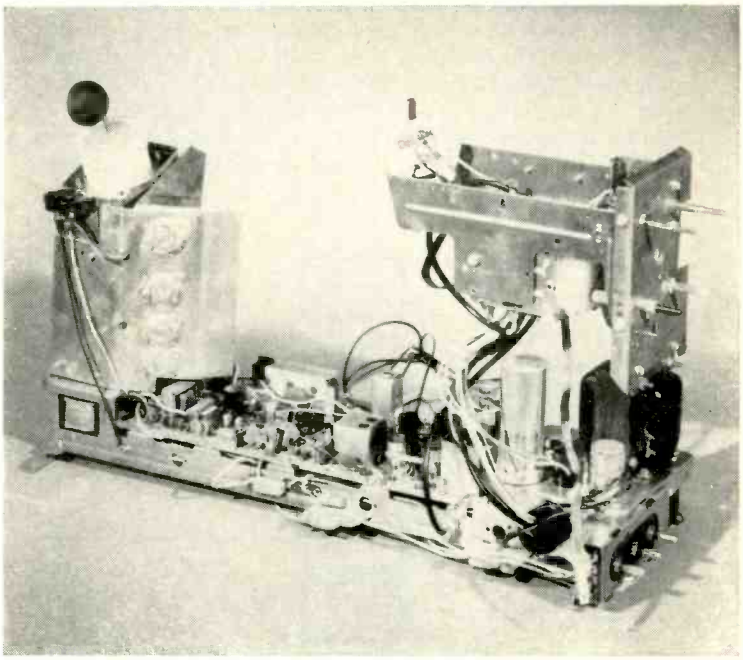
Fig. 2 shows the chassis layout, together with the printed-circuit wiring and a number of connectors. In addition to the a.c. interlock, there is the customary octal connector which brings the horizontal deflection yoke leads to the main chassis, while a second octal connector ties the volume control to the set and supplies a.f.c. and "B+" to the tuners. A special two-pin connector provides a +135-volt switching arrangement to eliminate the turn-off spot on the picture tube. The spot-killer circuit is part of the "on-off" switch and effectively connects the cathode of the picture tube to the first anode when the set is turned off. The 19CVP4 picture tube uses low-voltage electrostatic focus, has a special spark arrester of the spark-gap type built into the CRT socket, and requires 18 kv. as the second-anode voltage.

One of the interesting circuit features of this set is the frequent use of d.c. coupling. In the 4.5-mc. audio section, for example, the collector of the first sound i.f. stage is connected to the base of the second stage, with a feedback loop through a 1000-ohm resistor to the center-tap of the ratio detector transformer primary. In the audio output section, three stages are used and complementary circuitry permits straight d.c. connections. The first audio amplifier stage is a *p-n-p* transistor d.c.-coupled to the second amplifier, an *n-p-n* which, in turn, is coupled directly to the audio output stage which is again a *p-n-p* type.

The video amplifier section, shown in Fig. 3, also employs novel circuitry. The first video amplifier (*Q*1) acts as an emitter-follower, coupling directly into the video output transistor (*Q*2). The video signal from the detector is applied to the base of the first video amplifier, but this base is d.c.-biased by the voltage divider consisting of *R*1, *R*2, and *R*3. The "Video Bias" adjustment is a service control and is set for optimum sync pulse operation. The 4.5-mc. sound i.f. is taken off at the output of the first video amplifier.

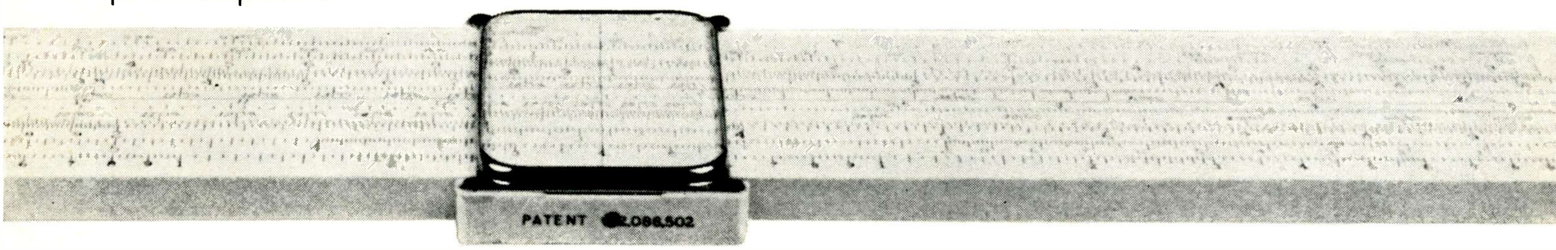
For the video output circuit, the similarity to a vacuum-tube receiver is quite apparent. In place of a cathode self-bias circuit, *C*1 and *R*4 set up an emitter self-bias, the collector goes to +135 volts through *R*5, *R*6, the contrast control, and *R*7. *C*2 and *C*3, together with *L*2, *R*8 assure the proper high-frequency response. The combination of diode *D*1 and *C*4 provide d.c. coupling of the video signal to the cathode of the picture tube. Brightness is controlled by the d.c. bias on the grid of the 19CVP4 through *R*9. (*Continued on page* 65)

Fig. 2. Basic arrangement of the AO1-2 chassis. Both yoke and volume control are attached through octal connectors.



# *DESIGN REQUIREMENTS for SOLID-STATE AMPLIFIERS*

Description of how the important factors of good performance, reliability, long life, and reasonable immunity to abuse are designed into transistorized high-fidelity power amplifiers.




By VICTOR BROCINER/Assistant to the President, H.H. Scott, Inc.

IT is an easy matter to find excitement in discussions of transistor amplifiers—so much so, in fact, that it is often a difficult task to determine what the facts are. There are the proponents of ultra-wide-band frequency response *vs* the "no-wider-than-necessary" arguers; the controversy regarding the effects of phase shift; the very high damping factorites, opposed by the "enough is enough" school; and finally, the thrilling battle of the "magic of transistor sound."

While the enthusiasts joust with each other, the music lover and/or audiophile is left to determine, as best he can, what constitutes a good design. Since he is interested in performance, reliability, long life, and reasonable immunity to abuse, as well as theoretical advantages in a new piece of equipment, this article tells how these factors can be achieved in practice.

When a new device becomes available, the device and its means of application usually engage in a sort of evolutionary foot race. For some time transistors were afflicted with certain handicaps that partially offset their advantages. Much ingenuity in circuit design was applied to overcome their deficiencies. Meanwhile, transistors themselves were being improved. Although expensive at the beginning, the evolving devices permitted some circuit simplifications which partially compensated for their higher cost, while offering improved performance. They have now reached the stage where their reduced cost permits their use in amplifiers that are practical, relatively simple in design, and economically competitive. These devices are diffused-junction silicon power transistors and high-frequency small-signal (amplifier) transistors useful to 20 megacycles.

Silicon power transistors have the following characteristics as opposed to germanium transistors:

Allowable junction temperature rise of 150°C *vs* 50°C for germanium, with up to 100 watts dissipation at 50°C case temperature. This greatly improves their ruggedness, particularly with respect to momentary overloads such as those caused by short circuits.

Much lower reverse leakage ($I_{CBO}$), which reduces the temperature stability problem.

Gain-bandwidth products of 1 megacycle, maximum voltage ratings of 100 volts at only moderately higher cost than germanium.

Somewhat lower power gain than typical germanium transistors, requiring more power to drive them.

The performance criteria of a solid-state amplifier and their relative importance must be related to new problems that need hardly be considered with tubes, such as change in performance with temperature. The problems will be dealt with as they arise in this discussion of means for attaining the design objectives. These are:

1. Wide frequency range.
2. Adequate power bandwidth.
3. Power rating consistent with ability to withstand abuse such as being driven past peak clipping, accidental short circuits of speaker leads, being over-driven by ultrasonic signals (such as from tape recorder bias oscillators).
4. Unconditional stability with various kinds of loads, including electrostatic speakers and open-circuited speaker lines. Freedom from parasitic oscillation.
5. Fast overload recovery.
6. Satisfactory performance over rated line-voltage range.
7. Means for adjusting of bias to obtain minimum distortion at all power levels without need for close-tolerance selection of power transistors.
8. High input impedance.
9. Protection of speakers against distortion caused by unbalanced d.c. in the speaker circuit.

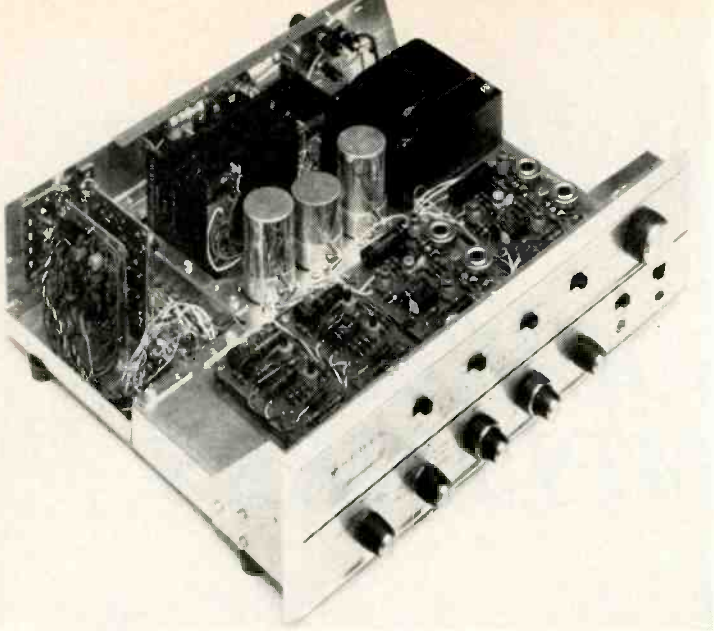
### The Power-Output Stage

A first examination of the ratings of silicon power transistors now available at moderate cost can lead to some interesting conclusions. Here is a typical set of figures:

Collector-to-emitter voltage, with effective base-emitter resistance of 100 ohms, 70 volts.

Transistor dissipation at case temperature of 50°C, 100 w.

Just to get an idea of the possibilities, let us assume an ideal class-B amplifier, that is, one with a perfectly regulated power supply and no series resistors to waste power. We know that maximum dissipation occurs when power output is 40.6% of maximum: $P_{DISS} = .406\ P_{O(MAX)}$. If we now assume



Top-chassis view of solid-state amplifier referred to in text.

the use of two transistors, each of which can dissipate 100 watts, this relationship tells us that we can have a maximum power output of 493 watts. However, we must not overlook two restrictions: the maximum safe supply voltage is 70 volts, and the amplifier must be designed to work directly into a load of at least 8 ohms, since output transformers for load-matching are taboo. An approximate formula (assuming perfect supply regulation, transistors with zero internal resistance, and no emitter resistance in the circuit) gives us the power output for two transistors in class B: $P_{O(MAX)} = (E_{bb}^2/8R_L) = (70^2/8\times 8) = 77$ *watts.*

This is quite a comedown, but it is still a respectable amount of power, and seems to indicate that we have a wide margin on dissipation. To be safe, however, let us check what happens with the amplifier driven to produce square waves:

*Maximum dissipation (two transistors)*$=0.5\times$ *(maximum sine-wave power output)*$=0.5\times 77=38.5$ *watts.*

This looks like nothing to worry about even though it is greater than for sine-wave operation $(0.406\times 77=31$ watts).

Suppose, though, the amplifier is handling a low-frequency signal—so low, in fact, that the transistors reach thermal equilibrium fast enough to keep pace with the signal waveform. The transistors are then operating like d.c. amplifiers and must be capable of dissipating their internal power loss at every point of the signal wave. For this condition:

*Maximum dissipation (two transistors)=maximum sine-wave power output*$=77$ *watts.*

This is still acceptable, but the safety margin is narrowing.

What of a reactive load? Speakers act much like capacitances and inductances over part of their frequency range (Fig. 1). The worst case would occur at very low and very high frequencies if the load were a pure reactance. Under these conditions, the load line is circular and:

*Maximum peak dissipation (two transistors)*$=5.2\times$*(maximum sine-wave power output)*$=400$ *watts.*

This is 100% *over* maximum allowable dissipation (200 watts). Fortunately, speakers do not act like *pure* reactances, the worst phase angle (for full-range electrostatics) probably being less than 70°; their impedance is relatively high in this frequency range, and internal resistances in the amplifier reduce the phase angle further, limiting dissipation.

And what happens on an instantaneous basis if the load terminals are short-circuited? Half the supply voltage is connected across the internal resistance of one transistor, plus its emitter resistor—say, a total of 1 ohm:

$$\textit{Instantaneous power dissipation} = \frac{\left(\frac{\textit{Power Supply Voltage}}{2}\right)^2}{\textit{Resistance}}$$

$$= \frac{(70/2)^2}{1} = 1225 \textit{ watts (per transistor).}$$

In this case we are helped by a transistor pulse-dissipation capability of over 2000 watts, sag in the power-supply voltage, and fuse action.

What should be expected in the way of power output for an actual amplifier? Fig. 2 indicates in graphical form the calculated power output for different supply voltages, assuming 1 ohm for the transistor saturation resistance plus its emitter resistor, and 7 volts of loss due to incomplete drive to satura-

Fig. 1. The phase angle and impedance of a typical 16-ohm, 3-speaker system.

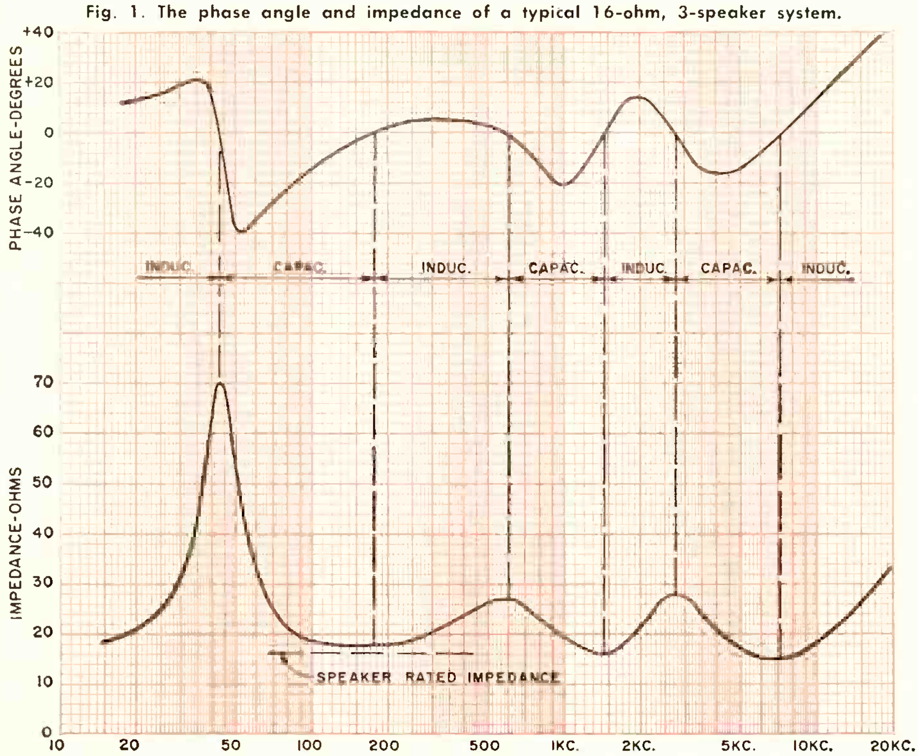
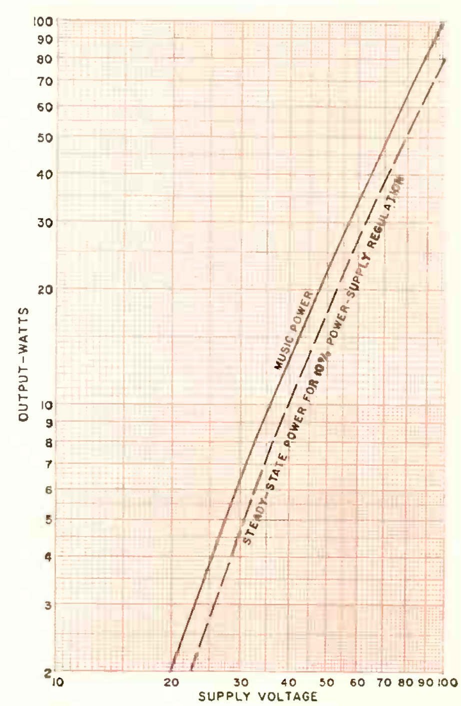



Fig. 2. The calculated output power versus the supply voltage. See text.



tion. For a 70-volt supply, $P_{r.m.s.}=38.7$ *watts*. Music power, on the assumption of no power-supply voltage change, should be 49 watts.

These figures compare well with the laboratory-measured power output of an *H.H. Scott* Model 260 amplifier. At 117 volts a.c. line, the unit produces between 30 and 40 watts r.m.s. per channel with total harmonic distortion between 0.15 and 0.4%, the range where clipping just begins. See Fig. 3. These figures are given in ranges because accurate determination of the power output at which clipping "begins" is difficult, and the exact value of power output will vary with line voltage, production variations in power transformers, transistors, and other components.

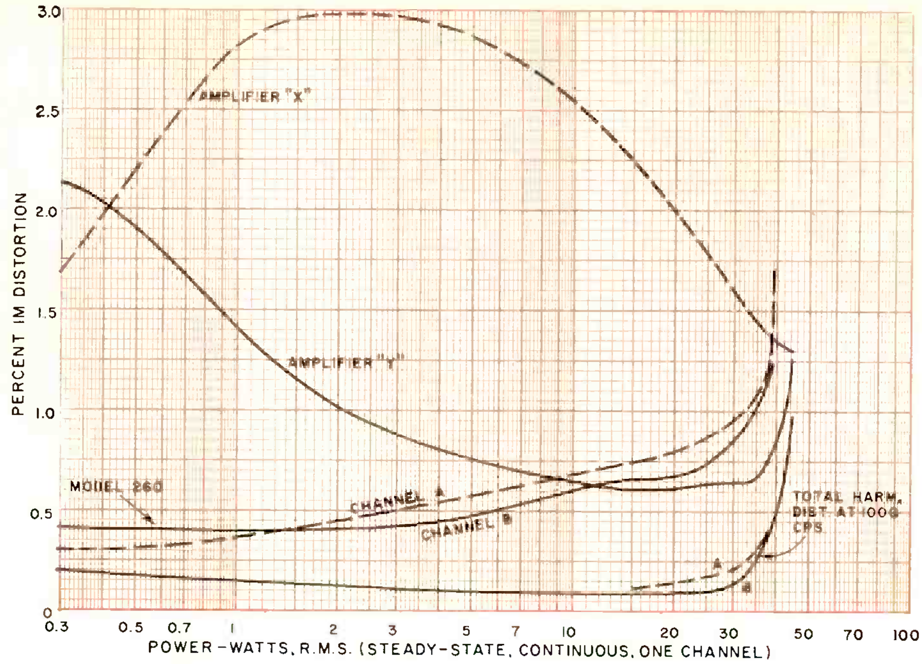



Fig. 3. Measured distortion versus power output for a number of amplifiers.

## Distortion at Low Power Levels

This is a matter with which we should be vitally concerned. While the maximum power rating of an amplifier determines how often occasional peaks are clipped, an effect to which the ears are not very sensitive, the amount of distortion present at low power levels has a large and continuous effect on the smoothness and purity of the sound.

How low are these power levels? Suppose we have two speaker systems (for stereo) capable of a peak acoustic output of 0.2 watt each. This corresponds to a sound pressure level of 111 db in an average living room (3000 cubic feet) and is about as loud as a truck air horn at 4 feet. If the speaker efficiency is 0.5%, this corresponds to a power *input of* 40 watts from each amplifier. For classical music, the average power (not the soft passages) will be at least 23 db below this figure, or 0.2 watt from the amplifiers. For compressed speech and popular music the average power is likely to be 6 db higher, or 0.8 electrical watt. This is where we (hi-fi fans; others listen at much lower levels) do most of our listening. Our ears are more sensitive to distortion at these levels than they are for loud passages. Unfortunately, this is also where ordinary class-B transistor amplifiers are likely to have nearly as much distortion as at full power output. Fig. 3 shows the results of measurements on some commercial units. Note the large differences in distortion at low power levels that occur among different designs.

In order to obtain low distortion at low power levels, we must have optimum bias adjustment of the class-B power stages and plenty of negative feedback. Neither of these remedies is easy to apply.

Bias adjustment is complicated by the need for temperature compensation of the output stages and the ability to handle variations in supply voltage. Compensation is frequently accomplished by means of a diode in the base circuit, which has the same temperature characteristics as the transistor junction whose effects it must compensate to keep the bias from shifting with changes in temperature.

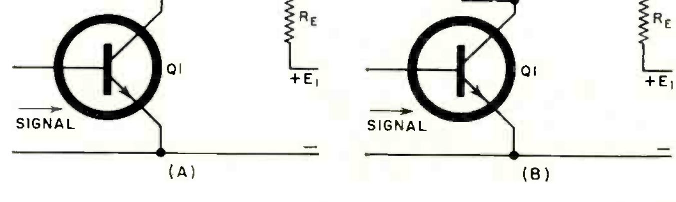
Fig. 4A is a simplified circuit for a single-ended stage which illustrates the difficulties. The value of *R*1 is determined by the desired operating point for *D*1 and has a rather high value, limiting the current in the driver transistor *Q*1 and restricting its driving power. If it is made adjustable, varying the adjustment will affect both the diode operating point and that of *Q*1. Fig. 4B shows the principle involved in the "variable-diode" circuit used in *H.H. Scott* solid-state amplifiers. *R*1 is fed from a point of relatively high voltage and its value is made sufficiently high so that the current through it is not appreciably affected by the position of the arm of variable resistor *R*2. In effect, $I_1$ is a constant current. *R*2 is a universal shunt that permits adjustment of the current through diode *D*1, varying its operating point so that the desired bias voltage can be applied to the transistor. This particular adjustment can be made without affecting the load that exists on the transistor *Q*1.

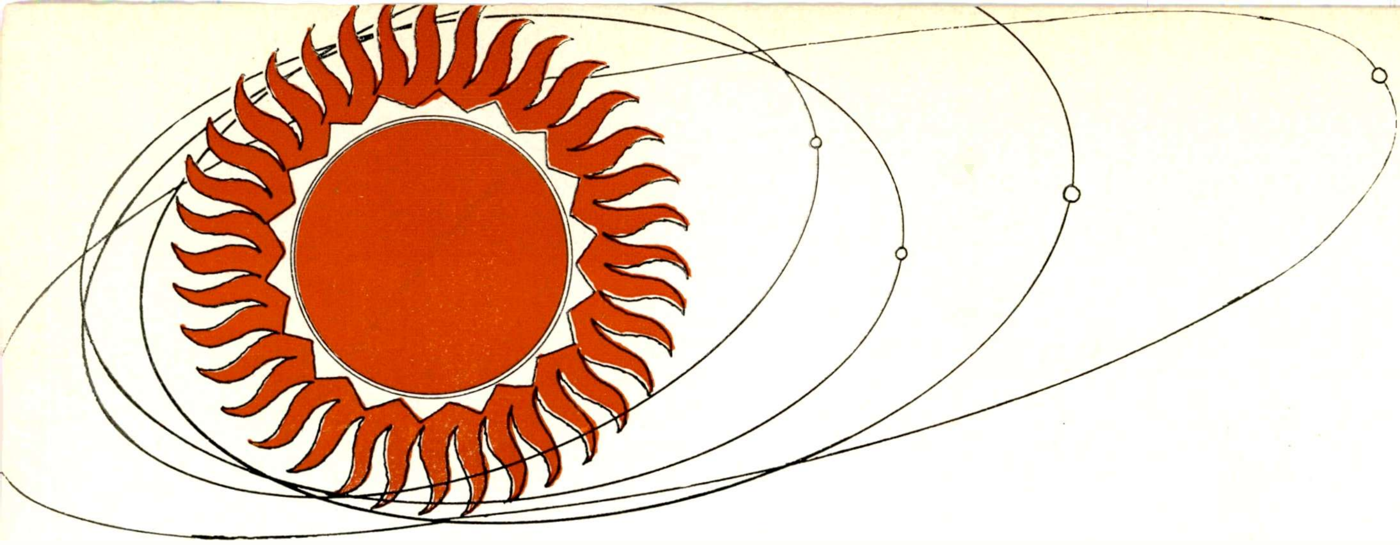
## Stability with Negative Feedback

It is well known that care is required in the design of multistage tube amplifiers using large amounts of negative feedback, if stability is to be preserved. At high frequencies, the behavior of tubes as shunt capacitances has to be taken into account. Transistors are not such well-behaved devices as tubes in this respect, having multiple phase shifts at high frequencies and being far more prone to oscillate over part of the signal wave. This may occur at frequencies of the order of 10 megacycles and higher.

One of the remedies is to use transistors having the widest possible frequency range. For diffused-junction silicon power transistors a practical limit is 1 megacycle (gain-bandwidth product), and for small-signal transistors, 20 mc. With frequency ranges of this order of magnitude, it becomes necessary to lay out components and wiring as if an r.f. amplifier were involved; which, in fact, it is. Allowance even has to be made for the inductance of electrolytic capacitors used for coupling. Wherever possible, direct coupling is used to eliminate such capacitors. (*Continued on page* 85)

Fig. 4. (A) Conventional and (B) variable diode bias circuit used for compensation.





*Description of various time scales and their significance, including solar, universal, ephemeris, atomic, sidereal time.*

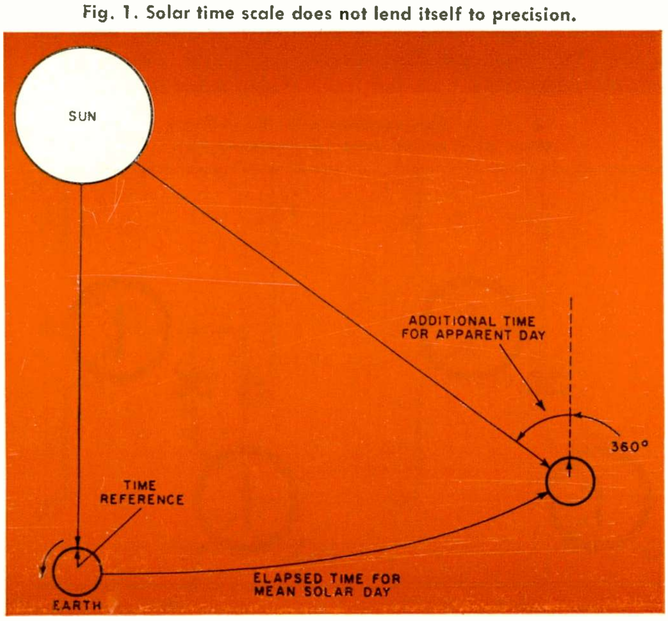
# Time Scales & Time Measurements

By EDWARD C. WILSON III

CONSIDER for a moment how often time is used as a reference. In applying Ohm's Law, time is used in every computation. For example, the definition of current flow is: "one ampere of current equals one coulomb of electrons past a given point in one second." When discussing the phenomenon of alternating current, whether it is in the low audio or s.h.f. bands, we consider the frequency to be the reciprocal of the time period. Likewise, we use time constants in various inductive and capacitive circuits. Still another instance, at one point on its journey, the Mariner IV satellite was reported to be 107.2 million miles from earth and that signals transmitted by the satellite took ten minutes to reach the monitoring stations. In some forms of pulse modulation, the time between pulses is critical.

Without some accurate reference all of these measurements, and many more, would be meaningless. The reference is time, and in the next paragraphs we will consider the various scales of time measurement and see how they are determined. Basically, the scales are: solar, universal, ephemeris, atomic, and sidereal. Some of these are broken down further into corrected categories within themselves.

Fig. 1. Solar time scale does not lend itself to precision.




## Solar Time

Solar time is the measurement of time in regards to the rotation of the earth around the sun. The sundial is a good example of a device used to measure Apparent Solar Time. One apparent solar day is the time required for the earth to make one rotation on its axis and present the same point to the sun. If the earth's orbit about the sun were perfectly circular, and there were no eccentricities in the axis, the solar day would be constant.

We know, however, that the orbit is elliptical and that the plane of rotation is 23.5 degrees to the plane of the equator. It is also known that a body which describes an ellipse is continually changing speed with regard to the point of reference. In our case the point of reference is the sun. Thus, when the earth is nearest the sun it is moving faster than when it is farthest away. Actually, a solar day in November could be up to 16 minutes longer than a day in June.

One attempt at compensating for this difference is the Mean Solar Day. In order to derive a mean solar day, we average all the apparent solar days in one solar year. If we wish to obtain one mean solar second, we would divide the mean solar day by 86,400. This would be fine if we wanted to know the approximate duration of one solar time period of a past year. But in order to forecast the length of a solar time period to come we would have to estimate or guess the eccentricities that the earth's orbit will take. See Fig. 1.

It can readily be seen that the solar time scale does not lend itself to precise, accurate measurements of time. This is mostly because it is based on the rotation of the earth, which is non-uniform. So perhaps we should put the sundials away with the Egyptians who invented them, in the same place as the dripping water clocks of the Chinese.

## Universal Time

The Universal Time Scale is based upon the rotation of the earth about its axis much the same as solar time. However, we add various corrections to the assumption that the earth rotates at a constant speed and we have the time scales UT-1 and UT-2. If we make no corrections, the time scale UT-0 is the equivalent of solar time.

The UT-1 time scale takes into consideration the polar motion of the earth and corrects for the shift that occurs in reference to the sun. Imagine that the earth is "nodding" while it is rotating and orbiting around the sun. In this case, a fixed point on the earth would appear to rotate faster if the nod, or "nutation" as it is called, were toward the sun, and slower if it were away from the sun. This, then, is the basis of correction for UT-1. It is based on the true angular motion of the earth around its axis.

There are other factors which affect the rotation of the earth and thus affect the measurement of time. If we somehow change the distribution of mass over the surface of the earth, we will change the balances of inertia. This will, to a small degree, change the orbital characteristics. An example of this is the seasonal displacement of mass in the form of icebergs which drift away from the polar regions. This particular displacement of mass occurs when the sun moves from the northern hemisphere to the southern hemisphere and back again during the year. This continuous change is one of the correction factors that is used to evolve the time scale known as UT-2.

The time references transmitted by WWV and WWVH are in close agreement with the UT-2 scale. For this reason, and because UT-2 takes into consideration all of the known factors which affect the rotation of the earth, UT-2 has become the most widely used of the time scales.

In spite of the corrections, UT-2 is still not the most accurate of the time standards. It is based upon the rotation of the earth which is erratic and unpredictable. As a result, the time standard clocks of the National Bureau of Standards used to keep Universal Time must be corrected periodically. Although these corrections are very small, there is still an inconsistency or error in this particular time scale.

## Ephemeris Time

The second of ephemeris time is imposingly defined as the fraction 1/31,556,925.9747 for 12 hours of the tropical year January 0, 1900.

First of all, January 0, 1900 is the same as December 31, 1899 and the 12 hours is merely the time at which the measurement is referenced. The fraction, as heavy as it may be, isn't very hard to interpret. If you make an equation of the fraction, then 31,556,925.9747 ephemeris seconds equal one ephemeris year. The important thing to consider about this scale is that it has remained a constant length since it was devised. And, it is accepted by the International Committee of Weights and Measures as the standard second.

Unlike the UT scales, ephemeris time is not affected by the irregular and unpredictable changes in the rotation of the earth around the sun or around its own axis. Instead, it is determined by measuring the time intervals between the relative positions of the moon and other celestial bodies. Due to the tremendous distances, these celestial bodies, except for the nearer planets, appear to be motionless in space. Therefore, at regular intervals of ephemeris years, these celestial bodies appear to return to the same relative positions in the heavens. These observations have been studied very thoroughly and now the common reference for the observation of ephemeris time is the moon and its rotational position around the earth in conjunction with various stars.

Because of the methods of determining the ephemeris second, that is by observations of the moon, it requires a fairly long time to determine if the scale is still accurate. After all, we couldn't blindly accept any standard without some form of cross-check. Therefore a precise measurement of an event that is measured with respect to ephemeris time would be held of questionable accuracy until the accuracy of the scale could be verified.

This cannot be done in advance, due to the unpredictable irregularities in the earth's orbit, and could take several years or more depending on the accuracy desired. It is mostly because of the inconvenience that scientists have looked elsewhere for a standard that is equally as good or better than what they have and one that won't take as long to verify. This leads us to the next subject, which is Atomic Time.

## Atomic Time

In the last few years, the National Bureau of Standards has developed and tested an atomic frequency standard. An oversimplification of the device would say that it compares the effect of magnetic fields on cesium atoms with the output of precision oscillators. The characteristic resonance of cesium under these conditions is found to be 9192.63177 megacycles with an accuracy of ± 20 cycles.

Here is an example of a vague reference. What time scale determines this frequency? In this case the scale is ephemeris. By using this extremely accurate frequency standard to control a system of clocks, the National Bureau of Standards has devised the time scale AT-1.

We have progressed now to a time scale that is both uniform and constant, and we have added to it the advantage of rapid verification of accuracy.

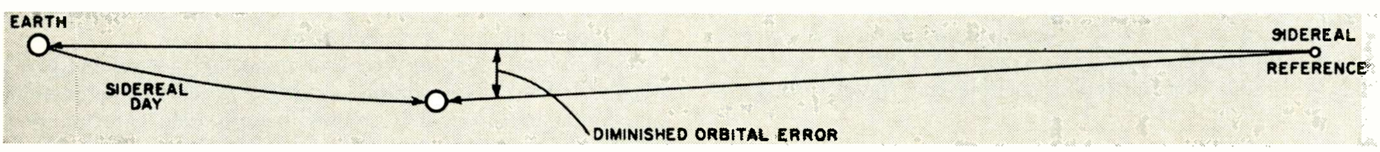


**Fig. 2. By using a very distant star as a reference, the shift caused by orbital motion is made extremly small.**

## Sidereal Time

Sidereal time is of little use in a majority of time measurements in electronics, although there are some applications that make it worthwhile to discuss here.

First let us review solar time. One solar day is based upon the elapsed period of the earth making one rotation about its axis with respect to the sun. We know that due to orbital motion, the length of the apparent solar day varies considerably from one period to the next, that is, if the earth is going away from the sun, it must rotate more than 360 degrees to present the same point to the sun as shown in Fig. 1. The opposite is true when the motion of the earth is toward the sun.

The effects of this orbital motion can be greatly diminished by extending our point of reference farther away. The farther away, the more accurate the measurement. This is what is done in sidereal time. A very distant star is used as the reference so that the shift caused by orbital motion is as small as possible. See Fig. 2.

There are still some effects on sidereal time caused by the movement of the earth so that the time periods are not completely uniform. There is also the curious fact that there is one more day in a sidereal year than there are solar days in the solar year.

No doubt you have noticed that the sun appears to be a little farther to the east in the heavens at a given time each day. At the end of a year's time the sun, in its apparent orbit around the earth, will have added one extra day. If the earth didn't rotate as it followed its orbital path, the sun would still rise and set—but only once during the year.

Scientists at laboratories and observatories all over the world are studying the phenomenon of time and new advances in time-keeping techniques are being made as a result of their measurements and observations. ▲


# RADIOLOGICAL SURVEY METERS

By J. G. ELLO / Supervisor, Nuclear Instrument Maintenance Section
Argonne National Laboratory

**Operation and maintenance of Civil Defense "fallout meters" using ionization chambers and Geiger-Muller tubes. Techniques used by technical personnel in the nuclear instruments field.**

EVER since the atom bomb was exploded over a wartime target, people have realized the destructive power of nuclear reaction employed as a weapon—not only at the time of detonation but also during its after effect called "fallout." Fallout products, which undergo nuclear disintegration, give off *alpha* and *beta* particles as well as *gamma* rays.

The *alpha* particle has a positive charge and is ejected from a radioactive atom at a velocity of 1/20 the speed of light. Although this particular particle can travel through 1 to 2 inches of air, it cannot penetrate a few sheets of a daily newspaper.

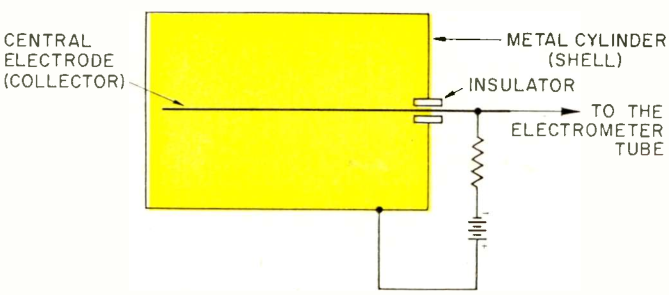



**Fig. 1. Construction of an ionization chamber radiation detector.**

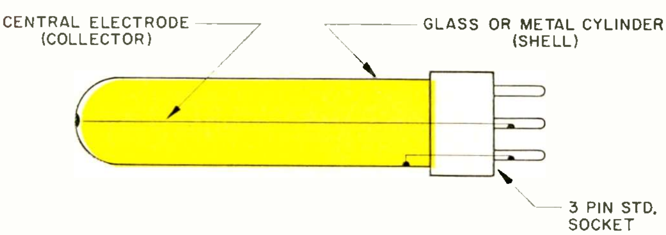
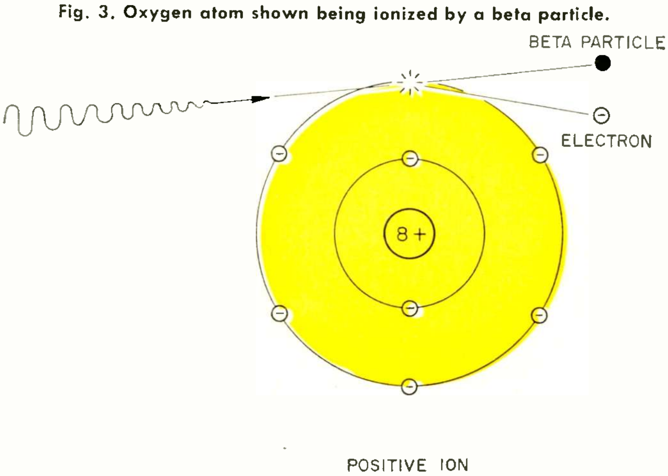



**Fig. 2. Construction of Geiger-Muller tube radiation detector.**

**Fig. 3. Oxygen atom shown being ionized by a beta particle.**




The *beta* particle, consisting of electrons, has a negative charge. Like the *alpha* particle, it can be deflected in a magnetic field but in the opposite direction. A *beta* particle emerging from an atom approaches the speed of light. It can travel through several feet of air but is absorbed completely by ¼ inch of plastic, such as Lucite.

The *gamma* rays, on the other hand, are not affected by a magnetic field. The *gamma* emission is an electromagnetic ray similar to x-rays. It is emitted from a disintegrating atom when an excess of energy remains after ejection of an *alpha* or *beta* particle. The *gamma* ray can penetrate 1 inch of lead, being reduced greatly in speed but not stopped or absorbed completely.

The unit used to measure detectable radiation is called a roentgen (R). A roentgen of radiation will produce one electrostatic unit of ions in one cubic centimeter of air. The order of magnitude most commonly measured is in the milliroentgen (mR) range, or one-thousandth of one roentgen.

### Radiation Detectors

Like a radio antenna, which is sensitive to electromagnetic waves, the radiation detector, under proper operating conditions is sensitive to effects caused by nuclear radiation. Detectors come in various sizes, shapes, and types. The *ionization chamber* and the *Geiger-Muller* types are the two of concern here.

The construction of an ionization chamber, shown in Fig. 1, is quite simple. It consists of an insulated central electrode enclosed by a chamber of conducting material which is separated from it by a very good insulation material. The chamber, either cubical or cylindrical in shape, can be of any size.

The ionization chambers used in many commercial survey meters are designed to detect the three kinds of radiation: *alpha, beta,* and *gamma*. One end of the typical chamber may be made of a very thin Mylar plastic-film material, enabling *alpha* or *beta* particles to enter the chamber and be detected. However, the ionization chamber constructed to detect *gamma* radiation only employs a completely metal shell.

Geiger-Muller (G-M) tube detectors are available in a variety of sizes ranging from ¼ inch to 5 inches in diameter, and ½ inch to 36 inches in length. They can detect *alpha* and *beta* particles and x- and *gamma* rays. Some G-M tubes are built to detect *beta* and *gamma* radiations only. Such a tube, shown in Fig. 2, consists of a central wire surrounded by a thin metal or conducting glass tube. The central wire is usually tungsten and acts as the anode. The cathode is the metal

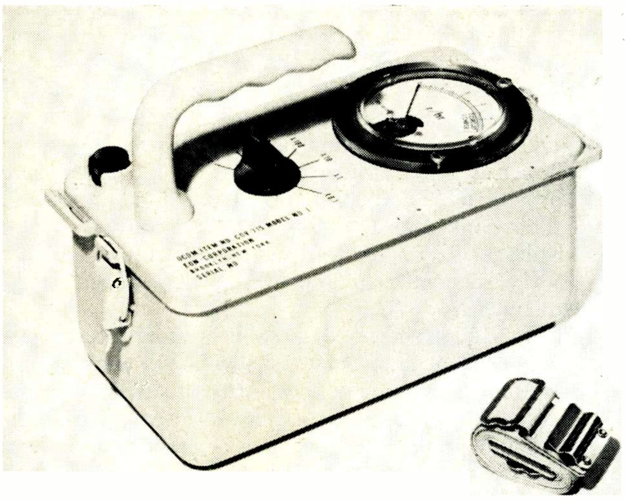


Fig. 4. The CD Model V-715 measures up to 500 roentgens/hour.

or conductive coated glass tube which surrounds it. The tube, sealed at both ends, is filled with a gas such as argon in which high gas amplification is readily achieved.

The ionization chamber has infinite life, but the Geiger-Muller tube becomes depleted and inefficient after counting more than a billion events. On the other hand, an ionization chamber requires a sensitive electrometer tube for amplification of the ionization current. The G-M tube does not need a sensitive amplifier because of internal gas amplification.

Within a detector, such as an ionization chamber, there is a large number of air molecules which are composed of electrically neutral atoms. When the neutral atom is disturbed by loss or gain of an electron, we say the atom is *ionized*. An oxygen atom being ionized by a *beta* particle within a detector is shown in Fig. 3. This *beta* particle collides with an electron, thus removing it from its original orbit and creating a positive ion. As long as no collector voltage is applied to the detector, the ion will capture a free electron in the vicinity and the atom once more becomes neutralized (stable).

If voltage is applied, the freed electron will not be recaptured by the positive ion. Since opposite charges attract, the positive ion would accelerate to the negative detector electrode and the electron would be attracted to the positive electrode. As a result, an extremely small current will flow in the detector and through the load resistor.

A G-M tube operates somewhat like the ionization chamber type of detector. However, freed electrons accelerate faster because the detector voltage, and consequently the electrostatic field, is higher. In addition, an argon atom has twice as many electrons and protons as an oxygen atom. Thus, when a *beta* particle enters a G-M tube, it will collide with a gas atom and free an electron from its orbit. This freed electron will be drawn to the positive electrode. On its way, it will collide with other electrons freeing them, in turn, by impacts. These additional electrons may also impinge on other gas atoms, and so on. The net result is a sizable ionization current, producing a large output pulse.

## CD V-715 Meter Circuitry

Civil Defense radiological survey meters are designed primarily for CD personnel who measure radiation dose rates resulting from a nuclear disaster. The meters are built to meet specifications of the Office of Civil Defense Mobilization. Police departments, fire departments, hospitals, schools, and Civil Defense units of local and state agencies make use of these meters.

The Civil Defense Model V-715, shown in Fig. 4, is used primarily for measuring total dose radiation rates up to 500 roentgens per hour (R/hr.). The circuits, powered by two conventional type "D" flashlight batteries, are partially transistorized to minimize current drain. The indicating meter is sealed to prevent vibration or shock resulting from rough handling. Two panel controls, one for zero adjustment and one to serve as a selector switch, are provided.

The circuit diagram of the CD V-715 survey meter is shown in Fig. 5. Before discussing the over-all operation, two internal circuits should be considered: the electrometer circuit and the indicating meter circuit.

The latter is a closed-loop meter circuit consisting of a 1.5-volt filament battery in series with a current-limiting resistor (*R*12) and a capacitor (*C*2) which is in parallel with the 50-μa. indicating meter (*M*1). The calibration controls *R*2 through *R*5 are bypassed.

When the switch *S*1 is rotated to the "Zero" check position, a forward current will flow through this closed loop, tending to drive the indicating meter up-scale. However, the indicating meter is also connected to the plate-return circuit of the electrometer tube *V*1. A bucking current supplied by *V*1 opposes the current flow of the closed-loop meter circuit. These two currents will cancel each other, giving a zero reading on the meter—provided *V*1 is properly biased by the "Zero Adjust" control *R*7.

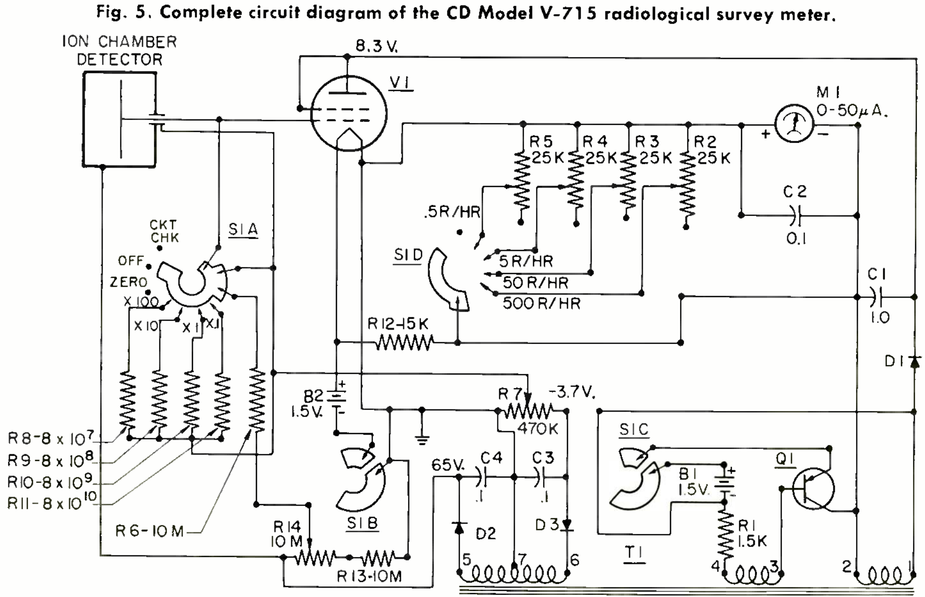
The four successive positions of the selector switch are the range positions. These are: ×.1, ×1, ×10, and ×100 corresponding to full-scale readings of 0.5, 5, 50, and 500 R/hr.

On the range position, the circuit is virtually the same as on the zero position except a selected range resistor, *R*8 through *R*11, is connected in series with the ion chamber.

When the survey meter is exposed to radiation, an ionization current is generated within the detector. This ionization current will then flow through whichever range resistor is selected. In turn, a positive voltage will be developed at the grid of *V*1. This positive voltage will result in an increase in tube current which destroys the balance of current through the indicating meter. The meter pointer will now move up-scale by an amount proportional to the intensity of the radiation entering the ionization-chamber detector.

The calibration controls *R*2 through *R*5 are wired across the indicating meter *via* switch *S*1*D* to shunt a portion of the current around the meter. In the "Circuit Check" position, resistors *R*6,*R*13, and potentiometer *R*14 (which is factory-

Fig. 5. Complete circuit diagram of the CD Model V-715 radiological survey meter.



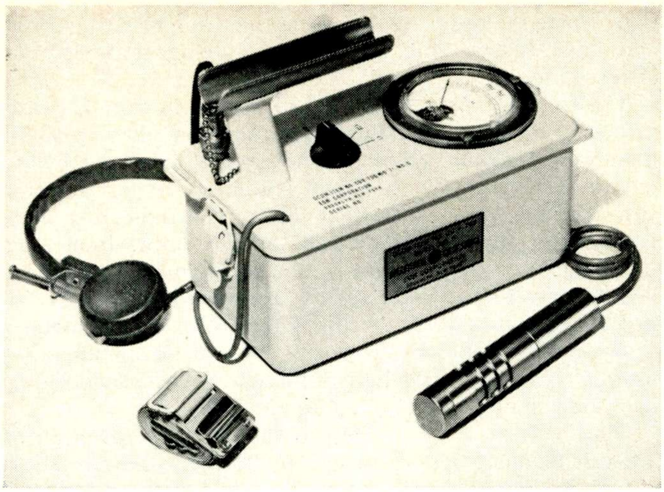


Fig. 6. The CD Model V-700 detects up to 50 milliroentgens/hour.

| Abnormal Indication | Probable Fault |
|---|---|
| 1. Meter reads zero (no reading) | a. Meter movement<br>b. Open meter circuit<br>c. Batteries<br>d. Corroded battery contacts |
| 2. Meter remains above zero (reads up) | a. Defective electrometer tube |
| 3. Meter remains below zero (reads down) | a. Battery<br>b. Electrometer tube<br>c. Transformer<br>d. Corroded battery contacts |
| 4. Erratic reading (random in nature) | a. Foreign matter affecting high-voltage insulations and input circuit components<br>b. Poor or open connections<br>c. Battery contacts |
| 5. Meter reads up or down scale after 5 minutes of use on ×1 range | a. Exhausted batteries<br>b. Dirty electrometer tube base<br>c. Corroded battery contacts |
| 6. Incorrect reading when checked by standard radiation source | a. Calibration<br>b. Batteries<br>c. Dirty range resistors R8 to R11 |
| 7. Resists calibration | a. Defective electrometer tube<br>b. R12 changed value<br>c. Meter movement<br>d. Exhausted batteries<br>e. Range resistors R8 to R11 |

Table 1. Fault-location chart for the CD Model V-715 meter.

Table 2. Fault-location chart for the CD Model V-700 meter.

| Abnormal Indication | Probable Fault |
|---|---|
| 1. No reading (background radiation) | a. High voltage<br>b. Open probe cable or connectors<br>c. G-M tube<br>d. Transistor Q1<br>e. Meter movement |
| 2. Reads up (no radiation present) | a. Circuit may be oscillating<br>b. High-voltage discharge<br>c. Short in cable or connectors<br>d. G-M tube<br>e. Diodes D1-D2 |
| 3. Reads low on all ranges | a. Calibration<br>b. High-voltage low<br>c. Meter movement<br>d. G-M tube<br>e. Batteries<br>f. Transistor Q1 |
| 4. Reads high on all ranges | a. Calibration<br>b. Same as "Reads up" |
| 5. Headphones dead, meter working | a. Diodes D3-D4<br>b. Capacitor C3<br>c. Headphones |

adjusted) are introduced into the circuit. When this happens, the grid voltage of *V*1 is altered to make the pointer read up-scale in the check portion of the meter scale.

Three separate d.c. voltages are required: grid-bias voltage, plate voltage, and ionization-chamber voltage. All three are obtained from the blocking oscillator power-supply circuit which consists of transistor *Q*1, resistor *R*1, transformer *T*1, and battery *B*1. Diodes *D*1, *D*2, and *D*3, along with associated filter capacitors *C*1, *C*4, and *C*3, rectify and filter the a.c. voltages from *T*1 into the required d.c. voltages shown on the schematic diagram. Filament voltage for *V*1 is supplied by battery *B*2.

The CD V-715 survey meter is calibrated by placing it in a *gamma*-ray field of known intensity. The ray may be produced by an x-ray machine or a quantity of such source material as cobalt-60, radium, or cesium-137. As an example, a 1-curie radium source will produce a *gamma*-ray dose of 4 R/hr. at a distance of 18.1 inches. When the center of the detector is positioned at this distance from the *gamma* source, the ×1 range of CD V-715 should read 4 R/hr. If the reading is either high or low, the survey meter should be calibrated by adjusting control *R*4.

Calibration is accomplished by adjusting the individual calibration control so that the proper reading is indicated on the meter dial. It is necessary to remove the survey meter from its case to recalibrate and replace it in its case for a correct reading. Errors in calibration may be introduced if the detector is brought too close to the *gamma* source. The detector should be no less than 12 inches from the source. This is to obtain uniform radiation intensity over the volume of the detector. *Warning: Calibration of all survey meters should be done only by personnel trained in the use of x-rays and radioactive isotopes.*

### CD V-700 Meter Circuitry

The Civil Defense Model V-700 survey meter shown in Fig. 6 is primarily used for detecting radioactive contamination up to 50 mR/hr. The survey meter employs a *beta-gamma* sensitive Geiger-Muller tube as its detector.

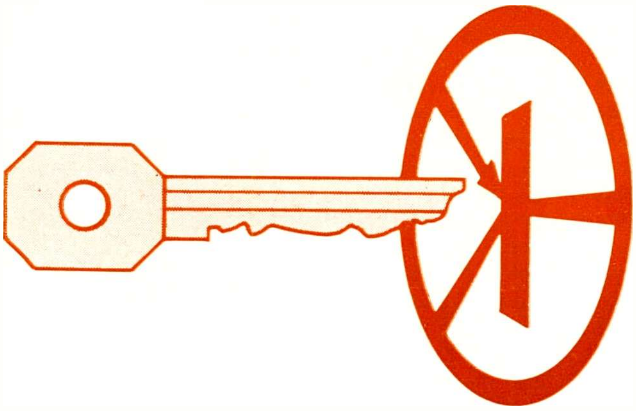
A single control selector switch operates the survey meter. The switch selects any one of the three ranges and also turns the survey meter "on" and "off." The instrument response to radioactive contamination is on an event-by-count basis. Aural monitoring is done through headphones. The completely transistorized circuit is powered by four type "D" flashlight batteries.

The circuit consists of a pulse shaper, count-rate meter, and an electronic high-voltage supply. The CD V-700 has only one calibration control for all ranges.

The G-M detector tube, housed in a nickel-plated brass probe, is connected to the survey meter (and its 900-volt d.c. supply) by a 3-foot cable. A rotatable shield prevents external *beta* particles from entering, making the detector sensitive to *gamma* rays only.

The pulse-shaper circuit of the CD V-700 (Fig. 7) is basically a blocking oscillator. The circuit consists of transistor *Q*1, transformer *T*1, coil *L*1, diode *D*1, and capacitor *C*1. When the instrument is "on," transistor *Q*1 is held at cut-off by a bias voltage network formed by resistors *R*2, *R*3, and the battery supply. The negative pulse produced by ionization in the G-M tube appears across *L*1 and *D*1. *L*1 provides a high-impedance path for these pulses while providing a low-impedance path for direct current. The diode *D*1 prevents oscillation across *L*1.

This G-M tube pulse, coupled to the base of *Q*1, activates the circuit by saturating *Q*1. At this point, most of the battery voltage, *B*1, is across the winding 3-4. As the current increases in the winding, a voltage is induced in winding 1-2. This induced voltage maintains the conduction of *Q*1. In winding 3-4, the current continues to increase until the transformer core saturates. (*Continued on page* 74)



# A PROVEN TRANSISTOR IGNITION SYSTEM

By CHARLES C. MORRIS

**Data collected over 60,000 miles of driving show an increase in gas mileage, more power, fewer tune-up expenses, as well as no ignition-component failures.**

DURING recent years many articles have been published describing transistorized ignition systems for use on automobiles. The majority of the systems described are similar in design and operation, and their purchase prices or construction costs are within the average range. One question often asked, though, is, "What are the merits offered by transistorized systems that are not already present in the conventional, simpler system? Does transistorized ignition significantly improve engine performance and extend component life enough to make installation worthwhile?" The answer comes, of course, after installation, trial, and evaluation of a typical system.

This article will point out some facts and results often omitted or overlooked by others. These facts and results have been compiled from evaluation tests made during 30,000 miles of driving with conventional ignition and 30,000 miles of driving with transistorized ignition. This represents a reported total driving test of about 60,000 miles. Most articles have reported results after less than 10,000 miles.

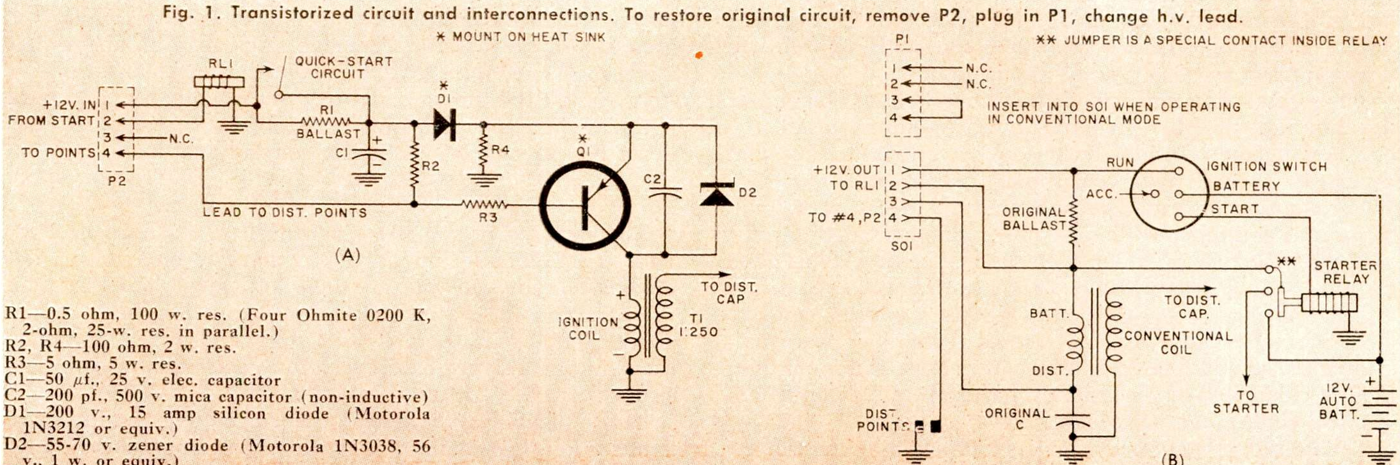
Included in this article are construction details for a complete and proven transistorized system, which can be constructed in about one weekend at a cost of $25 to $35, using new components. Installation in 12-volt negative ground cars has been simplified and is detailed. This system has now been in continuous use for nearly 40,000 miles of varied driving conditions with no failures or engine re-tuneup.

### The Transistorized System

The transistorized ignition system, as constructed, is shown schematically in Fig. 1A. The circuit has been kept simple in that no special or hard-to-get components are required. Good construction practices were followed throughout and, again, these requirements were kept simple by using standard metal parts and hardware. The circuit design is basic and is similar to that of many other available systems, including the one described in the August and December 1962 issues of this magazine.

The ignition coil, a 1:250 turns-ratio type, was used for several reasons. One, it is less expensive than the 1:400 coil, and, two, the 1:400 coil offered no significant improvement

Fig. 1. Transistorized circuit and interconnections. To restore original circuit, remove P2, plug in P1, change h.v. lead.




R1—0.5 ohm, 100 w. res. (Four Ohmite 0200 K, 2-ohm, 25-w. res. in parallel.)
R2, R4—100 ohm, 2 w. res.
R3—5 ohm, 5 w. res.
C1—50 μf., 25 v. elec. capacitor
C2—200 pf., 500 v. mica capacitor (non-inductive)
D1—200 v., 15 amp silicon diode (Motorola 1N3212 or equiv.)
D2—55-70 v. zener diode (Motorola 1N3038, 56 v., 1 w. or equiv.)
RL1—Any 12 v. d.c., 10 amp contact relay (Potter & Brumfield KRP14D relay or equiv.)
T1—1:250 turns-ratio coil (Mallory F-12T)
SO1—4-pin female socket (Amphenol 78 PF4)
P1, P2—4-pin male plug (Amphenol 86 PM4)
Q1—2N174 transistor (Delco)
1—Heat sink (Delco 7270725 or equiv.)

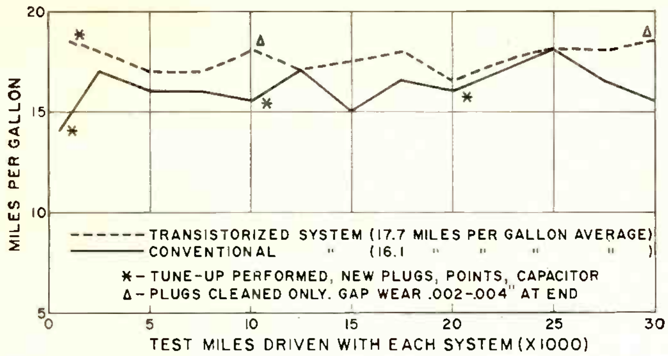


Fig. 2. Comparison of fuel consumed and maintenance frequency.

in performance when tested in this system. Test results indicate that for the particular circuit described, the 1:250 coil is superior to the 1:400 type. Any higher plug voltage generated, or "hotter spark" gained, does not increase the system performance unless, perhaps, at very high speed or race driving.

Relay *RL1* can be any 12-volt d.c. type with a contact rating of at least 10 amps. This relay is used as a quick-start aid by shorting out the ballast resistor, thus allowing a higher voltage to be applied to the ignition coil. The relay is connected to the starter circuit as shown in Fig. 1B. This particular circuit is used on *Ford* and some *Chevrolets*, and possibly other cars. A service schematic for your particular car should be consulted, though. When the starter is energized, the normal starter relay or solenoid is also energized. As soon as the engine starts, these components then return to their normal position. Relay *RL1* is connected in the same manner so that after the engine starts, the ballast resistor *R1* is reconnected in the coil primary circuit. Never leave the ballast resistor shorted out or bypassed while running the engine on a transistorized ignition system. The extra current would soon burn up the ignition coil.

External wiring between the transistorized system and the car's electrical circuit has been simplified by the use of standard 4-pin cable connectors. A connector change-over method is also provided should the transistorized system fail.

### Construction

The system was built in a 4" x 5" x 6" utility box. The heat sink used for *Q1* was mounted on the outside top of the box. Diode *D1* is also mounted on this same heat sink. *Q1* and *D1* must be electrically insulated from the heat sink and ground. This is done by mounting the components using their respective insulating hardware and by applying silicone grease on metal surfaces. The grease also aids in conducting heat away.

The ballast resistors are mounted on an outer side of the box in order to allow for air-cooling since they become hot during operation. These resistors come with appropriate mounting feet for this type of application.

The 4-pin cable connector is then mounted on one end of the box and all other components are mounted inside the box. Arrangement inside the box is not critical except that capacitor *C2* and diode *D2* should be mounted near *Q1*. These components could be mounted on the transistor collector and emitter pins directly under the heat sink.

Ignition coil *T1* is mounted on the engine firewall as close to the distributor as possible. No. 14 wire was used in all external wiring as well as for the transistor emitter and collector circuits. Otherwise, no critical techniques were employed and standard good practices were used. It is important, though, that well-made grounds be used and that all mechanical connections are secure.

The ignition system package was then mounted on the engine firewall. It could be mounted in another convenient location, but preferably not near the exhaust manifolds. Previous tests had indicated that it was not necessary to mount the package near the radiator or fan, thus simplifying installation.

The arrangement used for changing over from the conventional ignition system to the transistor ignition, and *vice versa*, is shown in Fig. 1B. It would be advisable to consult a wiring diagram for your particular car. This wiring setup is for a 1960 *Ford*. However, these circuits do not vary too much. Basically, the technique involves a plug-connector arrangement between the automobile circuitry and the two ignition systems. To operate in the conventional mode, connect plug *P1* to the automobile circuit connector *SO1* and plug the center high-voltage distributor lead into the conventional ignition coil. To operate in the transistor ignition mode, remove plug *P1*, then connect plug *P2* from the transistorized system to connector *SO1* and plug the center high-voltage distributor lead into the transistor ignition coil. Note that the conventional distributor capacitor has been removed from inside the distributor housing and is permanently mounted on, or as near as possible to, the conventional ignition coil. The capacitor must be well-grounded.

### Adjustment

The only checks required are to see that no components overheat and to recheck connections. The transistor will be warm but should never be too hot to touch. Since the ballast resistor dissipates 100 watts while operating, it may become quite hot, but this is normal. The ignition coil primary current should be 8 to 10 amperes with the engine running and distributor point current should be less than 1 ampere. Spark plug voltage can be visually checked to some extent by holding one plug wire connector near the engine surface while changing engine speed. The spark should remain intense and steady at all normal speeds. The frequency of the spark will, of course, depend upon engine speed. Be careful of high-voltage shock while performing this test. The ignition coil input voltage will not be 12 volts while the engine is running, due to the drop through the ballast resistor and because the voltage is switching on and off. With a d.c. meter, the author's *Ford* showed a voltage of less than 2 volts. The meter just simply cannot follow the switching time.

Some difficulty has been encountered while attempting engine tune-up using electronic tune-up equipment. If this problem is encountered, simply tune up the engine using the conventional ignition system, then switch over to the transistorized ignition system. Final adjustment of the timing and any hand touch-up of the carburetor can now be done. If the timing is advanced while operating on transistorized ignition, be sure to reset it to conventional specifications if switching back to that mode. In an emergency, though, short trips to a service garage should not cause any trouble if the driver is careful. Otherwise, engine overheating and valve damage may result. Of course, the more advanced the timing, the greater will be the risk of engine damage. The author has made marks on the distributor adjusting mechanism on his *Ford* so that the timing could be reset roughly by hand until a timing light could be made available. However, he has never had to switch over to the conventional mode.

### Evaluation Test

The car used in this test was a 1960 *Ford* "Fairlane 500" with the 292 cubic inch V-8 engine. The engine was not modified in any way, nor are there any power accessories on the car. The car was purchased new and had been driven about 20,000 miles before the start of the test. Automobile break-in and driving habits had thus been established. The author has been the only driver.

At the beginning of the test, the conventional ignition was in operation. The engine was tuned up using new spark plugs, points, and capacitor. The tune-up was made according to factory specifications. The car was then driven for 30,000 miles under varied conditions, including desert and snow country, as well as the usual city traffic. Regular servicing was performed as recommended. The same brand of gasoline was used as much as possible, rated at hi-test, or 100-plus octane.

Referring to Fig. 2, it can be seen that at every 10,000 miles another tune-up was performed in which new spark plugs, points, and capacitor were installed. The spark plugs were very bad after 10,000 miles, which is longer than the recommended usage. In most cases the plugs showed electrode erosion so bad that cleaning and re-gapping would have been useless. The photograph of Fig. 3 shows a plug in the conventional system (right) compared to a new plug (left). The used plug shown was the best one of the group. In comparison, the plug in the center was run for 30,000 miles with transistor ignition. In the case of the plugs in the conventional system, gap changes varied from about .010" to .020" more than the original .035" settings. The electrodes showed much oxidation and surfaces were burned unevenly. The plugs also broke down under compression and load tests.

The distributor points were also badly oxidized and pitted in the conventional system and were worn unevenly. In one case the points were worn so badly that only about half of the surface area was usable. This, of course, increases the rate of wear on the remaining surface. One capacitor tested still good but was replaced anyway.

Gasoline mileage averaged about 16.1 mpg, as shown in Fig. 2, but note the decline as tune-up time drew nearer. As compared to the transistorized ignition system curve, the mileage fluctuations are greater and the average level is somewhat less. This is a definite indication that a properly maintained and operating ignition system is a must if one is to realize greater economy and engine efficiency. The curve for the transistorized system shows a definite improvement over the conventional system as expected.

With the first phase of the test complete at 30,000 miles, the engine was tuned up again using all new ignition parts. With the exception of the timing which was advanced 2°, the same factory specifications were used in tune-up. The second phase of the test, using transistorized ignition, was again 30,000 miles in duration. The same type of driving conditions existed and regular maintenance and servicing were performed. Again, the same type of gasoline was used. All factors remained the same except for the change in engine timing.

After the first 10,000 miles, the spark plugs were removed and examined. Five plugs showed no electrode gap changes while three plugs showed gap changes of only .001". One plug in the group was weak under compression tests but was not replaced. All plugs still had sharp, flat electrode surfaces and only negligible oxidation was seen as compared to the previous plugs. All of the plugs were cleaned and placed back into the engine. The distributor points were checked next and no burning or pitting was seen. The surfaces were flat and even. The points were placed back into the distributor and reset to the original specifications. Incidentally, dwell angle and timing had not changed during this time. The test then continued for another 20,000 miles.

At the end of this second phase of the test (30,000 miles) the spark plugs were again removed and checked. Seven plugs had electrode gap changes of .002" to .004" and one had changed .006". All of the plugs passed the compression tests, including the previously mentioned weak plug. All plug electrode surfaces were flat with no uneven wear seen. Electrode surfaces were also considerably cleaner than those plugs used in Phase One of the test. This is of course due to the hotter spark and more complete combustion. The plugs were cleaned and re-gapped to .035" and placed back in the engine for continued endurance tests. A savings of the cost of two sets of new plugs had already been realized and these plugs will probably last 50,000 miles or longer. The distributor points were again removed and checked. A slight amount of surface wear was seen but was indicated to be mechanical rather than electrical wear. The surfaces were clean and free from oxidation and pitting. The slight wear seen was even. The distributor cam rubbing block was showing more wear than the point surfaces. The engine timing had slipped back about 1° during this test. The points were re-installed and the timing reset to 2° advanced for continued endurance tests.

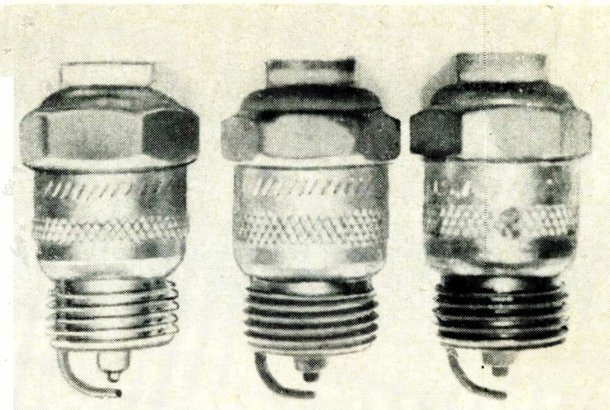


**Fig. 3. Plug at left is new and unused. Center plug has 30,000 miles on it in transistor ignition system. Note insignificant gap change and even wear. Plug at right was used in conventional ignition system for only 10,000 miles. Note large gap change and electrode distortion. The plug was replaced with a new one.**

With the transistorized ignition system no tune-ups were needed during the entire 30,000 miles. Also, no tune-ups have been performed although an additional 10,000 miles has since been logged. Gasoline mileage has picked up to between 1 and 2 mpg average, and has remained somewhat steadier than before. Note that the upper curve does not fluctuate as severely and that a higher average level is maintained. Several other advantages seen during Phase Two include improved performance, easier engine starting, better acceleration, increased power for hill climbing and passing, and smoother engine operation at highway driving speeds. Over-all economy has increased as well.

Another interesting point is that with about 80,000 miles now on the car, there are still no indications that it needs an engine overhaul or major repairs. Perhaps this cannot be associated with transistorized ignition but certainly the higher efficiency and better fuel combustion gained will be of benefit to the engine components. A cleaner burning engine will also reduce valve wear and piston deposits.

To conclude, while the transistorized ignition system began as an experiment, the test data and results obtained were proof enough that it was the system to use. The test car never performed so well so consistently. Since the test proved that previously made claims concerning transistorized ignition systems seem to be valid, the author's system will remain in continuous operation as an integral part of the car. As mentioned earlier, almost 40,000 miles have been driven with the transistor ignition system and there have been no ignition system failures or tune-ups since it was installed. The time and effort involved in building and testing the unit have certainly been worthwhile. ▲

*Editor's Note: The circuit discussed above is for cars with 12-volt negative-ground ignition systems. For 6-volt negative-ground systems, it would be necessary to reduce the value of ballast resistor R1 to 0.25 ohm or less so that 8 to 10 amps of primary ignition coil current flows. Also, the quick-start relay RL1 should be a 6-volt type. Finally, it would probably be preferable to use a 1:400 turns-ratio coil. For positive-ground systems, all points shown grounded in the circuit should be lifted from ground and connected to the negative battery lead. It is also necessary to insulate the breaker points by use of special point-insulating kits available for some cars at auto-supply dealers.*

# V.H.F.

# MARINE RADIO'S NEW HORIZON

By RICHARD HUMPHREY

**Why hasn't the "new" v.h.f. maritime service found greater acceptance? In spite of the congestion in the 2-3 mc. m.f. band, v.h.f. usage is low, although there are many advantages.**

DESPITE its general usage on most vessels plying European waters and as close to home as the St. Lawrence Seaway, the v.h.f. Maritime frequencies are just as unfamiliar to the general American boating public as they were twenty years ago.

According to its supporters, this 156-mc. band offers a possible long-term solution to the congestion and interference now existing on the present 2-3 mc. marine band.

"The possibility of the v.h.f. Maritime Service to supplement," says an official Coast Guard spokesman, "and relieve congestion in the 2-mc. band *has been recognized for several years.*"

Why, then, hasn't this "new" v.h.f. Maritime Service found greater acceptance than it has? Do the disadvantages *really* outweigh the advantages so much—and there are those who claim they do—or is it merely a misconception or else a lack of knowledge that accounts for the considerable lack of response on the part of the general-boating public?

### The Common Complaints

*Distance.* By far the most common "complaint" leveled against v.h.f. is "it won't go as far as m.f." This is where the large majority of potential users of v.h.f. miss the point. It is not *supposed* to go as far as the signals on the 2-3 mc. band. In fact, this is probably one of the major reasons why this particular frequency spectrum was chosen for this new service.

**Table 1. Frequencies above 156 mc. available for assignment.**

| Channel Designator | Frequency (mc.) Ship | Coast | Points of Communication | Authorized Communications |
|---|---|---|---|---|
| 6 | 156.3 | ——— | Intership (I.S.) only | Safety |
| 7A | 156.35 | 156.35 | I.S. & Ship-Coast | Bus. & Oper. |
| 8 | 156.4 | ——— | Intership (I.S.) only | Bus. & Oper. |
| 9 | 156.45 | 156.45 | I.S. & Ship-Coast | Bus. & Oper. |
| 10 | 156.5 | 156.5 | I.S. & Ship-Coast | Bus. & Oper. |
| 11 | 156.55 | 156.55 | I.S. & Ship-Coast | Bus. & Oper. |
| 12 | 156.6 | 156.6 | I.S. & Ship-Coast | Port Oper. |
| 13 | 156.65 | 156.65 | I.S. & Ship-Coast | (1) |
| 14 | 156.7 | 156.7 | I.S. & Ship-Coast | Port Oper. |
| 16 | 156.8 | 156.8 | I.S. & Ship-Coast | Safety-Calling (2) |
| 18A | 156.9 | 156.9 | I.S. & Ship-Coast | Bus. & Oper. |
| 19A | 156.95 | 156.95 | I.S. & Ship-Coast | Bus. & Oper. |
| 20 (3) | 157.0 | 161.6 | Ship-Coast | Port. Oper. |
| 24 (3) | 157.2 | 161.8 | Ship-Public Coast | Public Corres. |
| 25 (3) | 157.25 | 161.85 | Ship-Public Coast | Public Corres. |
| 26 | 157.3 | 161.9 | Ship-Public Coast | Public Corres. |
| 27 | 157.35 | 161.95 | Ship-Public Coast | Public Corres. |
| 28 | 157.4 | 162.0 | Ship-Public Coast | Public Corres. |

(1) Business and Operational in the Great Lakes area only; in other areas, Navigational.
(2) Authorized for call, reply, and safety purposes and, if necessary, for distress messages.
(3) Not available in Puerto Rico or Virgin Islands.

The "line-of-sight" behavior of these frequencies, the use of FM emission, and vertical polarization, as required by the FCC, combine to keep v.h.f. signals "in their own backyards."

To the U.S. Coast Guard and the Federal Communications Commission officials, this "compartmenting" or "pigeonholing" is the very idea of the v.h.f. marine band.

"For instance," says Captain Charles Dorian, Chief of the Coast Guard's Communications Division, in speaking of the Coast Guard's use of v.h.f., "several units engaged in a distress case may communicate on a common v.h.f.-FM frequency and not be interfered with by other units on this frequency which are some distance away. This, of course, applies equally well to a group of pleasure boats in a certain area."

The use of FM enhances this effect. With signals confined to a boater's immediate area, as it would be on v.h.f., interference from hundreds of miles away (common on the present m.f. band) would no longer be a problem.

Just what *is* the distance potential of this line-of-sight, vertically polarized v.h.f./FM marine band? Coast Guard authorities speak of its "reliable distance capacity of 20 to 30 miles." The FCC position isn't far from this. A good estimate would be 30 miles, give or take 10 percent for surroundings and conditions.

*There's nobody on v.h.f.* This is like buying a race-horse and complaining because it runs too fast. Still, it *is* a frequent complaint. In comparison with the 2-3 mc. frequencies, the v.h.f. band *is* bare but this doesn't mean it is a "wasteland" because numerically the units in use run into the thousands in the New York area alone. The difference is that there is more *monitoring* than transmitting on v.h.f. This is a practice, you will agree, that is noticeably lacking on the 2-3 mc. band.

*It is too expensive.* This is a valid point . . . to a point. Prices *do* run higher than comparable m.f. transceivers. Remember that a marine radiophone is a safety device, not a hobby or a diversion or a "party line." Money "saved" by buying a medium-frequency rig that is not able to get the message through is hardly a wise investment.

### Available Equipment

The wide choice of gear, such as is the case with m.f. equipment, just does not exist. This is, unfortunately, particularly true of units designed for the recreation-boating field. At the present writing, only four (there may be more) units have come to the author's attention. "Veterans" are the "Clipper" radiophones by *Canadian Marconi* (represented in USA by *Kaar Electronics Corp.*) and the "Sea Line" of *Aeronautical Electronics (Aerotron).*

The "Clipper" is a 5-channel, 25-watt-output rig with a double-conversion receiver. It comes powered either by a.c. or 12-volt d.c. *Aerotron's* "Sea Line" is 4-channel, has a 35-watt output, and also features a double-conversion receiver. It, too, is available in a.c. or 12-volt d.c. versions.

Latest entry into the v.h.f. field is *Hartman Marine Electronic Corporation's* "Hurricane" v.h.f./FM marine transceiver. The "Hurricane" will have 5 channels, and an output in the 15-watt or better class.

Also new is the *Konigsberg* "Konel" KR-53V. With 10 channels and a 50-watt output, it is just as exciting as the *Hartman*. The price of the "Konel" is rumored to be in the "low $500 class." These particular two new v.h.f. marine transceivers will undoubtedly be much in evidence at upcoming boat shows.

In addition to these, *Communications Company (Comco)* of Coral Gables, Florida has a 25-watter on the drawing board which will be fully transistorized—even the transmitter. This, they say, will be designed for the popular-boating market.

On the commercial side, things are brighter. *Comco's* commercial units, for example, come in 11-, 8-, and 2-channel models. You can have continuous monitoring of one, two, or even three channels if so desired. A nice feature which permits a watch on 156.8-mc. (calling and Coast Guard guarded) or some other channel or channels is of special interest.

You will find this watch-frequency provision an integral part of most commercially oriented transceivers. *RCA* has it on its 16-channel, 50-watt-output model as well as on its 32-channel equipment.

*Raytheon* is represented by a 31-channel rig with a 20-watt output. According to reports from the company, a "watchful eye" is being kept on the development of the v.h.f. marine band and when the pleasure-boat market materializes, the company will have equipment available.

*Canadian Marconi*, mentioned earlier, is also in the commercial field with 12-channel and 6-channel models. *Marconi* has numerous outlets (through *Kaar*) in the United States and is fully set up for servicing this equipment.

*General Electric* will modify its "Progress Line" to wide-band (the ±15 kc. required on the v.h.f. marine band) FM and provide four channels. *G-E* is one of the major suppliers of hand-held units to the various pilot's associations in the country. As for an out-and-out v.h.f./FM multi-channel marine transceiver, though, *G-E* does not presently have one.

*Hammarlund* and *Motorola* (along with *Comco*) supply the Coast Guard with v.h.f. marine gear but their reactions to the author's inquiries would seem to indicate only limited interest in v.h.f. marine—commercial or otherwise—at this time.

Actually, the major differences between "popular" and "commercial" gear is one of price, size (sometimes), and voltages. You will find 24- and 32-volt rigs available in most commercial lines, along with 12-volt d.c. and 117-volt a.c. models. If your purse is up to it and your boat can accommodate the extra size of some of the commercial equipment, one of these rigs might be suitable for you.

Note that output powers of both types of gear are in what might be called the "low-power" class. The big powerhouses (such as are found in m.f.) are not needed for the coverage involved in v.h.f. This means less battery drain.

Present 2-3 mc. antennas, with notable exceptions, are of the loaded whip variety. This means fairly low antenna efficiency. In the 156-mc. band, however, a full-size, quarter-wave whip is less than 20 inches long. This is quite a difference.

Of even greater interest are the various "gain" antennas being used more and more in v.h.f. Up to 10.5 db gain is claimed by some manufacturers and the antennas are no longer than some types used on present m.f. installations.

Methods used in achieving this gain are many. For example, *Communications Products* uses a colinear approach. Such an antenna radiates at right angles to the line of the array (vertical) and signal gain increases with the number of elements involved.

Other companies achieve gain in this and in other ways. Some of these firms are *GAM Electronics*, *White*, and *Prodelin*.

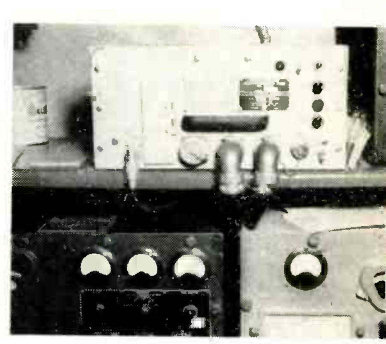
Probably the biggest difference you will notice when you compare the two marine bands is the increased number of intership channels available on v.h.f.

On the present 2-3 mc. bands are 2638 and 2738 kc. (2003 is substituted for the latter in the Great Lakes area and 2830 kc. in Gulf waters). With 2182 (international calling & distress) and the Marine Operator channels, that is just about it for the 2-3 mc. band.

But no less than *twelve* ship-to-ship and *sixteen* ship-to-shore frequencies are authorized by the FCC in the v.h.f./FM maritime band (Table 1). This isn't quite as good as it sounds, though. Outside of 156.3 and 156.4 (intership only); 157 (ship-to-coast only); and the five ship-to-shore Public Correspondence channels—the remaining frequencies are *dual purpose. Both* ship-to-ship and ship-to-shore traffic are authorized.

What it amounts to is this: The general boating public will be using, for ship-to-ship traffic, the same channels the commercial people are using for their business. There are exceptions which we will go into later. Transmissions by the commercial users are brief, to-the-point. This is a decided relief from the "party-boat kaffee klatches" on the m.f. band.

Channels 7A through 11 are used for "business and opera-



**(Left) Canadian Marconi's "Clipper" transceiver is shown mounted on a small boat. (Center) Aerotron "Sea Line," used by commercial and pleasure boaters, has a 35-watt power output. (Right) Dwarfed by its m.f. brothers, this Hammarlund v.h.f. unit is aboard C.G. Cutter "Tamaroa."**

tional" traffic as are 18A and 19A. (In Section 83.6(i) of the FCC Rules and Regulations, *business* communications are defined as "radiocommunication pertaining to economic, commercial, or governmental matters related directly to the purposes for which the ship is being used.")

Section 83.6(h) FCC R&R tells us that *operational* communications are those "concerning the navigation, movement, or management of a ship or ships." (Incidentally, "ship" is defined in Section 83.2(n) of the regulations as "every description of watercraft or other artificial contrivance, except aircraft, used or capable of being used as a means of transportation on water, whether or not it is actually afloat.")

Channels 12, 14, and 20 are restricted to "port operations." (Section 83.6(j) of the regulations describes port operations as "communications in or near a port, or in locks or waterways, between coast stations and ship stations, or between ship stations, in which messages are restricted to those relating to the movement and safety of ships and, in emergency, to the safety of persons.")

We are now left with 156.8 mc. (channel 16) which is the v.h.f. counterpart of 2182; and channel 13, the so-called "bridge-to-bridge" frequency. Referring again to Table 1, we see that channel 13 (156.65 mc.) may be used for business and operational traffic *only in the Great Lakes area.* Elsewhere, communications must be navigational in essence. Why the "bridge-to-bridge" terminology? It has two meanings; one to the commercial operator and the other to pleasure-craft skippers.

This is the frequency used by the pilots engaged in herding their giant charges in and out of port areas and to them the term "bridge-to-bridge" means "ship bridge-to-ship bridge." Of proven worth in Philadelphia, Savannah, New York, Baltimore, and other areas, this frequency may well become mandatory on most commercial vessels. In fact, a Coast Guard-FCC Committee has been seriously studying such a move for some time. In a recent article ("Proceedings of the Merchant Marine Council," April, 1965), Captain Wm. G. Foster, USCG, had this to say:

"The Coast Guard FCC Committee will prepare proposed legislation and appropriate proposed regulations. The two will be combined in a package that will be mailed to all interested organizations and groups for comments. After a reasonable period for receipt of comments, the proposals will be revised as indicated and then proposed legislation will be presented to Congress."

On the other hand, to the pleasure-boating public 156.65 mc. would be the "boat bridge-to-bridge and lock-tender" channel. It would enable the recreation-craft owner to talk directly to bridge and lock tenders and for those who do a lot of canal-hopping or have a bridge problem, it will certainly be of considerable use and save a lot of tooting and temper.

Another channel which the pleasure boater will find of interest is 156.45 mc. (channel 9). Section 81.351(5)(b) of the FCC R&R authorizes a limited coast station for "a person controlling public moorage facilities and otherwise serving the needs of vessels, or to a yacht club having moorage facilities." This means direct contact between the skipper and his yacht club or marina provided, of course, the club or marina has a shore station.

Of the 16 ship-to-shore channels authorized for ship stations, five are available for public correspondence (marine operator) use. Of these five, two are in use at the present time. Checking Table 1 we see there are 15 authorized *operating* channels on v.h.f.

The v.h.f. marine band also has some advantages that are purely constructional or, more accurately, "installational" in nature. First, the use of FM will eliminate irritating engine noise interference to a great extent. Those of you who have gone through the time-consuming and sometimes expensive job of tracking down "that infernal racket that's interfering with reception" know that this is a blessing. FM will also give more life-like clarity to received signals.

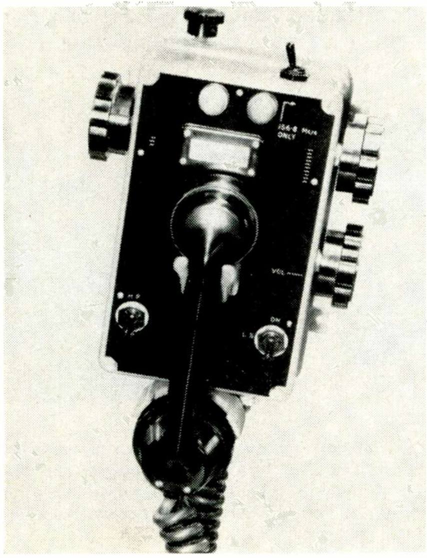
Another thing, at these frequencies you will find that that big, expensive chunk of metal, the ground plate, is not necessary for the radio gear. Although there may be a difference of opinion on this point, the author believes there is no advantage in using one on v.h.f. Neither is it required as far as the FCC is concerned. Section 83.107(c), (1) and (2) applies only to frequencies below 25 mc.

Add to this the fact that v.h.f./FM marine gear is, with a few exceptions in commercial rigs, usually much smaller physically than m.f. equipment and you have an attractive picture facing you when you make your installation. Don't forget a first or second class FCC licensee must do the final alignment.

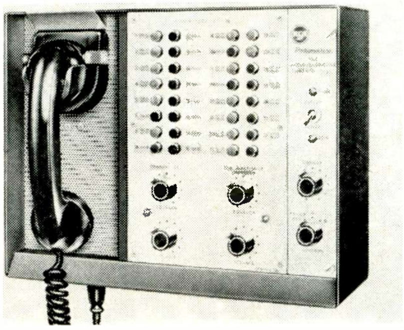
With the Coast Guard in the lead-off spot and the FCC batting clean-up, the v.h.f./FM marine service has a lot of support. The commercial shipping interests are making effective use of it. Perhaps the general boating public will soon abandon the present frequencies in collective disgust at the congestion and flee to v.h.f. The Coast Guard and the FCC both seem to hope so.

"The Coast Guard presently is equipped to handle foreseeable communication activity on v.h.f./FM," said Rear Admiral I. J. Stephens, Commander of the 3rd Coast Guard District when the author asked him his views, "and we encourage the boating public to make the shift to v.h.f./FM."

The v.h.f. band is there ready and waiting and you could find it is your ticket to an effective, interference-free communications tool in your immediate cruising area. ▲



**(Left) Control head for Raytheon v.h.f. gear is simple and compact. (Center) One of RCA Radiomarine's units which covers 28 v.h.f. channels and automatically reverts to 156.8 mc. after use. (Right) Designed by Comco for Coast Guard use, the 28-channel v.h.f. unit also reverts to 156.8 mc. when the handset used is replaced into its cradle.**



# JOHN FRYE

*Many conditions can produce wrong s.w.r. readings, but the position of the meter in the line is not one of them.*

## S.W.R. FACTS AND FALLACIES

SUDDENLY Barney hurled the magazine he had been reading during his lunch hour clear across the service shop. "I just can t take another sloppy, inaccurate explanation of s.w.r. measurement," he explained to Mac, his employer. "That guy solemnly writes that while you can insert an s.w.r. meter in a flat line anywhere and get a correct reading, on a mismatched line the s.w.r. meter will give different readings at different points *because of current and voltage nodes existing on the line*. He goes on to say that to measure s.w.r. accurately on such a line the meter has to be inserted a quarter-wave from the feed point of the antenna or an even multiple of half-waves from it."

"You don't agree?"

"Certainly not! He's saying the s.w.r. indication is a function of the voltage or current of the static standing wave on the line at the point where the meter is inserted. That's not so. An s.w.r. meter operates by measuring and comparing the forward and reflected waves traveling up and down the line, and the respective voltage and current of these two waves have the same magnitude at every point along the line when line loss is ignored. A carefully constructed, properly calibrated s.w.r. meter will give virtually the same reading wherever it is inserted in a low-loss line whose impedance is equal to that for which the meter is calibrated."

"This subject seems to have you really turned on," Mac observed. "Want to give stupid old me a little lecture?"

"Remember, you twisted my arm!" Barney warned. "You know every cycle of power delivered by a transmitter to the end of a feedline sends a wave of voltage and in-phase current traveling up the line to the antenna. If the antenna is resonant so that it looks like a pure resistance, and if the ohmic value of that resistance is exactly equal to the surge impedance of the feedline, all of the power of the incident wave is absorbed by the antenna, and the incident wave train is the only one present on the feedline. There are no reflected waves and no standing waves.

"But if the ohmic value isn't equal to the surge impedance of the line, or if the antenna load contains a reactive component that does not absorb power, all of the power of the incident wave is not absorbed by the antenna. A reflected wave consisting of a voltage wave and a 180° out-of-phase current is generated and starts traveling down the line toward the transmitter. Some writers speak of this wave as 'reflected power,' but I'm not sure this is a happy choice of words. Since the voltage and current are 180° out of phase, it has a negative power factor, and I'm not sure what negative power is. On top of that, if you insist that reflected power is real power, you are put in the embarrassing position of having to explain what happens to this 'power' when it is fed back into the transmitter!

"Anyway, voltages and currents of opposite-going wave trains combine algebraically to produce a resultant 'standing wave' on the line. At a particular point on the line, the phase of the incident and reflected voltage waves meeting at that point may be in phase so that their resultant is equal to their sum. A quarter wavelength away the voltages will be of opposite phase, and their resultant becomes their difference. Between these extremes lie intermediate values of standing-wave voltage. On a flat line, voltage or current measured at all points is the same, but when a standing wave is present it will be found that the voltage and current go through regularly spaced maxima (loops) and minima (nodes) as measuring instruments are moved up and down the line. The distance from loop to loop or node to node is a half wavelength of the line.

"The voltage-standing-wave ratio, v.s.w.r. or simply s.w.r., on a line is defined as the ratio of the maximum voltage to the minimum voltage found on the line. Very important is the fact that this turns out to be the ratio between the surge impedance of the line and the ohmic value of a resistor used as a load. For example, if a 50-ohm line is terminated in a 25-ohm resistor, the s.w.r. is 50/25 or 2/1. It is also 2/1 if the load resistor is 100 ohms (100/50) because the larger number is always placed in the numerator and both parts of the fraction are divided by the denominator so that you end up with a 'something-to-one' ratio. In either case, it will be found that the largest voltage on the line is twice the smallest voltage and, incidentally, that the largest current is twice the smallest current.

"This brings us to an important benefit of s.w.r. measurement: it provides information as to the amount of mismatch between the line and the load without actually measuring the load."

"Hold on. You say s.w.r. is determined by the loop/node ratio of voltage or current on the line, and you say a loop and a node are separated from each other by a quarter wavelength of line; yet you take exception to the writer's saying the s.w.r. meter gives different readings at different points on the line. How can you determine maxima or minima unless your measuring instrument moves up and down the line?"

"I was hoping you'd ask. Remember, maximum voltage is produced by adding incident and reflected voltage, and minimum voltage results from subtracting reflected from incident voltage. If we call incident voltage $V_i$ and reflected voltage $V_r$, the s.w.r. becomes $(V_i+V_r)/(V_i-V_r)$. To determine the s.w.r. on a line all we need is a gadget we can insert in the line to measure separately the incident components and the reflected components as the waves whiz past.

"The s.w.r. meters of the Micromatch or Monimatch types do this by taking advantage of the fact that voltage and current are in phase in the incident wave and opposite in phase in the reflected wave. A small voltage derived from the current in the line is combined with a sample of voltage from across the line. If the two voltages have the right amplitude relationship, the out-of-phase reflected components cancel and a voltmeter reads only the sum of the in-phase incident components. By reversing the phase of the current sample 180°, the forward components are made to cancel and the meter reads the sum of the reflected components. Neat, huh?"

"Very neat! And I think I see why the meter even does the necessary computing. If we adjust the sensitivity so that the incident wave produces a full-scale reading on our meter, we can assign a value of '1' to this. Now if the reflected components produce a half-scale reading of .5, the s.w.r. by the formula becomes (1 + .5)/(1 — .5) or 1.5/.5, or 3/1. The reflected scale can be marked off directly in s.w.r. making all pencil work or graph reading unnecessary. Why do you suppose misconceptions and fallacies about using the s.w.r. meter creep into print?"

"Partly because careless writers try to explain the subject without understanding it themselves. They simply repeat some over-simplified, fallacious description and probably add a few mistakes of their own. I'm reminded of Mark Twain's comment that the difference between a cat and a lie is that the cat has only nine lives. Some cockeyed ideas about s.w.r. have been knocking around for years.

"Another reason is that some writers draw their conclusions from their own experiments without taking into account possible sources of error. Many things can cause an s.w.r. meter to give a wrong indication. First, the meter must be carefully constructed, fully shielded, and calibrated so that it nulls *only* with a resistive load equal to the surge impedance of the line with which it is to be used. The signal passing through the meter must be relatively free from harmonics. The transmitter must be well shielded so that r.f. is confined to the inside of the transmitter, the coax line, and the meter itself.

"Another common source of error is to accept the nominal value of a coax line as the true value of its surge impedance. Remember that a line repeats the load impedance—with only a phase reversal—every half-wave you move away from the load. In other words, if a 52-ohm line is terminated in a 50-ohm resistor, the impedance as seen a half-wave from the load would be 50-ohms resistive, and an s.w.r. meter calibrated for 50 ohms would indicate 1/1 s.w.r. if inserted at that point, even though the true s.w.r. is 1.04/1. Moving the meter away from that point would produce some other s.w.r. indication. The meter is made to lie because it is used in a line for which it is not calibrated. An impedance bridge inserted in a lossless line at a half-wave point will indicate the impedance of the load, and maybe that's why some fellows think an s.w.r. meter must be inserted there, too, to get a true reading.

"Poor coupler 'directivity' is a common cause of incorrect s.w.r. readings. This is the characteristic by which the coupler discriminates between opposite directions of 'power' flow. Ideally, when the meter is measuring reflected components, the incident components completely cancel each other so that no incident power is coupled from the line. Practically, if the incident power coupled out when reading reflected 'power' is less than 1/10,000 the incident power

(*Continued on page* 58)

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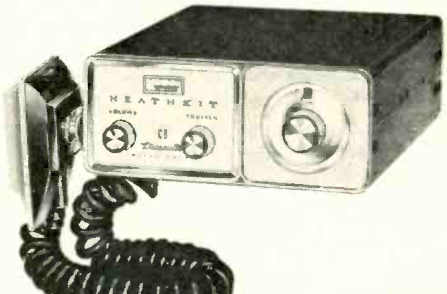


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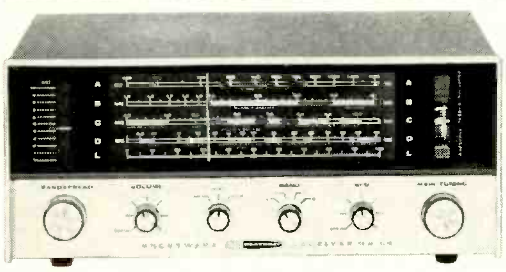

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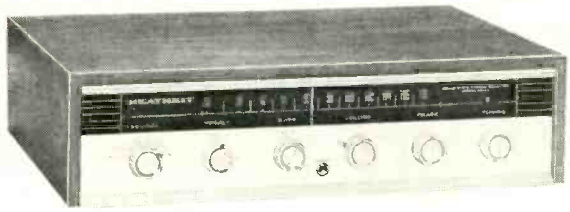



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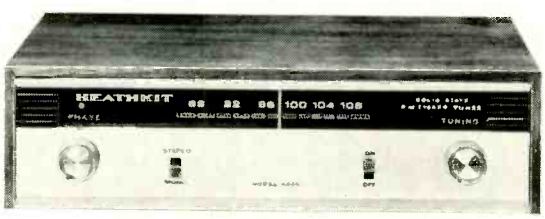


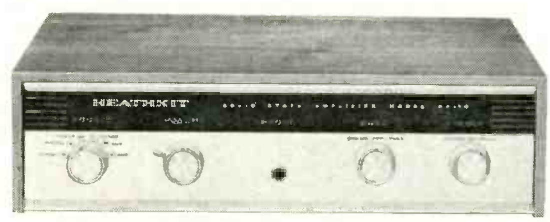


### New Transistor FM/FM Stereo Tuner

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coupled in the forward position, meter readings will closely approximate true s.w.r. However, if this fraction is increased to 1/1000, a true s.w.r. of 2.5 may read between 1.8 and 3.5. An indication of a coupler with poor directivity is that it will give different readings when moved up and down a quarter wavelength of line!

"Another cause of error occurs when the outside of the coax is not actually at ground potential at the load, such as occurs when coax is used to feed a dipole antenna. Under such circumstances, the outside of the coax becomes part of the load seen by the inside of the cable so that changing the cable length actually changes the load and produces incorrect s.w.r. indications.

"Finally, it is true that an s.w.r. reading taken at the bottom of any feedline cannot be completely accurate. Attenuation of the reflected components by the line loss make such an s.w.r. reading lower than would be found right at the load. The amount of this error depends on the line loss without a standing wave plus a proportion of this original loss produced by the s.w.r. The standing wave increases both the maximum current and voltage on the line—they are doubled when the s.w.r. is 4/1—and this contributes the additional loss. On a line that has a 6-db loss when flat with a 4/1 s.w.r. at the load, the additional loss contributed by the s.w.r. would be about 1.7 db, and an s.w.r. meter at the end of the line would indicate only about 1.35/1 instead of 4/1. Fortunately, not many lines have that much loss, nor are they operated with that high an s.w.r.; so the s.w.r. reading at the transmitter is much closer to that at the load. But it should be realized that the s.w.r. reading decreases gradually as the meter is moved down the line from the load. This change, however, is a gradual one and has nothing to do with s.w.r. loops or nodes. If you plotted the s.w.r. readings taken along a line on a Smith chart, you would come up with a spiral instead of the circle that ordinarily depicts the s.w.r. on a lossless line."

"We've got to get to work," Mac interrupted, "but let me see if I have digested what you have been saying. The position of an s.w.r. meter in a line with regard to the loops or nodes of the standing wave has nothing to do with the reading. If the meter and the line are what they should be, virtually the same s.w.r. reading will be indicated wherever the meter is inserted along, say, a quarter-wavelength of low-loss line. However, the s.w.r. reading does decrease from the true reading at the load as the meter is moved down the line. This is a function of the line loss. In fact, in a perfect setup, this line loss is the only factor that causes s.w.r. reading to change with regard to the meter's position in the line.

"However several other conditions can produce wrong s.w.r. readings and make it seem that the reading depends on where the coupler is inserted in the line. Among these are harmonics in the transmitter output, poor shielding of transmitter or coupler, an improperly constructed and calibrated coupler with poor directivity, a coax line with an impedance different from that for which the coupler is designed, or attempted measurement of s.w.r. on a coax line feeding a dipole antenna."

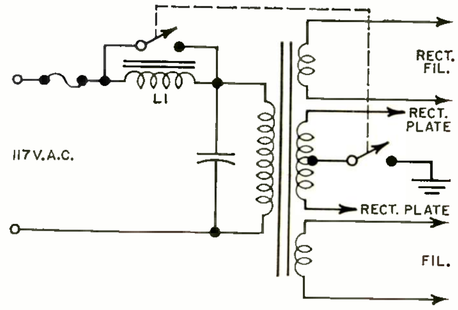
"That's the meat of the matter, but I'm sure you know we've barely scratched the surface of s.w.r. and transmission-line theory. Believe me, it's not simple; and even the experts do not agree on precisely what takes place along a transmission line and inside an s.w.r. meter. Some insist that the entire idea of reflected waves of current and voltage creating standing waves on the line is a convenient fiction similar to 'hole currents' in explaining transistor action. But it is a broadly accepted concept that permits explanation of practically all transmission-line behavior, and I intend to use it until someone comes up with a whole lot better non-mathematical explanation." ▲

## INSTANT-ON WITH TRANSFORMERS

**INSTANT-on a.c./d.c. sets use a diode in series with the filament string so that even when the set is turned off, the filaments are kept at a warm temperature thus reducing initial high current surges and metal fatigue within the tubes. In some of its latest TV sets, Westinghouse is applying the instant-on technique to the transformer-powered TV sets. In this case, a diode cannot be used in series with the transformer to reduce the primary voltage, as the d.c. component produced by the diode is incompatible with the transformer. Westinghouse has worked out an ingenious scheme for circumventing the problem.**

**The circuit shows circuit operation. When the two-pole power switch is open, reactor L1 is in series with the transformer primary and the center tap of the high-voltage secondary is open. The reactor presents an impedance to the 60-cps line current and reduces the applied voltage to about one-half. The filaments are kept in a standby condition, while the "B+" is turned off.**

**When the power switch is turned on, the reactor is shorted and the secondary center tap is completed.** ▲



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## Capacitance Nomogram

(*Continued from page 29*)

the pivot line in step (1). Extend this line. The answer, 8.2 μf., can then be found on the $C_X$ scale where the second line crosses it.

For higher values of capacitance than those shown on the scales, merely multiply both $C$ scales by $10^n$.

The need for calculation of $C_X$ can be eliminated and the value can be read off directly from the meter in the following manner: (1) Adjust the a.c. input voltage until $E_X$ appearing across $C_X$ is equal to $C_K$ in microfarads. Whether $E_X$ is in volts or millivolts doesn't matter, as long as $E_X$ and $E_K$ are both in the same unit. (2) Read $E_K$ across $C_K$. This value in volts is equal to $C_X$ in microfarads.

When it is necessary to measure large quantities of electrolytic capacitors, as in the case of incoming inspection departments, a test fixture can be constructed for rapid testing (Fig. 3).

A suitable means of rapid connect and disconnect should be provided for inserting and removing the capacitor under test.

The meter should be a reliable type of a.c. vacuum-tube voltmeter, such as the *Hewlett-Packard* Model HP-400. The decision must be made whether to use two meters as shown in Fig. 3 or only one meter with a toggle switch, as shown in the partial schematic of Fig. 1B.

The test can be made on a "go/no-go" basis by providing limit indications on the face of the meter. First, the $E_X$ meter should have a line drawn on it parallel to the needle. This line should be on the voltage point which is equal in magnitude to the value of $C_K$ in microfarads as previously described. This can be called the set-up point. Second, the $E_K$ meter should have a line drawn parallel to the needle at the voltage point which is equal in magnitude to the minimum value acceptable for $C_X$. Another can be added for the maximum value if specified.

The test for each capacitor can now be made in a matter of seconds by using the following procedure:

1. Insert the capacitor into its holder observing proper polarity.
2. Turn the "on-off" switch to its "on" position.
3. Adjust the variable transformer until the needle on the $E_X$ meter comes to the set-up mark.
4. Observe the position of the needle on the $E_K$ meter. It should fall on or between the two limit marks. If not, reject the capacitor.
5. Turn the "on-off" switch to the "off" position.
6. Remove the capacitor. ▲

## Sylvania Transistor TV Set

(*Continued from page* 38)

Another very interesting circuit of this set is the vertical sweep section. Here the analog to the vacuum-tube version is especially strong since only two transistors are used to provide both the vertical oscillator and the vertical output function. The circuit, shown in Fig. 4, is very similar to that of a duo-triode arrangement in which one section (Q2) performs both oscillator and output amplifier functions. D.c. coupling is used from the first stage collector to the output stage base.

The sync pulses pass through a conventional integrator circuit, *R*1, *C*1, *R*2, and *C*2 and then trigger the base of oscillator Q1. Feedback pulses from the collector of output stage Q2 are coupled back to the oscillator base *via* C3, *R*3, and *R*4. The vertical hold control, *R*5, affects primarily these feedback pulses and thus affects the oscillator frequency.

Vertical linearity is determined by *R*6 and *R*7 which control feedback from the emitter to the base of the output stage through C4 and C5. The main feedback path that keeps the circuit oscillating is *R*8 which couples the output emitter to the base of Q1. Resistors *R*9 and *R*10 control the bias on the output stage and therefore the picture height.

Between the base and emitter of the output transistor, a single thermistor, *R*11, is used to maintain constant amplitude for the vertical sweep signal. Because the output stage dissipates some power, it is mounted on a heat sink, together with the audio output, the horizontal driver, the horizontal output, and the damper diode.

The horizontal sweep section and the high-voltage flyback circuit are, in many respects, similar to those in other transistor receivers. The horizontal a.f.c. action is provided by a diode phase detector and the horizontal oscillator is an emitter-coupled multivibrator which has an *LC* circuit in the collector of the first stage to provide more stability, similar to its equivalent vacuum-tube circuit. A horizontal driver and the horizontal output transistor provides the power to drive the deflection yoke directly off the emitter of the output transistor. The high-voltage section uses a 1B3 vacuum-tube rectifier, the only vacuum tube (other than the CRT) in the set. ▲

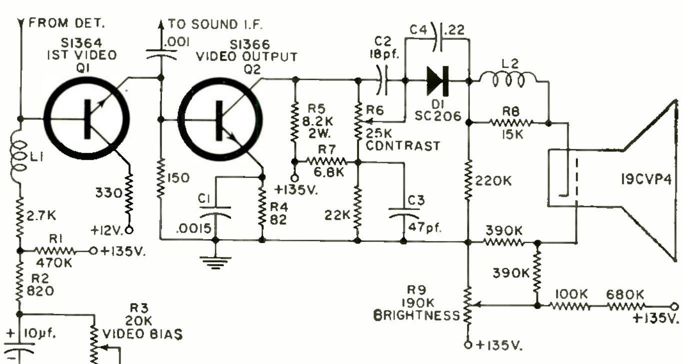
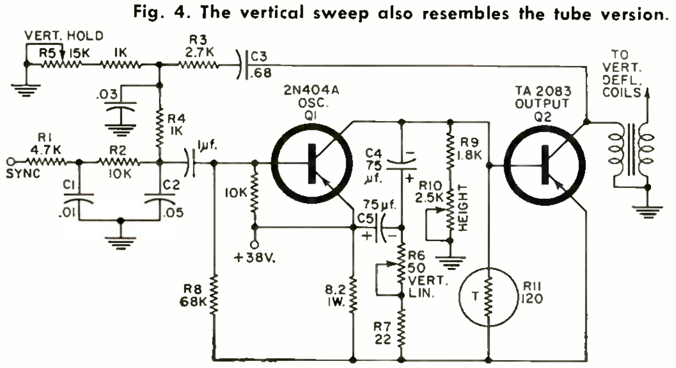
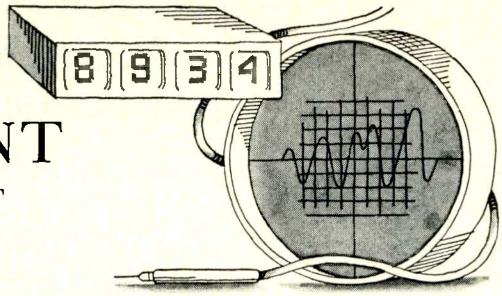



**Fig. 3. The video amplifier is similar to a tube approach.**

**Fig. 4. The vertical sweep also resembles the tube version.**

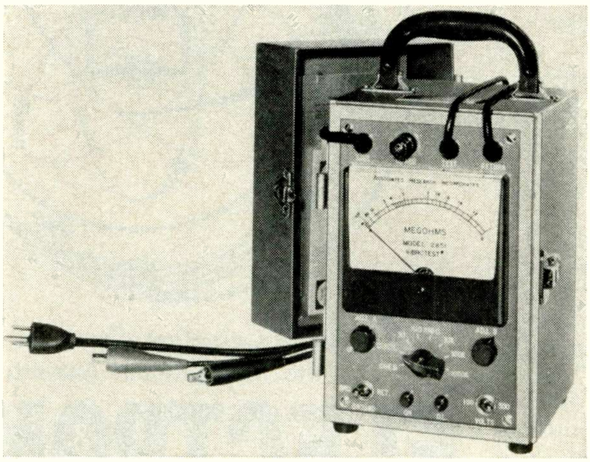


# TEST EQUIPMENT
*PRODUCT REPORT*




## Associated Research 2851 Megohmmeter

*For copy of manufacturer's brochure, circle No. 152 on Reader Service Card.*



A NEW portable megohmmeter which can measure resistances as great as ten million megohms at 500 volts d.c., or two million megohms at 100 volts, has been introduced by *Associated Research, Inc.* This instrument is designed with a 100-volt test potential to comply with the new EIA standard for measurement of composition, film, and wirewound resistors having resistances over 100,000 ohms.

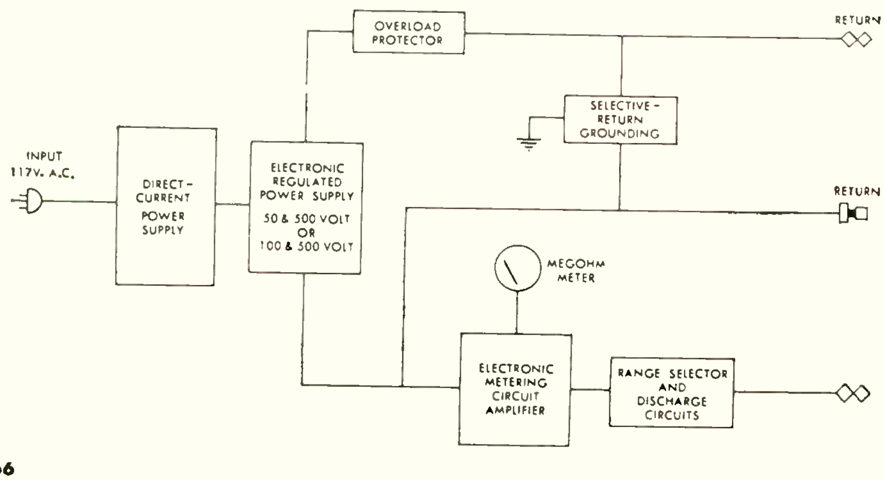
Known as the Model 2851 "Vibrotest" megohmmeter, the new instrument is powered by line-alternating current and provides direct-reading resistance measurements on a four-inch scale calibrated from 1 to 100 megohms.

The range may be multiplied by 1, 10, $10^2$, $10^3$, $10^4$, and $10^5$ by means of a rotary selector switch. Six megohm ranges are available at either 500 volts d.c., ±5 volts, or at 100 volts d.c., ±5 volts.

Accuracy of within 2% is achieved over the greater portion of the scale range when used at 500 volts, and at 100 volts, accuracy is within 5% over most of the scale.

The power supply of the unit uses silicon rectifiers which eliminate the need for hand cranking or batteries. Regulation against line-voltage fluctuations of ±10% is furnished by a cathode follower which provides a well-regulated power supply with very low ripple content to assure maximum reading stability.

A fused three-wire power input grounds the case for shock protection, and the instrument is protected from overload damage, even in cases of direct shorting, by the utilization of an electronic overload circuit.




The electronic metering circuit uses the latest miniature-type vacuum tubes to provide adequate sensitivity for measurements throughout all ranges. The indicating meter in the circuit is a 200-μa. unit.

Guard circuits control stray and leakage currents to assure accuracy at maximum sensitivity. A terminal for external guard use is provided, and a selective-return grounding circuit provides for maximum guarding flexibility when the instrument is used to test production components or permanently installed equipment.

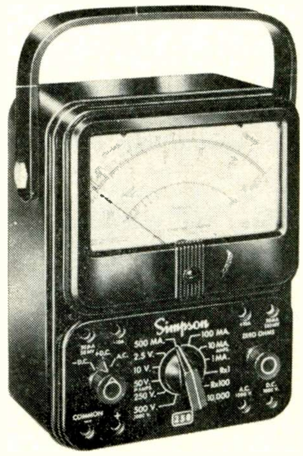
This new product lists for $305. ▲

## Simpson Model 250 Volt-Ohm-Milliammeter

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

THE new *Simpson* Model 250 v.o.m. has been designed with semiconductor circuits in mind. It has a constant millivolt drop on all its d.c. current ranges so that its effect on transistor circuits is regular and predictable.

Another new feature is the use of a taut-band suspension annular (ring) meter movement. Such a movement is self-shielding, and the suspension has superior repeatability due to the absence of normal pivot-jewel wear. These design improvements should result in an instrument with years of trouble-free service.



A special calibration circuit is included which yields increased accuracy and facilitates recalibration to original factory accuracy, should it ever be necessary.

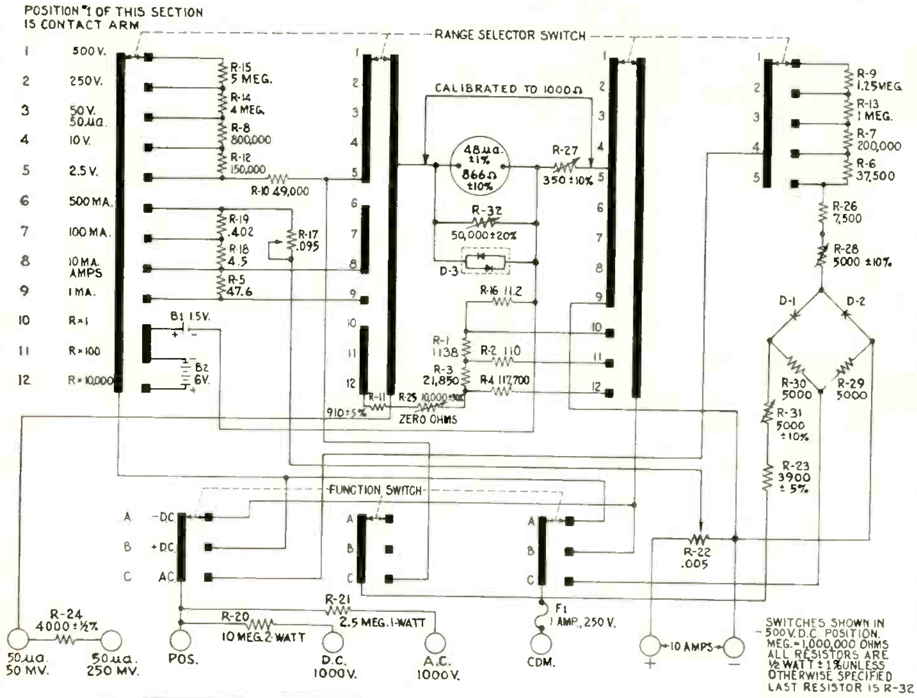
An internal fuse is incorporated which protects the v.o.m. from misuse on the ohmmeter ranges and from excessive overload on the milliampere ranges. A special silicon diode protects the meter movement even with 1000 times the current applied.

Accuracy is within 2% on the d.c. voltage and current ranges and within 3% on a.c. scales. Frequency response on a.c. is flat from 20 cps to 100 kc.

The Model 250 is housed in a sturdy,

phenolic case which is molded with reinforced walls. All the components are attached to the front panel so that the entire instrument slips into and out of the case in one piece. Most of the components are mounted on a printed-circuit board. A special stiff handle is attached to the case so that the v.o.m. can be supported in a convenient sloping position that allows easy viewing on the bench top.

The v.o.m. has all the usual current, voltage, and resistance ranges. It is priced at $56.95. ▲

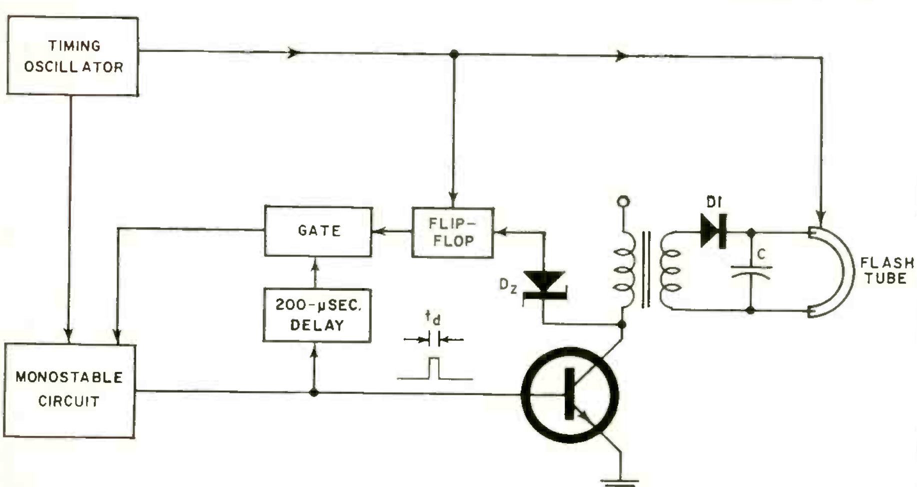



## General Radio Type 1538-A Electronic Stroboscope

*For copy of manufacturer's brochure, circle No. 153 on Reader Service Card.*

THE new *General Radio* Type 1538-A Strobotac® electronic stroboscope represents a new development in the technology of this well-known, extremely useful type of instrument. Maximum flashing rate, probably the most important single characteristic of a stroboscope, has been boosted to 150,000 flashes per minute—an improvement by a factor of six over previous stroboscopes. A flashing-rate capability of 150,000 per minute enables this new stroboscope to be used in motion analysis and speed measurement of the fastest machines known—some of which are capable of operating at speeds up to 1,000,000 rpm.

The stroboscope, essentially a flashing-light source with adjustable, calibrated control of flash frequency, is used to produce the optical illusion of slowed or stopped motion and to measure speed. The stroboscopic illusion depends on the periodic interruption of observation and on the persistence of vision—the eye's ability to hold an image for a split second after it disappears. If a cyclically moving object is viewed under a light that is flashing at or near the object's cyclic rate, the object will appear stationary or in slow motion. The tachometric application is a converse of this principle—that if the flashing rate is ad-



justed to produce a stationary image, the object's rate can be determined from a knowledge of the flashing rate.

The actual light flash in most stroboscopes occurs inside a xenon-gas tube as the gas is ionized by the rapid discharge of a capacitor. The gas must then deionize before the next flash can occur, and this deionizing time sets a limit on the maximum flashing rate. If voltage is applied to the tube before it has deionized, a continuous discharge known as "holdover" will occur.

The key to the substantial increase in flashing rate in *GR's* new Strobotac is a novel charging circuit which keeps voltage from being applied to the tube until it has deionized, then charges the tube very rapidly. The circuit is shown in the diagram. A normally off switching transistor is turned on by a triggering pulse for a period of time, $t_d$, equal to the deionizing time of the tube. This induces a voltage in the secondary of the transformer. The winding sense is such that the induced voltage back-biases the diode *D*1, and no current flows into the capacitor. Energy is meanwhile building in the transformer, and when the transistor switch is turned off (after time $t_d$), the collapsing magnetic field in the transformer induces a voltage in the secondary that forward-biases the diode. The energy stored in the transformer is transferred resonantly to the capacitor, charging it to the operating voltage for the tube.

The method of resonantly transferring voltage to the tube is another novel circuit feature of the Type 1538-A and may be seen from the block diagram. A trigger pulse from a timing oscillator flashes the strobe tube, discharging the capacitor, starts a monostable circuit, and sets a flip-flop to open a transistor gate. The monostable circuit generates a 200-μsec. pulse which turns on the transistor switch, causing a step of energy to be transferred to the charging capacitor, as discussed above. The 200-μsec. pulse is also fed to a delay circuit which, after 200 microseconds, opens the gate allowing the monostable to be retriggered. This produces a second pulse, which again turns on the transistor and raises the voltage in the charging capacitor another step. This process continues until the voltage in the transformer primary exceeds that of a zener diode ($D_z$). Then the zener diode conducts, the gate closes, and the monostable produces no more pulses. The next triggering pulse from the timing oscillator fires the strobotron tube, resets the flip-flop, and starts the monostable again.

The advantages of these new circuits are many. Besides increasing the maximum flashing rate sixfold, the transformer charging circuit permits the use of lower voltages, and thus transistors, throughout the instrument. Efficiency is also double that of traditional charging circuits using resistors. These benefits in turn have led to a battery-power option for the new unit, a most important plus in the case of an instrument that lends itself to a variety of portable applications.

Other features of the Type 1538-A are an accessory plug-in energy-storage capacitor, which increases the intensity of a single flash (for photographic applications) by a factor of ten, an accessory extension strobe lamp, and provisions for external electrical or mechanical triggering. The new Strobotac is housed in a "flip-tilt" portable cabinet and is priced at $465, f.o.b. West Concord, Massachusetts. ▲

## AUTO RECEIVER MOBILE-RADIO FM RECEPTION

By CHARLES C. MORRIS

**FM receiving equipment is becoming very popular now, especially for mobile use. This includes hi-fi, amateur, public service, and aircraft bands. One very popular method for receiving FM signals without resorting to an expensive FM receiver, is to use a converter ahead of the standard BC auto receiver, which is then adjusted for "slope detection." In this method, the signal is detected along the slope of the AM selectivity curve. This type of system has one drawback, though, in that the selectivity curve of the AM receiver is much sharper than that normally used for FM reception. Slope detection will work without any modification to the AM set, but tuning is usually critical and any receiver drift will affect the tuning once it has been set. If the AM receiver uses the 262-kc. i.f. commonly found in car radios, then the tuning is even more critical.**

**To broaden the tuning and, in effect, reduce drift problems, the AM set's i.f. circuits can be "swamped" by connecting a 1-megohm resistor directly across each i.f. winding at the winding terminals. A slight reduction in receiver gain was noticed when this was done, but this did not present any problems. Also, normal AM reception did not change.** ▲

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (ACT OF OCTOBER 23, 1962; SECTION 4369, TITLE 39, UNITED STATES CODE).

1. Date of filing: October 1, 1965. 2. Title of publication: Electronics World. 3. Frequency of issue: monthly. 4. Location of known office of publication: 307 N. Michigan Avenue, Chicago, Illinois, 60605, Cook County. 5. Location of the headquarters or general business offices of the publishers: One Park Avenue, New York, New York 10016.

6. Names and addresses of publisher, editor, and managing editor: Publisher, Phillip T. Heffernan, One Park Avenue, New York, New York 10016; Editor, William A. Stocklin, One Park Avenue, New York, New York 10016; Managing editor: None.

7. Owner: Ziff-Davis Publishing Co., One Park Avenue, New York, New York 10016; Amelia Ziff, David Ziff, One Park Avenue, New York, New York 10016; William Ziff, One Park Avenue, New York, New York 10016; Priscilla Stafford, One Park Avenue, New York, New York 10016.

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## Radiological Survey Meters

(*Continued from page 46*)

At this point, the circuit turns off, and an inductive kickback voltage or pulse appears across both windings. This pulse, appearing across winding 3-4, charges the integrating capacitor *C2 via* diode *D2* by an amount determined by the selected range resistor *R6*, *R7*, or *R8* and *R9*. The charge on *C2* discharges through the meter, *M1*, and its series resistor. The resulting meter current is dependent on the charge-per-pulse and pulse rate. The calibration control *R5* shunts part of the current around the meter, *M1*.

The kickback voltage pulse is also used for headphone aural monitoring. This pulse is rectified by the diode *D3* and applied to integrating capacitor *C3*. *R12* is an isolating resistor, and *D4* acts as a damper for the headphone.

The high-voltage supply consists of oscillator transistor *Q2*, transformer *T2*, rectifier *D5*, capacitors *C4*, *C5*, resistor *R11*, and the voltage-regulator tube *V2*, which maintains a constant 900-volt output.

Before the survey meter is placed in operation, it must be calibrated against a standard source of radiation—the sole source of radiation when calibration is performed. Calibration should not be undertaken when the background reading is above normal, nor when in a radiation field other than that produced by the known source supplied with the instrument.

Most material in the surroundings is slightly radioactive. All building material, on average, contains a few thousandths of one percent uranium. Natural radioactivity is produced by cosmic rays from outer space. The detector is constantly bombarded with all this natural radioactivity. Whenever the survey meter is in the "operate" position, the meter reads this natural radioactivity. This is the activity referred to as "background."

To determine the background count, set the survey meter to the "×1" position. The needle should be fluctuating over a range of 0.01 to 0.03 milliroentgen/hour. About 20 to 30 clicks per minute will be heard in the headphone. Background and other low-level radiation measurements can be made by counting the clicks, timing them with a watch.

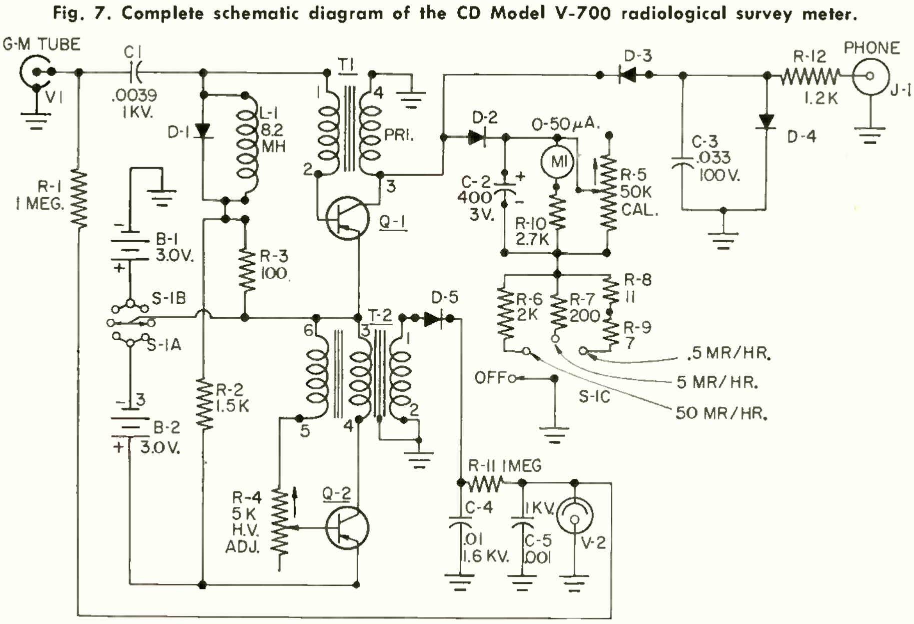
To calibrate the CD V-700, turn the meter to the "×10" position. Present the open window of the detector probe to the center of the nameplate under which is a radioactive source. The indicating meter should read between 1.5 and 2.5 mR/hr. If the indication falls below or above, adjust the calibration control *R5* for an average reading of 2 mR/hr.

### Maintenance of Meters

The CD V-715 and V-700 survey meters, while ruggedly constructed, should be considered delicate instruments. Severe shock to the survey meter might result in damage to the pivots and bearings of the microammeter movement. Most of the electronic components used are standard parts and can be checked readily by conventional means.

The detector insulators, electrometer tube, high-megohm range resistors, switch sections, and high-voltage insulator are all parts of the high-resistance input circuit. The insulating portions of these components should not be handled. The slightest contamination of these parts, by perspiration, dirt, or oils, will create leakage paths. If surface leakage is suspected, cleaning with methyl alcohol (190 proof) and a clean camel hair brush is recommended.

Fig. 7. Complete schematic diagram of the CD Model V-700 radiological survey meter.



When servicing these instruments, first segregate the fault and then localize it. (See Tables 1 and 2.)

If a meter movement is the suspected fault, check it for continuity and calibration accuracy. The preferred method used to test a meter movement for current drain is to compare it in series with a meter of suitable current range.

For a quick check of the CD V-715, merely rotate the switch to the zero position. If the survey meter can be zeroed, the counting circuit is operating properly.

If the high voltage is suspected, the following check can be made. With proper operation, a buzz of about 200 cps can be heard, due to the oscillation of the transformer laminations. If a buzz is not audible, the high-voltage supply oscillator may be adjusted improperly (in the Model V-700). Always use an electrostatic voltmeter to measure the output high voltage. The electronic high-voltage supply has a very low current output. Other voltmeters may load down the supply, resulting in a low reading. The voltage, measured between pins 1 and 3 of the G-M tube socket, should read about 900-910 volts d.c.

To check the counting circuit of the V-700, connect the headphone and listen for clicks while tapping pin 1 of the G-M tube socket with an *insulated* screwdriver. A series of clicks should be heard in the headphone on the ×1 position. If no click is heard, try the same test by tapping the junction of *C*1 and the pin-1 lead. If this produces clicks, the cable assembly might be at fault. If continuity tests fail to localize the fault, the circuit should be tested using an oscilloscope.

If the survey meter is to be stored for more than a month, the batteries should be removed and stored separately. Failure to remove the batteries can cause excessive corrosion to battery contacts and to other vital parts. The survey meter should be stored in a clean, dry place. Temperature should not exceed 120°F nor should it fall as low as freezing.

If the meter has been stored for long periods, batteries should be tested before installation. Batteries never should be used beyond the expiration date stamped on them, nor should they be used longer than one year from date of manufacture.

Survey meters have an accuracy of ±20 percent of full-scale. They are designed to be used as indicators of radiation not for absolute measurements. They are easy to operate, to maintain, and to calibrate. They are ruggedly constructed and, with proper care, are quite dependable.

(*Note: This article is based on work performed under the auspices of the U.S. Atomic Energy Commission.*) ▲







## Bass-Reflex Enclosure

(Continued from page 28)

nomogram of Fig. 6 can be used for obtaining the proper dimensions for any desired volume. The resulting shape is based on industrial design philosophy that no rectangle will be interesting as an abstract shape until its width equals at least the diagonal of the square on which it is based. The width is, therefore, 1.414 times the height and the height is 1.414 times the depth. Note: The dimensions obtained from the nomogram are *inside* dimensions and must have the material thickness added to them.

The proper method of using this nomogram is to draw a straight line between the desired volume on the two outside volume scales and obtain the dimensions from the intersection of this line with the three inner scales. The dimensions obtained should be rounded off to convenient numbers such as height (H) = 14⅜″, width (W) = 20⅜″, and depth (D) = 10¼″, for the example cited. The resulting volume will be well within the limits of accuracy required.

The speaker cut-out should be placed towards one end of the enclosure. The table below lists proper size cut-outs for 8-, 10-, 12-, and 15-inch loudspeakers.

| Speaker Size | Baffle Cut-Out |
|---|---|
| 8-inch | 6¾″ diameter |
| 10-inch | 8¾″ diameter |
| 12-inch | 10½″ diameter |
| 15-inch | 13¼″ diameter |

### Tuning & Damping

The enclosure must now be tuned to the free-air resonant frequency of the speaker. The charts of Figs. 7, 8, and 9 are used for this purpose. They are based on ducts (made of heavy cardboard tubes) which are available for $0.50 each from the Technical Service Department, *Jensen Mfg. Div.* of the *Muter Company*, 6601 S. Laramie Avenue, Chicago, Illinois, 60638. (*Heavy cardboard mailing tubes, or drawing or blueprint-carrying tubes, available in stationery or drafting stores, may be used.—Ed.*) The proper tube to use will be the largest diameter (inside) which gives a tube length of at least 1½ inches less than the inside depth of the enclosure. In the example chosen above, the duct is 4¾″ i.d. and has a length from the front panel of 3″. (Note: The photos shown at the beginning of this article were taken before the duct was cut to proper length.)

The speaker and tube should now be installed in the enclosure with the tube being somewhere near the speaker. Although the enclosure volume and tuning are now correct, the system may not be free from hangover or boom. The usual method of determining if adequate damping exists by measuring the height of the impedance peaks with the circuit of Fig. 1A can often be misleading. A speaker system that appears underdamped with this measurement may be adequately damped when operated with a high-fidelity amplifier. The reason is that the circuit of Fig. 1A does not include damping contributed by the amplifier which can be appreciable. For example, an amplifier with a damping factor of 20 appears as a 0.4-ohm resistor in shunt across the voice-coil terminals of an 8-ohm speaker. Many of the transistor amplifiers have damping factors of 50 and greater. The shunt resistance will be less than 0.2 ohm in these cases.

Damping should be investigated with the circuit of Fig. 1B. The value of $R$ can be determined if the amplifier damping factor and speaker impedance are known from: $R$ = *speaker impedance/amplifier damping factor.*

If the amplifier damping factor is not known, a ½-ohm resistor may be used. The battery can be an ordinary flashlight type while the switch can be a push-button or toggle type.

The circuit of Fig. 1B is connected to the voice coil of the

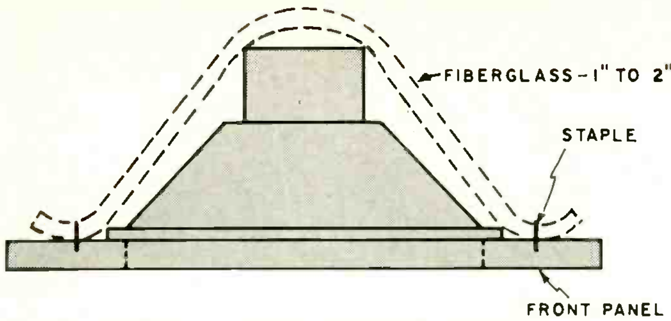


Fig. 10. Method of installing fiberglass for damping purposes.

loudspeaker which is now installed in the tuned enclosure. The switch is operated between its two positions and the resulting sound produced by the speaker is observed. If the sound is a distinct "click" with no low-frequency boom or "bong" in both positions, the damping is adequate. Chances are, however, that the "click" will be accompanied by some boom and additional damping in the form of acoustic resistance will have to be added.

The author prefers not to place damping material in the port. Somewhat better over-all results are usually obtained by placing it directly behind the speaker where it can then affect both "tuned circuits." Fig. 10 shows the method used. Generally a 1- to 2-inch thickness of lightweight fiberglass (½-lbs. density) stapled around the speaker so that the entire speaker is covered will produce a boom-free click.

### Mechanics of Good Construction

The enclosure should transmit, not absorb energy. Walls that are allowed to vibrate will absorb energy that otherwise would be radiated as sound and the total system efficiency and smoothness of response will suffer.

The key to good construction is rigidity. The walls must be rigid so that they cannot be vibrated by the pressures developed inside of the enclosure. Wall vibration can be minimized by using a good grade of at least ¾-inch thick plywood or ¾-inch composition board. The walls should be fastened together with adequate amounts of furniture glue and good-sized wood screws. Nails should not be used. It is common practice to use glue blocks inside the cabinet when exposed screw heads would be objectionable. All joints inside of the enclosure should be caulked after assembly to prevent leaks which could cause troublesome buzzes.

Sometimes, large heavy panels will vibrate in spite of good construction techniques and additional means of stiffening must be used. A 1″ x 3″ cross brace applied "on-edge" diagonally across the panel will usually suffice. In stubborn cases, a sturdy cross-strut reaching across from the center of one panel to the opposite one will be required.

A piece of grille cloth can be stretched over and stapled to the front panel prior to assembly. The assembled enclosure may be finished on four sides.

A final word of caution concerning the removable back is needed. This panel is very often improperly made because it is usually hidden from view. It is important that the construction be as good as that of the exposed panels, although this panel need not be finished. The speaker system connection terminals are located on the back and the terminal board used must not permit air leaks. The back must be made of the same material thickness, must fit properly, and must be fastened to the main structure by at least five good sized wood screws along each edge. In addition, felt stripping should be applied between the mating surface of the back and enclosure so that a proper seal is obtained and panel buzzes are prevented.

A number of loudspeaker enclosures have been constructed employing the design principles that have been described in this article. These enclosures have performed well and in accordance with expectations. ▲

## EW Lab Tested

(*Continued from page* 22)

making it one of the heaviest speaker systems of its size.

The manufacturer emphasizes the omni-directional character of the sound. The bass is truly omni-directional because of its 360-degree slot radiator. The wide dispersion of the speaker's highs, which complements its low-frequency characteristics, is the result of its dome radiators and acoustic lenses. Although they do not cover a 360-degree angle, they do provide exceptionally wide dispersion, with a subjective effect of room-filling sound.

A speaker system such as this, which uses the reflection from room surfaces to enhance its effective dispersion, cannot be tested meaningfully in a "live" room. We located the Model 9000 in our test room about 20″ from a wall and measured its frequency response at six points in the room. The average of the six curves is shown as the frequency response of the speaker. The dashed line is the inherent low-frequency response of our test room, and the response of the speaker should be judged by comparison with this line.

The irregularities in the response below 1000 cps are due, in part, to the reflections from the wall behind the speaker canceling some of the forward radiation. It is not possible to isolate this effect from any inherent irregularities in the speaker's response. Above 1000 cps, the response becomes very smooth and flat, with a drop of 5 db commencing at about 7 kc. *(This characteristic, according to the manufacturer, was designed into the system to provide for optimum over-all listening.—Editor)*

The low-frequency harmonic distortion, with a 10-watt driving signal, is very low down to 60 cps and is only 10% at 38 cps and 16% at 30 cps. The 10-watt input level represents a rather high volume, far louder than would normally be used in the home.

The tone-burst response is good over the entire range. The first unit we tested had a few frequencies in the mid-range which showed some hangover, but this did not show up in a second unit, so we assume the first was defective in some manner. The two units had a very similar frequency-response characteristic, although the second had a somewhat better mid-range sound which was consistent with its improved transient response.

The sound of the Model 9000, as might be deduced from the curve, is slightly muted on the highest frequencies, with a rather heavy sounding low-end response. It does not need nor was it designed for corner placement to enhance its low-frequency response; in fact, such a location might make it undesirably bassy. It is a very smooth, easy-to-listen-to speaker, without the "sizzling" or "airy" sound often heard from speakers with strong high-frequency response, yet by no means dull or lacking in high-frequency definition. A very bright, "live" room would probably show it off to best advantage. On the other hand, a heavily upholstered room might cause it to sound uncomfortably heavy.

The excellent dispersion of the speaker system was much in evidence in our listening tests. It has a "big sound" at any volume level, yet one can stand close to it without being overpowered. We did not have the opportunity to use a pair in stereo, but its omni-directional properties are ideally suited to produce optimum stereo performance.

The distinctive and tasteful styling of the "Royal Grenadier" is likely to appeal to the lady of the household, and, with due allowance for individual listening preferences, its sound will not offend the most critical listener. It is completely free from harshness or stridency, which makes for easy listening without strain or fatigue.

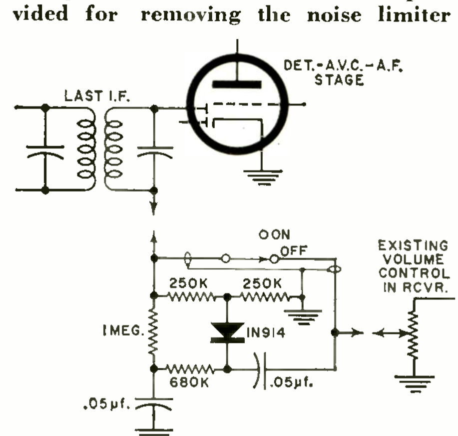
The *Empire* Model 9000 "Royal Grenadier," with the walnut top, sells for $239.95. With a marble top, the Model 9000M is $249.95. ▲

## NOISE LIMITER

By CHARLES C. MORRIS

**THE noise limiter shown in the schematic was built for use with a 12-v. automobile radio when used with a transistorized high-frequency converter for reception of the higher frequency ham bands.**

**The noise limiter effectively reduces ignition and atmospheric noise to a reasonable level without a great reduction in signal level. A switch has been provided for removing the noise limiter**




**from the circuit should very weak signals be received.**

**With the exception of this switch, the entire circuit can be built on a terminal strip and mounted within the auto receiver. The switch can be mounted on the receiver case, or at any convenient place outside of the receiver, using shielded leads.** ▲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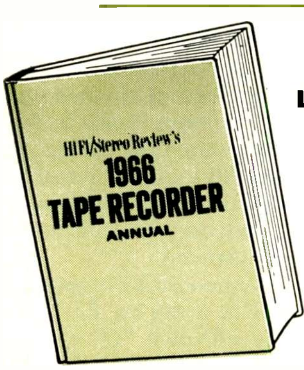


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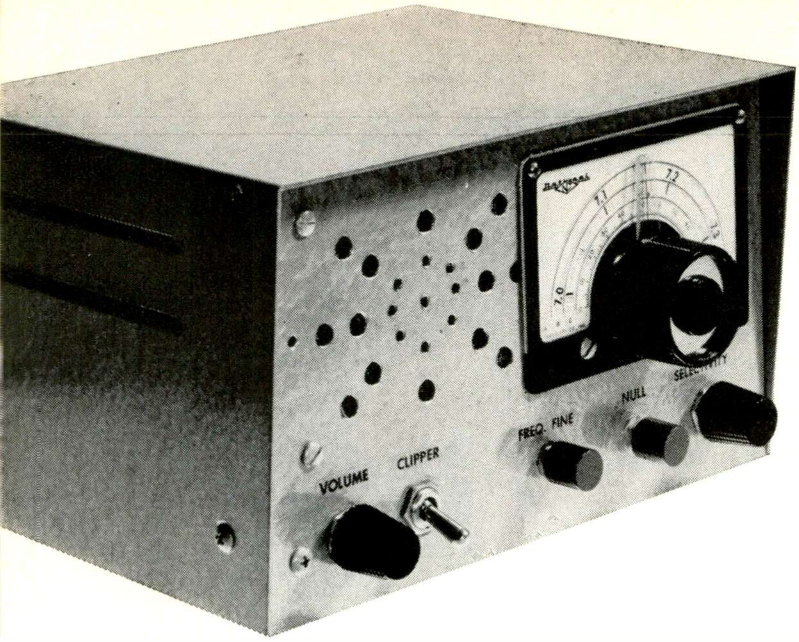



The receiver was built into a compact LMB utility case (Type W-1C) measuring only 5" x 6⅛" x 8½". Dial is National MCN.

**Design and construction details on a 40-meter amateur receiver in which a balanced mixer-detector provides unusual sensitivity and selectivity.**

By DALE HILEMAN, WB6NTR

# A Heterodyne Receiver

THE superheterodyne principle was developed in response to a need for increased selectivity in radio receivers. The relatively narrow bandpass of an i.f. amplifier affords the required selectivity; but the frequency-conversion process introduces spurious responses, often called "spurs."

The most troublesome spur is the image, although there are a number of others to which a superhet is subject. Arising in somewhat the same manner as images, these other spurs produce extraneous tweets and whistles, collectively referred to as "birdies" in amateur radio parlance.

Most images and birdies can be avoided by the use of two or three tuned r.f. stages ahead of the first mixer or converter. Besides increasing the cost and complexity of a receiver, however, r.f. stages contribute problems of their own, involving stability, tracking, cross-modulation, and gain control. Most inexpensive superhets represent a compromise between spurs and cost, using either one r.f. amplifier or none.

### Heterodyne Receiver

This article describes a receiver designed to circumvent the spur problem in the simplest and least expensive way, using the heterodyne principle of detection. With this method, the local oscillator is injected at the same frequency as the received signal; in effect, then, the i.f. frequency is zero. Hence the image and any other spur depending on the difference between local oscillator and received signal is eliminated, making r.f. amplifiers unnecessary. No. i.f. amplifier is used, either, because there is no intermediate frequency.

Nor is there any need for a b.f.o.; in a heterodyne receiver, the local oscillator performs the same function as the b.f.o. of a conventional superhet. In other words, only one conversion or beat-frequency action takes place in a heterodyne receiver, the incoming signal being converted directly from r.f. to audio in the heterodyne mixer.

Since it behaves outwardly like a superhet with b.f.o. on, the heterodyne receiver is best suited for SSB and c.w. reception. It is also capable of AM reception, but the local oscillator must be held very close to the incoming carrier frequency for intelligible results.

The bandwidth of a properly designed heterodyne receiver is determined not by the selectivity of any tuned circuit but by the bandpass of the audio amplifier. This is so because the heterodyne mixer is a product detector, responding not to the envelope of a signal but to the difference in frequency between local oscillator and signal. Since the detector responds to signals on either side of the local oscillator, receiver bandwidth is twice audio bandpass.

Incidentally, therein lies one disadvantage of heterodyne detection: in c.w. and SSB reception, signals adjacent to the local oscillator but on the side opposite the desired signal can cause interference. However, this is also true of inexpensive superhets and is a small price to pay for freedom from spurs. Also, in SSB reception, this apparent drawback has some of the aspects of an advantage since it makes tuning easier. An upper-sideband signal tunes the same as a lower-sideband signal.

Another disadvantage of heterodyne detection is susceptibility to overloading by strong adjacent-channel signals; but this is the toll exacted for good sensitivity. The addition of a low-gain r.f. stage will prevent most overloading, but this remedy should be considered only if the receiver is to be used very near an adjacent-channel transmitter.

### Circuit Analysis

The heterodyne receiver (Fig. 1) uses five tubes and covers the 40-meter amateur band of 7.0-7.3 mc. Adjustable selectivity is provided by active networks in the audio circuits of the receiver. The power supply, using a semiconductor rectifier, operates with 117-volt, 60-cycle input.

Mixer *V1* is a balanced product detector, accepting parallel signal inputs from antenna coil *L1* and push-pull injection from local oscillator *V2*. Balancing of a product detector minimizes the effect of overloading by strong adjacent-channel signals. Grid balance trimmer *C8* adjusts the capacitance in the grid circuit of *V1A*, making it possible to equalize the signal inputs. Cathode balance potentiometer *R3* makes it possible to equalize gain of the two triode sections. Since balance is also affected by tuning of the antenna tank circuit, "Null" control *C1* is provided as a fine balance adjustment.

Sensitivity of the product detector is enhanced by regeneration introduced from the wiper of *R3* to a tap on *L1*. The regenerative action also increases the effective "*Q*" of the antenna tank circuit, thereby helping minimize the effect of overloading.

The push-pull injection voltage is provided by local oscillator *V2*. Hartley oscillator *V2A* drives phase splitter *V2B*. Phase trimmer *C24* compensates for the Miller effect in *V2B*,

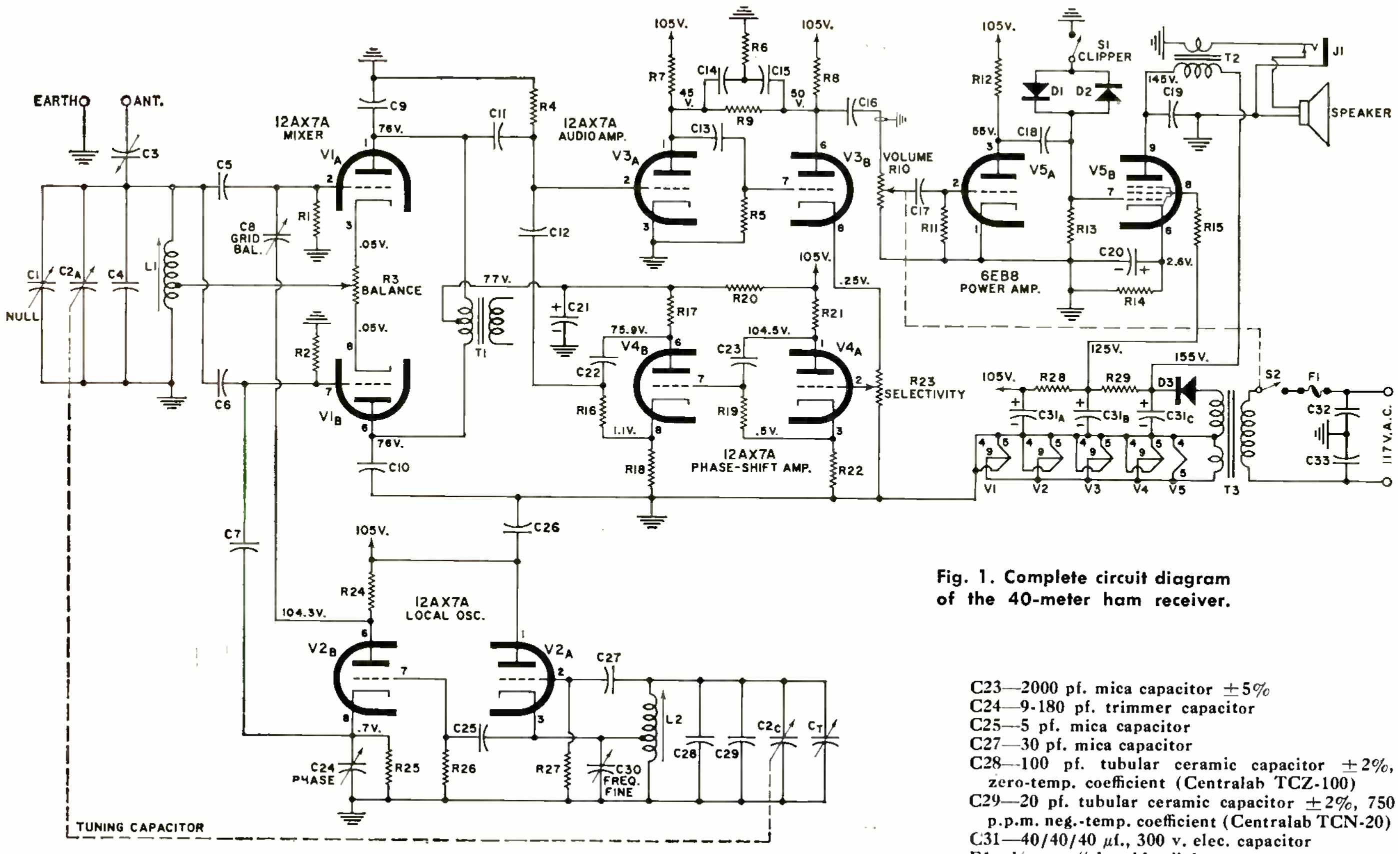



**Fig. 1. Complete circuit diagram of the 40-meter ham receiver.**

R1,R2,R26,R27—100,000 ohm, ½ w. res.
R3—100 ohm linear-taper composition pot.
R4,R5—1 megohm, ½ w. res.
R6—47,000 ohm, ½ w. res. ±10%
R7,R8—220,000 ohm, ½ w. res.
R9—2.2 megohm, ½ w. res. ±10%
R10—500,000 ohm volume control with switch S2)
R11—1 megohm, ½ w. res.
R12—120,000 ohm, ½ w. res.
R13—680,000 ohm, ½ w. res.
R14—100 ohm, ½ w. res.
R15,R24,R25—1000 ohm, ½ w. res.
R16—120,000 ohm, ½ w. res. ±5%
R17,R18—2000 ohm, ½ w. res. ±5%
R19—82,000 ohm, ½ w. res. ±10%
R20—10,000 ohm, ½ w. res.
R21,R22—1000 ohm, ½ w. res. ±5%
R23—1000 ohm linear taper composition pot.
R28,R29—3300 ohm, ½ w. res.
C1,C30—1-5 pf. midget var. capacitor (Hammarlund MAC-5)
C2—3-gang tuning capacitor (center gang B not used), 5-20 pf. per gang; trimmer $C_T$ part of rear gang C. J. W. Miller 1460.
C3—2.7-30 pf. trimmer capacitor.
C4—120 pf. mica capacitor ±5%
C5,C6,C7—33 pf. mica capacitor ±5%
C8—5-80 pf. trimmer capacitor
C9,C10—.01 µf., 500 v. disc ceramic capacitor ±10%
C11,C12,C13,C16,C17,C18,C26,C32,C33—4700 pf., 600 v. disc ceramic capacitor
C14,C15—560 pf. mica capacitor ±5%
C19—4700 pf., 1000 v. disc ceramic capacitor
C20—50 µf., 15 v. elec. capacitor
C21—16 µf., 250 v. elec. capacitor
C22—200 pf. mica capacitor ±5%
C23—2000 pf. mica capacitor ±5%
C24—9-180 pf. trimmer capacitor
C25—5 pf. mica capacitor
C27—30 pf. mica capacitor
C28—100 pf. tubular ceramic capacitor ±2%, zero-temp. coefficient (Centralab TCZ-100)
C29—20 pf. tubular ceramic capacitor ±2%, 750 p.p.m. neg.-temp. coefficient (Centralab TCN-20)
C31—40/40/40 µf., 300 v. elec. capacitor
F1—½ amp "slow-blow" fuse
L1,L2—17 t. #24 en. wire on ½-in. dia. x 11/16" long slug-tuned form (National Radio XR-50 coil form), tapped 4 t. from ground (slug) end
D1,D2—1N456 diode
D3—5E6 silicon rectifier, 350 ma., 600 p.i.v. (International Rectifier)
S1—S.p.s.t. toggle switch
S2—S.p.s.t. switch (on R10)
Spkr.—3"x 5", 3.2-ohm speaker (see "Construction")
T1—Magnetically shielded audio transformer; one winding 20,000 ohms c.t., other winding not used (see "Choice of Parts")
T2—Output trans., 4000 ohms to 3.2 ohms
T3—Power trans. 125 v. @ 50 ma.; 6.3 v. @ 2 amps (Allied Radio "Knight" 6-K-28 HF or equiv.)
J1—Closed-circuit jack
V1,V2,V3,V4—12AX7A tube
V5—6EB8 tube

making it possible to adjust the phase relationship of the cathode and plate r.f. voltages to exactly 180 degrees. This phase relationship provides best balance and greatest output from the mixer, and also minimizes local oscillator radiation.

Selectivity of the receiver is controlled by *RC* networks surrounding audio amplifier *V3* and phase-shift amplifier *V4*. Selectivity adequate for phone reception is provided by the bridged-tee network *R9*, *C14*, *C15*, and *R6* between the plates of *V3*. This network provides an audio response centered at about 1000 cps.

Variable selectivity for c.w. reception is provided by phase-shift amplifier *V4*. Inspired by the "select-o-ject" circuit popular in amateur radio circles, *V4* introduces regeneration to audio amplifier *V3*, at a discrete frequency of about 1030 cps. This figure was selected because it is the operation frequency of an FL-8 or FL-30 Range Filter, a surplus item used by many amateur operators as an aid to c.w. reception. The regeneration frequency of *V4* may be varied, if desired, by changing the value of *R16* or *R19*.

Power-amplifier stage *V5* includes clipper *D1* and *D2*, intended to soften the effects of transmitter key clicks when the receiver is used in full-break c.w. communications. With "Clipper" switch *S1* closed, the voltage excursion on the control grid of *V5B* is limited to about 2 volts, as established by the forward conduction barrier of silicon. If more clipping is desired, a small resistor may be connected in series with cathode bypass capacitor *C20*, or else this capacitor may be removed entirely. If less clipping is desired, an additional diode may be connected in series with *D1* and one with *D2*. The added diode should be another 1N456 or other silicon type and must be oriented the same way as the one with which it is connected in series.

Resistor *R15* in the screen-grid circuit of *V5B* helps stabilize the +105-volt potential when the power amplifier is overdriven. If the clipper is turned off and a loud signal appears, excessive drive voltage may be applied to *V5B*. Under these conditions, the average plate current of *V5B* drops, but at the same time, the average screen-grid current rises. Resistors *R29* and *R15*, acting as a voltage divider, maintain a constant voltage at the junction in spite of the rise in potential at one end and the drop in potential at the other end.

## Choice of Parts

Most of the parts are not critical. The majority can be substituted freely, and most tolerances given in the parts list can be exceeded without disastrous results. However, a few parts are critical in one way or another, and these will be discussed in the order in which they appear in the parts list.

*R*3—To avoid reactive effects, this particular potentiometer must be of the composition type, and not wirewound.

*R*17,*R*18—The value of these resistors is not critical, but for sharpest c.w. selectivity, the two should be as nearly equal as possible.

*R*21,*R*22—See the foregoing comment regarding *R*17 and *R*18.

*C*28,*C*29—For best frequency stability during warm-up, the temperature coefficients given in the parts list must be observed. Or these two capacitors may be replaced by a single 120-pf. capacitor having a negative temperature coefficient of 125 parts per million.

*C*31—Ratings not critical. This unit may, if desired, include *C*20, but to avoid hum *C*21 must be separate.

*D*1,*D*2—Nearly any silicon diode is suitable, but not germanium.

*D*3—Any common rectifier capable of 35 ma. d.c. and 350 peak inverse volts is suitable.

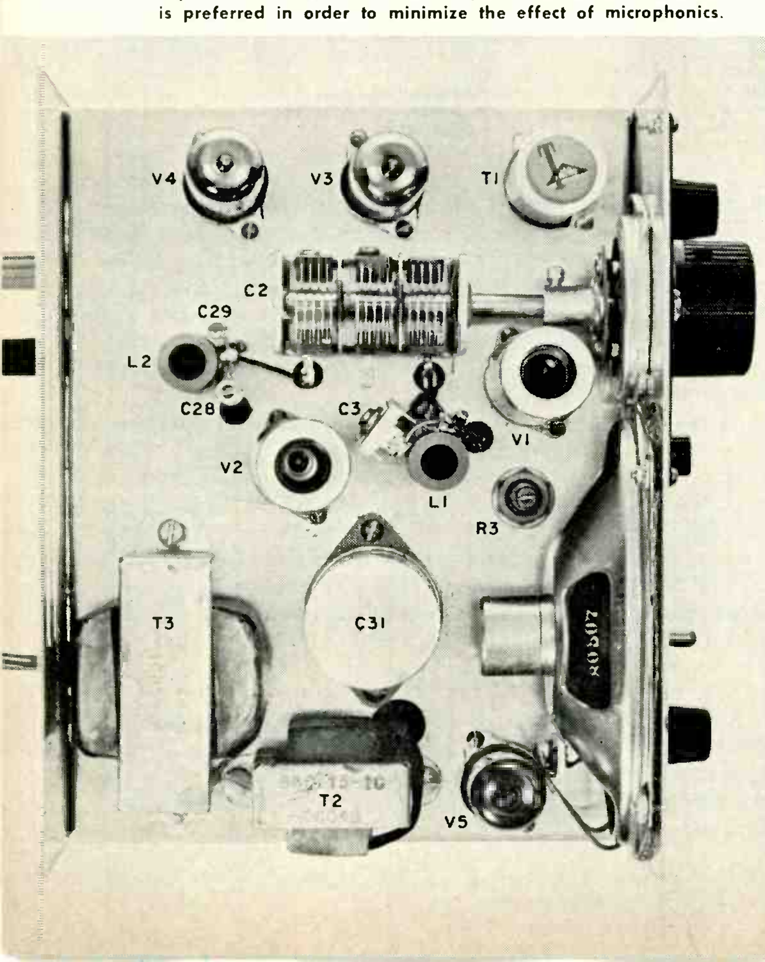
*T*1—Impedance of the winding is not critical, but the transformer must be magnetically shielded to avoid hum pickup. An open-frame type is positively not usable. At least 45 db of magnetic shielding is required. Since well-shielded transformers are expensive, it is recommended that this item be obtained surplus if at all possible.

### Construction

Because of high audio gain in the heterodyne receiver, two important precautions must be observed to prevent stray coupling. A most important precaution, to prevent feedback and hum pickup, is to mount mixer transformer *T*1 as far as possible from power transformer *T*3 and output transformer *T*2 (see top view). Furthermore, if *T*1 is not a well-shielded unit, it is recommended that permanent mounting provisions for the transformer be deferred until the receiver is finished and can be tested. It may be necessary to orient the transformer for minimum hum.

A second most important precaution concerns the grid circuit of mixer *V*1. All conductors connecting to pins 2 and 7 must be kept as short as possible. All other conductors must be kept as far as possible from these tube pins and from capacitors *C*5 through *C*8. It is especially important to keep the antenna lead well away from the grid circuit of the mixer.

**Top view of chassis. Set includes speaker but external speaker is preferred in order to minimize the effect of microphonics.**




The mixer is sensitive not only electrically but also mechanically. To minimize microphonics, it is recommended that *V*1 be shock-mounted, especially if the loudspeaker is nearby. In fact, it is preferable to use an external loudspeaker exclusively.

Another important precaution to be observed in planning the layout is to mount antenna coil *L*1 near cathode-balance potentiometer *R*3, and *R*3 near mixer *V*1. (See bottom view.) Keep the leads between these three parts as short as possible to prevent parasitic oscillation.

In wiring the receiver, there are several minor precautions it would be well to observe:

The leads from pins 6 and 8 of phase splitter *V2B* to capacitors *C*7 and *C*8 need not be very short, but they should be kept close together and slightly away from the chassis.

All conductors connecting to pin 2 of audio amplifier *V3A* should be kept as short as possible.

Capacitors *C*17 and *C*19 in the power-amplifier circuit of *V*5 should be mounted as far apart from one another as consistent with short leads.

Capacitor *C*29 should be mounted at least 1¼ inch from the nearest tube.

Once wiring is completed, adjustment may begin. The local oscillator is adjusted first and then the mixer.

### Local Oscillator Adjustment

1. *Equipment setup*: Connect the antenna to the receiver. Loosely couple a signal generator to the receiver by connecting a short antenna to the r.f. output of the signal generator.
2. *Presetting the controls*: Set antenna trimmer *C*3 and grid balance trimmer *C*8 near maximum capacitance. Set "Freq. Fine" control, *C*30, to mid position and "Selectivity" control, *R*23, to its extreme counterclockwise position (wiper at ground end). Set "Volume" control, *R*10, as required for a comfortable listening level.
3. *Initial adjustment of oscillator*: Set the receiver tuning dial 5 percent from maximum capacitance position, and set the signal generator to 7.0 mc., unmodulated. Adjust oscillator slug *L*2 to obtain zero-beat. Now set the receiver tuning dial 10 percent from minimum capacitance position, and set the signal generator to 7.3 mc. Adjust oscillator trimmer $C_T$ to obtain zero-beat.
4. *Final adjustment of oscillator*: Repeat step 3 until slug and trimmer require no further adjustment. Then calibrate the tuning dial in increments consistent with the accuracy of the signal generator. Alternately, it is feasible to employ a nearby receiver for calibration since the local oscillator of the heterodyne receiver radiates enough signal to be heard.

### Mixer Adjustment

1. *Equipment setup*: Leaving the antenna connected to the receiver, attach an a.c. voltmeter across the receiver speaker.
2. *Presetting the controls*: Make sure "Freq. Fine" control, *C*30, is still at mid position and "Selectivity" control, *R*23, is at the extreme counterclockwise position. Set antenna trimmer *C*3 at 15 pf. or about mid position, and set grid balance trimmer, *C*8, at 33 pf. or about mid-position. Set cathode balance potentiometer *R*3 and "Null" control *C*1 also to mid position. Throughout the following procedures, "Volume" control *R*10 may be readjusted as necessary for comfortable listening level.
3. *Adjustment of antenna slug*: Set the receiver tuning dial and the signal generator both to 7.15 mc. Using a *modulated* signal, carefully adjust the receiver tuning dial for maximum output (near zero beat). Now adjust antenna slug *L*1 and phase trimmer *C*24 alternately for maximum output, progressively reducing the level of the signal generator to maintain only a minimum usable signal. Also, as *L*1 approaches reso-

nance it may prove necessary to readjust the receiver tuning dial slightly for maximum output.

4. *Initial check of antenna coupling*: Observing the a.c. voltmeter, adjust antenna slug *L*1 throughout its entire range. If two distinct peaks occur, slightly increase the capacitance of antenna trimmer *C*3 (the setting of *C*3 is fairly critical) and then return to step 3. If only one peak occurs, proceed to step 5.

5. *Adjustment of balance*: Leaving the receiver tuning dial set at 7.15 mc., set the signal generator to about 6.5 mc. Then increase the level of the signal generator until overloading occurs, that is, modulation is heard in spite of the receiver and signal generator being tuned to different frequencies. To obtain overloading, it may be necessary to further increase the signal level by bringing the signal generator antenna nearer the receiver antenna or lengthening the signal generator antenna; but use no more coupling than absolutely necessary. Now adjust grid balance trimmer *C*8 and cathode balance potentiometer *R*3 alternately for a null.

6. *Final check of antenna coupling*: Turn "Null" control *C*1 back and forth. If a distinct null occurs at or near mid position, then alignment is complete and no further adjustments are required. If not, proceed as follows: Set "Null" control *C*1 to mid position, slightly decrease the capacitance of antenna trimmer *C*3, and return to step 3.

### In Case of Trouble

Parasitic oscillation, hum, noise, imbalance, and howl are the most likely troubles. Parasitic oscillation in the grid-cathode circuits of the mixer, resulting in poor sensitivity, may be due to excessive lead lengths in either circuit. Shorten these leads or connect a 10-pf. mica capacitor from the arm of cathode-balance potentiometer *R*3 to ground.

The most likely cause of hum is magnetic coupling between power transformer *T*3 and mixer plate transformer *T*1. Reorient *T*1 or replace it with a better-shielded unit. The next most likely cause of hum is excessive lead length in various grid circuits, especially the circuit of mixer *V*1. Before proceeding to rewire, however, try replacing tubes.

Since audio gain of the heterodyne receiver is very high, hum may also be caused by proximity of a battery charger, or any other electrical device generating a substantial fluctuating magnetic field. In some cases, removing one of the line bypass capacitors (*C*32 or *C*33) may reduce hum.

Slight hum may be the result of excessive regeneration, especially if accompanied by instability and microphonics. To decrease regeneration, replace injection coupling capacitor *C*7 with one of slightly greater value, and then realign mixer.

Sputtering or staticky noise is caused by a defective component part, often in the mixer circuit. Grid balance trimmer *C*8 is a likely offender, especially if it is of the mica variety and not brand-new. Capacitors *C*9-*C*12 may also be suspected. Before replacing any of these components, however, first try replacing tubes.

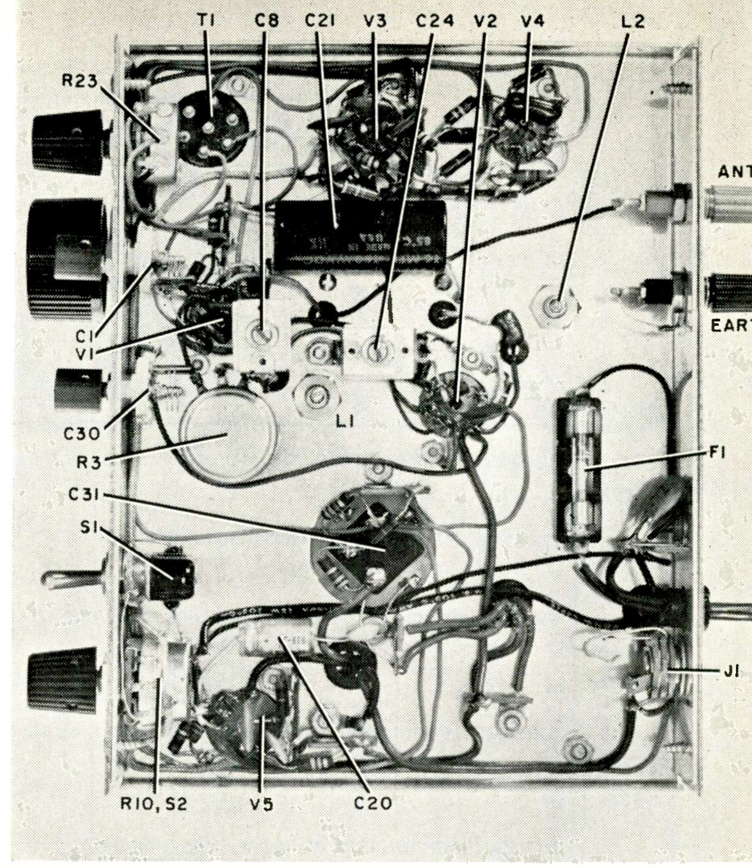
Inability to achieve proper balance is due to lack of symmetry in the mixer, especially in its grid circuit. Check for excessive lead length, incorrect component value, or wiring error. Before making extensive changes, though, try replacing mixer tube *V*1 and realigning the mixer.

Interference by a broadcast station or other medium-frequency signal may appear if the antenna lead has been routed anywhere near the component parts of the mixer grid circuit.

Feedback resulting in audio howl may result if capacitors *C*17 and *C*19 in the power amplifier circuit of *V*5 are mounted too close together. Microphonics may also cause howl. If microphonic howl persists even when an external loudspeaker is used, try interchanging mixer *V*1 with one of the other 12AX7A tubes, or set the receiver on a foam-rubber pad.

### Operation

Except for "Null" control *C*1 and "Selectivity" control *R*23,




**Bottom view of chassis. Components in mixer circuit, including L1, C8, and R3, are mounted near V1 to minimize hum, imbalance.**

the heterodyne receiver is operated in much the same way as any other receiver. Although the "Null" control serves a function similar to that of the antenna trimmer in an ordinary receiver, its effect is not the same. The "Null" control is not used to peak the incoming signal but instead acts as a fine balance control. It is used only to minimize the effect of overloading in case of interference by a strong adjacent-channel signal, so rarely needs to be adjusted during normal operation.

"Selectivity" control *R*23, used in c.w. operation, adjusts gain at a certain discrete audio frequency of about 1030 cps. Turning the control clockwise increases the gain at this frequency, thereby increasing selectivity. Advancing the control beyond a certain critical point, however, results in oscillation. In tuning weak signals, best results are obtained at a setting just below the point of oscillation. Under these conditions, however, tuning is extremely sharp. Therefore it may prove necessary to occasionally readjust "Freq. Fine" control *C*30 to compensate for slight drift of the local oscillator or signal frequency.

In case of interference from a signal 1030 cps on the opposite side of the local oscillator, it is necessary only to tune the "Freq. Fine" control away from the interfering signal and through the desired signal to a point that is 1030 cps on the other side of the desired signal.

### Conclusion

This article has described an experimental receiver using the heterodyne principle of detection. Although simple in design, the heterodyne receiver in many ways surpasses a much more elaborate superheterodyne. The heterodyne detector shows promise for other applications, such as portable equipment, where simplicity is an important requirement. Also, since the local oscillator frequency is the same as the frequency being received, the amateur radio operator will recognize the chance of using a common oscillator for his transmitting and receiving system.

It is hoped that this article will stimulate further research and experiment with the heterodyne principle of detection. ▲

(Continued from page 35)

## Solid-State Tuners

| Model | With AM | IHF usable sens. (μv.) | IHF capture ratio (db) | IHF selectivity (db)[a] | THD @ 100% mod. (%) | FM tuner audio freq. response (mono) @ rated output and 100% mod. (cps) | Drift (kc) | R.M.S. output voltage @ full limiting (v.) | Front end | Interstation muting | SCA or noise filter | AFC | Physical size (inches) W | H | D | Assembled price ($) | Kit price ($) | Cabinet ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BOGEN COMMUNICATIONS, P.O. Box 500, Paramus, N.J. 07652** | | | | | | | | | | | | | | | | | |
| FT-160 | no | 2.5 | 3 | 35 | .7 | 30-15 k | 10 | .5 | trans. | no | yes | yes | 15 | 4⅝ | 10 | 199.95 | — | 27.95 |
| | **ELECTRO-VOICE, INC., Buchanan, Mich. 49107** | | | | | | | | | | | | | | | | | |
| 1155[b] | no | 3 | 2.5 | — | 1.5 | 20-20 k | 20 | .12 | trans. | no | yes | yes | 8¼ | 3⅜ | 10¼ | 160.00 | — | inc. |
| | **FISHER RADIO CORP., 21-21 44th Dr., Long Island City 1, N.Y.** | | | | | | | | | | | | | | | | | |
| TFM-300 | no | 1.8 | 2 | 55 | .4 | 20-15 k | 10 | — | tube | yes | — | no | 15⅛ | 4 13/16 | 11⅞ | 279.50 | — | — |
| TFM-200 | no | 1.8 | 2.2 | 55 | .5 | 20-15 k | 10 | — | tube | yes | — | no | 15⅛ | 4 13/16 | 11⅞ | 229.50 | — | — |
| | **GROMMES, PRECISION ELECTRONICS INC., 9101 King St., Franklin Park, Illinois** | | | | | | | | | | | | | | | | | |
| 2000[c] | yes | 2 | 4 | 50 | .5 | 20-20 k | 10 | 1 | nuvistor | yes | no | no | 15 | 6½ | 13½ | 249.95 | — | no |
| C-107 | yes | 2 | 4 | 50 | .5 | 20-20 k | 10 | 1 | nuvistor | yes | no | no | 15 | 4⅞ | 11 | 199.95 | — | no |
| | **HARMAN-KARDON, INC., Plainview, Long Island, N.Y.** | | | | | | | | | | | | | | | | | |
| ST-2000 | yes | 2.9 | 4 | — | 1 | 10-20 k | 1 | .7 | trans. | — | SCA | no | 14 | 4¼ | 10 | 189.00 | — | 24.95 |
| | **HEATH CO., Benton Harbor, Mich., 49023** | | | | | | | | | | | | | | | | | |
| AJ-43D | yes | 2 | 3 | — | 1 | 20-20 k | — | .5 | trans. | yes | yes | yes | 15¾ | 5½ | 14¾ | — | 109.00 | 6.95<br>12.95 |
| AJ-33A | yes | 3 | 4 | — | 1 | 20-20 k | — | .5 | trans. | yes | yes | yes | 15⅝ | 3¾ | 11½ | — | 94.50 | inc. |
| AJ-14 | no | 5 | 3 | — | 1 | 20-15 k | — | .5 | trans. | no | SCA | yes | 12 | 3¼ | 9¾ | — | 49.95 | 3.50<br>7.95 |
| | **KENWOOD ELECTRONICS INC., 3700 S. Broadway Pl., Los Angeles, Calif. 90007** | | | | | | | | | | | | | | | | | |
| TK-500 | no | 1.8 | 2 | 20 | 1 | 20-20 k | 10 | 2 | nuvistor | yes | yes | yes | 15¼ | 5¾ | 12¼ | 174.95 | — | inc. |
| | **KLH RESEARCH AND DEVELOPMENT CORP., 30 Cross St., Cambridge, Mass. 02139** | | | | | | | | | | | | | | | | | |
| 18 | no | 3 | 4 | — | .6 | 30-15 k | — | .8<br>1.4 | trans. | no | yes | no | 8⅞ | 4 | 5⅜ | 116.95 | — | inc. |
| | **KNIGHT, ALLIED RADIO CORP., 100 N. Western Ave., Chicago, Illinois 60680** | | | | | | | | | | | | | | | | | |
| KN-265A | yes | 3 | 3 | — | .5 | — | 25 | — | trans. | — | — | yes | 13⅞ | 4½ | 12 | 149.95 | — | 14.95 |
| | **KNIGHT-KIT, ALLIED RADIO CORP., 100 N. Western Ave., Chicago, Illinois 60680** | | | | | | | | | | | | | | | | | |
| KG-790 | yes | 1.5 | 5 | — | .7 | — | — | 1.25 | trans. | yes | yes | yes | 16¾ | 5 | 15 | — | 139.95 | 19.95 |
| KG-765 | yes | 2.5 | 9 | — | 1 | — | — | 1 | trans. | yes | yes | yes | 13 | 2¾ | 11 | 139.95 | 94.95 | 12.95 |
| | **OLSON ELECTRONICS, INC., 260 S. Forge St., Akron, Ohio 44308** | | | | | | | | | | | | | | | | | |
| RA-750 | yes | 2 | 4 | — | .5 | 20-20 k | neg. | .5 | trans. | no | SCA | yes | 14¼ | 4¼ | 10 | 99.98 | — | inc. |
| | **PILOT RADIO INC., 100 Electra Lane, East Station, Yonkers 4, N.Y.** | | | | | | | | | | | | | | | | | |
| T1100 | — | 2 | 1.5 | — | .3 | 20-15 k | 20 | 1.5 | trans. | yes | yes | no | — | — | — | 229.95 | — | — |
| T300 | — | 3.5 | 4 | — | .4 | 20-15 k | 20 | 1.5 | trans. | no | yes | no | — | — | — | 179.95 | — | — |
| | **H. H. SCOTT INC., 111 Powder Mill Rd., Maynard, Mass. 01754** | | | | | | | | | | | | | | | | | |
| 315 | no | 2.7 | 6 | 40 | 1 | d | 20 | 1 | FET trans. | no | yes | no | 15 9/16 | 4 15/16 | 12¼ | 184.95 | — | 13.95 |
| 312 B | no | 1.9 | 4 | 45 | 1 | d | 20 | 1 | nuvistor | no | yes | no | 15 9/16 | 4 15/16 | 12¼ | 249.95 | — | 13.95 |
| LT-112 | no | 2.2 | 4 | 45 | 1 | d | 20 | 1 | nuvistor | no | yes | no | 15 9/16 | 4 15/16 | 12¼ | — | 179.95 | 13.95 |
| | **SHERWOOD ELECTRONIC LABS INC., 4300 N. California Ave., Chicago, Illinois 60618** | | | | | | | | | | | | | | | | | |
| S-3300 | no | 1.6 | 2.4 | — | .3 | 20-20 k | 10 | 1.5 | trans. | yes | yes | no | 14 | 4 | 10½ | 167.50 | — | 7.50 |
| | **V-M CORP., P.O. Box 659, Benton Harbor, Mich. 49023** | | | | | | | | | | | | | | | | | |
| 1487 | yes | 5 | — | — | — | — | 100 | .25 | trans. | no | yes | yes | 11 | 3⅜ | 7 | 129.95 | — | inc. |

All information supplied by manufacturer. All stereo units. All have tuning meters except Heath AJ-14 and V-M 1487. All have stereo indicator lights except Olson RA-750 has meter. All have automatically switched stereo except Heath AJ-33A, AJ-14, KLH 18, Knight-Kit KG-765 have manual switching.
[a]Taken at ±200 kc. [b]Model 1156 same as 1155 except with AM. [c]Model 1000 same as 2000 except no AM and costs $197.50. [d]Exceeds FCC limit.

## Solid-State Amplifiers

(*Continued from page* 41)

High-frequency oscillations that do occur are hard to observe, even with wide-band oscilloscopes. For one thing, transistor circuits are low impedance, which means that voltages are low. The oscillation may appear as a tiny notch in the waveform and still cause enough of a shift in the operating point of the amplifier stages to be heard.

### Overload & Voltage Changes

In a class-B amplifier, little current is drawn from the power supply when no signal is present. Application of a large signal results in heavy current drain from the supply, with a corresponding drop in supply voltage. If this voltage change is fed back to the low-level stages, it acts as an additional large signal, or it can even change operating points sufficiently to cause the amplifier to block. The fed-back signal sometimes causes the amplifier to "swallow" the input signal, and follow it with a large internally generated transient. This effect has been referred to as "gulp distortion." In an extreme case it can actually cause an amplifier to have a lower music-power output than its steady-state rating.

The remedy is to operate low-level stages from a voltage-regulated supply and to design the feedback circuits so that oscillation cannot occur at any frequency, and with any type of load that might be applied.

Since the power output of an amplifier is approximately proportional to the square of the d.c. supply voltage, it can be expected to vary in a similar way with variations in line voltage. If the amplifier is rated at 117 volts, as is customary, operation at 105 volts can reduce output by 20%. This is less than 1 db, and not audible. More important, however, is the fact that line-voltage changes can shift operating points, *greatly increasing distortion*, especially at low power levels. Voltage-regulated supplies for low-level stages, choice of non-critical circuit conditions, and use of bias diodes are the most common means of preserving optimum performance despite voltage fluctuations.

### Speaker Protection against D.C.

Direct connection of the speaker to the output stage is attractive since it eliminates a bulky and expensive electrolytic capacitor. The "half-bridge" connection sometimes used connects the speaker between the junction of the series- (for d.c.) connected power transistors and the mid-point of the dual power supply. For true class-B stages, which have zero idling current, and for perfect balance, this is fine. However, practical transistor amplifiers are operated class-AB to avoid

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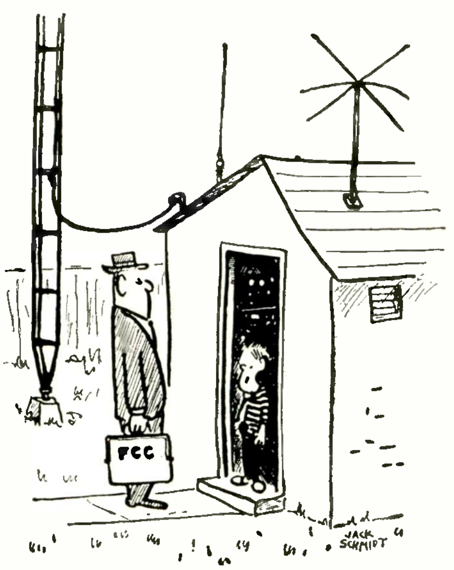
crossover distortion and there is likely to be some unbalance present as well. In such a case, the unbalanced d.c. flows through the speaker voice coil, displacing it from its center rest position and causing it to produce distortion due to its non-symmetrical displacement by an applied signal. In the admittedly unlikely, but not impossible event of power transistor failure, the speaker finds itself connected directly across the power supply—until the fuse blows.

If the decision is made to retain the coupling capacitor, what can be done to preserve low-frequency damping and stability? Negative feedback taken from the output side of the capacitor keeps the damping factor high even at very low frequencies. The phase shift in the capacitor is prevented from causing stability problems by taking the negative feedback signal from its input end as well as from the output.

## Input Impedance

Transistors are inherently low input impedance devices; the input impedance of a typical grounded-emitter stage is less than 2000 ohms. On the other hand, magnetic pickups and tuners require terminations of 50,000 ohms or more. High input impedance is readily obtainable in transistor amplifiers by using negative feedback. The attendant loss of gain must be made up by additional amplification, which increases cost. This is not the place to economize if wide-range, distortion-free operation is to be obtained with auxiliary equipment.

The *H.H. Scott* Model 260 amplifier illustrated in the photo embodies the principles covered in this article. The design objective of this amplifier was simply: superior performance at moderate cost. It expressly excluded the concept of using transistors just because they are transistors. ▲

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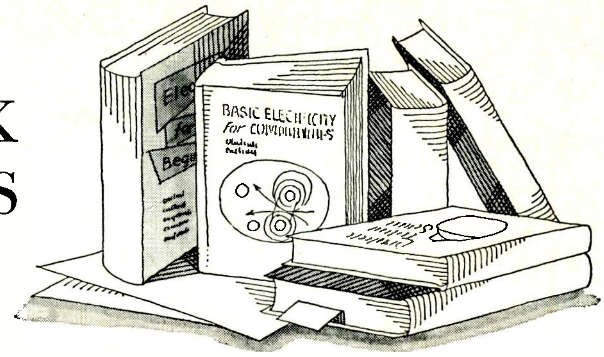
# BOOK REVIEWS



**"ELECTRONIC COMPONENTS HOBBY MANUAL"** edited by R. G. Kempton. Published by the Electronic Components Division, *General Electric Company,* Owensboro, Ky. 199 pages. Price $1.50. Soft cover.

This handy little volume contains a wide variety of projects for amateurs, hobbyists, and engineers. One of the most valuable sections of this book deals with the operation of components—ranging from capacitors through tubes, rectifiers, SCR's, photoconductors, thermistors, magnetic reed switches, etc. The text also includes instructions on the care and handling of components, safety precautions, troubleshooting, device symbols and connections, and other pertinent data.

The balance of the book is divided into four main sections outlining automobile projects, entertainment projects, home or camp projects, and workshop projects. Each of these construction projects is described in detail, illustrated by a photograph of the completed unit, and accompanied by pictorial, schematic, and complete parts listing.

* * *

**RADIO & TV SERVICING INFORMATION** compiled by M. N. Beitman. Published by *Supreme Publications,* Highland Park, Illinois.

Three volumes have recently been issued by this publisher in the familiar "Most-Often-Needed" diagram format. The volumes include No. R-25 ($2.50) covering radio, stereo amplifiers, AM-FM tuners, portables, and clock radios in the 1965 lines of most of the principal manufacturers. Vol. TV-23 ($3.00) performs the same service for television receivers in the 1965 line.

The third volume, Vol. 1 ($2.50), covers radio diagrams and servicing information for sets released during the years 1926 through 1938—a boon for those who collect and restore old-time radio receivers. This is a reprint of an earlier volume.

* * *

**"TRANSMISSION LINES, ANTENNAS AND WAVE GUIDES"** by R. W. P. King, H. R. Mimmo & A. H. Wing. Published by *Dover Publications, Inc.,* New York. 338 pages. Price $2.00. Soft cover.

This is a corrected and enlarged edition of a book which was originally derived from an intensive wartime training course given at the Graduate School of Engineering, Harvard University.

It provides practical insight into the fundamentals of radio transmission and radiation and is addressed to the practical engineer, radio astronomer, radio amateur, and college-level student. New material incorporated in this edition includes a set of 24 new graphs for distribution of current, impedances, and effective lengths of dipole antennas, and for self- and mutual-impedances of coupled antennas, incorporating new information and conclusions.

The bibliographies appended to each chapter have been updated through 1964.

Since there are practical problems presented in connection with each chapter, some with answers, this volume can be used both as a textbook and a reference work.

* * *

**"BASIC ELECTRONICS"** by Bernard Grob. Published by *McGraw-Hill Book Company,* New York. 578 pages. Price $10.50.

This book for the beginner enjoyed wide popularity when it was first published in 1959, and deservedly so. This second edition is revised, updated, and expanded to make it a completely self-contained reference and self-study guidebook.

Since the author is an instructor at *RCA Institutes,* his selection of subject matter and emphasis is based on long experience in imparting electronics fundamentals to beginners.

The text is divided into 25 chapters with the material presented in logical progression. Early chapters cover electrons and electricity. The text progresses to d.c. circuits, magnetism, a.c. circuits, vacuum tubes, and transistors. The text is lavishly illustrated and well peppered with summaries, self-examination questions, tables, and a mathematical review which makes it ideal for the student working on his own.

* * *

**"TRANSISTOR CIRCUITS"** by K. W. Cattermole. Distributed by *Gordon and Breach, Science Publishers, Inc.,* New York. 462 pages. Price $14.50.

This second edition incorporates a number of additions and revisions necessitated by the advances in transistor technology since the first edition appeared in 1959. But, basically, the author has adhered to his original, successful format of relegating the high technical and mathematical treatment to appendices and limiting his text material to a straightforward discussion.

In fourteen chapters the author discusses the place of the transistor, semiconductors, the electrical properties of transistors, elements of transistor operation, single-stage amplifiers, multi-stage amplifiers, power amplifiers, hi-fi amplifiers, supplies and bias stabilization, negative resistance, binary circuits, waveform generation, counting, timing, and logic; modulation, detection, and frequency changing; and the measurement of transistor properties.

The level is fairly elementary and the text is addressed primarily to those whose interest lies in some field of transistor application.

* * *

**"ULTRASONIC ENGINEERING"** by Julian R. Frederick. Published by *John Wiley & Sons, Inc.,* New York. 365 pages. Price $15.00.

Judging by the inquiries we receive for all types of information on ultrasonic equipment and applications, there is a genuine need for a book of this type.

Although written for engineers, much of the material will be perfectly clear to those involved in deciding whether ultrasonic techniques are applicable to a specific problem.

The first chapter is general in nature and serves as a brief history of the art and speculates on its future. The balance of the text covers the basic principles of acoustics, an introduction to ultrasonic processing, ultrasonic transducers for industrial processing, applications of ultrasonics to processing, the uses of ultrasonics in measurement and control, flaw detection, application of ultrasonics to biology and medicine.

Since the range of applications covered by the author is so wide, this book should be able to meet the informational requirements of individuals in various industries and disciplines.

* * *

**"RECEIVING TUBE SPECIFICATIONS & SUBSTITUTIONS"** compiled and published by *Techpress, Inc.,* Brownsburg, Ind. 138 pages. Price $1.95. Soft cover.

This handy reference manual carries specifications on more than 2000 American and foreign tubes including information on tube type, application, filament voltage and current rating, maximum plate voltage, current and power ratings, input and output capacitance, and base pin mechanics and internal connections.

A "similar-types" section suggests tubes best suited for use as substitutes for the various listed tubes. ▲

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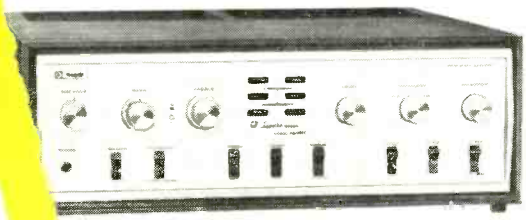

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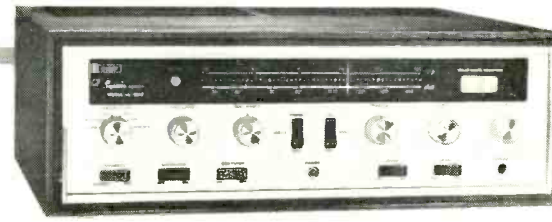

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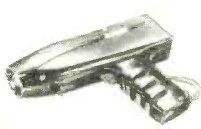

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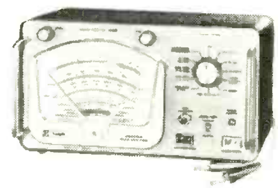
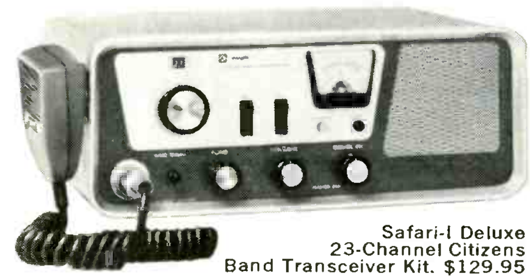
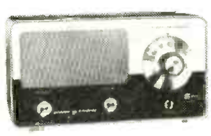


KG-375 Solid-State Universal Auto Analyzer Kit. $49.95

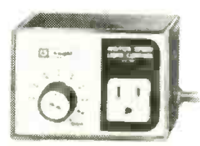


Safari-I Deluxe 23-Channel Citizens Band Transceiver Kit. $129.95

C-540 Low-Cost 5-Watt Citizens Band Transceiver Kit. $49.95



KG-221 FM Monitor Receiver Kit (police, fire, marine, weather bands, etc.) $39.95



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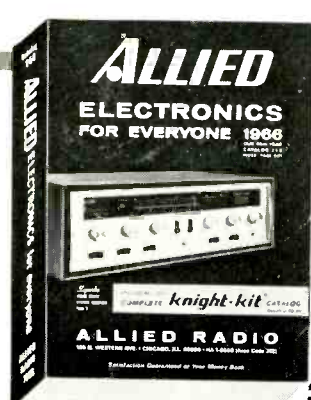


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# ALLIED RADIO

## Magnetic Measurements

(*Continued from page* 37)

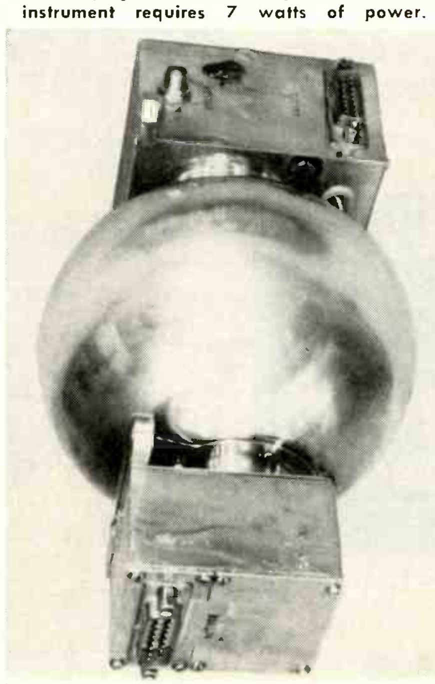
in an ordinary transformer. In the transformer the coil does not move in position, but the field builds up and collapses as a.c. passes through the primary winding, so the field "passes through" the coil.

The search-coil magnetometer may be attached to a motor shaft and rotated, independent of spacecraft spin, or fixed to the spacecraft and rotated as the spacecraft rotates. Despite the simplicity and rugged construction, search coils are not practical for very low field measurements. The SCM output must be related to spacecraft position for meaningful results, since the angle between coil and field must be known.

### The Fluxgate Magnetometer

To understand the fluxgate magnetometer, refer to Fig. 1. An oscillator of frequency $f_o$, usually around 10 kc., drives the primary of a magnetic core. The field to be measured aids the a.c. field over one-half cycle, and opposes it for the other half-cycle. The presence of the aiding/opposing field causes harmonics of the frequency $f_o$ to be generated. By winding each half of the primary in opposite directions, the fundamental frequency $f_o$ and all *odd* harmonics ($3f_o$, $5f_o$, $7f_o$, etc.) are cancelled out. The secondary winding "sees" only *even* harmonics ($2f_o$, $4f_o$, $6f_o$, etc.), and a filter is usually employed to pass only the $2f_o$ frequency. The voltage amplitude of frequency $2f_o$ is then proportional to the strength of the field to be measured.

**Helium magnetometer carried in Mariner/Mars. Unit was mounted on low-gain antenna mast. It weighs 1 1/4 lbs. while the accompanying electronics weighs 6 lbs. The instrument requires 7 watts of power.**



More sophisticated fluxgate magnetometers have been designed, but the principles remain the same. Fluxgate magnetometers have been built with sensitivities of 1/10 of a *gamma* and range of thousands of *gammas*. Several of these magnetometers may be flown on a spacecraft to record the field in several different directions.

### Atomic Magnetometers

At least three different types of atomic magnetometers have been developed. We arbitrarily classify the *proton-precession*, *rubidium-vapor*, and *helium* magnetometers together since they all make use of atomic interactions to measure the magnetic field.

In the *proton-precession magnetometer* a sample of a fluid rich in hydrogen is placed in a coil which is energized to a magnetic field much stronger than the field to be measured. Some of the protons (hydrogen nuclei) will line up so that their *spin* is aligned with the field. Other protons will line up with their *spin* opposite the magnetic field. *Spin* may be thought of as the direction in which the nuclei rotate, say clockwise or counterclockwise, with respect to the applied strong field.

When the applied field is switched off, the number of nuclei which have a particular spin is reduced in proportion to the field which remains, the field we wish to measure. As these nuclei are reduced in number they emit r.f. energy of a frequency proportional to the field to be measured. A sensing coil, which may be the same coil as used for excitation, detects the r.f. signal. This r.f. signal is 0.0426 cycle per *gamma*. Hence, at 100 $\gamma$ the output frequency is only 4.26 cps, which is difficult to amplify. Thus, proton-precession magnetometers are not used for deep-space probes, where fields are very weak.

Fig. 2 shows a block diagram of a system used aboard sounding rockets which reach an altitude of up to 2500 miles. Two different proton samples (a mixture of kerosene and oil) are used to record field strength in two directions. The *programmer* and associated relays automatically switch between coils.

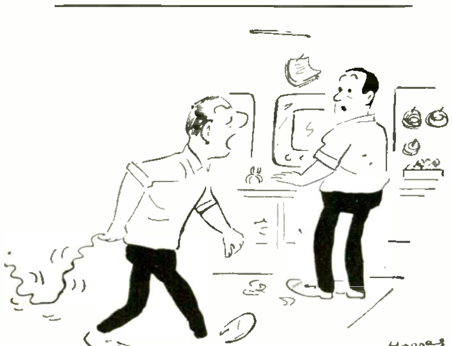
The *rubidium-vapor magnetometer* as well as the *helium magnetometer* make use of the principles and techniques of lasers. For details of the laser, see the articles by Warren Groner in this magazine, "Lasers" (August 1965), "Laser Practice and Applications" (September 1965), and "Laser Measurements" (November 1965).

A light beam of one frequency (monochromatic) that is characteristic of the light source (rubidium or helium) is focused upon a sample of rubidium or helium vapor. As shown in Fig. 3, the light which passes through the vapor cell is focused on a photocell. The presence of the magnetic field causes a change or splitting of the characteristic absorption frequency of the vapor. This is called the *Zeeman effect*. This change in frequency is proportional to the strength of the magnetic field. For rubidium 85 it is 4.67 cycles per *gamma*, and for rubidium 87 it is 6.99 cycles per *gamma*. Rubidium 85 and 87 are examples of isotopes, atoms of the same element which have different atomic weights. For helium the change in frequency is approximately 23 cycles per *gamma*. Hence, small changes in magnetic field produce large changes in frequency.

If a weak a.c. field is applied to the vapor cell perpendicular to the field to be measured, the light will be intensity-modulated. By feeding back this signal from the photocell to the r.f. coil, the system is self-sustaining. Also, monitoring the r.f. frequency yields the magnetic field intensity. The system shown in Fig. 3 features automatic phase detection so as to work for either direction of the magnetic field. Fig. 4 shows a system which eliminates phase switching by providing dual cells, one for each direction of the magnetic field. Rubidium-vapor magnetometers have been built with an accurate range of 0.05 to 10,000 $\gamma$.

Since the atomic magnetometers described have an output frequency proportional to the applied magnetic field, and these proportions are very precisely known, no calibration is required. Thus, atomic magnetometers have a distinct advantage over other types.

The Mars fly-by performed by Mariner 4 resulted in valuable information about the planet. A helium magnetometer was carried by the spacecraft. It was this instrument which measured the magnetic fields between the Earth and beyond Mars. Results show that the fields close to Mars are not appreciably stronger than the regions of space far removed from the planet. Hence we may conclude that Mars has little or no magnetic field associated with it. While perhaps not as spectacular as the Martian photographs transmitted back to earth, these results are perhaps more useful and significant. ▲




"What do you mean, 'Why am I pulling this wire?' Ever tried pushing one?"



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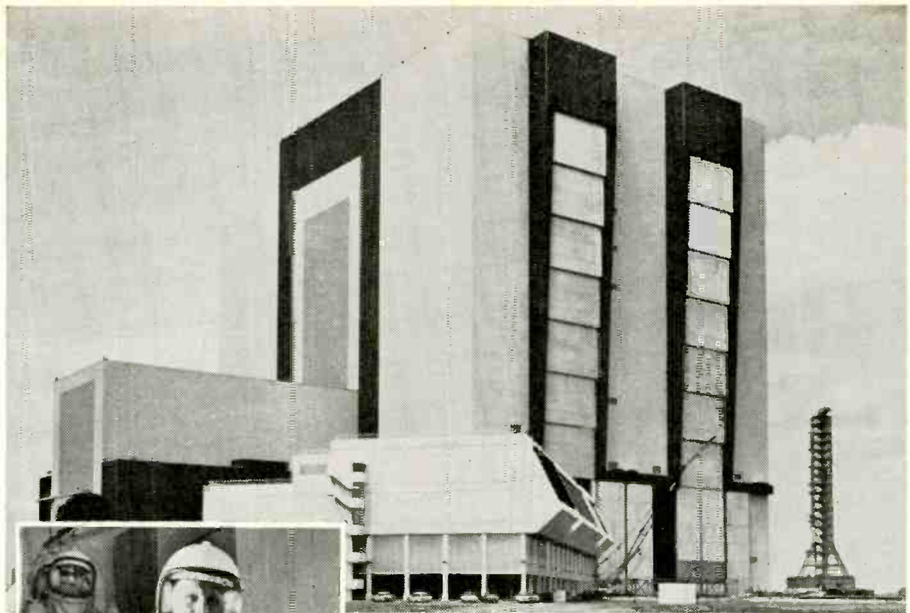
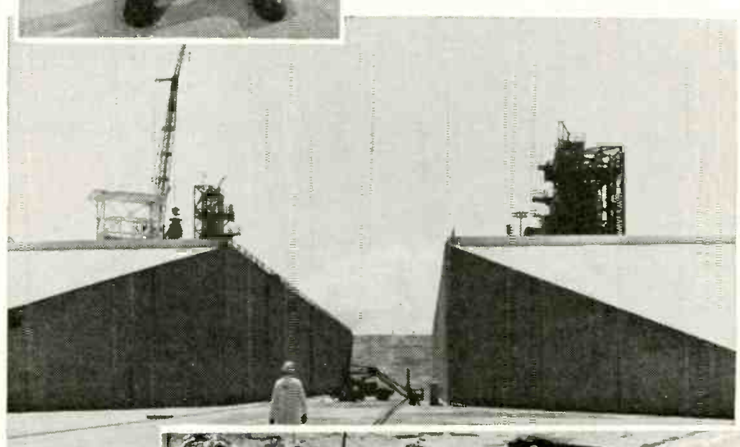
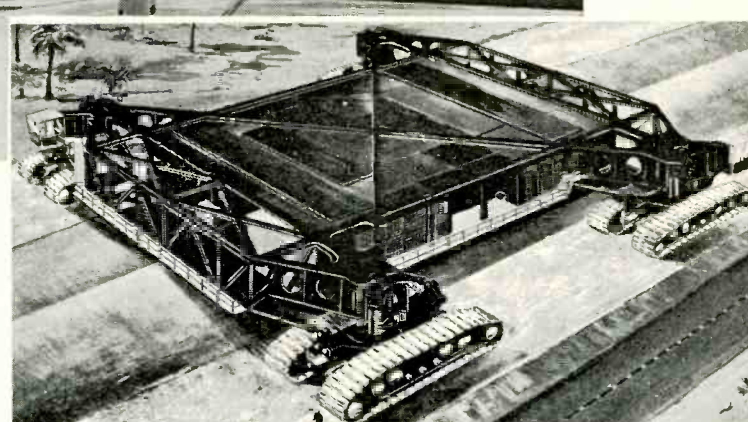


**AIRPORT TO THE MOON**

(See "For the Record" on page 6 for further details.)

(Above) The Vehicle Assembly Building (VAB) at NASA's Kennedy Space Center, Florida where four Saturn V launch vehicles will be assembled. (Left) A Bendix worker wears a SCAPE suit needed in areas where "exotic" spacecraft fuels are handled. These fuels are extremely toxic. The wrench, made of non-sparking beryllium, is required around highly flammable propellants. Wire is part of the communications system to keep him in touch with fellow workers. (Below) The fiery blast of Saturn V, when it takes off for the moon on Project Apollo, will be smothered in this "flame bucket." A million-gallon water system will supply the nozzles with sufficient water to cool the flames generated by the powerful engines. (Bottom) An artist's rendering of the Crawler-Transporter which will be used to move the assembled Saturn V vehicles from the Vehicle Assembly Building to the launching pad, a distance of about three miles, at a speed of one mile per hour.





# TESTING DIODES

By DONALD LUDWIG

FREQUENTLY it is necessary to test the condition of a diode or other semiconductor device when a v.o.m. is the only test equipment available. With a knowledge of the multimeter, and the configuration of the device to be tested, this can be accomplished by the following procedure.

The true polarity of the v.o.m. must be known to avoid confusion in the tests. Some multimeters have their positive-marked lead connected, either directly or indirectly to the negative terminal of the meter's internal voltage source, while the negative-marked lead is connected to the positive terminal of the internal source. Meter lead testing is as follows.

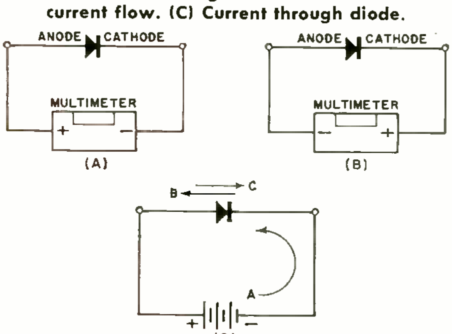
Place the v.o.m. on a relatively high-resistance scale. Connect a known good semiconductor diode with the anode to the positive-marked v.o.m. lead, and the cathode to the negative-marked v.o.m. lead, as shown in Fig. 1A.

If a low resistance is indicated on the v.o.m., and by reversing the leads, as shown in Fig. 1B, a high resistance is indicated, the markings on the v.o.m. test leads correlate with the internal voltage source. However, if a high resistance is obtained using Fig. 1A, and the low resistance with Fig. 1B, then the v.o.m. leads are improperly marked and this should be remembered when making semiconductor tests.

In these tests, forward resistance is in the direction of forward electron current flow from cathode to anode. Reverse resistance is in the direction of reverse current flow from anode to cathode. Fig. 1C shows the direction of forward current flow (*A*), the direction of forward resistance (*B*), and the direction of reverse resistance (*C*).

Diode testing is similar to testing for multimeter polarity. When checking the condition of a diode, both forward and reverse resistance are measured. For a good diode, forward resistance should be low, while reverse resistance should be high. If a reasonably high ratio is not obtained, then the diode is faulty, and should be discarded. ▲

**Fig. 1. (A) Low resistance forward current flow. (B) High resistance reverse current flow. (C) Current through diode.**



# 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, fill in coupon on the Reader Service Card.*

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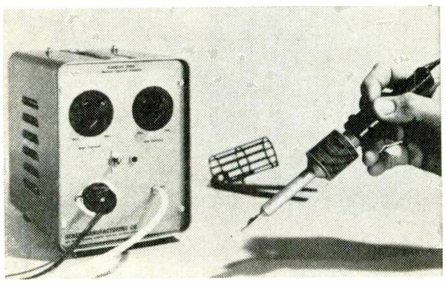
### FLAMELESS TORCH

A 1000°F temperature capability, coupled with precise controls for air flow and temperature, are features of a new 4-ounce pencil-type hot air torch, the Model FT-200.

The new unit features changeable tips ranging in diameter from 0.037" to 0.093", allowing the



user to match the size of the superheated air stream to the application requirement. Temperatures and air flow at the torch tip can be set precisely for predictable and repeatable levels via a master control console.

The torch is a production tool designed for all soft soldering operations, heat shrinking of thermal-fit tubing, plastic working, and heat curing or drying. Henes

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### LONG-LASTING BATTERY

A new and different transistor radio battery, which is said to last up to seven times longer, has been introduced as the "Duracell."

The new battery is one of a series in an advanced system of mercury and alkaline manganese batteries especially adapted for use in transistor radios, tape recorders, transceivers, and other consumer items. Mallory

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### ALL-DIFFUSED SCR'S

Four new all-diffused SCR series are now available with guaranteed d.v./d.t. rating of 110 volts per microsecond, minimum. The NL-C45 and C46 series are rated at 55 amps r.m.s. while the NL-C50 and C52 series are 110-amp r.m.s. units. There is no peak forward voltage limitation, the maximum required gate voltage is 3 volts, and the maximum required gate current is 70 ma. National Electronics

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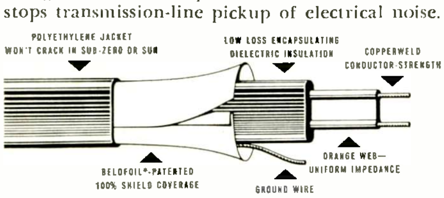
### SHIELDED TV ANTENNA LEAD-IN

A new television antenna lead-in, the 8290 shielded "Permohm," that combines the strong signal strength of 300-ohm encapsulated twin-lead cable and the clean signal protection of shielded cable has been announced.

Specially designed for 82-channel color-TV reception, the new lead-in features an orange web, assuring uniform impedance, encapsulated in a low-loss cellular polyethylene insulation and utilizing "Beldfoil," a patented 100% shield that stops transmission-line pickup of electrical noise.




A thick, non-contaminating polyethylene jacket covers the lead-in over-all.

The lead-in matches the impedance of most TV antennas and receivers, eliminating the need for costly matching transformers and connectors. To further simplify hook-up, the lead-in is furnished in 50-, 75-, and 100-foot lengths with factory installed terminals, as well as in bulk lengths. Belden

**Circle No. 2 on Reader Service Card**

### SERVICE NOTES FOR SINGLE SETS

A new service which supplies data on individual model television receivers has recently been established. Each service model pack contains the schematic of the set, a parts list, chassis views, parts location, tuner data, tube complement, alignment, waveforms, voltages, changes, and remote control service information.

Manuals covering sets from 1955 to 1965 are available on Admiral, Emerson, General Electric, Magnavox, Motorola, Philco, RCA, Sylvania, Westinghouse, and Zenith black-and-white and color sets. Singlpak TV

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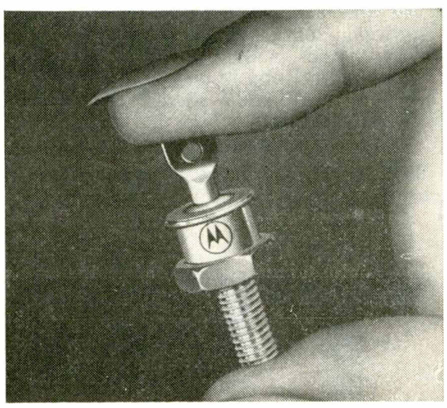
### 12-AMP SILICON RECTIFIERS

A new MR1120-30 series of 12-ampere stud mounted silicon rectifiers is now on the market to give designers more power handling capability at substantially lower cost in the low/medium current area.

This 50-1000-volt series carries its full rated 12-ampere load at an elevated case temperature



of 150°C. In addition, the new series has 300-ampere current surge protection, 0.55 v. average forward voltage, and is available with reverse polarities. Full technical details are available on request. Motorola Semiconductor

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### LIGHT DETECTOR FOR LASERS

The development of an advanced, supersensitive light detector that could be employed for practical laser communications has been announced. The device can sense up to 100 million intensity changes a second in a beam of light, giving it the capability of distinguishing as many as 25 separate TV programs being carried simultaneously on a single laser beam.

The new light sensor is a freckle-sized speck of photoconductive material mounted in a small cavity continuously bathed in microwaves oscillating at 10 billion cps. When light-bearing information in the form of intensity variations enters the cavity and strikes the photoconductor, electrons are freed and begin to oscillate rapidly up and down within the material in response to the alternating electric field inherent in the surrounding microwaves. These electron oscillations, in turn, control the amount of microwave power permitted to leave the cavity. Thus intensity variations in the light are converted to intensity variations in the outgoing microwaves which are detected and processed by conventional microwave techniques. RCA

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### WIRING HARNESS LACER

The development of a specially designed flat braided lacing tape for wiring harness applications has given rise to the development of a companion "Cable-Lacer," a tool designed to speed, ease, and improve the lacing of wiring harnesses for the electronic and electrical industries. The new tools consist of a long, tool-steel hook, and a spring action brake to stop the feeding of the lacing tape. A bobbin of tape in the handle feeds tape as needed. This makes unnecessary the handling of long sections of tape, at the same time reducing the number of splices.

The hook, which can be arranged for left-to-right or right-to-left-hand lacing makes passing the tape over and under the wiring a swift and easy operation. An additional hook is supplied with each unit for shaping to suit any special operation. Gudebrod Bros.

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### SHIELDED COIL FORMS FOR PC'S

A new series of shielded coil forms designed for use in printed-circuit applications is available as the "Cambion" 1159 and 1163. Both units are engineered for use in circuits up to 125°C operating temperatures. Both are mounted on a printed-circuit grid with separate grounding being provided for static shielding. The polyester fiber glass internally threaded coil form provides smooth tuning in the ranges from 1 μhy. to 40 mhy. and enables the coil to be closely coupled to the magnetic path for high "Q" and increased inductive ranges. Cambridge Thermionic

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### SCHEMATIC SYMBOLS IN TAPE FORM

More than 300 frequently used symbols have been produced in roll form and packaged in handy dispensers to speed the preparation of schematics and other electronic diagrams. Each dispenser has its own built-in burnishing tool. The transfer is accomplished by positioning the symbol in its exact location on the working surface and rubbing lightly with the dispenser's burnishing tool. A special heat-resistant adhesive backing and cohesive ink prevent the symbols from moving, cracking, or bubbling in hot reproduction or when sprayed with fixative or lacquer.

The roll "Deca-Dry" is available in ½" x 75"; ½" x 100"; 1" x 100"; and 2" x 100" sizes. Symbols not listed as standard catalogue items are available on special order. Chart-Pak

**Circle No. 132 on Reader Service Card**

### CONTROL-CIRCUIT KITS

Three new experimenter's kits, enabling electronics enthusiasts to build 14 different electronic control circuits using silicon controlled rectifiers, thermistors, and photocells have been announced.

The basic kit, KD2105, provides the user with maximum flexibility in the variety and number of circuits he can build at minimum cost. The kit includes one silicon controlled rectifier, five silicon rectifiers, and two transistors. An 80-page instruction manual accompanies the kit.

Two "add-on" kits, a heat sensor experimenter's kit and a light sensor kit, can be used with the basic kit to construct more exotic control devices. RCA Electronic Components

**Circle No. 4 on Reader Service Card**

### CRT CHECKER CONVERSION KIT

A conversion kit for its Models CR125 and CR128 CRT checkers to permit them to be updated with a variable G2 voltage has been announced. It can be installed in minutes and comes complete with control and new panel plates. With the conversion kit installed, the checker can be set up directly from a picture tube manual or with a setup book from the firm's CR133. Sencore

**Circle No. 5 on Reader Service Card**

### SQUARE TRIMMER

A panel-mounted miniature square trimming pot with solder-hook terminations has been put on the market as the Model 160. The new pot features a heat dissipator as an integral part of the solder-hook design. In addition, both the panel-mounting bushing and the terminating solder hooks are molded into the plastic case for rugged, dependable mechanical bonds.

The wirewound unit measures .453" x .468" x .282" and is available in resistance ranges from 10 ohms to 50,000 ohms. Power rating is one watt at 50 C, derating to 0 at 175°C over an operating range of −65 to +175°C. Techno-Components

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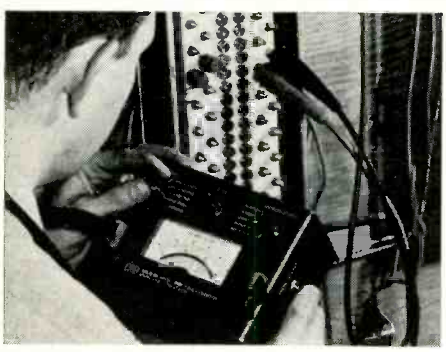
### OPEN FAULT LOCATOR

A new portable instrument which enables a technician to determine with a single reading the location of an open fault in paired communications cable up to 20 miles in length is on the market as the Model 4910A.

The locator self-calibrates for variations in conductor capacity to give precise readings in feet



to the location of an open in a communications cable. Battery-operated, this all-solid-state instrument utilizes the latest automatic charge sampling technique. The taut-band meter in the instrument has five linear-reading distance scales: 100, 200, 1000, 10,000, and 100,000 feet. Delcon

**Circle No. 134 on Reader Service Card**

### SUBMINIATURE TOGGLE SWITCH

A new type of lightweight, subminiature toggle switch, especially designed for use on printed-circuit boards and a wide variety of lightweight, portable equipment is now available as the Type TT-2.

Weighing only 1/6 ounce, the switch is 1/4" square and projects approximately 1/4" from the mounting surface. Contact arrangement is d.p.d.t. The unit functions with high reliability through a temperature range of −65 to +200°F. Electrical rating at 28 volts d.c. resistive is 7 amps; at 28 volts d.c. inductive, 2.5 amps; and at 125 volts a.c. resistive, 7 amps. Milli-Switch

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### LONG-LIFE LAMPS

A wide range of microminiature lamps for electronics and instrumentation use is now available. Bulb diameters as small as .094" and lengths as short as .145" make them ideal for applications where space is at a premium. Most lamps in the line have lives approximating 100,000 hours and are designed to withstand both normal and unusual conditions of vibration, shock, and thermal variation.

The lamps are available in voltages from 5 to 28 volts and in three styles: sub-midget flanged base, unbased with wire terminals, and with axial lead wire terminals. Hudson

**Circle No. 136 on Reader Service Card**

### IMAGE-ORTHICON TV CAMERA

A high-resolution, image-orthicon TV camera, which is capable of producing pictures obtained from scenes illuminated only by starlight, is on the market as the Rayscan 150. Adequate bandwidth is provided to obtain 900 TV lines horizontal resolution with 875 scan lines per frame.

The unit is a two-piece system with fixed scan rates from 525 to 1023 lines. The camera weighs

28 pounds and measures 5½" x 7½" x 20". The camera control measures 7" x 17" x 17". The system draws 175 watts. Accessories include full EIA synchronization, and a wide range of optics and automatic light control. Raytronics

**Circle No. 6 on Reader Service Card**

### "OVERLAY" TRANSISTOR

A new "overlay" transistor, the first single transistor to offer watts of power in the microwave frequency region, is being marketed as the 2N4012. The new device extends transistor performance into the 1-gc. frequency region with 2.5 watts output and 4 db conversion gain (minimum) when operated as a tripler. One single 2N4012 can now replace both the transistor power-amplifier and varactor-diode stages previously required to achieve this performance.

This epitaxial silicon "n-p-n" planar transistor with an "overlay" emitter electrode structure is especially designed to provide high power as a frequency multiplier into the u.h.f., or L-band, frequency range for military and industrial communications equipment. RCA

**Circle No. 137 on Reader Service Card**

### MINIATURE PUSH-BUTTON SWITCH

A miniature push-button switch assembly, designed for either printed-circuit or hand wiring applications, is now available in various configurations. Over-all thickness, including contacts, is under 5/8" and when used with a printed-circuit board the height over the board is under 15/32".

Assemblies are available from 1 to 12 buttons and each button can be supplied with a maximum of 8 poles d.t. with hard silver-plated brass contacts. Mechanically it provides several latching functions on one assembly and several mounting possibilities. Seacor

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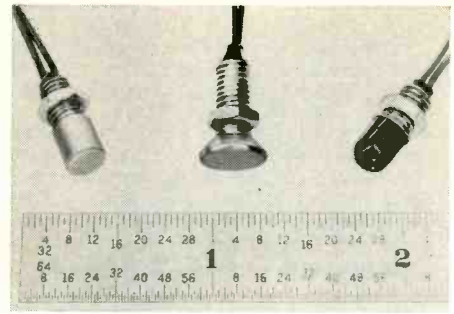
### SOUND SWITCH

A compact, lightweight, portable sound switch that can be plugged into a power-line socket and one or more appliances plugged into it, is now available as the "Sonuswitch." Measuring 6½" x 5½" x 3½" tall, the unit is designed to replace manually operated electrical switches. Sonus

**Circle No. 7 on Reader Service Card**

### SUBMINIATURE INDICATOR LAMPS

A line of subminiature indicator lights has been added to the firm's line of RFI-shielded front-of-panel components. In these new lights,



RFI is absorbed by a unique mesh shield within the plastic indicator lens. A special conductive seal connects this shield to the indicator case which, in turn, provides a low-impedance r.f. path to ground. This combination effectively eliminates RFI radiation in the important 0.15 to 1000 mc. range.

These subminiature lamps measure only 9/16" over-all and weigh less than 0.032 ounce. Information on the various types in the new line will be supplied on request. Controls Company of America

**Circle No. 139 on Reader Service Card**

### ABSOLUTE LINEARITY POTS

New, improved linearities in the 900 and 930 potentiometers are now standard according to a recent announcement. The ten-turn 900 series now offers ±0.1% absolute linearity, while the three-turn 930 offers ±0.25% absolute linearity. The improved absolute linearity is being offered at no additional cost over the former independent linearity pots.

The new design eliminates all trimming costs and results in a lower ultimate over-all production cost to the manufacturer. Amphenol Controls

**Circle No. 140 on Reader Service Card**

### ANTENNA BOOSTER/COUPLER

The Model 65-1 booster/coupler is a two-tube, four-set v.h.f. TV and FM distribution amplifier designed for small commercial and deluxe home distribution systems. Delivering 8 db gain in the low band, FM, and high band at each of the four output terminals, the unit is housed in a perforated steel cabinet that measures only 6 5/16" x 3 7/16" x 3 9/16". The unit is convenient to mount and easily accessible for tube servicing. It operates

on 117-volt, 60-cycle a.c. and features an "on-off" switch, an a.c. convenience receptacle on the chassis, and no-strip terminals. Finney Co.

**Circle No. 8 on Reader Service Card**

## HI-FI—AUDIO PRODUCTS

### AUTOMOTIVE REVERB KIT

A completely self-contained automotive speaker/reverb unit which requires no connection to the car's battery is being offered as the "Cathedral-Sonic" Series 400.

The new unit replaces the rear speaker without additional wiring. The circuit is designed to eliminate road noises, provides full-range reverb, incorporates a dynamic 6" x 9" speaker, and will handle 6 to 8 watts. Cleveland Electronics

**Circle No. 9 on Reader Service Card**

### CAR TAPE SYSTEM

A new tape sound system for automobiles which can play back through the car radio as well as record and be easily removed from the car for use as a completely separate portable recorder is being marketed as the "Car-Mount."

This two-part unit comprises a specially designed universal mounting which is attached below the dashboard and the "Carry-Corder 150," a cordless, cartridge-loaded portable tape recorder. The "Car-Mount" is powered by the tape recorder, eliminating drain on the car battery.

The recording feature permits the motorist to tape reports, travel information, vacation sights as well as pre-recorded selections of favorite music for playback through the car radio. Norelco

**Circle No. 10 on Reader Service Card**

### RECORDERS FOR LANGUAGE LABS

A new language laboratory that is completely transistorized and modular constructed is now offered as a package. Each system features a master control panel with plug-in electronic strips to accommodate up to 40 students per system; a built-in transistorized amplifier or tape recorder; and acoustically damped, sectionally designed student booths with interchangeable parts.

The Model 92 teacher's tape recorder is a three-speed, half-track unit featuring record-play-

back frequency of 30-16,000 cps at 7½ ips. The student unit, Model 10-21, is transistorized and has special two-track stereo heads and printed circuitry. This recorder is used in conjunction with the record/compare system and is built into the student booth. Full details on the system are included in a 12-page illustrated brochure which is available on request. Tandberg

**Circle No. 11 on Reader Service Card**

### SOLID-STATE STEREO RECEIVER

A 70-watt solid-state AM-FM-FM stereo receiver has been recently introduced as the Model RT-8000. The new model features counterbalanced flywheel tuning, automatic FM-stereo switching, remote and local speaker selection, oversized heat

sinks for cool operation, protective fused circuitry, tape monitor input, four rocker switches, instrument-type tuning meter, and a "stereo minder."

FM-section sensitivity is 2.5 $\mu$v. and distortion is less than 0.5% at full output. Hum and noise level is 60 db below 100% modulation. Bogen

**Circle No. 12 on Reader Service Card**

### MULTI-PURPOSE INTERCOM

A multi-purpose, six-station intercom designed for a wide range of applications in the home or office is housed in an oiled walnut cabinet to blend in with any decor. This all-master system incorporates up to six master stations enabling three private conversations or a six-station conference to be held. The master-to-remote mode permits the master station to communicate with up to five remotes either separately or together. The master unit has a five-station selector control, three-way "talk-listen-dictate" switch, and a volume control. The unit is designed for 117-volt, 60-cycle a.c. Lafayette

**Circle No. 13 on Reader Service Card**

### PRE-RECORDED TAPE LINE

An initial release of 12 three-hour tapes ranging from light jazz to heavy classical has been announced. The new "Tape-Mates" include vocals, show tunes, variety, and dance, all performed by top recording artists at 3¾ ips, using a new recording concept to parallel the original recording quality. Additional releases will be marketed at regular intervals. American Tape Duplicators

**Circle No. 14 on Reader Service Card**

### BOOKSHELF SPEAKER SYSTEM

A high-compliance, acoustic-suspension system which weighs only 9 pounds and measures 10½" x 7½" x 7" deep is now being marketed as the "Sonomaster" Model RM-0.5. The new unit will handle a maximum power of 20 watts average program material and 40 watts peak. Frequency range is 55 to 22,000 cps. Impedance is 8 ohms and the tweeter/woofer crossover is at 5000 cps.

The system includes a 4" linear high-compliance woofer and one 2" high-frequency cone tweeter. The speakers are matched by means of an LC crossover network. The system is housed in a hand-rubbed oiled walnut finished cabinet. Sonotone

**Circle No. 15 on Reader Service Card**

### HEAVY-DUTY TAPE RECORDER

A new design magnetic tape recorder/reproducer which has been specifically engineered for radio stations, industry, and public safety organizations requiring a rugged mechanism for continuous use is being marketed as the Model R70.

The recorder is available for tape speeds from 7½ ips (wide range) down to $\frac{15}{32}$ ips (communication and logging). From one to eight separate tracks may be recorded on ¼-inch tape. The self-contained electronics are designed around the A-70 series of silicon-transistor, octal plug-in amplifiers. In addition to the record and playback, amplifier accessory modules include automatic gain control, voice or signal-operated relay, and monitor amplifiers.

Full specifications on this heavy-duty unit are available on request. Stancil-Hoffman

**Circle No. 141 on Reader Service Card**

### FLUTTER METER

A solid-state, automatically self-calibrating flutter meter is now available as the Model B-8100.

Designed for use by the tape recorder manufacturer, broadcaster, and recording studio, separate meters indicate drift and flutter. A precision "coarse-fine" zero-set pot permits absolute pitch determination with a resolution of 0.02%. A front-panel switch selects weighted or unweighted r.m.s. flutter measurements. Full-scale sensitivities range from 0.01% to 10% for flutter and 0.03% to 10% for drift. Bahrs Industries

**Circle No. 142 on Reader Service Card**

### "MOVING MASS" CARTRIDGE

A new cartridge with a minute moving system that performs below the critical point of record groove yield has been introduced as the Model 10/E. The new stereo unit has a "moving mass" about one-third that of the best magnetic cartridge, according to the manufacturer.

This induced-magnet cartridge has a sensitivity of 4 mv. at 5.5 cm./sec. recorded velocity, a channel separation of 30 db from 50 to 10,000 cps; frequency response of 10 to 20,000 cps ±2 db, a vertical tracking angle of 15°, a tracking force range of ½ to 1 gram, and an elliptical stylus with a contact radius of 0.0003". Compliance is 35 x $10^{-6}$ cm./dyne. Audio Dynamics

**Circle No. 16 on Reader Service Card**

### THREE-SPEED TAPE RECORDER

A new professional tape recorder which features three-speed (3¾, 7½, and 15 ips) operation at a frequency response up to 26,000 cps is being offered as the Model 70-ESF. The machine records stereo or mono on ¼-track tape as well as sound-on-sound. It has two 4½" vu meters, NAB equalization, hysteresis-synchronous direct-drive motor for minimum flutter and wow at all speeds, two additional high-torque motors for the supply and takeup reels, and four electric push-buttons for all services.

The tape deck and preamp control panel is standard 19" rack mount. A portable carrying case for the instrument is available extra. Premier Electronic

**Circle No. 17 on Reader Service Card**

### TURNTABLE FOR HI-FI

The Model SLT-21 turntable features straight-line tracking and a free-floating tonearm assembly completely unaffected by friction and

inertia. The tracking arm holds the stylus tangent to the record groove at all times, eliminating inner groove distortion, skating force, and uneven stylus wear.

The 12-pound precision-machined turntable has tungsten carbide thrust bearings and a precision ground drive belt to provide maximum isolation from acoustical feedback with rumble of −112 db. The high-compliance pickup and arm are designed specifically for this unit.

The turntable operates at 33⅓ and 45 rpm with flutter and wow better than 0.04%. Frequency response is 20 to 20,000 and compliance is 30 x $10^{-6}$ cm./dyne. The stylus is an elliptical diamond.

The unit measures 18¼" wide x 14" deep x 6½" high and weighs 27 pounds with its walnut base. Marantz

**Circle No. 18 on Reader Service Card**

### 60-WATT FM-STEREO RECEIVER

The Model TK-50 is a 60-watt FM-stereo receiver powered by silicon transistors and providing a total music power of 60 watts (IHF at 4 ohms) and 50 watts (IHF at 8 ohms).

The unit features a four-gang, all-transistor front end, power transistor protection circuit, automatic silent switching to proper mode, four i.f. stages with 3 noise limiters and wideband ratio detector, SCA noise eliminator, direct tape

monitor system, and a front-panel stereo headphone jack.

Amplifier response is 20-70,000 cps ±1 db with IM distortion less than 1% up to 18 watts per channel. Tuner sensitivity is 2.5 $\mu$v. (IHF) with a signal-to-noise ratio of 63 db. FM image rejection is 80 db at 98 mc. while the capture ratio is 2 db. FM-stereo separation is 35 db at 400 cps.

The unit measures 16½" wide x $5\frac{13}{16}$" high x 14" deep and weighs 22 pounds. Kenwood

**Circle No. 19 on Reader Service Card**

### STEREO TAPE DECK

A new professional-quality tape deck which provides such features as sound-on-sound and tape and source monitoring is being marketed as


the Sony 350. The deck provides 4-track stereo and mono recording and playback, has solid-state circuitry including the recording amplifiers and playback preamps, three heads, two VU meters, and tape/source monitor switches for audible comparison between source and the tape being recorded.

Tape speeds are 7½ and 3¾ ips with frequency response 50-15,000 cps ±2 db. Signal-to-noise ratio is better than 50 db while flutter and wow is less than 0.19% at 7½ ips and 0.25% at 3¾ ips. The unit will handle a full 7" reel. Superscope

**Circle No. 20 on Reader Service Card**

## CB-HAM-COMMUNICATIONS

### BASE-STATION MICROPHONE

A transistorized, base-station microphone which features an adjustable output level is now on the market. The Model +2 microphone makes it possible to increase the range and signal strength of any transceiver. A volume control on the microphone enables the operator to dial the output level that is best for his set, allows changing the output to suit a big or little voice, or for working close or far away from the microphone.

The mike also features exclusive touch-to-talk

or lock "on-off" switch. Simple screwdriver adjustment allows terminal wires in the base to be connected for electronic or relay switching.

The SSB response is limited to voice frequencies of 300-3000 cps. The unit is heat and humidity proof. Turner

**Circle No. 21 on Reader Service Card**

### "VISIBLE" MOBILE ANTENNAS

An extensive line of mobile communications antennas made with brilliant fluorescent material, "International Emergency Orange," is now being offered to aid in identifying vehicles equipped with two-way radios.

These "Colorguard" antennas are available in both fiber glass and stainless-steel models, with the coils on the latter model encased in molded fluorescent plastic jackets. Antenna Specialists

**Circle No. 22 on Reader Service Card**

### CODED GARAGE-DOOR OPENER

A new automatic garage-door operator that provides complete freedom from phantom operation is now being marketed as the Model G-670.

An exclusive radio coding system guarantees garage privacy. The new unit complies fully with the rules set forth by the FCC and may be installed and operated without a license.

The door operator is an all-solid-state device, with the transmitter and receiver of all-transistor design and the motor controlled by a computer-logic circuit.

Full details on this door operator are included in a four-page data sheet which will be supplied on request. Perma-Power

**Circle No. 23 on Reader Service Card**

### 10-BAND TRANSISTOR PORTABLE

A new portable radio with 10 bands and a number of deluxe operating conveniences is now offered in kit form as the Model GR-43.

The portable tunes 150-400 kc. long-wave, 88-108 mc. FM, 550-1600 kc. AM, plus seven short-wave bands covering 2-22.5 mc. Tuning a single band is made easy by the 10-position rotating dial. The unit uses 16 transistors, 6 diodes, and 44 factory-assembled and aligned r.f. circuits. Two separate AM and FM tuners are pre-assembled and ready to drop into place.

There are two built-in antennas, one a ferrite rod and the other a 5-foot telescoping whip. A

special battery-saver switch cuts current drain up to 35% for normal indoor listening or provides full power for strong, outdoor reception. The unit operates on six "D" cells plus a "C" cell to power the dial light. It can also be operated on 117 volt a.c. with an optional converter/charger. Heath

**Circle No. 24 on Reader Service Card**

### MICROWAVE R.F. EQUIPMENT

A new, solid-state 6000-mc. operational fixed-band microwave r.f. equipment, the MR-30, combines advanced state-of-the-art solid-state design with the economic advantages of an ultra-reliable transmitting klystron.

The MR-30 provides a transmission medium capable of toll quality performance utilizing companion single-sideband or FM carrier equipment. It will handle voice, telemetering, facsimile, and data communications at lower channel cost, lower maintenance cost, and lower total communications cost than existing equipment, according to the company.

The complete basic terminal equipment occupies only 22¾" of space on a standard 19-inch rack and requires less than 70 watts from a 24-volt battery system; 48-volt d.c. and 120-volt a.c. operation are also available. Motorola

**Circle No. 143 on Reader Service Card**

## MANUFACTURERS' LITERATURE

### SWEPT-FREQUENCY MEASUREMENTS

Complete information on microwave swept-frequency measurements and techniques is provided in a new 42-page, fully illustrated booklet, Application Note No. 65.

An introductory section covers history and basic concepts and also contains a discussion of leveled systems. Four additional sections explain methods of displaying or recording broadband measurements of attenuation, impedance, power, and frequency.

Transparent s.w.r. and db scales are included for direct readout on linear oscilloscopes. Hewlett-Packard

**Circle No. 144 on Reader Service Card**

### SELECTING ADHESIVES

Information on choosing the proper adhesive, coating, or sealer for the original equipment market is now available in a new 8-page illustrated selection guide (Z-SOEM).

Three comprehensive tables list product descriptions, performance data, properties, and applications for all materials covered. 3M

**Circle No. 145 on Reader Service Card**

### EDUCATIONAL TV

A new brochure outlining closed-circuit educational TV systems capabilities is now offered. Entitled "Is Your School Ready for ETV?" the booklet discusses consultation services, applications engineering, installation, and maintenance programs. Sylvania

**Circle No. 25 on Reader Service Card**

### SHIELDING & GROUNDING

Practices, problems, and methods of shielding and grounding for instrumentation systems are discussed in a new 8-page, completely illustrated paper. Dynamics Instrumentation

**Circle No. 146 on Reader Service Card**

### "OP ART" CATALOGUE

The latest art form—"op art"—is employed in a new 1966 tape-recorder catalogue covering fourteen recorders, thirteen microphones, three types of recording tape, and various accessories. Featured in the eye-catching booklet are a 5½-pound portable recorder and a voice-activated microphone. Sony/Superscope

**Circle No. 26 on Reader Service Card**

### TECHNICAL JOURNAL

Two new pieces of electronic equipment are fully described and illustrated in an 8-page technical publication (Vol. 17, No.1). The first device is the Model 414A "Autovoltmeter," a precision analog volt-ohmmeter with automatic ranging. The second item is the Model 1784A oscilloscope recorder plug-in unit for recording fast and low-level waveforms. Hewlett-Packard

**Circle No. 147 on Reader Service Card**

### PROFESSIONAL RECORDERS

Information on the AG-350 series of solid-state professional audio recorders/reproducers is now available in a new 6-page foldout. Used for broadcasting, recording-studio, industry, and medical applications, the series comes in four basic models and unmounted, portable, and console styles. Complete technical specifications are given in the brochure. Ampex

**Circle No. 148 on Reader Service Card**

### PILOT LIGHTS

Information on specifying the proper push-button or indicating light is now available in a new 12-page selection guide (GED-5289). Tables are included listing a wide range of factors to be considered in choosing the proper device.

The illustrated brochure also contains cross-references to six other publications which provide further technical information on the push-buttons and indicating lights covered. General Electric

**Circle No. 149 on Reader Service Card**

### WIRE GUIDE

A new wall-chart wire guide containing data on standard annealed copper wire and copper wire stranded construction is now available. Birnbach Radio

**Circle No. 150 on Reader Service Card**

### CONTROL REPLACEMENT

A new 2-page illustrated replacement chart covering all plain, single-tap, and dual-tap controls in the "Fastach II" line has been issued.

Plastic-laminated for durability, the chart provides information on resistance, taper, taps, shafts, mounting hardware, and switches. Centralab

**Circle No. 27 on Reader Service Card**

### LIGHT DIMMERS

A new 6-page, full-color booklet showing the effective use of "Li/Trol" light dimmers in a series of decorator-styled room settings has been published. Although intended primarily to stimulate consumer interest in dimming effects for decoration, the booklet also contains wiring diagrams, dimensional drawings, and installation instructions. Federal Pacific Electric

**Circle No. 28 on Reader Service Card**

### LAB CHART & CATALOGUE

A reference chart of standard formulas and tables designed for use by electronic technicians with laboratory test equipment is now available. Featured are typical test set-ups for determining return loss and response, amplitude response, and u.h.f. converter performance.

Also offered is a new catalogue of test instruments covering sweep generators, field-strength meters, delay lines, fixed attenuators, and high-output detectors. Blonder-Tongue

**Circle No. 29 on Reader Service Card**

### CONNECTOR CATALOGUE

The "DBA Series" of thread-coupling, bayonet-lock, and push-pull types of miniature electrical connectors is fully illustrated and described in a new catalogue (DBA2), which comes in the form of 22 data sheets.

All connector styles feature the rear-release contact retention system, interchangeable accessory hardware, and a single insertion/removal tool. Deutsch

**Circle No. 151 on Reader Service Card**

### NICKEL-CADMIUM CELLS

Information on rechargeable, sealed nickel-cadmium batteries is offered in a new 4-page illustrated technical brochure (BA-125). Physical and electrical characteristics of the company's complete line are given in a handy table. Sonotone

**Circle No. 30 on Reader Service Card**

### BLOWERS AND FANS

Six new catalogue sheets have been issued covering a completely redesigned line of blowers and fans. Products described include the "Skipper," "Caravel," and "Mark 4 Muffin" fans, the "Spiral" high-pressure/vacuum air mover, the "Centrimax" blower, and the "Batac" d.c. to a.c. solid-state inverter.

Each bulletin discusses in detail one particular unit and provides such information as applications, materials, temperature ranges, mounting, motor characteristics, and special features. All catalogue sheets are fully illustrated and contain performance curves and dimensional drawings. Rotron

**Circle No. 31 on Reader Service Card**

### PLASTIC DATA GUIDE

A new pocket-sized, plastic "Electronics Data Guide" containing a variety of commonly used conversion factors, formulas, tables, and color codes is now available. Ohm's Law formulas for d.c. and a.c. circuits, sinusoidal voltages and currents, resonant-frequency formulas, and a decibel table are among the items listed on this handy guide. Cleveland Institute of Electronics

**Circle No. 32 on Reader Service Card**

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**CIRCLE NO. 111 ON READER SERVICE CARD**

**ELECTRONIC** Ignition Kits, Components. Free Diagrams. Anderson Engineering, Epsom, New Hampshire 03239.

**WEBBER** Labs. Transistorized converter kit $5.00. Two models using car radio 30-50Mc or 100-200Mc, one Mc spread. Easily constructed. Webber, 40 Morris, Lynn, Mass.

**ACHTUNG!** Das machine is nicht fur Gerfingerpoken und mittengraben. Is easy schnappen der Springenwerk, blowenfusen und poppencorken mit spitzensparken. Ist nicht fur gewerken by das Dummkopfen. Das rubbernecken sightseeren keepen hands in das pockets. Relaxen und watch das Blinkenlights. This attractive, brass metal plaque only $2.00 ea. ppd. Southwest Agents, Dept. E, 8331 Hwy. 80 West, Fort Worth, Texas 76116.

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**TELEVISION** Cameras Transistorized also monitors. Spera Electronics, 37-10 33 Street, L.I.C., N.Y.

**TRANSISTORIZED** Products Importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

**INVESTIGATORS**—Subminiature Electronic Surveillance Devices. **NEW** 1966 Professional models ready **NOW!** Free details. Trol Electronics-EW, 342 Madison Avenue, New York, N.Y. 10017.

**MESHNA'S TRANSISTORIZED CONVERTER KIT** $4.50 Two models——converts car radio to receive 30-50 mc or 100-200 mc (one mc tuning). Meshna, Lynn, Mass. 01901.

**SECURITY ELECTRONICS** introduces its **NEW** 1966 line of **SURVEILLANCE EQUIPMENT.** Improved **NEW** designs for maximum performance and greater value. **FREE DETAILS.** Security Electronics-EW, 11 East 43rd St., New York, N.Y. 10017.

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**CALEMCO** *The diversified line of transformers. Dept. E, Box 585, San Fernando, Calif.

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**BATTERY OPERATED GADGETS.** Latest novelties, for home and office. Catalog available. Takeshi Kodama, 8-12 Sendagi, 3-chome. Bankyo-ku. Tokyo.

**SHELL** Model 102 tube and vibratortester, latest tube chart, money back guarantee, $9.00, F.O.B. Indianapolis, John Kirby, 3606 Delmar Road, Indianapolis, Indiana 46220.

**SAFEGUARD PRIVACY!** New instrument detects electronic "bugs," wire-tapping and snooping devices. Free information. Dee Equipment, Box 7263-7, Houston 8, Texas.

**SIGNAL-CORPS** Technical Manuals——World's Largest list. Quaker Electronics, Hunlock Creek, Pa. 18621.

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| 18** | .18 | .40 | .60 | .70 |
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| Amps | 300 PIV | 400 PIV | 500 PIV | 600 PIV |
|---|---|---|---|---|
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| 3 | .25 | .28 | .35 | .40 |
| 15 | .90 | 1.30 | 1.40 | 1.65 |
| 18** | .85 | 1.25 | 1.85 | 2.50 |
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| Amps | 700 PIV | 800 PIV | 900 PIV | 1000 PIV |
|---|---|---|---|---|
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