The Transistor's 10th Birthday — Special Issue

MAY 1958

Radio-Electronics

TELEVISION · SERVICING · HIGH FIDELITY

HUGO GERNSBACK, Editor

SPECIAL TRANSISTOR FEATURES

Plus:

A VTVM Calibrator

■

More About Cathode Followers

■

Build a 6-Band Transistor Portable

■

Birth of a Transistor

(See page 4)

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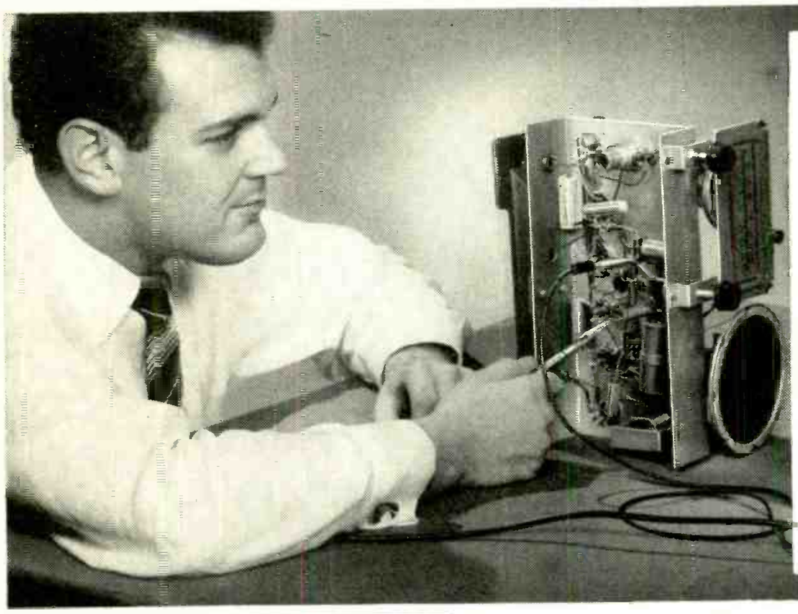

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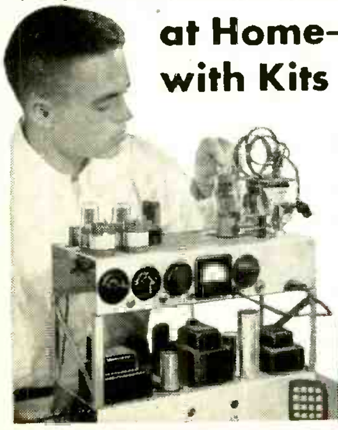

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ON THE COVER

A single crystal of germanium is being formed as it is drawn slowly out of the pool of molten germanium in the white crucible. Parts of the copper-tubing induction-heating coil can be seen in the rear.

Color original courtesy Texas Instruments, Inc.

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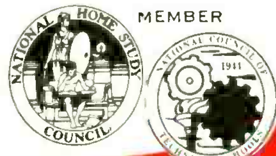

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News Briefs

SPACE GUIDANCE, Doppler navigation and coded communications are among the possible applications of the first portable maser oscillator, announced by the Polytechnic Research and Development Co. of Brooklyn, N. Y. The fundamental principles of the maser were described in RADIO-ELECTRONICS, June, 1955.

The 20-pound unit is a sealed, ammonia type oscillator which generates a 23.8701294-kmc signal. Its stability exceeds one part in a billion.

A device for recirculating ammonia back to its reservoir after 50 hours of operation eliminates the need for auxiliary pumping equipment. The high vacuum essential to the system is maintained by using a getter-ion tube, which flashes periodically to remove the residual and rare gasses. Stability by the resonant cavity is assured by a temperature control system.

FIVE NEW TV STATIONS reinforce the nation's networks this month:

WETV, Atlanta, Ga.	30
KTVU, Oakland, Calif.	2
KDUH-TV, Hay Spring, Neb.	4
WBPZ-TV, Lockhaven, Pa.	32
WSUR-TV, Ponce, Puerto Rico	9

WETV is an educational station. WSUR-TV, Ponce's second TV station, is an affiliate of San Juan's WAPA-TV, channel 4.

Call letters have been amended:

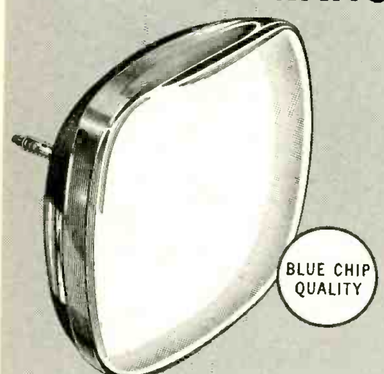
WECT, Wilmington, N. C. (formerly WMFD-TV)	6
KOCO, Enid, Okla. (formerly KGEO-TV)	5

Our March issue reported new call letters, WNEP-TV, for WARM-TV, Scranton, Pa., channel 16. WNEP-TV is the result of a corporate merger between WARM-TV and WILK-TV, Wilkes-Barre, Pa., channel 34. The latter station will temporarily remain on channel 34 as a satellite.

Our total of US operating stations is now up to 539 (444 vhf and 95 uhf). Of these, 31 are noncommercial.

RADAR NAVIGATORS are scheduled to go into operation in the New York Air Traffic Control Area. Made by the Decca Radar Navigator Co., London, England, the installation will be used initially by New York Airways helicopter service. However, it may develop into a test of the system to see if it can solve the air traffic-control problem.

The system provides area coverage particularly suited to helicopter service and does not confine pilots to main air lanes. The basic unit of one master and three slave stations, placed 70 miles apart, sends up a continuous pattern of



radio waves which gives the pilot a reference grid by which to navigate.

NEW STEREO DISC system was announced by CBS. Press time was too early to permit learning details, which were to be described at the Institute of Radio Engineers' convention in New York City, by Peter Goldmark, William Bachman and B. B. Bauer, but it was understood that it would resemble the Westrex system.

DEAF MAN HEARS AGAIN thanks to a combination of surgery and electronics. According to *Press Medicale* (Paris, France), when tumors blocking his ears were removed, the hearing structure was also destroyed. A miniature coil was imbedded in his ear, with one end connected to the hearing nerve. A separate unit containing a microphone, amplifier, and large coil is used as external equipment. Audio signals fed to the large coil induce electric currents in the coil attached to the hearing nerve.

The patient can now distinguish some words, although sounds he hears are said to be distorted and metallic.

AUTOMATIC FACTORIES of the future were foreshadowed in a recent demonstration of the *Digitape* electronically controlled metal-parts production line. The new technique was shown to a large press delegation by Hughes Aircraft Co. at Los Angeles.

The Digitape technique arranges electronically controlled machines to perform operations in sequence, thus turning out a complete part that may require several operations of different types. The battery of machines demonstrated consisted of a milling machine, a combination drill which alone permits selection of any of 20 drill sizes and a boring machine for larger holes.

The electronic portion of the system consists of computerlike elements using transistors and diodes, and is actuated by punched tape. The tape is automatically switched from machine to machine during the sequence of operations, so that work can be started on a new production run without waiting for all operations to be finished on the last piece of the old run.

This flexibility combined with automatic sequencing is precisely the new and essential feature of this technique. Electronically controlled single machines have been used, and the complete automatic fabrication of a single part is possible by mechanical means, using a large number of machines, each performing a single operation. The new system has two main and immediate advantages. The first is its great flexibility, permitting it to perform a large number of operations without the expensive tooling up that at present makes short runs so expensive. Thus small numbers of parts or even a single experimental item may be made economically. The second is the great saving of time in fabricating small numbers of parts, which would normally progress very slowly through a machine shop. A third and very important advantage is that spare-parts inventories can be cut down drastically. Instead of holding a large stock of rarely called-for repair parts, the tape can be stored and a new part machined whenever needed.

Calendar of Events

Western Joint Computer Conference, May 6–8, Ambassador Hotel, Los Angeles, Calif.

National Aeronautical & Naval Electronics Conference, May 12–14, Dayton Biltmore Hotel, Dayton, Ohio.

Spring Assembly Meeting of Radio Technical Commission for Marine Services, May 13–15, Benjamin Franklin Hotel, Philadelphia, Pa.

1958 Electronic Parts Distributors Show, May 19-21, Conrad Hilton Hotel, Chicago, Ill. RADIO-ELECTRONICS and the GERNSBACK LIBRARY will exhibit in Room 601. (This is a closed show for manufacturers, representatives and distributors.)

EIA Conference on Maintainability of Electronic Equipment, May 27–28, University of Pennsylvania, Philadelphia, Pa.

Armed Forces Communications and Electronics Association's Show, June 4–6, Sheraton Park Hotel, Washington, D. C.

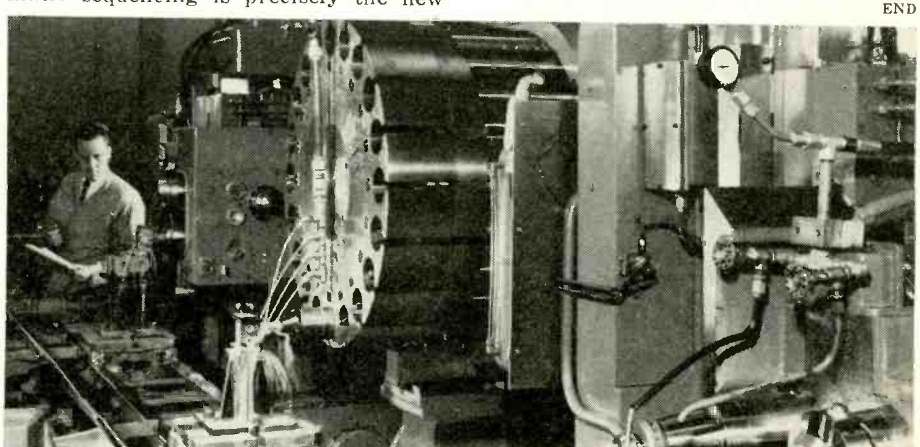
National Symposium on Production Techniques, June 5–6, Hotel New Yorker, New York, N. Y.

Southwest High Fidelity Show, June 6–8, Shamrock Hilton Hotel, Houston, Tex.

National Convention on Military Electronics, June 16–18, Sheraton Park Hotel, Washington, D. C.

French Electronic Components Show, June 20–26, 23 Rue de Lubeck, Paris.

END



The electronically controlled production line. At left is the milling machine: center, the drill, and foreground, the boring machine.

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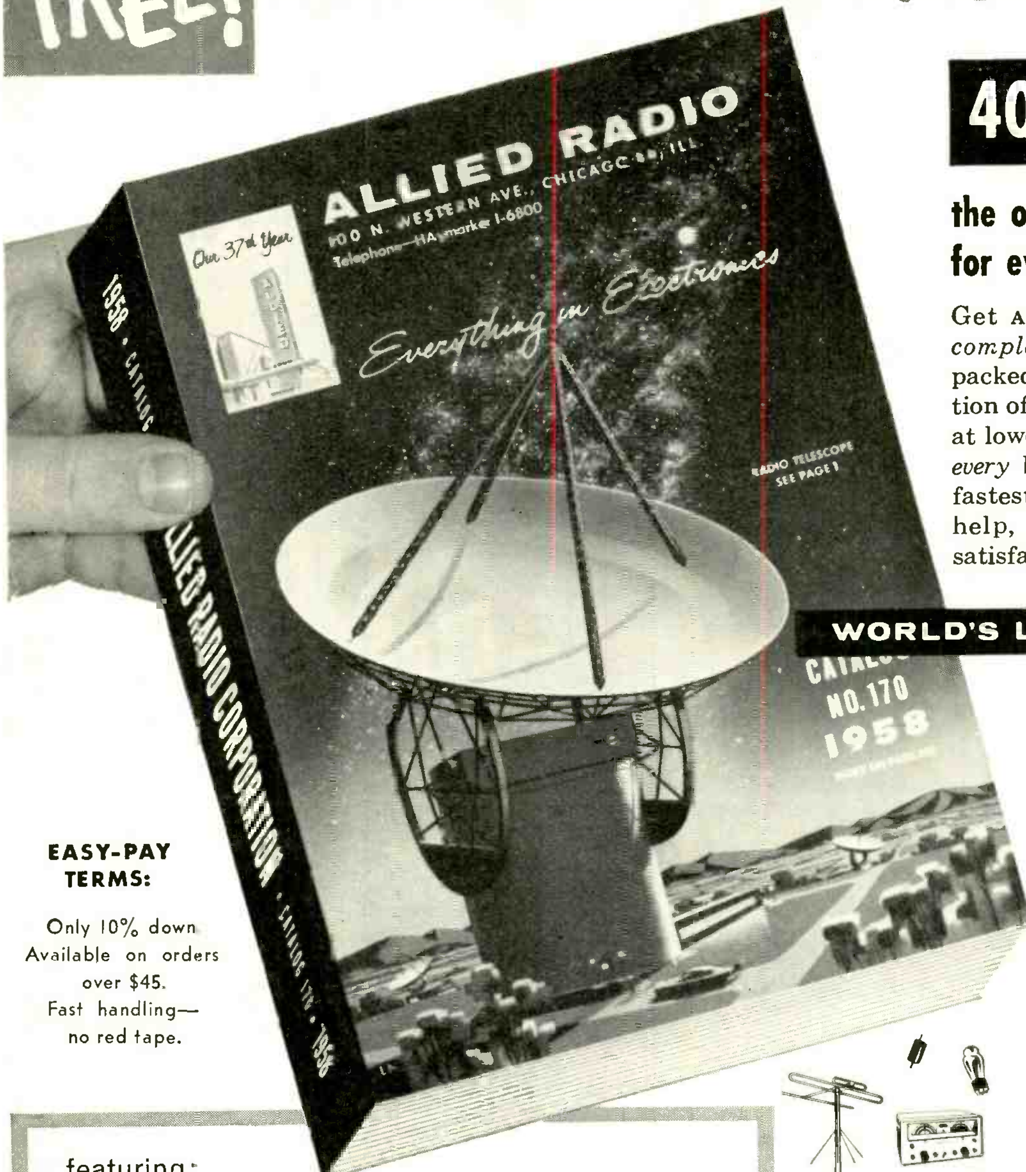

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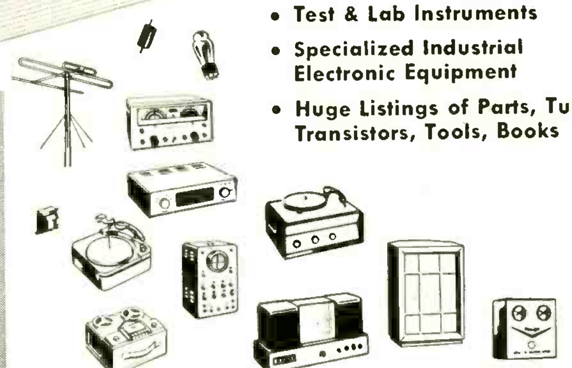

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Correspondence

LET'S STOP PAY TV

Dear Editor:

During the four years I have subscribed to RADIO-ELECTRONICS I have read a number of interesting and entertaining discussions in the Correspondence column. Until the pay TV issue came along I have never entered the ring. However, this is something I cannot overlook.

Television is our main entertainment facility at home. The programs we watch are being paid for by the advertisers and in turn by us. Then, too, we have to buy the set. Why should we be deprived of much of this entertainment? Why not stop this corruptive idea, which would seriously injure the blessings of our democratic way of life?

I suggest that you attach a petition to the next issue of RADIO-ELECTRONICS demanding legal action against pay TV on the behalf of the readers. I am confident that at least 95% of your readers would sign such a petition. This problem concerns us and we must solve it. Let's do it now before it gets later than you think!

M. CIKETIC

Los Angeles, Calif.

JUST FIX IT

Dear Editor:

The article "Do You Do a Maximum or Minimum Job" by Art Margolis in the December, 1957, issue certainly needs some honest clearing up. Some of these writers are trying to teach their customers the gentle art of repairing their own sets while fixing them and apologizing for each tube, resistor, dead rat or what-not they replace. I am not in the habit of running to my customers and saying, "Look, mighty sir, this tube has a silvery, pink or green glow and do you, august sir, agree to a new tube which I will guarantee for ever and ever!"

My customers let me do my work and I tell them nothing except that their set is economically beyond repair or that there may be some abnormally high fee necessary and I would like their OK to go ahead with the job.

For years I have given my customers an honest estimate of charges for work to be done. If they don't want the set repaired, they pay me for the estimate. I never worry about the customer who doesn't want to pay more than a couple of dollars to jack up his set and slip a new chassis under it. They generally return to me later, and of course sadder, and then they are my customers.

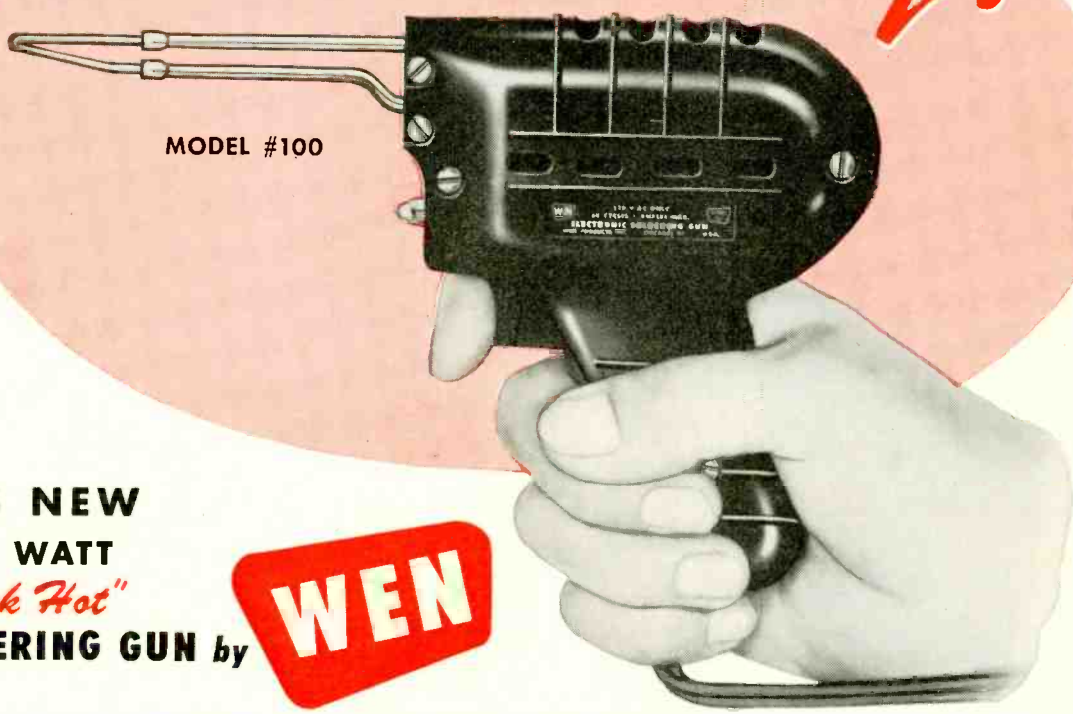
I do not do cheap jobs. It is the best

(Continued on page 14)

SERVICE MAN — SALESMAN — DEALER — JOBBER
HOME WORKSHOPPER — PROFESSIONAL REPAIRMAN

THEY ALL SAY

It's a Honey!



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way to lose a customer you don't really want. I repair a set the way I know how or nothing doing. I haven't lost a thing by doing this and some of you boys who are afraid of losing two-bit customers can chew on this for a while.

Please have enough faith in your professional service to the public, to let them remain the public. They have their job and you have yours. If repairing radio and TV sets were so simple, they wouldn't need you in the first place, and wouldn't have called.

Clearwater, Fla. HOWARD L. NOWRY

FAST-MOVING ELECTRONICS

Dear Editor:

Here are two indications of how swiftly progress in transistor development is being made.

In my article "More About Transistor Types," in the November, 1957, issue, I stated that double-diffused transistors were not yet commercially available. No sooner had that issue hit the stands than Charles Clough of Texas Instruments (TI) wrote to say that since the article was written TI had introduced four models of "diffused-junction silicon transistors" which he said were actually double-diffused.

In the December issue, readers noted my prediction (page 109) that the high-frequency transistor of the foreseeable future would be a micro-alloy thin-base unit. In that same issue (page 6) you may have noticed this prediction reduced to fact. Philco has introduced just such a transistor, which they call the MADT model.

In this field you have to keep running just to stand still!

Cambridge, Mass. PAUL PENFIELD, JR.

WHY WIND COILS?

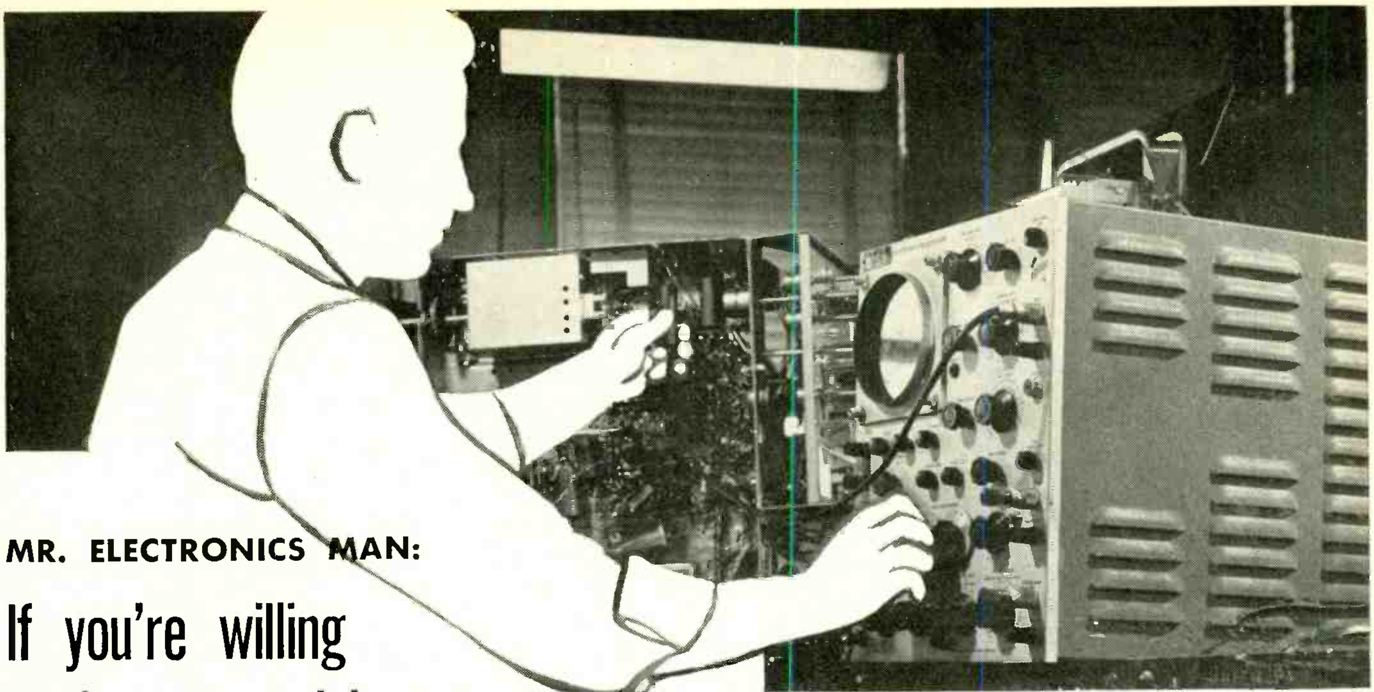
Dear Editor:

Why is it that most authors of construction projects have an aversion to using commercially available coils? In most of the projects in your magazine there is the necessity for winding at least one coil.

Looking at the practical side of these construction projects, it seems that the majority of people who build them would prefer using available coils. Using the article "Vanguard 108" by Richard Graham in the January, 1958, issue as an example, how many people have a roll of No. 16 tinned or No. 30 enameled wire? Few, if any. To wind these coils, which require only a few inches of the specified wire, the builder must purchase a roll of several feet of the wire. This is expensive and the chances are that he'll never need the wire again. Oh yes, I forgot to mention the necessity of obtaining the specified coil forms.

With the thousands of commercially available coils on the market, I see no reason why the coils in the Vanguard converter could not be ready-made.

(Continued on page 16)



MR. ELECTRONICS MAN:

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CORRESPONDENCE *(Continued from p. 14)*

I have been building magazine projects for many years and when I see a home-wound coil, I pass it up.

Chicago, Ill. KEN GREENBERG

(The J. W. Miller Co. has a very complete line of coils and transformers on the consumer market, but their catalog does not list coils that may be used as exact replacements for L1, L2, L4, L5 and L6 in the Vanguard 108. As frequency goes up, the coil's Q becomes increasingly important. Also, coils with the required Q and inductance are not available with taps or additional windings as needed. You may consider that the transformer formed by L5 and L6 could possibly be replaced by a shortwave antenna coil designed for 6–10 mc or so. This would work, but then you would have to tune it with a capacitor of around 200 $\mu\mu$f or more. The high ratio of capacitance to inductance would not permit the user to get optimum performance from the combination.

J. W. Miller type 1454 and 1456, 88-108-mc antenna and oscillator could have been used for L1 and L4, respectively, with slight modifications in the circuit. There is one drawback. These coils are not listed by many mail-order catalogs and are not stocked by many radio parts suppliers. Most retailers are reluctant to order single units such as this and the manufacturer doesn't sell retail.

We feel that it is doing you and other readers a disservice to specify an item when we know that it is not universally available and that many readers will have trouble in getting it. Similarly, why specify a coil that may cost $5 when you can wind it for about one-tenth the price.—*Editor*)

WHERE DO YOU TURN?

Dear Editor:

What is happening to the radio parts retailing industry? I've been an active experimenter and constructor for over 25 years and I've never seen conditions more discouraging. Sales personnel don't know what they have in stock nor are most of them even remotely aware of the characteristics or applications of even the most common components. They are only interested in pushing TV and radio replacement parts.

Manufacturers are continuously introducing new components of interest to the experimenter, but retailers and distributors are not cooperative. Try and get a photocell, a set of all-wave coils for a receiver, or a sensitive relay. Most manufacturers don't sell retail and retailers won't accept orders for single units.

Recently I decided to build the Twin-Coupled Amplifier from details in the November, 1957, issue. I went from store to store trying to obtain any of the four brands of output transformers specified for the amplifier. All stores carried products made by at least two of the four manufacturers, but none

(*Continued on page* 20)

PRINTED CIRCUITRY IS HEAD OF ZENITH'S RESEARCH DEPT.*, THERE'S

NO PRINTED CIRCUITRY IN ZENITH TV CHASSIS

*Even though Dr. Alexander Ellett, head of Zenith's research department, is recognized as the daddy of printed circuitry through his work on radio proximity fuses, still Zenith uses no printed circuitry in its TV chassis because it means more service headaches and often causes service delays.

QUALITY BY

ZENITH®

CORRESPONDENCE *(Continued from p. 16)*

stocked the required units. In some cases, the clerks disclaimed any knowledge of the specific parts. Others admitted that they had seen manufacturers' circulars describing the transformers, but would not accept an order.

I started telephoning manufacturers' sales representatives. The usual answer was that "ABC Electronics Distributors carries our complete line. If they don't have the type transformer you need, they'll order it from us." The distributors named did not have the item in stock, but would order it if the order was placed through a local retailer. Some distributors claimed that the desired transformer was a fast-moving item and that they had sold quite a few to retailers, but couldn't tell me where I could lay my hands on one. Only through luck and persistence was I finally able to locate the necessary pair of transformers.

If I'd known the trouble I was in for, I never would have considered the project. In the future, I'll submit the complete parts list to a retailer and will place the order only on an all-or-nothing basis.

New York, N. Y. E. WILHELM

NOTE TO TV DXERS

Dear Editor:

A new publication, available from the Government Printing Office, Washington 25, D.C., may be of interest to serious TV dxers. Titled "Broadcasting Stations of the World, Part 4," it contains information about FM and TV stations outside the USA. It gives frequencies, power and other technical data. Information is arranged by country and also by frequency. The printing office number is: PR 34.659:-957/Pt. 4. Its price is 75 cents.

Many other books and pamphlets about radio, TV, and electronics are available from the Government Printing Office and a request will bring recent lists to anyone interested.

ROBERT W. WILLIAMS
Fairfield, Conn.

LIKE THAT AMPLIFIER

Dear Editor:

I would like to take this opportunity to thank you for the wonderful amplifier in RADIO-ELECTRONICS, November, 1957 ("Twin-Coupled Amplifier," by Norman Crowhurst).

I have completed the unit and have had it in constant use for about six weeks. I believe it to be as clean sounding an amplifier as I have heard. I find its 15 watts more than ample and its sound second to none. It has completely amazed some of the local dealers. I hope that you will print an article on a similar amplifier with greater power. This is the first piece of electronic equipment that I have ever built from a schematic and you can imagine how happy and proud I was at my success and to acquire such an instrument.

GEORGE E. MOCK
Indianapolis, Ind. END

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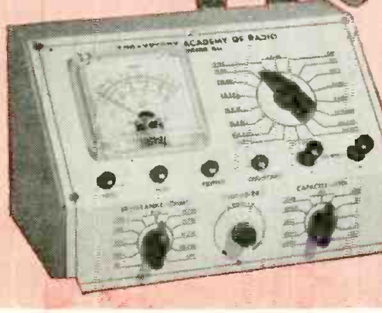

You build the new Sprayberry tester —a complete 18-range Volt-Ohm-Milliammeter test meter.

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★ ★ ★ ★ This great industry is begging for trained men . . . to step into good paying jobs or a profitable business of their own! Our new plan opens the doors of Radio-Television wide to every ambitious man who is ready to act at once!

Men by the thousands... trained Radio-Television Service Technicians...are needed at once! Perhaps you've thought about entering this interesting, top paying field, but lack of ready money held you back. Now—*just $6 enrolls you* for America's finest, most up to date home study training in Radio-Television! Unbelievable? No, the explanation is simple! We believe Radio-Television *must* have the additional men it needs as quickly as possible. We are willing to do our part by making Sprayberry Training available for less money down and on easier terms than ever before. This is your big opportunity to get the training you need...to step into a fine job or your own Radio-Television Service Business.

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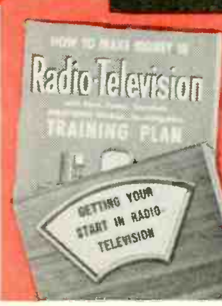

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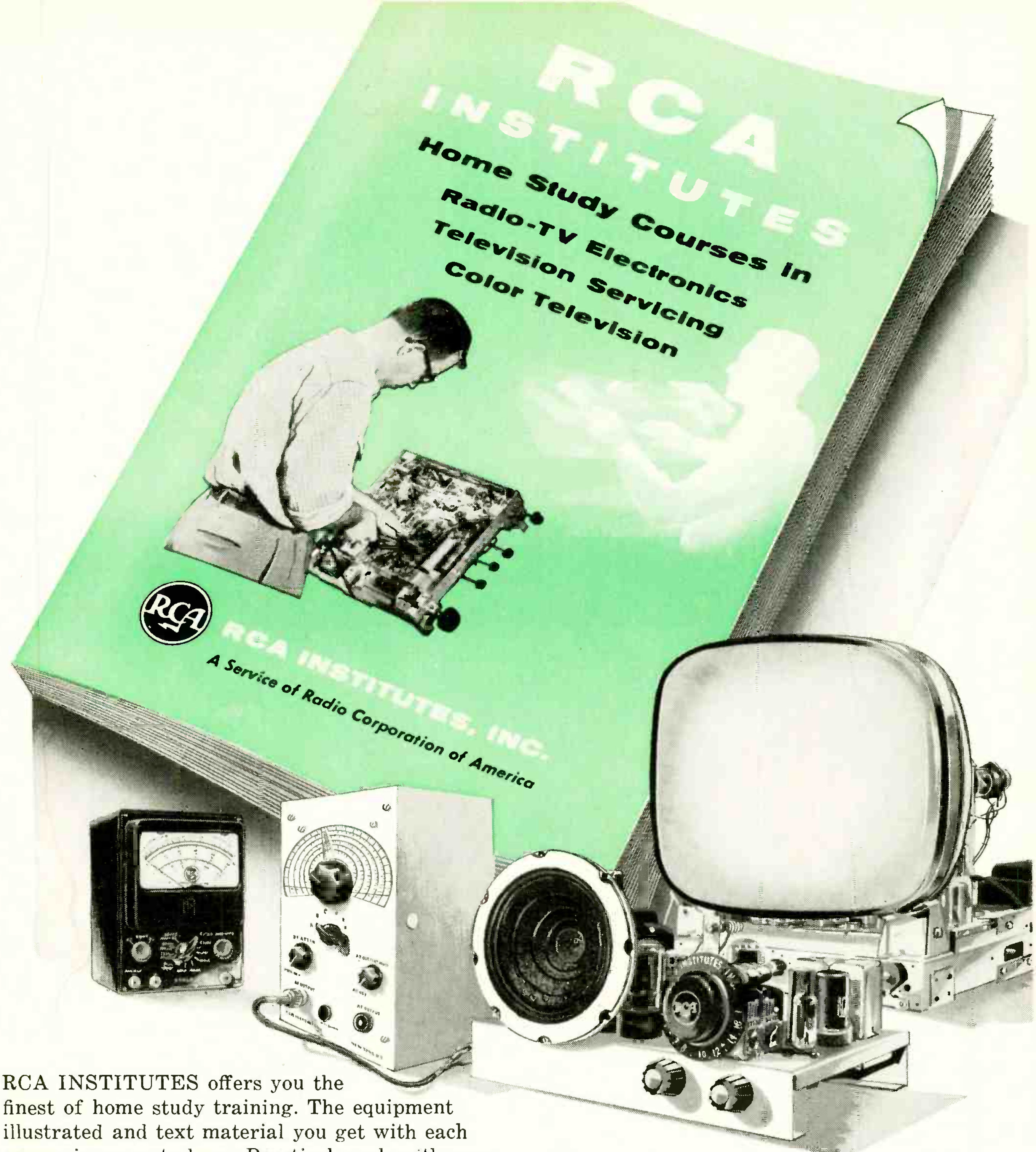
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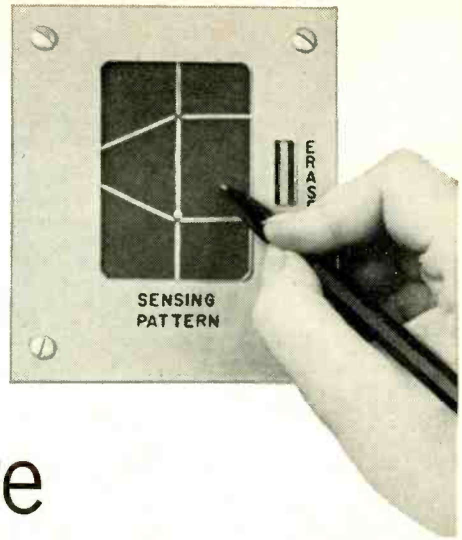
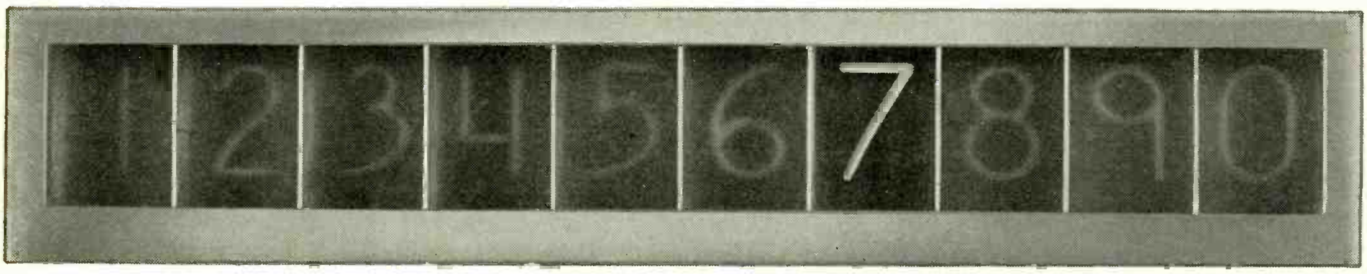


and read it here



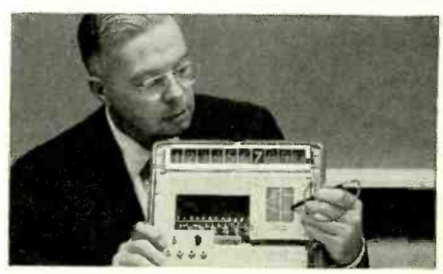
on new Bell Labs machine

A new device invented at Bell Laboratories "reads" a numeral while it is being written and instantly converts it into distinctive electric signals. The signals may be employed to make a numeral light up in a display panel, as above, or they may be sent to a computer or to a magnetic "memory" for storage.

The writing is done with a metal stylus on a specially prepared surface. Two dots, one above the other, are used as reference points. Seven sensitized lines extend radially from the dots. Transistorized logic circuits recognize numerals according to which lines are crossed.

The concept of a number-reader has interesting possibilities as a new means of communication from humans to machines. For example, in an adjunct to a telephone, it might provide inexpensive means of converting handwritten data into signals which machines can read. The signals could be transmitted through the regular telephone network to a teletypewriter or computer at a distant point. In this way, a salesman might quickly and easily furnish sales data to headquarters, or a merchant might order goods from a warehouse.

Modern communication involves many more fields of inquiry than the transmission and reception of sound. The experimental number-reader is but one example of Bell Telephone Laboratories work to improve communications service.



Tom Dimond, a B.S. in E.E. from the University of Iowa, demonstrates an experimental model of his number-reading invention. A similar device can also be made to read alphabetical characters. Small size and low power requirements result from transistor circuitry.

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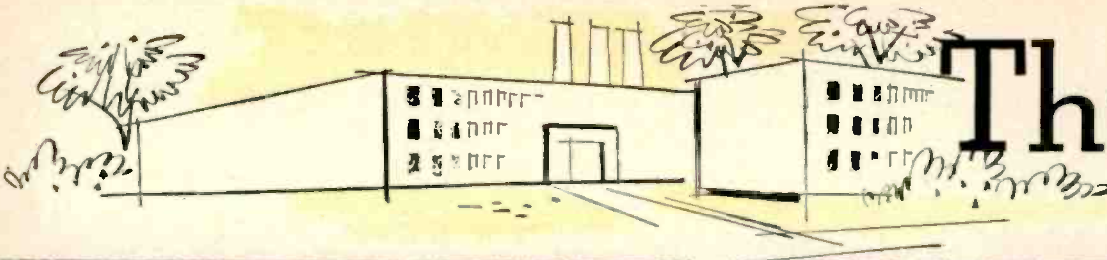

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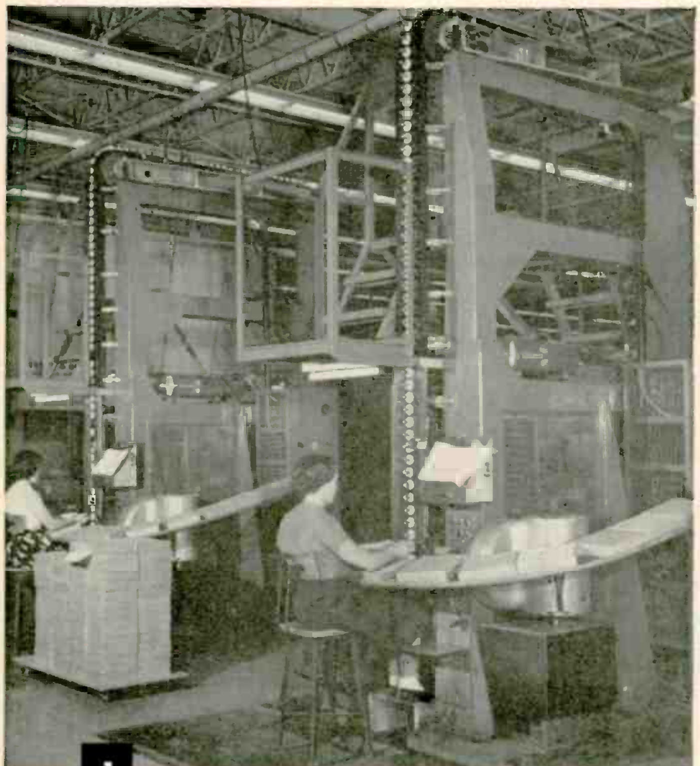
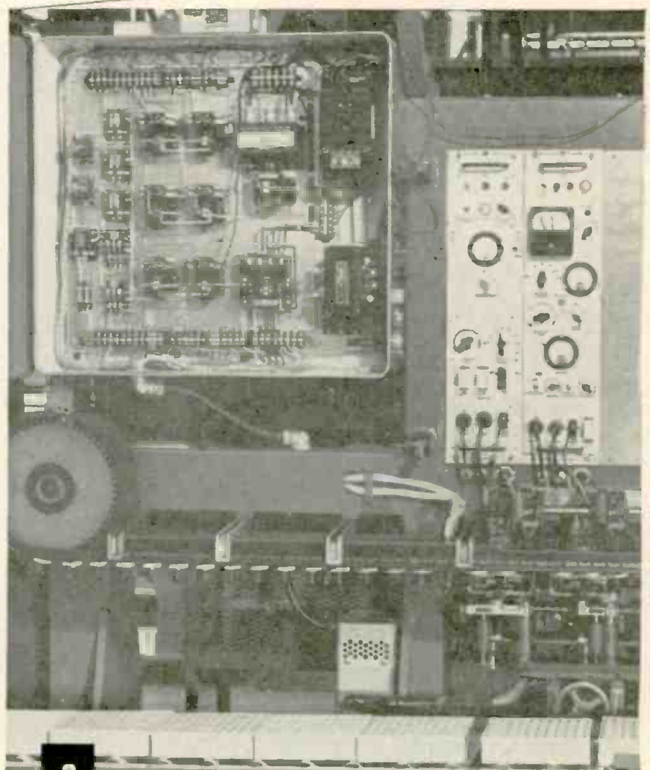
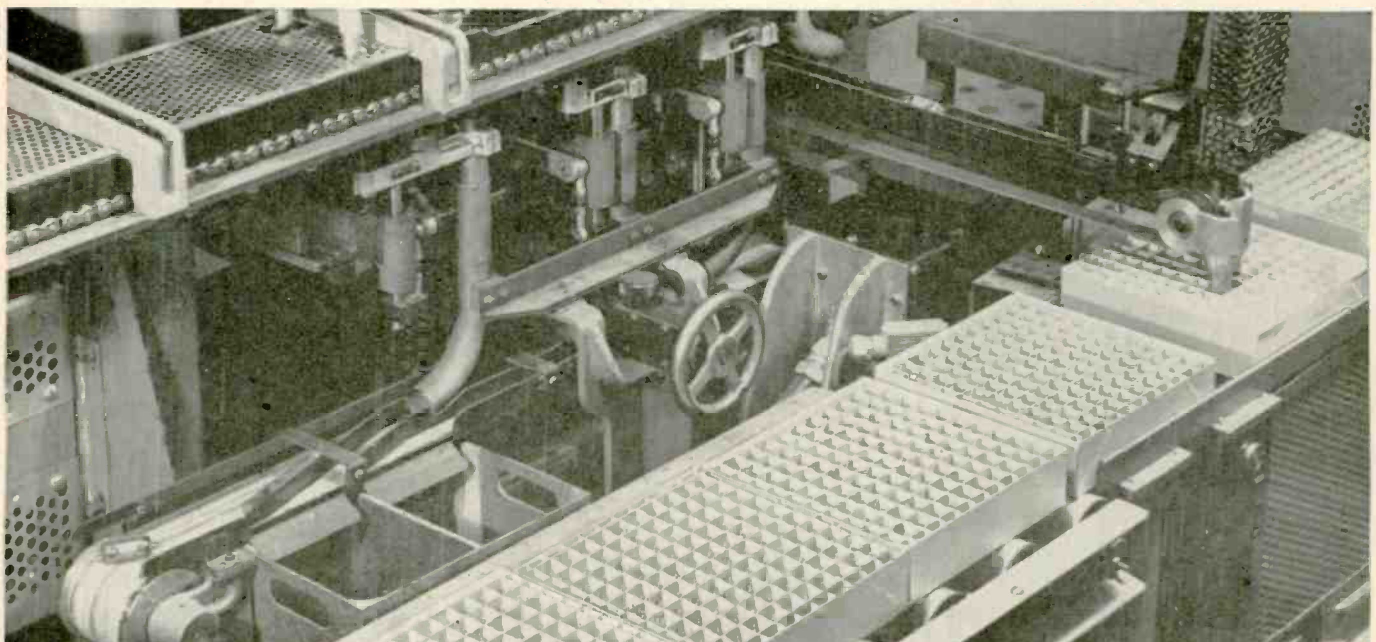


1 Overall view of two automatic testers highlights "chain belt" where tubes are preheated in preparation for tap tests. Operator loading tubes checks pins for straightness.

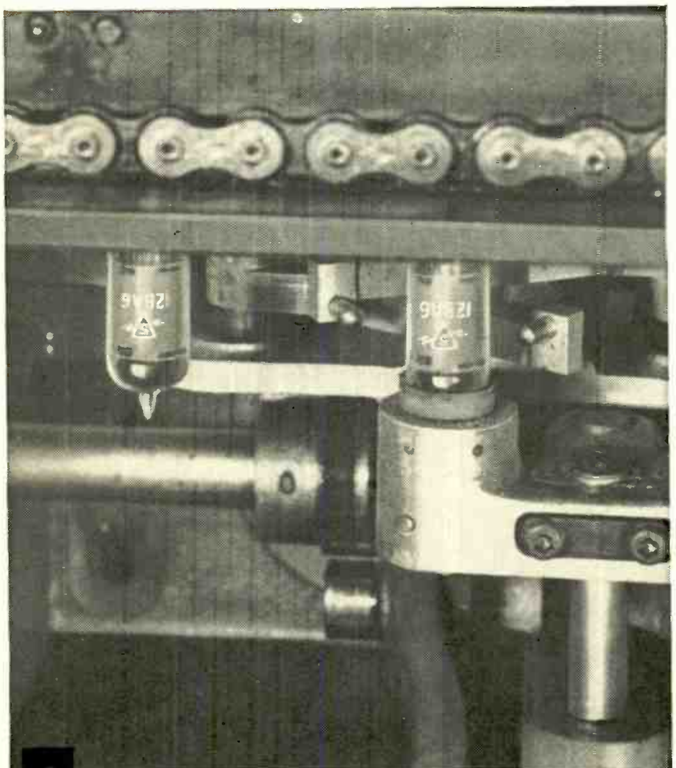


2 Electronic brain of the tester is designed by Sylvania so that any tube type can be tested simply by plugging in its proper adapter (about the size of a pack of cigarettes).



4 —Automatic unloading of "good" tubes into cartons comes after all tests have been made and "inoperatives" separated. Rejects are dropped to conveyor belt, collected into bins, and scrapped.

Sylvania Williamsport



3 Close-up of tap test position. Here each tube is automatically tapped with 100 g (100 times gravity's force). Tube is tapped in two positions in two planes 90° apart—first for opens; second for shorts.

5 —*Testing the tester.* As a constant check on the accuracy of the automatic tester—samples from each lot tested, are retested on similar equipment used as a standard. Records are kept of all tests serving as data to feed back to design, manufacturing, and quality-control groups.

—where automation is at work to keep your tube stock free from "inoperatives"

FOR every four thousand tubes tested at Sylvania's plant in Williamsport, Pa., not more than one "inoperative" will escape Sylvania's automatic testing "dragnet" or reach your shelves.

Like Williamsport, all major tube-finishing plants are equipped with automated testers designed and built by Sylvania. Automation makes it possible to test each tube individually and more efficiently for *opens, shorts, leakage* and *emission*. As a result, Sylvania maintains the industry's lowest percentage of inoperatives. For you this means more efficient and profitable servicing—bothersome, time-consuming returns are kept to an absolute minimum.

Why not try using Sylvania exclusively as many dealers do? You'll find that's the best way to profit from Sylvania's exclusive testing program.

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Not when you buy Raytheon TV and Radio Tubes

First of all, Raytheon has no factory TV-radio service organization that competes with you for profitable servicing business — you're not helping a "competitor" when you buy Raytheon Tubes.

Then, too, when you buy Raytheon TV and Radio Tubes you get the finest quality tubes money can buy — tubes designed for top performance in all makes and models of receivers. Raytheon does not manufacture sets and therefore must make tubes that will meet the rigid performance requirements of the many sets produced — tubes ideal for all replacement work.

And last, but by no means least, when you buy Raytheon Tubes you deal with local *independent* tube distributors who are anxious to give you the best in service and technical assistance. They are eager to supply you with the hundreds of helpful shop and sales aids Raytheon makes available for you—helps that make your job easier, more efficient and more profitable.

Make all of your tube dollars work for you — always ask your Tube Distributor for Raytheon quality TV and Radio Tubes.

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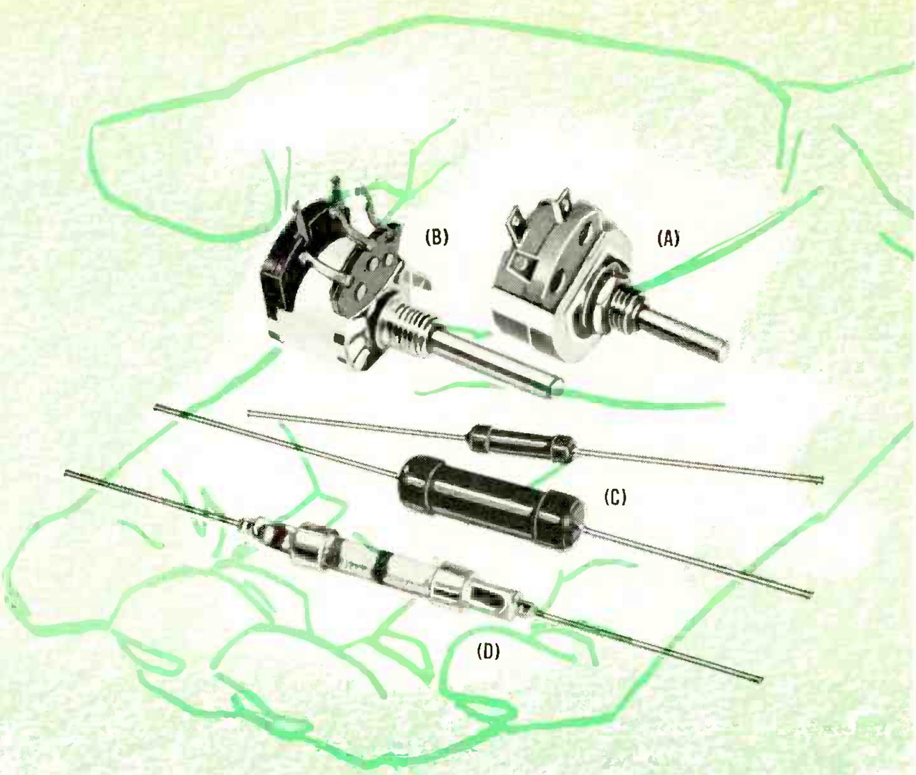
Raytheon makes all these — Receiving and Picture Tubes, Reliable Subminiature and Miniature Tubes, Semiconductor Diodes and Transistors, Nucleonic Tubes, Microwave Tubes.

RAYTHEON

Excellence in Electronics



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(A) Series 49 wire-wound potentiometer. Only 25/32" dia. Molded phenolic casing. With or without switch. Single or dual. 1.5 watt rating. 1 to 20,000 ohms. Also Series 48 composition-element. 5/8" dia. 0.2 watt rating. Linear, 200 ohms to 5 megohms; tapered, 1500 ohms to 2.5 megohms. With or without switch. Single or dual.

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*Reg. U. S. Pat. Off.

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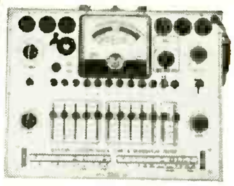

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KIT $69.95 WIRED $109.95

COMPLETE with steel cover and handle.

SPEED, ease, unexcelled accuracy & thoroughness. **Tests all receiving tubes** (and picture tubes with adapter). **Composite indication of** Gm, Gp & peak emission. **Simultaneous sel** of any 1 of 4 combinations of 3 plate voltages, 3 screen voltages, 3 ranges of continuously variable grid voltage (with 5% accurate pot). **New series-string voltages:** for 600, 450, 300 ma types. **Sensitive** 200 ua meter. **5 ranges meter sensitivity** (1% shunts & 5% pot). **10 SIX-position lever switches:** freepoint connection of each tube pin. **10 pushbuttons:** rapid insert of any tube element in leakage test circuit & speedy sel. of individual sections of multi-section tubes in merit tests. **Direct-reading** of inter-element leakage in ohms. **New gear-driven rollchart. Checks n-p-n & p-n-p transistors:** separate meter readings of **collector leakage current & Beta** using internal dc power supply. Deep-etched satin aluminum panel; rugged grey wrinkle steel cabinet. **CRA Adapter $4.50**

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KIT $44.95
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7" PUSH-PULL OSCILLOSCOPE #470
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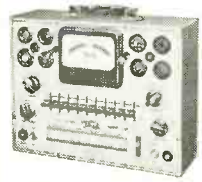
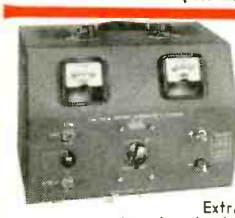


TUBE TESTER #625
KIT $34.95
Wired $49.95
- tests 600 mil series string type tubes
- illuminated roll-chart

Pix Tube Test Adapter $4.50



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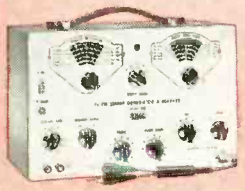
Extra filtered for transistorized eqpt, #1060:
KIT $38.95, Wired $47.95



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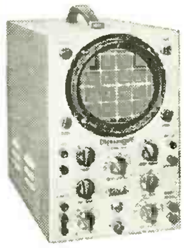
Entirely electronic sweep circuit (no mechanical devices) with accurately-biased **Increductor** for excellent linearity. **Extremely flat RF output: new AGC circuit** automatically adjusts osc. for max. output on each band with min. ampl. variations. **Exceptional tuning accuracy:** edge-lit hairlines eliminate parallax. **Swept Osc. Range** 3-216 mc in **5 fund. bands. Variable Marker Range** 2-75 mc in **3 fund. bands;** 60-225 mc on harmonic band. **4.5 mc Xtal Marker Osc., xtal supplied.** Ext. Marker provision. Sweep Width 0-3 mc lowest max. deviation to 0-30 mc highest max. dev. 2-way blanking. Narrow range phasing. Attenuators: Marker Size, RF Fine, RF Coarse (4-step decade). Cables: output, 'scope horiz., 'scope vertical. Deep-etched satin aluminum panel; rugged grey wrinkle steel cabinet.



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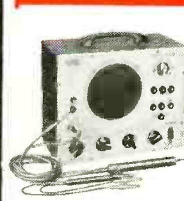
• Features DC Amplifiers!

Flat from DC-4.5 mc, usable to 10 mc. **VERT. AMPL.:** sens. 25 rms mv/in; input Z 3 megs; direct-coupled & push-pull **thruout;** K-follower coupling bet. stages; 4-step freq-compensated attenuator up to 1000:1. **SWEEP:** perfectly linear 10 cps-100 kc (ext. cap. for range to 1 cps); **preset TV V & H positions;** auto. sync. ampl. & lim. **PLUS:** direct or cap. coupling; bal. or unbal. inputs; edge-lit engraved lucite graph screen; dimmer; filter; bezel fits std photo equipt. High intensity trace CRT. 0.06 usec rise time. Push-pull hor. ampl., flat to 400 kc, sens. 0.6 rms mv/in. Built-in volt. calib. Z-axis mod. Sawtooth & 60 cps outputs. Astig. control. Retrace blanking. Phasing control.



Sep. hi-gain RF & lo-gain audio inputs. Special noise locator. Calibrated wattmeter.

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DELUXE MULTI-SIGNAL TRACER #147

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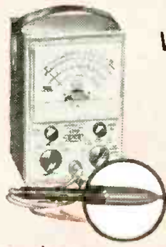

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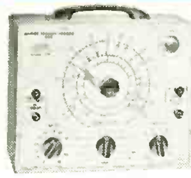

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TRANSISTOR TRENDS

. . . Transistor Evolution Has Only Begun . . .

BEFORE 1948—a brief decade ago—the transistor was unknown. Electronics, with a few exceptions, was based chiefly on the vacuum tube, which in various ways supplied us with the indispensable stream of electrons for our instrumentation. Free "hot" electrons were generated in incandescent filaments or heated cathodes, which had their initial start in the Edison effect in 1883.

The transistor ushered in a new and revolutionary era which in many ways repeated—and often excelled—the history of the vacuum tube. It did away with heated filaments and cathodes and, consequently, with the cumbersome and uneconomic heating currents. Instead of the vacuum tube's "hot" electrons, the transistor works with free, "cold" electrons.

Nor does the transistor require the high voltages needed by the vacuum tube for its best functioning. Less than 15 volts is required in the average transistor radio set, as contrasted to the 115 to 300 volts of the vacuum-tube receiver.

Great as the transistor's progress has been to date, its evolution has but begun. In the beginning, great difficulties in manufacture were encountered. Over 80% of all assembled transistors were rejected. This trouble has now been mostly overcome and the industry is settling down to mass production with smaller and smaller percentages of rejections.

In 1955, when we produced only 12¾ million transistors—against 28¾ million in 1957—the present writer in the August, 1955, editorial ventured the opinion that 50c (retail) transistors were on the horizon. (Vacuum tubes sold for 33c each wholesale in 1955.) It is thus not surprising that recently a high-placed spokesman of the industry predicted that 25c transistors are now a distinct possibility.

So far transistor production lags far behind vacuum-tube manufacture. The reasons for this great disparity are simple. Vacuum tubes wear out and break. Transistors are most rugged and so far no one has determined how long they will last. A probable life may be 50 years. Hence, there may not be much of a replacement market for generations. Further, transistor radios are still in the luxury class—they cost almost twice as much as comparative vacuum-tube sets. Why? Being, as a rule, so much smaller, they are more tedious to assemble and the miniature parts are more expensive, as is the labor. This, however, is a transitory stage, familiar to the industry. The day will come when good six- to eight-transistor sets will sell for around $10—not this year or next, but in the foreseeable future. The reason for this forecast is, of course, automation–mass production.

One of the reasons for the more than 100% manufacturing increase of transistors last year is found in the flood of new types. In 1956 there were only about 275 transistor types. Now there are over 750! And this rapid increase will continue for a long time.

New uses for transistors are found daily. Research in practically every endeavor and art requires advanced and specialized types. This trend is increasing.

Take, for instance, space electronics. One cannot well imagine a modern rocket or a satellite without a vast array of many types of transistors—all built with an eye to shockproof ruggedness, minimum weight and minimum dimensions.

From outer space to a defective beating heart may be a far jump, but it demonstrates the ubiquity of the transistor. Recently, Dr. Folkman of Children's Medical Center and Dr. Watkins of Harvard Medical School visualized how a defective heart block could be corrected, thus saving the patient's life. They knew that a blocked ventricle could be stimulated and made to contract electrically by applying electrodes to it. An electronic consultant, C. F. Vanderschmidt, constructed a tiny R-C-coupled, two-transistor amplifier. It amplifies the minute 5-millivolt auricular pulse into an 0.5-volt pulse required to contract the ventricle.

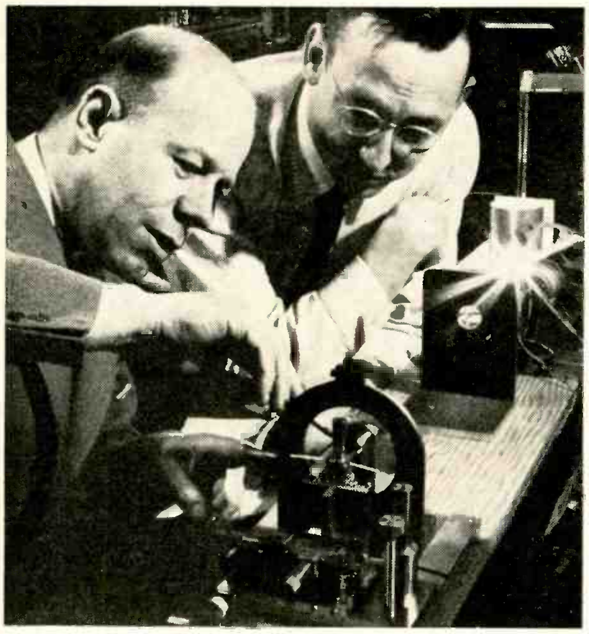
A dog with a heart block was used for the first experiment. He was operated on and electrodes sewn to the right auricle and right ventricle. Special insulated stainless steel wires connected the heart electrodes to the amplifier, which in turn was firmly attached to the dog's back. His recovery was uneventful and rapid. Subsequent improvement in technique gave affected dogs a life of several months. It probably will not be many years before humans with heart blocks, instead of resting in their graves, will be walking the streets with tiny transistor amplifiers firmly strapped to their chests.

Despite the 750 existing transistor types, here are a few important needed ones, which are distinct future possibilities. Let us remember—the transistor has only begun.

Atomic Transistors, frequently mentioned in this magazine, are technically feasible and have been demonstrated in the laboratory. Such a type, when finally evolved commercially, will make radio and television sets independent of batteries and outside current supply. They will last for many years without attention. They will all be truly portable and can be used and operated anywhere. Their upkeep will be minimal.

Transistor Picture Tubes. Today's television scanning tubes are of the cathode-ray variety. To function, they must use a high voltage (15,000 and over) and the electron beam must oscillate rapidly from side to side. In the future, it is almost certain that the huge television picture tube of the present will not prevail. Already there are a number of patents for thin and flat picture tubes. All of these, however, still require high operating voltages.

We can imagine the future flat–thin TV picture tube, atom-transistor equipped in which electroluminescence is used to produce the image. The entire screen is made up of several hundred thousand electroluminescent points, all "steered" by transistors. The latter, being atomic, supply a sufficient current to light the screen vividly. There will be no moving ray, no motion at all. Only luminiscent points, lighting, extinguishing as necessary to create the image. Such a TV receiver will be truly portable, even in a large screen size. Self-powered, it can be used anywhere within reach of a TV transmitter. —*H.G.*



Testing the alignment of phototransistors used to "read" information stored by electronic computers, are Dr. J. N. Shive (left), who developed the phototransistor and Dr. R. M. Ryder, both of Bell telephone Laboratories.

end of the bar. By repeated sweeps, undesirable impurities can be reduced to less than 1 part in 1,000,000,000. The technique takes advantage of the fact that the solubility of impurities in liquid semiconductor material is different from the solubility in the solid.

The importance of the purification process is apparent when you realize that active impurities of as little as 1 part in 1,000,000,000 can affect transistor operation. It is essential that the material be as pure as possible to begin with, so that the desirable properties can be obtained by introducing controlled amounts of the desired impurity.

Throughout the semiconductor development process, efforts were made to improve the frequency range of transistors, both as oscillators and as amplifiers. One approach was to reduce the thickness of the center layer of the sandwich, but certain limitations were encountered. A major step in overcoming these limitations was achieved with the invention of the tetrode transistor[4]. By 1955, this transistor had been developed to the point where it could be made to oscillate at more than 1,000 mc, thus breaking into the microwave region for the first time with solid-state amplifiers.

Operation at such high frequencies was achieved by adding a fourth electrode to the basic junction transistor, plus other refinements. This fourth electrode permitted the center layer of the transistor to be biased in a way that reduced its effective thickness. This, combined with an actual reduction in thickness to less than 0.2 mil, provided operation at ultra high frequencies.

The field-effect transistor

The foregoing discussion has revolved around a particular type of transistor action, namely the injection of charge carriers by a p-n type junction into a thin slice of semiconductor and their collection by another junction. It is also possible to get amplification by other means, as in the field-effect transistor, where a transverse electric field controls the flow of current. A number of such "unipolar" transistors were described by Shockley in 1952[5]. This type of operation may have important advantages; in particular, high input impedance of the order of 10 megohms and the possibility of very high frequency response. Very similar in concept are the "analog" transistor and the spacistor.

A field-effect transistor using an external "gate" is shown schematically in Fig. 3, while Fig. 4 shows a field-effect transistor using a p-n junction to produce a capacitor "gate" within the body of the semiconductor.

Another significant step in high-power and high-frequency operation was the introduction of the p-n-i-p, or "intrinsic-barrier" transistor.[6] This transistor is in essence a club sandwich, in which a layer of comparatively pure material is interposed between two of the layers of a conventional transistor. This layer permits closer control of the stream of charge carriers, isolates input and output areas and reduces the stored energy to make functioning at higher frequencies possible. The increased separation of input and output areas also permits operation at higher voltages than possible with earlier transistors. The intrinsic layer might be compared very roughly with the screen grid in a vacuum tube.

Intrinsic barrier type transistors can provide uniform amplification over bands of hundreds of megacycles, and theoretically units can be made which will oscillate at 3,000 mc. They can also be designed to produce some 3 to 10 times more power than earlier junction transistors at high frequencies.

The surface-barrier transistor[7] represented another step toward high-frequency operation. In this unit, both sides of a thin wafer of germanium are electrolytically etched away until only an extremely thin layer remains. Electrodes are then deposited electrolytically. Because of the very thin base layer, high-frequency operation is possible. This transistor has since been further improved by incorporating a diffused base and by closely controlled alloying of the junctions.

The diffusion technique

In 1954, Bell Laboratories announced a development which has proved to be a major breakthrough in transistor technology — the diffusion technique. Diffusion is a process by which minute amounts of impurities are introduced into a material in a controlled manner. As mentioned previously, one of the limitations in extending the operation of conventional junction transistors to ever higher and higher frequencies is the difficulty of reducing the thickness of the center layer of the transistor sandwich. By introducing impurities in a controlled manner by the diffusion process, this layer can be made as thin as 30/1,000,000 inch.

The diffusion technique[8,9] can be used for other semiconductor devices as well. Among these devices is the Bell solar battery.[10] This battery consists of a thin wafer cut from a single crystal of n-type silicon into which a small amount of boron has been diffused to produce a thin layer of p-type silicon. When illuminated, this cell produces electricity. In direct sunlight, its conversion efficiency may run as high as 11%.

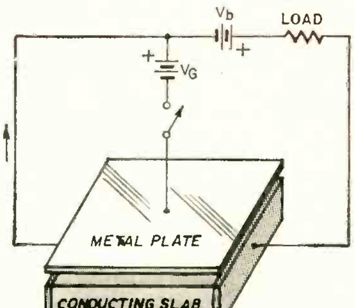


Fig. 3—Schematic representation de- field-effect transistor in a ci through signed to illustrate how cur by applying the slab can be contro metal plate. a voltage to th

[4] R. L. Wallace, Jr., L. G. Schimpf and E. Dickten, "A Junction Transistor Tetrode for High-Frequency Use"; *Proceedings of the IRE*, Vol. 40, p. 1395, November, 1952.

[5] W. Shockley, "A Unipolar 'Field-Effect' Transistor"; *Proceedings of the IRE*, Vol. 40, p. 1377, November, 1952.

[6] J. M. Early, "P-n-i-p and N-p-i-n Junction Transistor Triodes"; *Bell System Technical Journal*, Vol. 33, p. 517, May, 1954.

[7] W. E. Bradley, et al, *Proceedings of the IRE*, December, 1953.

[8] M. Tanenbaum, D. E. Thomas and C. A. Lee, "Diffused Emitters and Bases for Silicon and Germanium Transistors"; *Bell System Technical Journal*, January, 1956.

[9] C. S. Fuller and J. A. Ditzenberger, "Diffusion of Donor and Acceptor Elements in Silicon"; *Journal of Applied Physics*, Vol. 27, May, 1956.

[10] D. M. Chapin, C. S. Fuller and G. L. Pearson, "The Bell Solar Battery"; *Bell Laboratories Record*, July, 1955.

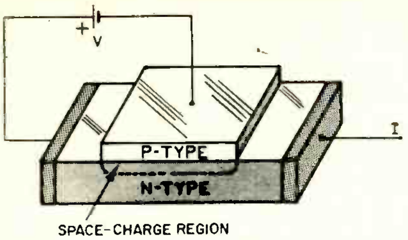


Fig. 4—A field-effect transistor using a p-n junction to produce a "capacitor" within the body of the semiconductor. A voltage that is applied between the p- and n-type material causes a penetration of space charge, creating a region within the body of the n-type material that will not contribute to current flow through the semiconductor.

At present, it appears that the diffusion technique will achieve widespread recognition as a reliable, controllable process for making transistors and many other semiconductor devices. Enough information has been obtained on this process to make it adaptable to mass-production operations. Units have been fabricated which will oscillate and amplify at well over 1,000 mc, and the frequency barriers are continually being forced higher and higher.

The "drift transistor" emphasizes another feature which has importance for high-frequency transistors.[11] By control of the distribution of impurities in the thin central layer, one can obtain a "built-in" electrical field which speeds up the electron stream and thereby makes the transistor somewhat faster. Experimentally, the easiest way to achieve an appropriate structure is by diffusing the base as just mentioned above. Typically, the frequency response improves 10 or 100 times by making the base layer thinner while the built-in field gives a further improvement of the order of 1.5–4 times.

Last year a new device was announced which combines high-frequency operation with high-power output to an extent not previously attained. This new transistor can provide an output of better than 5 watts at 10 mc, either as an oscillator or an amplifier. It has alpha-cutoff frequency of about 100 mc and has produced an output of better than 1 watt at this frequency.

To achieve the combination of high power and high frequency required extensive research and the utilization of many different techniques. The unit employs the basic p-n-i-p type of construction and so takes advantage of the intrinsic-layer idea. Silicon is employed to permit operation at higher temperatures and thus allow greater heat dissipation. Diffusion techniques are used to form the emitter and collector regions. And the electrode areas themselves are kept as small as possible consistent with the desired power-handling capacity. Thus, by combining a number of techniques, both frequency and power barriers have been lifted.

[11] H. Kromer, "Theory of the Germanium Rectifier and the Transistor"; *Zeitschrift Physik*, Vol. 134, pp. 435–50, March 25, 1953.

Electronic computing machines are one of the newest fields that transistors are expected to dominate because of their size, power, speed and reliability. Closely related is the field of automatic telephone switching, which now uses electromechanical switches such as relays but which is expected to go increasingly electronic in coming years. A prominent new device for use here is expected to be the p-n-p-n diode, a four-region transistor switch, invented by Shockley. As now realized in diffusion techniques in silicon, the device in the off condition has a resistance of 100 megohms. When switched on either by a pulse or by a high voltage, its on resistance is only about 2 ohms, with a less than 1-volt sustaining voltage. The device can be switched between these conditions at megacycle rates if necessary.

New fabricating processes

A major problem in fabricating transistors, particularly those intended for high-frequency operation, is attaching leads to the semiconductor material. A significant advance in this field is the development of the thermocompression bonding technique at Bell Laboratories. In this technique, the leads are attached by a combination of temperature, pressure and time. One method that works very satisfactorily in the laboratory is to force the lead against the semiconductor surface with a heated wedge-shaped tool. Neither the temperature nor the pressure is great enough to damage the semiconductor surface nor to introduce any impurities, and the time can be kept short enough to permit rapid assembly.

Advantages of this method over soldering or welding are many. There is less danger of contamination; leads can be attached to very small areas—particularly useful in high-frequency transistors—and the bond between the lead and the semiconductor is stronger than the lead itself.

Although today's practical transistors all use germanium or silicon, at least passing mention must be made of a new family of materials called intermetallic semiconductors. Silicon and germanium are in Group IV of the periodic chart; that is, they each contain four valence electrons in the outer ring. Compounds formed by taking elements from Group III (three valence electrons) and Group V (five valence electrons) will have an "average" of four valence electrons, and thus may exhibit characteristics similar to the materials now used.

A great deal of exploratory work is being carried out in laboratories both in this country and abroad to determine the characteristics of these intermetallic compounds. Particularly active in this field is H. Welker, in Germany. Results have been very encouraging—it appears that these materials may be useful for producing more versatile transistors and other devices. In fact, intermetallic diodes are now on the market. Notable among the compounds under investigation are indium antimonide, gallium arsenide and indium phosphide.

More complex compounds having an average of four valence electrons in the outer ring are also being investigated, and it is reasonable to expect that within a few years materials will be available which are superior in specific areas to either germanium or silicon.

Important areas of exploration, at present, are in the areas of surface phenomena and external contamination. To produce reliable transistors having the desired characteristics without excessive rejects requires careful control of all the steps in the manufacturing process, with particular emphasis on avoiding contamination of any kind. Past efforts in this direction have paid off handsomely. Work is also under way to increase power and frequency capabilities of transistors to approach more closely the performance now available from electron tubes.

An attempt has been made here to touch on the highlights of the last 10 years of transistor development. Many important contributions and contributors have of necessity been omitted for lack of space. It is important to emphasize that in this field, as well as any other scientific endeavor, notable advances are the result of the combined efforts of a number of scientists striving to unlock the secrets of nature. END

The Author

Robert M. Ryder was born March 8, 1915, in Yonkers, N. Y. He graduated from Yale in 1937, receiving a Bachelor of Science degree in physics. He obtained a PhD degree, also from Yale, in 1940.

In July, 1940, he became a member of the technical staff of Bell Labs, working on microwave amplifier circuits. During World War II, he contributed to Bell Labs' research on the signal-to-noise performance of radars. In 1945, he joined the Electronic Development Department to work on microwave oscillators and amplifier tubes for radar and radio relay applications. He is currently a transistor development engineer, particularly interested in transistor development for high-frequency and other transmission applications.

In 1957, Dr. Ryder received an award from the Institute of Radio Engineers "for contributions to the development of microwave tubes and applications of transistors."

He is a member of the American Association for the Development of Science, Sigma Xi and the Yale Engineering Society.

10 YEARS

TRANSISTORS

PAST PRESENT FUTURE

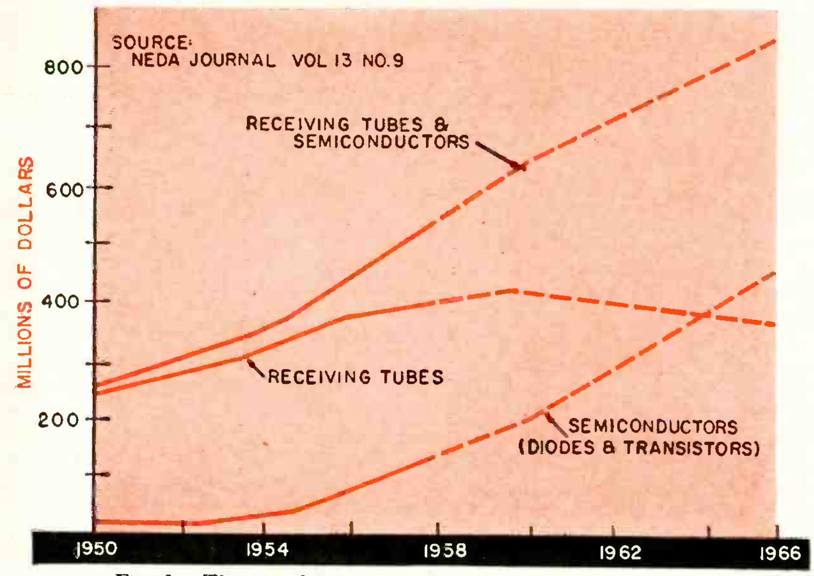


Fig. 1—The trend in semiconductor vs receiving tube sales.

A survey of the uses of transistors from their inception, 10 years ago, to their predicted future

By GEORGE R. SPENCER*

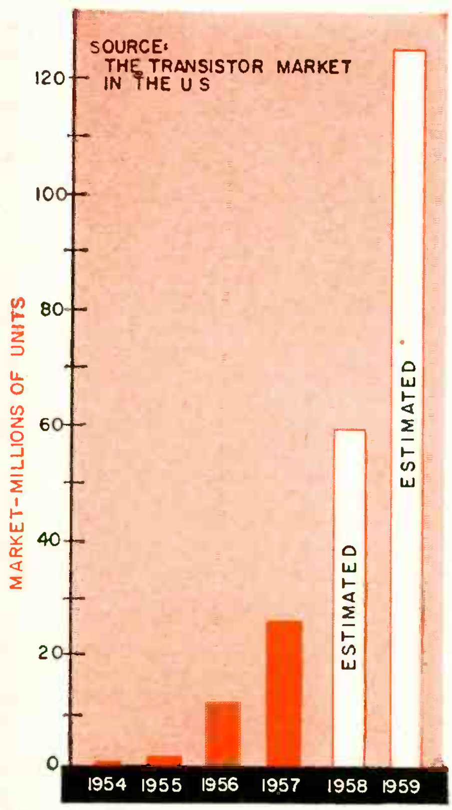


Fig. 2—Six-year survey of transistor sales.

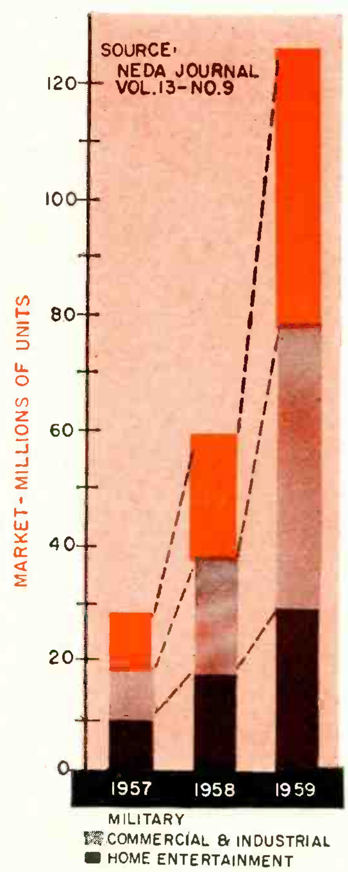


Fig. 3 (right)—Projected transistor sales broken up into types of application.

A DECADE has passed since Bardeen and Brattain of Bell Telephone Laboratories announced the invention of the transistor. At that time the transistor was expected immediately to rival the vacuum tube for many of the amplifier applications that the vacuum tube held as a monopoly. The advantages of this new device were its small size, predicted long life, ruggedness and, of course, the lack of heater power.

However, as might be expected for a new invention, development into commercial reality was slow and beset by many obstacles. The operation of these devices was understood in a general way, but the commercial practicability of the transistor was not feasible as a large area of unexplained and puzzling limitations in their manufacture still existed. Some of these limitations were:

1. *Performance* — Early transistors were characterized by low gain, poor noise figure, low frequency response and poor power-handling capabilities. Furthermore, it was difficult to design and develop transistors to overcome these deficiencies.

2. *Reproducibility* — Units intended to be alike varied considerably from one another. Improved manufacturing processes and material combined with a better technological understanding of transistor devices have resulted in transistor production becoming more of

**Raytheon Manufacturing Co., Semiconductor Div., Newton, Mass.*

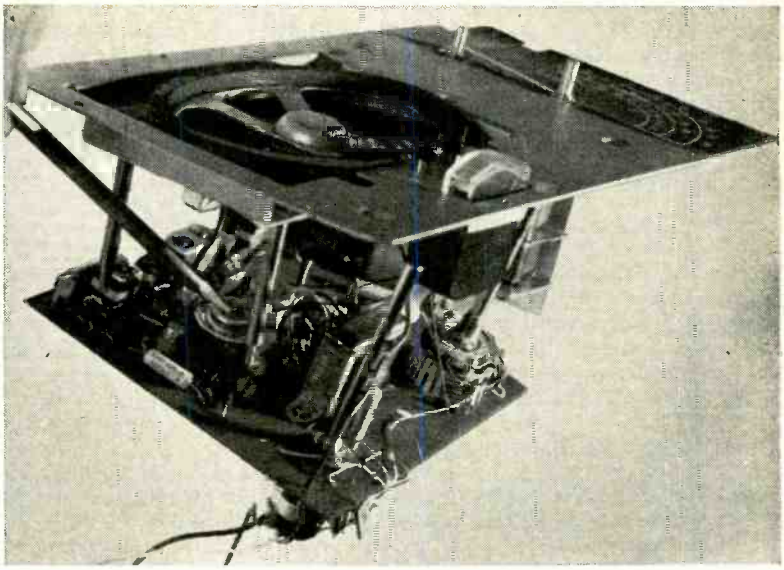
a science and less of an art. However, a fundamental difference still exists between vacuum tubes and transistors. Tubes are generally manufactured to be a given type, while transistors are manufactured to be a family separated into two to several types by selective testing.

3. *Poor reliability*—Certain percentages of the devices changed excessively with time, temperature or humidity, while others remained stable. The early problems affecting reliability are now minimized to the extent that the transistor's *inherent* ruggedness and long life can be realized. These inherent properties can be appreciated by comparing the complex structure of a vacuum tube to the relatively simple mechanics of a transistor, and by recalling that the life of a vacuum tube is dependent on how long its cathode will support emission.

These limitations resulted directly in poor availability and high initial cost of transistors for the first few years after their invention. As a result, their application and use in commercial and military equipment were on a small scale compared to the existing market for vacuum tubes. This first 10 years of transistor progress has shown considerable improvement over these limitations and transistors are now available with good engineering performance at a competitive price. Furthermore, there is a definite trend toward standardizing packages and types. For example, the 2N425, 2N426, 2N427 and 2N428, germanium n-p-n computer types, are manufactured by three separate companies in the standard JETEC 30 case, a package which is also common to numerous other types.

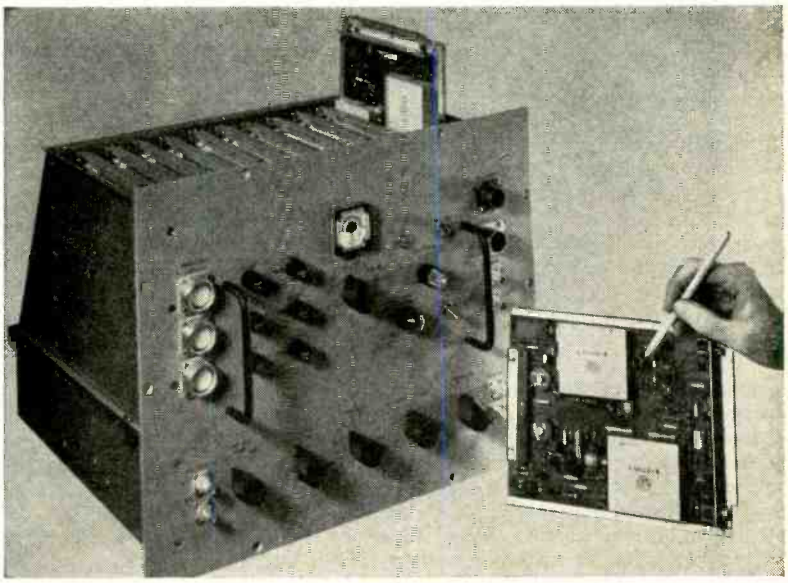
The growth of transistor sales since 1948 has been tremendous and should continue for the next decade with the same acceleration. Fig. 1 shows the overall sales growth of semiconductors (transistors and diodes) compared to that of receiving tubes and is projected to the year 1965. This chart indicates that, although increasing technology will increase the number of amplifier and related applications, the sale of receiving tubes is expected to level off and eventually decline during the next decade.

Fig. 2, a chart of the transistor market, projected to 1959, indicates that 125 million transistors will have been sold in 1957. The question that arises is: in what applications have these transistors been used and what applications are likely in the future? Also of interest are the fields that transistors are least likely to invade in the near future—those fields where receiving tubes will maintain definite advantages.



(Above) Internal view of an all-transistor direction finder. Pencil points at a power transistor.

(Below) This transistor pulse code modulator allows simultaneous transmission of multiple channels of information in coded form.



10 years of transistor progress

About 30 companies in the United States are manufacturing transistors, and there are over 500 EIA types now registered, in addition to more than 400 non-EIA types. These can be classified broadly as point contact, junction or surface barrier; with the point-contact transistors now relegated to a minor role. A review of EIA types indicates that the following characteristics are now available, which clearly shows the progress made in the last decade.

1. *Frequency response* — The low-frequency response of early transistors limited their application to a large degree. The alpha-cutoff frequency characteristic of a transistor is frequently used to predict frequency response for a given application as it is the frequency at which the common base current amplification drops to 70% of its low-frequency value. The alpha-cutoff frequency of transistors is limited by the time it takes the signal carriers (electrons or holes) to diffuse or move from emitter (input) to collector (output). Recent techniques in the construction of transistors have extended this upper operating frequency limit an order of magnitude, and transistors are now available that operate throughout the vhf well into the uhf band. The 2N502, a Philco microalloy diffused-base transistor (MADT) will give a minimum power gain of 8 db at 200 mc and has a maximum frequency of oscillation over 500 mc.

2. *Power and temperature* — Transistors were limited, to a large extent, by their inability to give satisfactory gain at the high current levels needed for power stages. Power transistors are now available that will stand more than 40 watts of collector dissipation at 25°C and give a class-A gain in excess of 30 db. Typical of these is the Motorola type MN21, a germanium

p-n-p power transistor rated at 45 watts at 25°C with a power gain of 35–40 db in a class-A single-ended circuit. This unit is also rated for a maximum collector to base voltage of 80.

Transistor performance depends on the surrounding ambient temperature to a much greater degree than vacuum tubes. Germanium transistors are generally rated for a maximum junction temperature of 75° to 100°C, whereas silicon transistors are usually rated for a maximum of 160° to 200°C. As power dissipation raises the internal junction temperature higher than the surrounding ambient temperature, precautions must be taken to assure that power dissipation does not raise the internal temperature over the allowable rating. For example, a germanium transistor rated for 40 watts at 25°C ambient temperature might be limited to 10 watts dissipation at 80°C.

The availability of silicon transistors means that applications requiring a minimum power dissipation at high ambient temperatures can now be fulfilled by transistors. Furthermore, collector current of a silicon transistor with its emitter open-circuited (cutoff current) is typically 100 to 1,000 times lower than for a germanium counterpart. This low cutoff current has resulted in the use of transistors in dc amplifiers and similar critical applications, as cutoff current doubles with every 8° to 10°C rise in temperature. Although a typical value of 10 μa dc for a germanium transistor does not seem excessive, the effect of collector cutoff current of a common-emitter amplifier is usually 10 to 100 times higher, depending on the input termination to the amplifier and the alpha (short-circuit current gain) of the transistor.

Silicon transistors cost more than germanium types and their main use has been in military applications where operation over a wide range of temperatures is necessary. Typical is the use of Raytheon 2N329 transistors in both the Vanguard and Explorer satellites. This higher cost of silicon transistors may not continue forever if refinement processes can be improved to produce lower-cost refined silicon. This also could result in the obsolescence of germanium transistors.

3. *Noise* — Today there are many audio transistors that have equal or better signal–noise ratios than vacuum tubes; examples are Raytheon's 2N422, RCA's 2N105 and Philco's 2N204-A. Raytheon's type 2N422, a germanium p-n-p transistor, is a typical low-noise unit presently available. It has a maximum noise figure of 6.5 db, and its size is such that over 350 units (exclusive of leads) could fit in a volume of 1 cubic inch. Low noise figure coupled with no heater power to give hum troubles has resulted in the transistor finding wide usage in preamplifier circuits. The transistor portable radio with sensitivity comparable to receiving tube sets and the use of transistors in commercial hearing aids are evidence of their advantages in applications where noise problems could be prevalent.

4. *Reliability*—The early encapsulation of transistors was not adequate for all applications. Transistors were apt to fail under extreme moisture conditions or when subjected to high heat. Considerable work has been done on the development of hermetic seal encapsulations with the result that reliability is now excellent.

For example, in a recent test at Raytheon a random group of 200 germanium switching transistors were life-tested for 1,000 hours (200,000 transistor hours). One half of the lot was operated at 45-mw dissipation at 65°C (149°F), the remaining units were storage-tested at 85°C (185°F) with no operating voltages. There were no failures, and the average current gain of the transistors showed only a negligible change with life. Raytheon also has data which indicates that their fusion-alloy process of manufacture results in less than one open in 800,000 hours. This data was secured on life tests over the last 2 years.

During 1958, transistor production is expected to rise to 60 million units (Fig. 3). Of these, 55,000,000 will be germanium and 5,000,000 will be silicon types. Approximately 17,000,000 units will be used for radios and consumer electronic products, 22,000,000 for commercial and industrial electronic equipment and 21,000,000 for military applications.

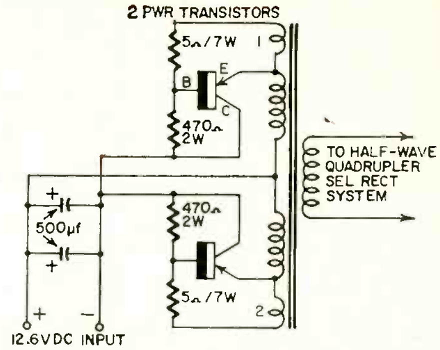


Fig. 4—Primary circuit of the Telecom 2D11 transistor power converter. Windings 1 and 2 are feedback windings for maintaining oscillations.

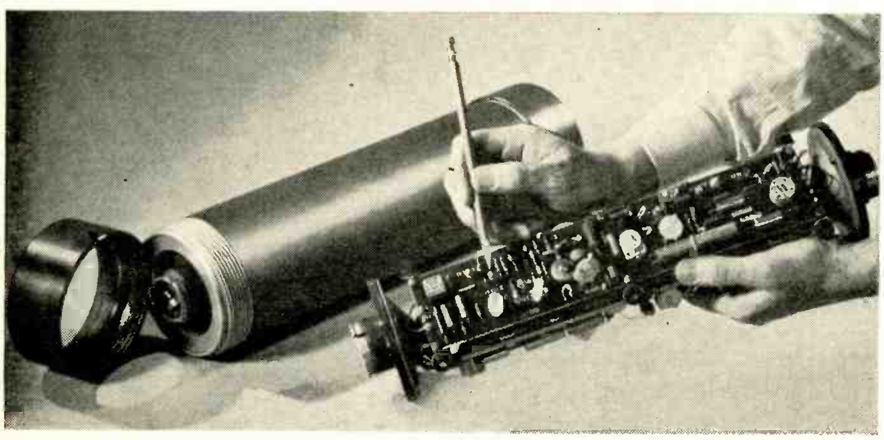
7,000,000 power transistors

Power transistors are expected to account for more than 7,000,000 of the transistors used, the majority turning up in auto radios. Their advantage for this use is, of course, the necessary minimum of 2–3 watts of audio output can be obtained without using a vibrator power supply. Because of the ability of power transistors to control large amounts of current with relatively small voltage drops, they have been used widely in both commercial and military equipment, in power regulating systems, servomechanism devices and a host of control and instrumentation devices.

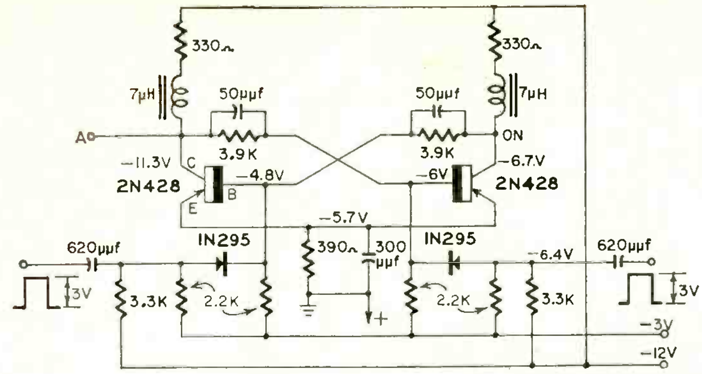
A 6CD6 beam power tube at 0 grid bias with 150 volts on the screen grid, requires 50 volts on the plate to pass 0.45 ampere. The total consumed power, including heater and screen power, is approximately 50 watts. A typical germanium power transistor can pass 3 amperes with less than 0.5 volt on its collector, using only 1.5 watts. The transistor power converter typifies the efficiency and practical application of power transistors.

A unit now on the market, the Telecom 2D11 transistor power converter, converts 12.6 volts dc to simultaneous power outputs of 500 volts at 200 ma and 250 volts at 100 ma with an overall efficiency of 80%. A schematic of the primary circuit is shown (Fig. 4). The transistors are being used as power oscillators at 1,000 cycles.

High-frequency transistors are expected to account for about 45% of this year's production. Fusion-alloy and grown-junction types were limited to about 5 mc due to low alpha-cutoff frequencies and high collector capacitances. Development work in the last decade has turned up several types of high-frequency transistors, such as drift, surface-barrier and field-effect types. There are transistors that will give useful gain at frequencies in excess of 50 mc. As examples, the 2N384 has a minimum power gain of 15 db,



Transistor line repeater developed for the US Signal Corps. These units are inserted at 1-mile intervals along the transmission cable.



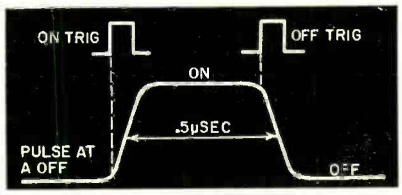


Fig. 5—Typical circuit of a nonsaturated, double-input flip-flop. A switching rate of 1 mc is possible. The diodes prevent triggering by negative impulses.

The Author

George R. Spencer was born March 18, 1927. He received a Bachelor of Science degree cum laude in electrical engineering in 1949 from Norwich University, Vt., where he had been a member of the Academic Honor Society. In 1954, he obtained a master's from Northeastern. He has done graduate work at MIT as well.

From 1949 to 1951, he was a teaching assistant at MIT. He then joined Tracer Labs in Boston for a period of about a year. Later, he became a member of the Engineering Division of Raytheon, where he is now employed in the Semiconductor Division. His previous work was as application engineer on receiving tubes for crystal diodes. His present specialty is that of transistor application engineering.

Mr. Spencer belongs to the Theta Chi fraternity.

at 50 mc; the 2N503 a minimum of 11 db, at 100 mc, and the 2N502 is controlled to have a minimum power gain of 8 db at 200 mc.

High-frequency transistors have been used to a great extent in computers and data-processing equipment where their role has been, not as a small signal amplifier, but as a switch (see Fig. 5). This equipment depends on the control of direct currents in a minimum of time. With transistors such as the 2N501 it is now possible to attain switching rates up to hundreds of megacycles.

The entertainment field has used many transistors in manufactured portable radios, not to mention the large number of radio kits that are being marketed. All-transistor car radios and broadcast receivers are now marketed and an all-transistor battery-operated TV set was shown to the public recently.

The military field has used transistors in missile guidance systems, communications, radar, power supplies and regulators as well as computer applications. The industrial and commercial field has applied transistors to all of the aforementioned applications, including also telephone systems, alarm systems and data-processing equipment.

Receiving-tube usage has been affected already to a significant extent. Transistor hearing aids and portable receivers have caused a marked reduction in subminiature and miniature tube production of types formerly used in these applications. Although considerable progress has been made in improving transistors' power-handling and temperature capabilities, voltage ratings and frequency response, it is in these abilities that the vacuum tube still has an advantage.

The transistor is essentially a high-current low-voltage device ideal for low-impedance circuitry, whereas the tube is a low-current high-voltage device suited for high-impedance applications. As a result, in those applications requiring high frequency response with either high-voltage or high-power ratings, the tube still maintains a definite advantage. Power transistors generally have a cutoff frequency of less than 50 kc and are rated at less than 100 volts for collector–base voltage, while high-frequency types of transistors are normally rated below 30 volts.

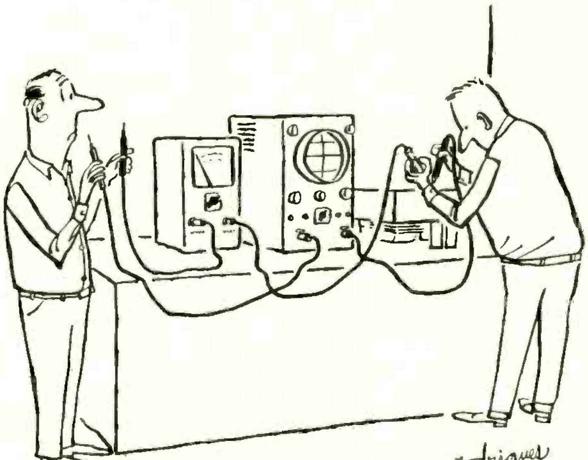
What will the future bring?

Fig. 3 depicts probable sales for 1957, 1958 and 1959 in the three main product categories. It is expected that commercial industrial use and military use will increase at a faster rate than the home entertainment market, with the entertainment usage still multiplying rapidly. Expected new uses will be television receivers, hi-fi amplifiers, all-wave receivers, all-transistor car radios, phonograph amplifiers, tape recorders, FM tuners and controls for home appliances. The automobile is likely to use the transistor in fuel injection systems, where transistors coupled with solenoids control the amount and timing of the fuel injected into each cylinder.

Pleasure boating and aviation are potential transistor markets that are beginning to be exploited. Gasoline vapor detectors, altimeters, depth-finding equipment, receiver and direction-finding equipment (see photos) are just a few examples.

Transistor types now under development will open even greater roads to new and untried applications. Raytheon's recently announced spacistor (see "Two New Approaches to Amplification," RADIO-ELECTRONICS, November, 1957) is just one example. This device, similar in appearance to a tetrode (four-terminal) transistor shows promise of increasing the useful frequency range of transistors to 1,000 mc and higher. Furthermore, this device has a very high input and output impedance, allowing it to compete directly with vacuum tubes.

The conclusions of this article are evident; the trend to transistors is increasing at an exponential rate. Their small size, long life, and excellent reliability are the keystones of their success. END



Part I—Not all semiconductors are transistors—some can be used as voltage-variable capacitors, electronic switches or to measure magnetic fields

more jobs for semiconductors

By PAUL PENFIELD, JR.

SAY "semiconductor" to most people and what do you get back? If the person knows anything about electronics you'll hear him say, "transistors." All of us know that transistors are made out of semiconductors, usually germanium or silicon. How many of us know about the many other practical applications for semiconductors?

The many peculiarities of semiconductors can be used in making all kinds of devices. To describe all the characteristics completely a knowledge of advanced physics and quantum mechanics is necessary, but this is not needed here since the practical man is more interested in the actual device than the advanced theory. In this article we have space to discuss only *practical* devices that work—no purely hypothetical ideas. It is assumed that the reader has some knowledge of the theory of diode and transistor action[1].

Semiconductor diodes have a history as old as radio itself. Remember galena crystals and catswhiskers? Galena is a semiconductor that comes with many built-in p-n junctions—by moving the catswhisker around you can locate one to use for rectifying the signal. Dry-disk rectifiers, copper-oxide instrument rectifiers and selenium rectifiers are other examples of early semiconductor diodes.

As often happens, the practical diode was used long before its theory was well understood. But with the added knowledge of the theory of conduction in semiconductors came new methods of making diodes, and many new types. Now point-contact and junction diodes are available in a wide range of current and voltage levels. Some are made specifically for rf detection, some for high-power rectification, etc.

But there are several ways to use diodes other than as rectifiers. Many special-purpose types are available.

The Varicap

One such special-purpose diode is the Varicap[2]. In a circuit this diode behaves like a variable capacitor in parallel with a high resistance (or in series with a low resistance). The value of the capacitor is changed by varying the voltage across the device.

Its operation is easy to understand. In a junction diode in reverse bias the electrons and holes are pulled away from the junction. That, after all, is why so little current flows. Because the electrons and holes are pulled away, a depletion layer[3] is built up at the junction—a layer with no current carriers in it (see Fig. 1). This acts just like a capacitor whose value depends on the thickness of this depletion (dielectric) layer, which in turn depends on the voltage applied. All junction diodes act this way, but the Varicap is designed to take advantage of this changing capacitance and gives a range of about 3 to 1 in capacitance. Therefore some obvious applications for this device, such as frequency modulation or automatic frequency control. The device as presently made is useful into the uhf range.

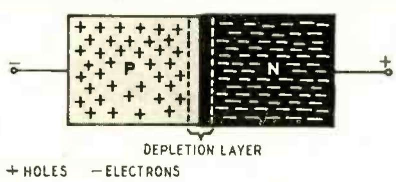


Fig. 1—With a reverse bias a region with no electrons or holes surrounds the junction.

Another interesting special-purpose diode makes use of this same depletion layer. This is the "punch-through" diode developed at MIT in recent years.

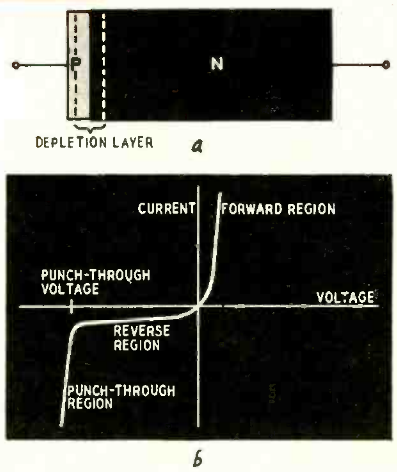


Fig. 2—The punch-through diode (a) and its volt-ampere curve (b).

In this device one of the contacts (see Fig. 2) is placed very close to the junction. At low voltages it behaves like a normal junction diode. But as soon as the depletion layer gets big enough to hit the contact (as soon as reverse voltage gets large enough) a large current can pass. The volt-ampere curve for this device is shown in Fig. 2. There are many computer applications calling

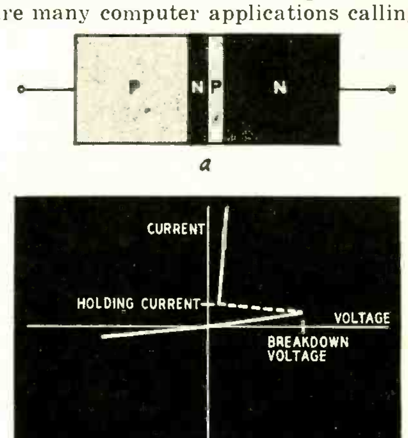


Fig. 3—The Shockley 4-layer diode: a—diode construction; b—volt-ampere curve of the bi-stable unit.

[1]P. Penfield Jr., "Transistor Action," *Audio*, October, 1956, page 15.
P. Penfield Jr., "Confused About Transistor Types?," RADIO-ELECTRONICS, October, 1956, page 104; November 1956, page 78.
P. Penfield Jr., "More About Transistor Types," RADIO-ELECTRONICS, November, 1957, page 35; December, 1957, page 108.
P. Penfield Jr., "Transistors In Audio Circuits," Part I, *Audiocraft*, October, 1956, page 18.
Rufus P. Turner, *Transistors — Theory and Practice*, Gernsback Library Inc.

[2]Pacific Semiconductors, Inc., 10451 W. Jefferson Blvd., Culver City, Calif.
[3]Also called a space-charge layer.

for just such a curve. Another use is as a voltage regulator.

Essentially the same volt-ampere curve describes another type of diode—the Zener diode. The result is nearly the same but the method of getting that result is different. Instead of putting a contact close to the junction, the doping of the two sides of the diode is fixed so that the entire voltage drop is across a very small depletion layer. That way, moderate reverse voltages can be used to break down the crystal, allowing high currents to pass. The Zener diode and the punch-through diode can be used in much the same way.

The last specialized diode we'll consider here is the Shockley four-layer

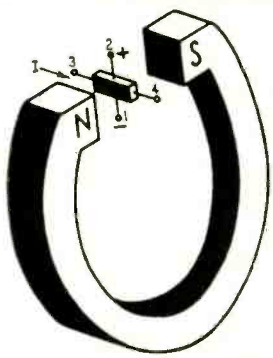


Fig. 4—Diagram of the basic Hall-effect device.

diode (Fig. 3-a). This is just like a hook transistor except that there is no base lead. As the volt-ampere curve in Fig. 3-b shows, at low currents the device is a high resistance. But as soon as the voltage reaches the breakdown point, the device becomes a low resistance. It can be turned on and off (low resistance—high resistance) at will by varying the applied voltage and current, and making it a good switching component. Multivibrators, sine-wave and sawtooth generators, ring counters, and switching circuits for computers can be made using the device.

The operation of the Shockley four-layer diode reminds one of the old "coherer." It acts in a similar fashion. As the current is brought up, the device flips from a high-resistance condition to a low-resistance state. The difference is that the coherer remains in the low-resistance state even after the current is brought down. The only way to get it back into the high-resistance state is to tap it gently with something like the end of a screwdriver. The coherer, recently marketed under the name, "semiconductor relay," is especially useful for one-shot applications, such as proximity fuses or detonation caps.

Hall-effect devices

An electron (and also a hole) is acted on not only by an electric field, caused by applying a voltage, but also by a magnetic field. The magnetic field makes the particle swerve—the force of the field is at right angles to the direction in which the particle is moving.

The Hall effect is the influence of a magnetic field on electrons and holes in solids. A device employing the Hall effect is shown in Fig. 4. The magnetic field is produced by the permanent magnet with N and S poles as indicated. An electromagnet could also be used. If current I is made to flow through the semiconductor (terminals 3 and 4) placed in the field, both holes and the electrons will tend to be deflected upward. The vertical voltage across the semiconductor (terminals 1 and 2) depends on whether more holes or more electrons get deflected. In a p-type sample there are more holes than electrons and so the voltage has the polarity shown. For n-type material the polarity at terminals 1 and 2 would be reversed.

The action is very similar to magnetic deflection of the beam in a cathode-ray tube.

What good is such a device? Well, there are at least three ways to operate it. First, it can be run without a magnet. Then there will be no voltage at terminals 1 and 2. But if you have a magnetic field you would like to measure, simply stick the device in it and measure the output voltage. This is one of the simplest ways to measure the strength of a magnetic field and can be calibrated to give a direct-reading gauss-meter.

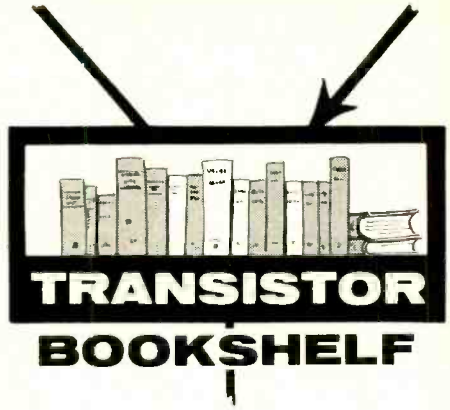
Second, we can use an electromagnet instead of the permanent magnet. Supplying a signal to the electromagnet, the strength of the magnetic field depends on the signal. The output at terminals 1 and 2 will then depend on the input to the electromagnet. What we have here is an amplifier, although for most purposes not a very good one. This same circuit can also be used as a computer multiplying circuit, since the output is proportional to both the electromagnet current and the current I.

Lastly, the device can be operated as a gyrator. A gyrator is a four-terminal device that is not reciprocal—the transfer impedances or transconductances are not the same in opposite directions. Draw any four-terminal network using resistors, capacitors, inductors and transformers, and you will find it is reciprocal. The Hall-effect gyrator is not.

Circuit-theory people have known about gyrators for many years and have devised circuits around them, in spite of the fact that no practical gyrator existed. Now these circuits can be used with the Hall-effect gyrator. They are useful mainly for computers.

Hall-effect elements for all three purposes are being made and sold by the Siemens Co. in West Germany. Theoretically a metal could also be used for such a device, but the effect is very, very small in metals whereas it is rather large in semiconductors.

Next month we will investigate some more semiconductor devices. Among them will be photoresistors, photodiodes, photocells, thermistors and thermocouples. TO BE CONTINUED



TRANSISTOR BOOKSHELF

A brief rundown of some of the basic and advanced texts on transistor theory and applications

By RUFUS P. TURNER

SINCE the first public announcement of the transistor 10 years ago, an enormous amount of technical literature concerning this device has become available. In 1949, students and technicians inquired where they might find any book that might help them understand transistors. Today, the question has changed to *which* book is best for a particular reader.

After making a close inspection of many transistor books, I have selected those which appear most serviceable to the practical workers found in large numbers among the readers of RADIO-ELECTRONICS. The books listed in Group I present theory in terms not requiring a knowledge of higher mathematics. They contain numerous transistor applications of the kind so important to the practical circuit man. In most instances, no mathematical knowledge beyond simple algebra is needed.

Listed in Group II are more advanced transistor and semiconductor texts. To understand the material in this second group of books thoroughly, the reader must have a good foundation in higher mathematics (calculus and beyond), engineering and physics, including modern theory of solids.

Group I

BOOK OF THE TRANSISTOR. *J. S. Kendall* (Wehman). Contains simple explanations of transistor theory and action, how to make point-contact transistors, care of transistors, electrical characteristics of American and European transistors. 44 pp.

FUNDAMENTALS OF TRANSISTORS. *Leonard M. Krugman* (Rider). Basic semiconductor and transistor theory, circuit theory for transistor amplifiers and oscillators. Requires some easy familiarity with algebra. 140 pp.

HANDBOOK OF SEMICONDUCTOR ELECTRONICS. *Lloyd P. Hunter, Editor*

(McGraw-Hill). Complete coverage of semiconductor theory. Semiconductor devices and manufacture. Typical applications illustrated with skeleton circuit diagrams. Some sections will be better understood if the reader has a good mathematical foundation. Book is divided into 20 sections. A good reference manual.

HOW TO MAKE A TRANSISTORIZED PORTABLE RADIO, AND 20 OTHER APPLICATIONS FOR RF TRANSISTORS. (Sylvania). Collection of practical circuits for amplifiers, oscillators, broadcast receivers, ham radio, test instruments and miscellaneous devices. 34 pp.

TRANSISTOR APPLICATIONS, VOL. I. (Raytheon). Collection of 53 articles on practical applications of transistors reprinted from various magazines, 25 of them from RADIO-ELECTRONICS. Electrical characteristics of Raytheon transistors. 116 pp.

TRANSISTOR APPLICATIONS. VOL. II. (Raytheon). Simplified transistor theory; practical transistor circuit design principles; installation, care and testing of transistors; miscellaneous practical circuits and devices; reference data; electrical characteristics of Raytheon transistors. 58 pp.

TRANSISTOR CIRCUIT HANDBOOK. *Louis E. Garner, Jr.* (Sams). Simplified survey of transistor theory, numerous practical circuits, reference data and electrical characteristics of commercial transistors. 410 pp.

TRANSISTOR CIRCUITS. *Rufus P. Turner* (Gernsback). Over 150 practical circuits for transistor audio amplifiers, rf and if amplifiers, dc amplifiers, oscillators, power supplies, radio receivers, triggers and switches, control devices, test instruments, amateur and miscellaneous devices. 160 pp.

TRANSISTOR CIRCUITS AND APPLICATIONS. *John M. Carroll* (McGraw-Hill). Numerous reprints of articles previously published in *Electronics* magazine. A good cross-section of all areas of practical applications of transistors. 283 pp.

TRANSISTOR ENGINEERING REFERENCE HANDBOOK. *H. E. Marrows* (Rider). Simplified transistor theory and some practical circuit applications. Much space devoted to characteristics of commercial transistors and to circuits of commercial transistor devices. Divided into five sections. 288 pp.

TRANSISTOR MANUAL. 2nd Edition. (General-Electric). Simplified transistor theory, transistor and rectifier construction, transistor and rectifier circuit applications, physical dimensions of transistors, practical circuits for the experimenter, characteristics of General-Electric transistors and principal electrical characteristics of registered JETEC transistor types from all manufacturers. 113 pp.

TRANSISTOR TECHNIQUES. *Bohr, Braumbeck, Kampf, Knight, Padgett, Prensky, Queen, Reed, Schenkerman, Steen and Turner* (Gernsback). Practical data on transistor care, testing, performance, and measurements. Numerous practical circuits. 96 pp.

TRANSISTORS. *Louis E. Garner, Jr.* (Sams). Simplified introduction to transistor theory and transistor circuits, transistor circuit components and electrical characteristics of commercial transistors. 105 pp.

TRANSISTORS HANDBOOK. *William D. Bevitt* (Prentice-Hall). Theory of semiconductor and transistor action. Transistor types. Many practical circuits in all areas of application from simple amplifiers to computers. Knowledge of elementary algebra helpful to understanding of some theory sections. 410 pp.

TRANSISTORS IN RADIO AND TV. *Milton S. Kiver* (McGraw-Hill). Elementary presentation of electronic and semi-conductor theory, transistor action and applications of transistors to radio, television and related circuits. Electrical characteristics of transistors. Servicing of transistor equipment. 220 pp.

TRANSISTORS, THEORY AND PRACTICE. *Rufus P. Turner* (Gernsback). A standard textbook for the beginning transistor student and refresher for the experienced worker. Contains chapters on semiconductor theory; transistor characteristics; equivalent circuits of transistors, amplifiers, oscillators; duality in transistor circuit design; triggers and switches; practical transistor circuits; tests and measurements, and characteristics of commercial transistors. 144 pp.

28 USES FOR JUNCTION TRANSISTORS. (Sylvania). Simplified transistor theory; 28 practical circuits employing transistor types 2N34, 2N35, and 2N68 in amplifiers, oscillators, control devices and test instruments; electrical characteristics of Sylvania transistors. 47 pp.

Group II

ELECTRONS AND HOLES IN SEMICONDUCTORS. *William Shockley* (Van Nostrand).

INTRODUCTION TO JUNCTION TRANSISTOR THEORY. R. D. Middlebrook (Wiley).

INTRODUCTION TO TRANSISTOR CIRCUITS. *E. H. Cooke-Yarborough* (Oliver & Byrd).

PRINCIPLES OF TRANSISTOR CIRCUITS. *Richard F. Shea, Editor* (Wiley).

PROGRESS IN SEMICONDUCTORS. Vols. I and II. *Alan F. Gibson,* Editor (Wiley).

SEMICONDUCTORS: THEIR THEORY AND PRACTICE. *G. Goudet, C. Meuleau,* and *E. M. Deloraine* (MacDonald & Evans).

TRANSISTOR AUDIO AMPLIFIERS. *Richard F. Shea* (Wiley).

TRANSISTOR CIRCUIT ENGINEERING. *Richard F. Shea* (Wiley).

TRANSISTOR ELECTRONICS. *Lo, Endres, Zamels, Waldhauer,* and *Cheng* (Prentice-Hall).

TRANSISTORS I. RCA Laboratories (RCA).

TRANSISTORS AND OTHER CRYSTAL VALVES. *T. R. Scott* (Macdonald & Evans).

TRANSISTORS: THEORY AND APPLICATIONS. *Abraham Coblenz* and *Harry L. Owens* (McGraw-Hill).

Publishers

Publishers or distributors listed in the foregoing text are identified below:

General Electric. General Electric Co., Semiconductor Products Dept., Electronics Park, Syracuse 1, N. Y.

Gernsback. Gernsback Library, Inc. 154 W. 14th St., New York 11, N. Y.

Macdonald & Evans. Macdonald & Evans, Ltd., London, England. (American distributor: Essential Books, Inc., Fair Lawn, N.J.)

McGraw-Hill. McGraw-Hill Book Co., 327 W. 41st St., New York 36, N. Y.

Oliver & Byrd. Oliver & Byrd, Ltd., London, England.

Prentice-Hall. Prentice-Hall, Inc., Englewood Cliffs, N. J.

Raytheon. Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.

RCA. RCA Laboratories, Inc., Princeton, N. J.

Rider. John F. Rider Publisher, 116 W. 14th St., New York 11, N. Y.

Sams. Howard W. Sams & Co., Inc. 2203 E. 46th St., Indianapolis 5, Ind.

Sylvania. Sylvania Electric Products, 1740 Broadway, New York 19, N. Y.

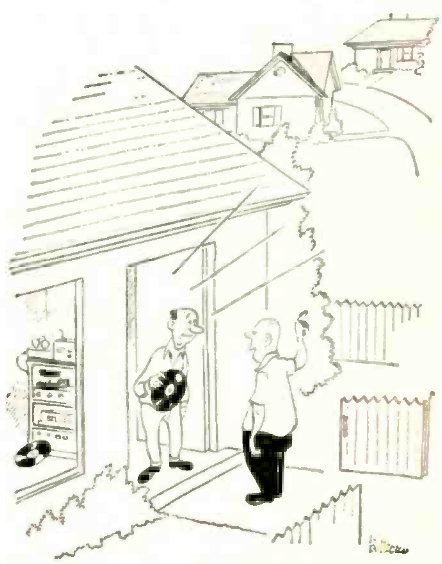
Van Nostrand. D. Van Nostrand Co., Inc., 250 Fourth Avenue, New York, N. Y.

Wehman. Wehman Brothers, 712 Broadway, New York 3, N. Y.

Wiley. John Wiley & Sons, 440 4th Ave., New York, N. Y.

Acknowledgement

The author is indebted to Technical Book Co. of Los Angeles for placing at his disposal each of the books reviewed in this article. END



"Good evening! I live about a half-mile up the road, and my wife and I have been arguing about the composer of the last symphony you played."

THE TRANSISTOR "FIFTH"

Compact one-fifth watt amplifier is powered by 6.3 volts ac

By I. QUEEN
EDITORIAL ASSOCIATE

WANTED: a light-duty amplifier with low distortion, plenty of volume. Must be compact.

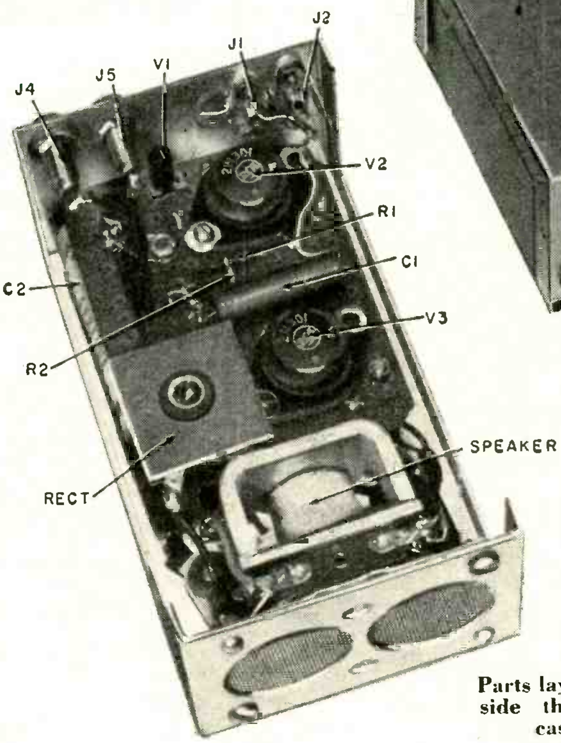
That was the problem after I bought a new FM tuner. An amplifier was needed for FM listening and monitoring tape recordings being made from the FM programs. It would also be used for various utility purposes.

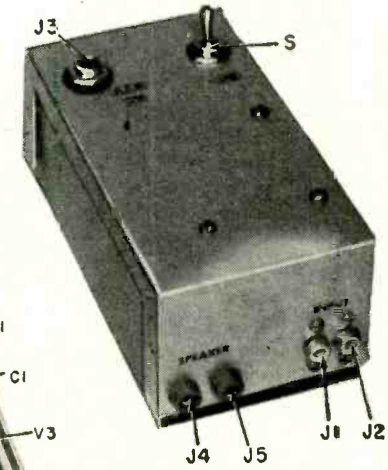
Tests showed that 100 mw delivered to an efficient speaker produces all the sound that is needed in an ordinary room. Therefore, I decided to build an amplifier with a 200-mw output (1/5 watt, from which unit derives its name). In this age of audio amplifiers that deliver 50 and 60 watts, you may feel that 1/5 watt is just a whisper. However, this equals the power of many thousands of people talking at once. (Average individual voice power in conversation is in the order of 30 μw.) Certainly it is far more than most neighbors will stand for!

The amplifier measures only 5¼ x 3 x 2 inches. This includes a self-contained small speaker. Of course, connections for a good external speaker are provided. I use a Lansing D208 in a 2 x 1-foot enclosure.

Frequency response is excellent. It is down about 2 db at 12,000 cycles and about 0.8 db at 12 cycles. *Undistorted power* output is 200 mw—about 1.3 volts across 8 ohms. Maximum input is about 0.1 volt. No volume control is included because the amplifier is used with an FM tuner which has a gain control. An interesting feature is the absence of transformers. Besides improving frequency response, this saves money and space. The two stages are direct-coupled, with the speaker fed directly by a power transistor. A 16- or 8-ohm speaker is recommended, but 4-ohm units give good results.

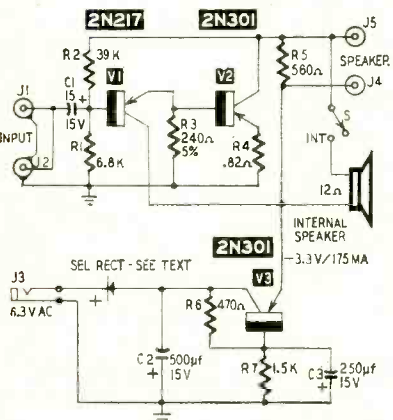
The circuit is in Fig. 1. V1 effectively in a grounded-collector stage is followed by a grounded emitter V2. The output transistor is an RCA 2N301. It delivers the 1/5 watt with about 3.3 volts on its collector. V1 is a 2N217, chosen after various tests with other driver transistors. It gave maximum power with minimum distortion, at this low voltage.





The completed unit. Switch on top selects internal or external speaker.

Parts layout inside the tiny case.



R1—6,800 ohms
R2—39,000 ohms
R3—240 ohms, 5%
R4—0.82 ohm
R5—560 ohms
R6—470 ohms
R7—1,500 ohms
All resistors ½-watt 10% unless noted
C1—15 μf
C2—500 μf
C3—250 μf
All capacitors 15-volt electrolytics
J1, 2—phono jacks
J3—phone jack
J4, 5—pin jacks
S—spst toggle
V1—2N217
V2, 3—2N301
Selenium rectifier, see text
Speaker, 12-ohm coil, 2 x 3 inches (RCA 214S1 or equivalent)
Socket, transistor, 3-pin, in-line, for V1
Socket, 9-pin miniature (2) for V2 and V3
Perforated bakelite board, cut to size
Case, 5¼ x 3 x 2 inches
Miscellaneous hardware

Fig. 1—Circuit of the 200-mw amplifier.

The power supply

This amplifier operates from an unusual but easy-to-find power source, 6.3 volts ac. This voltage (at less than 0.3 amps) is found in many electronic instruments. It must be rectified and filtered before being applied to the amplifier. Since the voltage is so low, there is no need for an entire (117-volt) rectifier stack. I removed two elements from a 150-ma stack and connected them in parallel. See Fig. 2. This permits up to 300-ma drain (at 6.3 volts). The amplifier consumes less than 175 ma.

The rectifier elements are mounted on a long screw which holds the unit to a bakelite board and serves as the negative terminal. A cardboard sleeve insulates the screw from the elements and washers. One side of each element has a smooth metallic surface. The other side is rough-looking because it is coated with selenium. These are identified as M and S, respectively, in Fig. 2. Washers are used to make good contact with the surfaces.

After rectification, ripple is smoothed by V3, another 2N301. This is done by

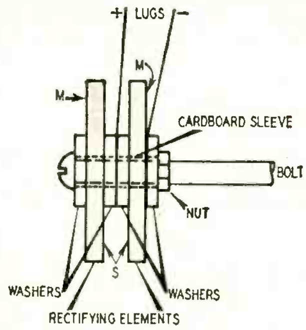


Fig. 2—Assembling the rectifier: Left washer contacts head of screw. Nut also contacts screw. Therefore, negative lug and screw contacts both M surfaces. Cardboard sleeve over screw insulates positive lug and S-surfaces.

supplying the rectified voltage to the transistor base. The output from this transistor is nearly pure dc. (For a detailed description of this action see "Transistor Low-Voltage Supply," RADIO-ELECTRONICS, October, 1957.) At full gain, the hum is hardly audible even if you place your ear right up against the speaker cone. Neither V2 nor V3 is provided with a heat sink since both are worked far below their maximum ratings.

The amplifier circuit is built on a perforated sheet of bakelite held in place by long screws and spacers. I used a 2 x 3-inch RCA model 214S1 speaker in one end of the aluminum box. A switch cuts this speaker in or out as desired. Resistor R5 closes the power amplifier load circuit should the internal speaker and the external unit be both disconnected at the same time.

Two input terminals (phono jacks) are connected in parallel. One may be used for the incoming signal, the other for connection to a tape recorder. In many recorders the speaker is automatically disconnected during recording (to prevent acoustical feedback into a mike). With this pair of input terminals, the FM tuner feeds the recorder while you monitor it with the amplifier. When you connect the Fifth to an FM tuner, the signal lead shield provides the common ground between tuner and amplifier. The only other lead you need

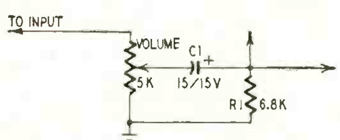


Fig. 3—Use this circuit to add a volume control to the amplifier.

is to the 6.3-volt supply, assuming the other filament lead is grounded.

To operate the Fifth from batteries instead of ac, eliminate V3 and its circuitry. Apply 3 or 4 volts to the V1, V2 circuit. A pair of flashlight D cells will last a long time and give plenty of volume when this amplifier is fed from a portable transistor tuner. A single cell supplying less than 25 ma provides ample volume for low-level listening.

If your application calls for a volume control, connect it as shown in the circuit of Fig. 3. END

NEW DISCS and STEREO TAPES

Reviewed by
CHESTER SANTON
Station WQXR, New York City

A TAPE recorder scarcely adequate for a baby's unsteady mid-range gurgle cannot do justice to today's stereo tapes. These require steady transport past a well-aligned head of proper frequency response. Test tapes of acknowledged accuracy have been used for years to uncover any increase in equipment wow and flutter, improper head alignment and impaired frequency response. Such tapes are useful only where adjustments can be made to improve the performance of a tape machine. In the past the only test tapes commonly used by radio stations, recording companies and top-flight repair men were the two Ampex test tapes. These are individually made custom jobs—the 15-ips tape going out to 15,000 cycles, the 7½ out to 10,000 cycles. The sole difficulty for the rest of us—the price of the 7½-ips tape (5563) goes out to $14.50. Ampex test tape 5563 contains the following: 10,000 cycles of long duration for alignment of the tape head; 250 cycles at 0 VU reading; 250 cycles at —10 db which is their standard test level, then test frequencies from 10,000 down to 50 cycles. Before recording these test frequencies on each tape, Ampex selects the center-line cuts of blank tape and then polishes it thirty times by running it against itself. This assures optimum contact with your playback head and accounts for the price of the finished tape. That was the situation in test frequency tapes until a few weeks ago when Livingston Audio Products, a pioneer in recorded tapes, announced a custom-engineered test tape at $9.95, the LX-1E. I immediately made an appointment with John White, their chief engineer, to see how they do it. Instead of polishing the tape beforehand, they depend upon automation for uniform results while recording. In a specially designed laboratory set apart from their Caldwell, N. J., plant, I watched the operator produce each tape individually. As each test frequency from 50 to 12,000 cycles is announced, relays (audible on the finished tape) activate a compressor amplifier designed to maintain constant levels by taking into consideration any variation in the tape itself. This system does away with the need for bias readjustment ordinarily required. (Where needed they have substituted precision military components to insure stability. "Red base" tubes are in virtually every socket.) Heads and tape drive are cleaned every 10 tapes. The LX-1E test tape also contains a 3,000-cycle tone for testing wow and flutter, 5,000-and 10,000-cycles for head alignment, a 250-cycle tone at zero level followed by a section of unrecorded tape for judging signal-to-noise ratio. The handiest feature of all is the vertically striped leader tape which acts as a stroboscope for checking the speed of the transport mechanism. Service technicians will welcome this strobe when getting acquainted with an unfamiliar machine. The Livingston LX-1E fills a need in its price range. For some time now Audio Devices, Inc., has offered an excellent custom-made test tape at $10. That tape, however, is designed solely for head alignment. Recorded at 15 ips, its test tones of 2, 10 and 15 kc jump to 1,000, 5,000 and 7,500 cycles at 7½ inches per second. Next month we'll take up test tapes made on duplicators.

Dance Hits of the 30's and 40's
New World Theatre Orchestra
Bel Canto Stereo Tape ST-30
(7-inch; playing time, 22 min. $9.95)

Taking full advantage of the relatively uniform dynamic range in dance music compared to that found in symphonic writing, Bel Canto offers a reel recorded at about twice the level found on classical orchestral tape recordings. Yet they manage this without introducing distortion. At this sound level, tape hiss ceases to exist as a factor in reproduction on first-grade equipment. High-level recording in commercial tapes has been tried in the past with small instrumental groups but I've never heard a taping of a dance band of this size with distortion held to this minimum. The music consists of tasteful arrangements of five old favorites including *Paper Doll, Dream, Stars Fell on Alabama, etc.* Go out of your way to hear this recording. This is tape with all the problems solved.

WILLSON: *The Music Man*
Original Broadway Cast Album
Capitol Stereo Tape ZF-41
(7-inch; playing time, 46 min. $14.95)

Capitol has captured in depth the small-town flavor of Meredith Willson's musical comedy. Robert Preston as the brassy band-instrument salesman can really demonstrate his wares in stereo. Throughout the show, only stereo can distinguish with ease the close layers of harmony built up by an old-fashioned male quartet as well as the tiniest inflections of the chorus. Very live recording helps. Smart New York audio-dealers are using this tape to demonstrate wide-range stereo's benefits on expensive sound equipment.

Holiday for Trumpets
Warren Kime and his Five Trumpets
Replica Stereo Tape T-110
(7-inch; playing time, 24 min. $7.95)

From the Iowa of *Music Man* to present-day Illinois where this Replica tape was made. Here is light, popular music featuring clever arrangements for five trumpets. Very easy to take. Sweet, untroubled highs and crisp bass set apart this well-recorded tape. Many of the individual trumpet touches would have been lost in single-channel recording.

PROKOFIEV: *Lieutenant Kije*
Fritz Reiner conducting Chicago Symphony Orchestra
RCA VICTOR Stereo Tape BCS-96
(7-inch; playing time, 20 min. $8.95)

Other than the concert hall, RCA's brilliant new tape provides the ideal medium in which to hear Prokofiev's larger-than-life score. The music makes exaggerated use of bass drum, fife, brasses and cymbals in depicting the life span of the imaginary Lieutenant Kije. No record has ever conveyed the full scope of this satire of military life under the czars. The man at the controls, Lewis Layton, has drawn upon the experience gained by RCA in more than a dozen stereo recordings of the Chicago orchestra. His handling of the live acoustics matches the broad sweep of Fritz Reiner's performance.

Fiesta Flamenca
Carlos Montoya and Spanish dancers and singers
Cook Stereo Tape 1027
(7-inch; playing time, 24 min. $12.95)

The heel-stomping of the Spanish dancers in this troupe offers ideal material for testing the bass transient response now possible in this medium. An old favorite in the Cook catalog, *Fiesta Flamenca* is set in motion again on this stereo tape.

Deutschmeister on Parade
Julius Herrmann conducting Deutschmeister Band
Westminster Sonotape SWB 7004
(7-inch; playing time, 17 min. $6.95)

This stereo tape is uniqe in one respect. In the first selection *Castaldo March*, this perky little brass band is heard far in the distance on the left microphone alone. No sound whatever issues from the right channel for the next 35 seconds. Then as the band nears the normal stereo field, the right-channel mike is slowly opened and the band parades across the room in stereo. Finally the left-channel microphone is slowly closed and we have 35 seconds of music on the right channel alone. Following this maximum illusion of directionality, the band offers a group of sprightly continental marches in typically clean Westminster sound.

Ruffles and Flourishes
Music for Field Trumpets and Drums
Frederick Fennell conducting members of Eastman Symphonic Wind Ensemble
Mercury Stereo Tape MS5-13
(7-inch; playing time, 21 min. $8.95)

A truly rousing entry by Mercury in the heightening competition to exploit stereo's advantages. The military trumpets are carried on one channel, the drums on the other. Without a symphony orchestra in the way, the bass drum and cymbals have a surprise in store for any speaker system. A note of caution: after listening to this tape on top-notch equipment, the steep attenuation of lowest bass frequencies on discs will become most apparent.

Vic Dickenson Septet
AV-Vanguard AV-752J
It Might as Well Be Spring
Sol Yaged and Quintet
AV-Herald AV-755J

These two monaural tapes of modern jazz can demonstrate on a first-class system that single-channel hi fi is also capable of a very high degree of presence. Both have a big bass and a good sharp high highs, though not as prominent as those in *Dancing and Dreaming*.

Note: Records below are 12-inch LP and play back with RIAA curve unless otherwise indicated.

HAYDN:
Symphony No. 100 in G (Military)
Symphony No. 101 in D (The Clock)
Antal Dorati conducting London Symphony Orchestra
Mercury MG 50155

Every audiophile will want to know how the "Battle" movement of the Haydn *Military* symphony is waged in Dorati's version. The answer: musically. Many listeners today will welcome the fact that Mercury's single-mike technique doesn't permit undue emphasis on cymbals and drums found in other versions. Clean sound and brisk, well-detailed playing.

The Sounds of Holland
Capitol T-10133

A tour of Holland in sound. A year of painstaking work with very fine Dutch-made portable tape recorders went into this album. With narration by the noted actor, Hans Conried, the tour includes an airport, railroad station, the harbor, canals and traffic sounds including hundreds of bicycle bells. The best "documentary" touch is the clomp of wooden shoes on a cobbled sidewalk.

Italian Interlude
Murray Dickie, Tenor, with Gianni Monese and His Orchestra
Vox VX 25.190

A collection of Neopolitan favorites sung in pleasant native style by a tenor from Scotland. Signor Monese and his orchestra provide authentic accompaniment. Up-to-date sound such as this may revive interest in this type of song so popular in the early days of radio.

RAVEL: ***Bolero***
LISZT: ***Mephisto Waltz***
Hermann Scherchen conducting Vienna State Opera Orchestra
Westminster Lab Series W-Lab 7059

Westminster's policy of holding down the maximum peak level in this deluxe series to 14 cm/sec pays off handsomely in the Ravel *Bolero*. The music builds naturally from a low-level beginning yet the climax does not contain the distortion present in virtually every other recorded version. The point of superiority is fast becoming academic, however, because many Lab Series buyers are now going over to $6.95 stereo tapes.

STRAVINSKI: ***Petrushka***
Firebird
Leopold Stokowski conducting Berlin Philharmonic Orchestra
Capitol PAO 8407

Uncommonly spacious sound typical of that favored by German recording engineers. The effect of a huge concert hall does not disguise the fact that Stokowski cannot persuade the Berlin players to unbend at any point in their rigidly correct performance of *Petrushka*. *The Firebird*, with less flexibility required of the orchestra, is more successful. A highly professional job of recording marred only by excessive poise in the performance.

TCHAIKOVSKY: ***Swan Lake***
Joseph Levine conducting Ballet Theatre Orchestra
Capitol PAO 8416
TCHAIKOVSKY: ***Excerpts from Sleeping Beauty***
Pierre Monteux conducting London Symphony Orchestra
RCA Victor LM-2177

Both ballets receive excellent treatment on these discs. The sweet sound of Tchaikovsky's strings is heard to better advantage in the Capitol performance because a flatter recording curve is employed but Monteux has the last word on the music he conducts. Very enjoyable.

HAYDN: ***Concerto (for harpsichord) in D***
BACH: ***Concerto (for harpsichord) in D Minor***
Sylvia Marlowe and Concert Arts Chamber Orchestra
Capitol P-8375

It still seems to me that in this series of Marlowe records Capitol is doing the best job of presenting the harpsichord in all but living presence. Those who own systems capable of presenting the high end with a minimum of coloration will be especially delighted by the purity with which the harpsichord tone in the upper register is presented, and, conversely, that same purity can do a beautiful job of showing off such a system. The small chamber orchestra contributes a rich and gutty bass and a fine contrasting solidity to the fragile harpsichord. The two works also present a contrast in style and variety and give the harpsichord plenty of opportunity to show off its own variety.

Mammoth Fair Organ
Carrousel Becquart
London LL 1644

If the range of your sense of humor matches that of your sound equipment you'll enjoy this record. Here is the most sophisticated 50-year-old mechanical organ on discs today. A feature of the Carrousel Becquart in Belgium, it romps through several items well known in this country, but most of its perforated rolls contain music familiar only to generations of visitors to Belgian fairs. Capitol Record's barrel organ production *Afternoon in Amsterdam* created a following for music of this sort by reason of the lavish care taken in recording it. Now London ffrr offers a mechanical organ of more lasting appeal. Your tweeters will appreciate the subtle clarity of the organ bells and your friends will find humor in the optimistic approach to the intricate orchestral arrangements. A. Schollaert, the man who devised the rolls, obviously found fun in science.

Resort Favorites for Dancing
Harry Marshard and His Orchestra
Unicorn 1049

An easy way to crash a swank affair offering music by Harry Marshard, the Boston-based society dance favorite of the past 25 years. What really will catch your ear in this record is the uncanny mike work of Peter Bartok — perhaps the shrewdest of the top handful of recording engineers who have achieved fame in the LP era, a fame limited to owners of really top-notch sound systems, yet a fame nonetheless. Bartok's symphonic recordings have been models of orchestral balance and realism. Working on stage at Town Hall in New York with a well-drilled society dance band, he uses both to maximum advantage. Without an echo chamber or other studio gimmicks, he gets the full sound of each instrument while retaining the overall balance. Through placement of the instruments, he achieves the definition that others think they get by boosting the upper end of the record curve. The orchestra doesn't relax for a second because the medleys on the record include the brightest favorites of the dancing set at six East Coast resort areas.

OFFENBACH: ***Gaité Parisienne***
Felix Slatkin conducting Hollywood Bowl Symphony
Capitol PAO-8405

Can they go much beyond this point in recording *Gaité Parisienne* on monaural discs? Not without recourse to hokum—devices such as artificial volume expansion or peaks in the frequency range at the point where cheap speakers fall off in response. We already have several "Gaités" with souped-up sound on other labels. Capitol now has the top version with a pleasing performance and wide range yet natural sound. For excitement beyond this, I refer you to stereo.

Gypsy Strings
Yoska Nemeth and his Gypsy Orchestra
Vox VX-25220

A fine change of pace both musically and sonically. This group gives fiddle, clarinets, cello and cimbalon opportunity to show off individually, and in combination to produce an opulence as colorful as gypsy costumes. The recording is fittingly spacious and very live and, despite the high average level, very clean. One of the best gypsy records in the catalogs. Most of the traditional gypsy airs and dances are included in the repertoire of some 26 or 27 selections.

SCHUBERT: ***Symphony No. 2***
Symphony No. 6
Couraud conducting Bamberg Symphony
Vox P-10240

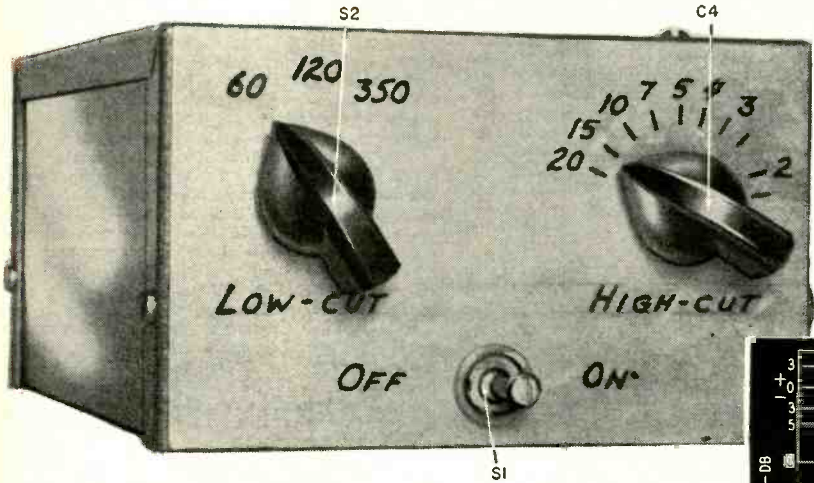
A sympathetic performance and excellent recording of two of the six symphonies Schubert composed between the ages of 16 and 21. No great challenge here to hi-fi capabilities but just another excellent subject for using hi fi for what it does best—reproducing music worth listening to and delightful to hear.

Vienna Midnight
Liane and Boheme Bar Trio
Vanguard VRS 9026
Paris Midnight
Liane and Boheme Bar Trio
Vanguard VRS 9018

Audiophiles discovered years ago that the velvety voice of Liane and the close-up piano, bass and alternating guitar and accordion of the Boheme Bar Trio gave them "presence" on any speaker. The early 10-inch Vanguard recordings of these cafe favorites employed the NAB recording curve. General advances in the recording art and use of the RIAA curve put these 12-inch discs near the top of the list. END

Name and address of any manufacturer of records mentioned in this column may be obtained by writing Records, RADIO-ELECTRONICS, *154 West 14 St., New York 11, N.Y.*

Audio Filter has VARIABLE Bandpass



This valuable audio accessory uses three bass rolloffs and a wide-range variable treble rolloff to improve hi-fi reproduction or amateur reception and transmission

By Dr. CARL F. ROTHE

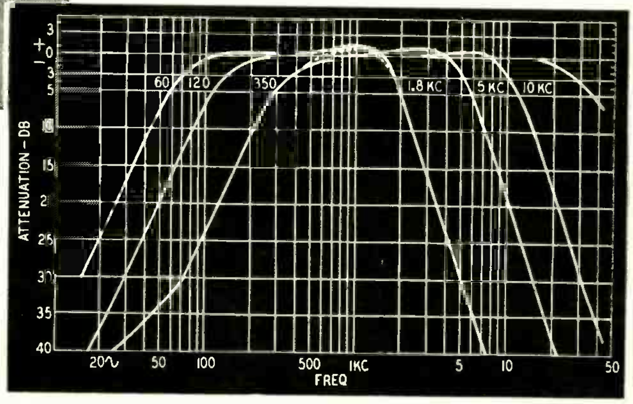


Fig. 1 — Response curves of the variable-bandpass filter.

An inexpensive audio filter with variable high- and low-frequency cutoff lets the experimenter or audiophile demonstrate the effect of high- or low-frequency losses. It also provides a way to reduce noise or rumble and a simple method of evaluating program material. By cutting back on the frequency response from either end until a reduction in response is heard, you can estimate the quality of the program or audio system. Using the treble control to reduce static or noise generally cuts the useful program material much more rapidly than does this sharp-cutoff filter.

The low-frequency cutoff selectively cuts excessive bass if the speaker is not properly loaded. It also helps to reduce switching transients and hum when experimenting with an audio system, thereby protecting the speaker.

The bandpass filter described here gives a choice of three low-frequency cutoffs (60. 120 and 350 cycles) at 12 db per octave, and a continuously variable high-frequency cut at 18 db per octave, between 1.8 and 28 kc. The filter is designed to be placed between the preamp and power amplifier of an audio system. It can also be used with the speech amplifier of ham gear to limit bandpass, or with experimental equipment.

L-C filters provide sharp cutoff, but are not easily variable and are expensive, especially if magnetically shielded inductors are used to reduce pickup of the ever-present hum. R-C networks give ultimate attenuation of 6 db per octave per section and, when three are put in series, a very comfortable 18 db per octave is obtained. However, as with the bridged-T network, the knee is far from sharp and the cutoff is slow at first.

Using R-C networks with an amplifier with 20-db gain, and applying negative feedback, the knee is sharpened and unity gain realized at the middle frequencies. The final responses are shown in Fig. 1.

The high-cut filter is similar to that described by Lawrence Fleming in *Radio & Television News*, May, 1955. Several improvements are incorporated in the present circuit. The noise output of Fleming's filter varied inversely with the cutoff-frequency setting. When using the filter with a high-gain power amplifier, such as the Heathkit W-5, the noise was objectionable at low-frequency cutoff settings. Bypassing the cathode resistor with a 15-μf capacitor eliminated the noise (see Fig. 2).

The characteristic 3-db hump, just prior to cutoff as described by Fleming, is reduced by using less feedback around the high-cut filter. The extra gain thus available permitted the use of more feedback around the low-cut filter, resulting in a sharper knee in its response curve.

Low-cut filter

The low-cut filter presents a major design problem since, ideally, the reactive components should be in the shunt-to-ground legs of the network and thereby have little effect at the flat response part of the curve. This cannot be done without using inductors. A three-section R-C network with the capacitors in series was used with feedback. With feedback from the large 0.1-μf output coupling capacitor C1, attenuation was sharp until the reactance of the network capacitors became so high that the signal bypassed the filter by taking the lower impedance path offered by the feedback line. This limited attenuation to about 20 db. By using a smaller capacitor (C15) for the feedback loop the low frequencies were effectively kept from entering the output.

Maximum possible frequency response is often desired, so a switch was added to bypass the filter. Resistors R1 and R2 were added to keep the coupling capacitors of the filter, preamp and power amplifier at the same dc potential and thus reduce switching transients.

If greater selection of cutoff frequencies is desired, different values of capacitors in the filters can be used. Doubling the capacitors' size gives a cutoff at about half the previous frequency. If a fourth position were available on the LOW-CUT selector switch, three .01-μf capacitors could be added to give flat bass response to about 40 cycles. This would effectively reduce turntable rumble with a minimum loss of bass. Using feedback extends the cutoff frequency (where the response is down 3 db) from that obtained without feedback. Theoretically, the cutoff frequency equals $\frac{1}{2}\pi$RC (R in megohms, C in μf, $2\pi = 6.28$). Under the conditions used here, it is approximately 1/9RC for the low and 2/9RC for the high end. For exact values, experimenting will have to be done.

Because of the large amount of feedback, the input impedance is about 300,000 ohms and so the impedance of the source should be relatively low.

The filter is highly stable since there is no overall gain.

Construction details

The filter was built into a 7 x 5 x 3-inch case. The three-gang capacitor was put in one corner, and the 12AU7 on a bracket behind it. This left half of the box for the low-cut filter capacitors and other components.

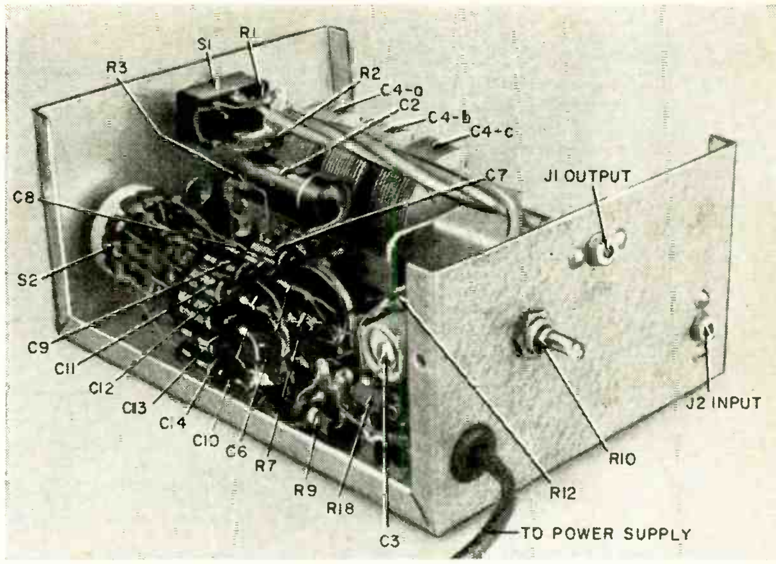
The layout is not particularly important, since the signal level is relatively high and the gain unity. However, if greater than 30-db cuts are desired at high frequencies, it is well to keep the input circuitry of the high-cut filter and the capacitors and wiring of the low-pass unit at least ½ inch apart. The heater leads, of course, should be twisted together, kept short and close to the chassis. Center-tap grounding of the heater transformer helps minimize hum. The heater circuit shown in Fig. 2-b can be used with power supplies with one side of the heater supply grounded to the B-minus supply or with a floating heater winding.

Resistor R3 was picked to give a stage gain for the high-pass filter of about 1.5 at 1,000 cycles. Feedback resistor R10 for the low-pass filter was then chosen to give an overall gain of 1 for the whole filter at 1,000 cycles. I used a 1-megohm pot for this resistor (see photos). A 560,000-ohm fixed resistor (see schematic) can be used.

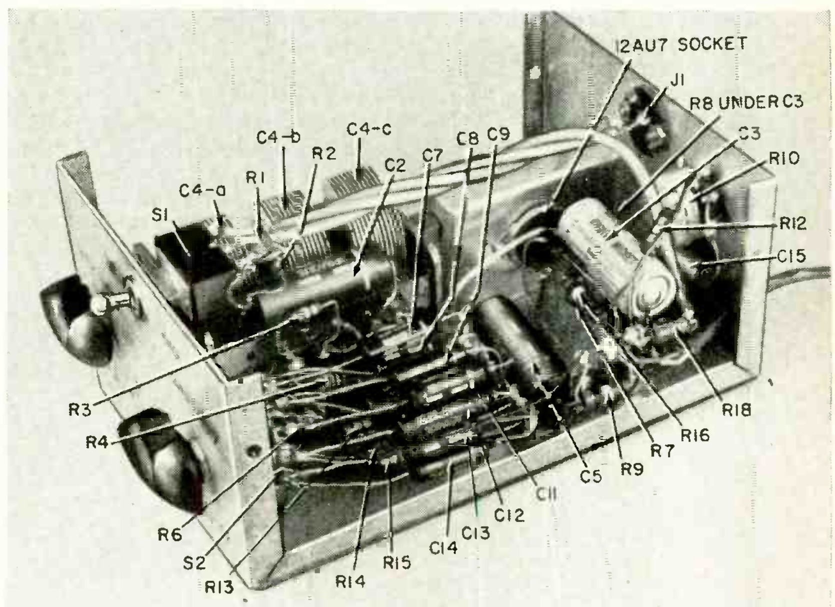
I calibrated the filter with a Hewlett-Packard audio generator and a Heathkit vtvm. Variations in output of the generator and response of the vtvm were eliminated by comparing the indicated voltages at the various frequencies with the filter selector OFF to those with the filter ON. If equipment is not available for calibration, the standard broadcast-band trf capacitor used gives the following cutoff points: fully closed, 1.8 kc; one-quarter open, 3 kc; one-half, 5 kc; three-quarters, 10 kc; seven-eighths, 16 kc, and fully open, 28 kc.

The calibration points were marked on a separate aluminum panel, but could have been made directly on the gray hammertone panel.

The filter has greatly improved the reception of weak AM stations when static or heterodyning is present. Boomy male voices are made more intelligible, and turntable rumble, when present, is reduced. The effects of loss of bass are clearly demonstrated. END



Above, an inside view showing the Low-Cut switch assembly. And, below, another look at the filter's insides.



R1, 2—4.7 megohms
R3—820,000 ohms
R4, 11—470,000 ohms
R5—1 megohm
R6, 7, 12, 13, 14, 15—270,000 ohms
R8, 17—2,200 ohms, 1 watt
R9, 16—100,000 ohms, 1 watt
R10—560,000 ohms
R18, 19—47 ohms, 1 watt
All resistors ½-watt 10% unless noted
C1—0.1 μf, tubular
C2, 5—.06 μf, tubular
C3—15 μf, 25 volts, electrolytic
C4—10-365 μμf per section, 3-gang trf type variable capacitor (Allied 60 H 726 or equivalent) with extender 60 H 366 for adapting ⅜-inch shaft to ¼ inch
C6, 9, 12—.0068 μf, tubular
C7, 10, 13—.0033 μf, tubular
C8, 11, 14—.0015 μf, tubular
C15—.01 μf, tubular
All capacitors 600 volts unless noted
J1, 2—phono jacks
S1—dpdt toggle
S2—3- or 4-position 3-pole rotary (single deck)
V1—12AU7
Chassis, 7 x 5 x 3-inch box
Miscellaneous hardware

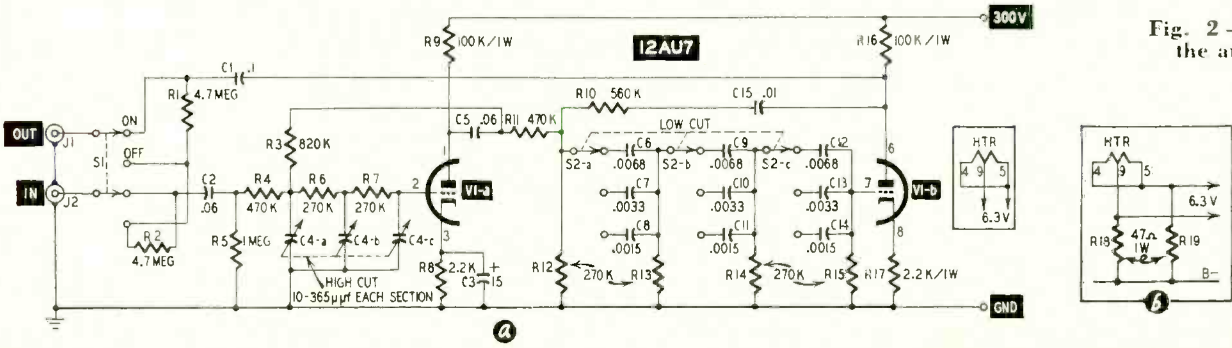


Fig. 2 — Circuit of the audio filter.

more about the CATHODE FOLLOWER

Designing a preamp output stage that uses a cathode follower isn't quite as easy as it sounds

By NORMAN H. CROWHURST

IT seems that I have gone through all this before. My previous article on the subject, "Getting the Cathode Follower Straight" (RADIO-ELECTRONICS, December, 1954) elicited more correspondence from readers than any other article to date. These could be grouped under two headings: (1) the reader who appreciated the presentation (often because he had found the matter out the hard way himself) and therefore found it useful (2) the reader who felt I was doing the cathode follower an injustice!

The latter had apparently been taught in college that the cathode follower is a panacea, not only for all audio troubles, but almost all electronic troubles. Without checking up on the statements I made, he felt my article to be a slight on such a wonderful device.

Recently, however, a friend of mine approached me about designing a cathode-follower output stage for a preamplifier. He had been trying, somewhat unsuccessfully, to apply data obtained from various sources and remembering my article, he thought I might be able to help him solve his problem.

As that article treated the matter only theoretically, it will not be inappropriate to give readers the benefit of this help, so anyone who wishes can apply the correct principles himself. To highlight the possible pitfalls—and make sure some readers do not still think I am misrepresenting their pet circuits—let's follow my friend's course, by trying first to use the available data.

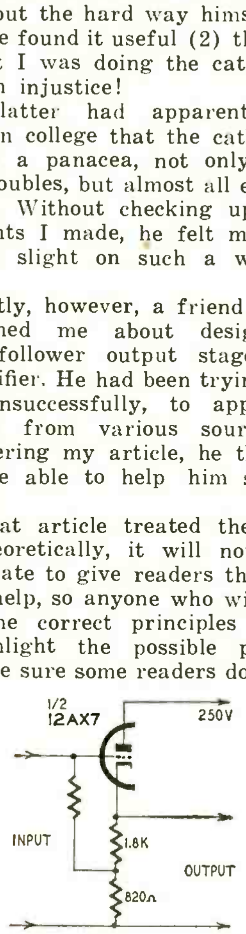


Fig. 1—Circuit—with values calculated from formula and tabulated data—for using a 12AX7 as a cathode follower to give a 500-ohm output impedance.

Published data

Using the symbol R_s for the output source impedance, R_p for the plate resistance, R_L for the cathode load resistance and μ for the tube's amplification factor, several authorities correctly give the formula for output source impedance as

$$R_s = \frac{R_L R_p}{R_L(\mu + 1) + R_p}$$

This formula can be rearranged to find the appropriate cathode load resistance

$$R_L = \frac{R_s R_p}{R_p - R_s(\mu + 1)}$$

My friend found the second formula (written out in full) in the RCA receiving-tube manual. He first thought a feasible tube would be one half of a miniature twin triode, the 12AU7. Looking up the values, he found that, with a plate supply voltage of 250, it requires a grid bias of −8.5 volts, has an amplification factor (μ) of 17 and a plate resistance of 7,700 ohms.

Substituting these values into the formula, assuming a desired 500-ohm output source impedance, he came out with a cathode load resistor of *minus* 3,000 ohms! Not having any negative-value resistors in his junkbox, he decided that a different approach was necessary.

He went on to try a different tube—a 12AX7—but, before we follow him, let's see just what this negative value really means. Go back to the formula for source resistance and substitute successively higher values of cathode load resistance R_L, until we reach a theoretical value of infinity. At this point, the odd term R_p in the bottom of the fraction becomes negligible compared to the terms that contain R_L as a factor in both top and bottom. This means that, *for this particular condition,* the source resistance reduces to the expression

$$R_s = \frac{R_p}{\mu + 1}.$$

Hence, for this particular tube, with a theoretical infinite cathode load resistance, the source resistance will be 7,700 ohms divided by (17 + 1), or 430 ohms. This happens to be less than the desired 500 ohms. Using any practical value of R_L, instead of this theoretical infinite value, produces a source resistance that is *lower* than 430 ohms.

Thus, the only way, in theory, that the source resistance could be raised to 500 ohms would be to extend the cathode load resistance beyond infinity and into the negative resistance region. This is all very well in theory, but cannot be done in practice! However, there is a simple and practical way over the difficulty which we shall come to later in the article.

Meanwhile, my friend who turned to the 12AX7 found the relevant values were: grid bias −2, amplification factor (μ) 100, plate resistance 62,500 ohms. Substituting these into the formula gave a cathode load resistor of 2,600 ohms.

Plate current is given as 1.2 ma, so to get a bias of −2 volts, the resistance in this part of the circuit should be only about 1,660 ohms. Using a practical value of 1,800 ohms, with a further series value of 820 ohms to make up the cathode load, the circuit appears as shown in Fig. 1. This supplies correct bias to the tube and should land up with a 500-ohm source resistance.

So my friend went ahead and built this circuit. It came as somewhat of a shock to him to find considerable distortion when he fed the output into a 500-ohm load. Using a distortion meter he found that, with 1 volt out, he was getting up to 20% distortion. Removing the 500-ohm load, the output rose to about 4 volts. Turning the input down a little, he found he could now get 3 volts output with 5% distortion.

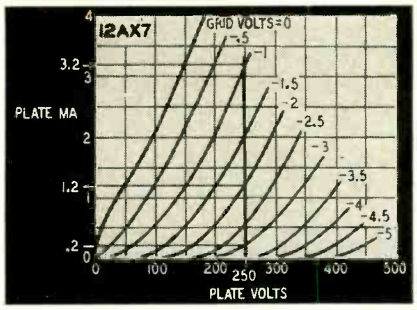


Fig. 2—Characteristics of the 12AX7 show operating condition produced by circuit of Fig. 1.

Even this, however, is rather short of *high* fidelity! It was at this stage that my friend came to me in desperation.

Why the distortion?

Before showing him how to get better results, it will be well to explain the distortion. Let's take the tube characteristics shown in Fig. 2. A load line representing 2,600 ohms will be so nearly vertical as to be indistinguishable from a constant voltage of 250. The well-known formula for gain of a cathode follower is

$$A = \frac{\mu R_L}{R_p + R_L (\mu + 1)}$$

Using R_L = 2,600 ohms, R_p = 62,500 ohms, μ = 100 for the unloaded condition, this works out to be 0.8. In other words, the voltage swing between cathode and ground is 4 times that between grid and cathode, with the result that the cathode-to-ground swing is four-fifths of the voltage applied between grid and ground.

Assume that we can appy a grid to cathode swing of 1 volt either way from the −2-volt bias point. Going negative to −3 volts, plate current is 0.2 ma. At −2 volts, plate current is 1.2 ma while, at −1 volt, plate current rises to 3.2 ma. So, for a 1-volt sinusoidal input between grid and cathode, the output will give a fluctuation of 2 ma one way and 1 ma the other way.

This represents a second-harmonic distortion given by $\frac{a - b}{2 (a + b)} \times 100$, or 16⅔% under this condition. As a cathode follower, however, there would be 4-volt swing from cathode to ground, requiring 5 volts swing from grid to ground to achieve this condition. The feedback will tend to neutralize the distortion to something less than 16⅔%. The gain reduction is 5 to 1 because without feedback 1 volt in produces 4 volts out, while with feedback it takes 5 volts in to produce 4 volts out. So we should expect to reduce the distortion 5 times, or to 3⅓%.

But 3⅓% of 4 volts is 133 mv. If the input is pure, there must also be 133 mv of antiphase second harmonic between grid and cathode to balance this. Referred to 1 volt, 133 mv is 13⅓%. As the tube generates 16⅔% from the fundamental in opposite phase, this leaves us the difference of 3⅓% in the output, as assumed. This is illustrated in Fig. 3.

So we land up with a peak voltage of 4 with distortion of 3⅓%. Since 3 volts rms is about 4.5 volts peak—a little more than this—it is not surprising to find that distortion read on the meter is 5%.

Now for the loaded condition. Instead of 2,600 ohms for the cathode load resistor, we now use the combined resistance of 2,600 ohms with the 500-ohm resistor in parallel, giving us 420 ohms. From the formula this gives a voltage gain of 0.4, which means that for 3 volts in, between grid and cathode, there will be 2 volts out, between cathode and ground. It will take a 5-volt input to produce a 2-volt swing at the output.

Looking at the distortion on the tube characteristics, swinging 2 volts each way from the bias point of −2: for zero grid voltage the current is about 6 ma (this is beyond the curves given, so is estimated) and for −4 volts, it is zero. Thus the positive swing is 4.8 ma while the negative swing is 1.2 ma. This figures out to 30% second-harmonic distortion.

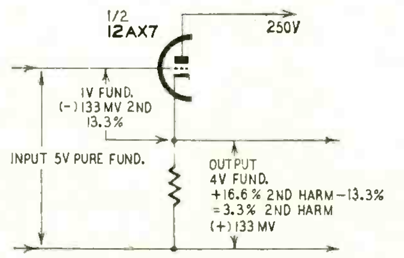


Fig. 3—Distribution of distortion components.

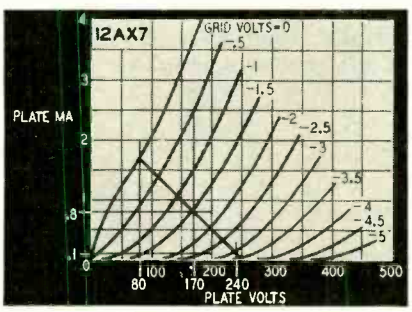


Fig. 4—Characteristic curves of a 12AX7 with a 100,000-ohm load line.

Feedback, however, reduces the gain by three-fifths because, without feedback, 3 volts in would give 2 volts out, while with feedback it requires 5 volts in to give 2 volts out. This means the distortion should be reduced to 18%.

A peak swing of 2 volts between grid and cathode, as just considered, will give 1⅓ volts between cathode and ground and will require an input of 3⅓ volts. The output of 1⅓ volts peak is equivalent to 0.7 times this, or about 0.95 volt rms.

With a theoretical distortion of 18% for 0.95 volt it is not surprising to find that we measure 20% with 1 volt.

A good cathode follower

So theory backs the measurement. How, then, are we to improve the performance of a cathode follower for a preamplifier output circuit? Using this example, it is evident that loading with 500 ohms produces an actual plate circuit load of 420 ohms. This not only produces excessive nonlinearity but reduces the working gain of the tube by one-third.

If we use a higher resistance in the cathode circuit, we should improve this situation somewhat because the effective cathode load would then be nearer the external value of 500 ohms. While this would reduce the distortion a little, the best solution is to operate into an open circuit, or at least a virtual open circuit. This way, the only 500 ohms present is that provided by the tube's cathode circuit. This method, using a larger value of resistor in the cathode circuit, considerably improves the output.

Reworking the characteristics, we could use a 100,000-ohm cathode load and arrange to have a bias of 1.5 volts (see Fig. 4). This gives a plate current of 0.8 ma, so the bias resistor should be about 2,000 ohms.

A 1.5-volt swing each way, measured between grid and cathode from the bias point, yields a swing from 170 volts at the bias point to 80 and 240 volts. This represents 10% distortion since there is a 60-volt excursion one way and 90 volts the other.

However, a 3-volt peak-to-peak swing input produces 150 volts peak-to-peak output, which means the tube is operating at a gain of 50. As a cathode follower it will require 153 volts in to give an output of 150. This means that the gain reduction is 51. Dividing the 10% distortion by the factor of 51 gives us an overall distortion of slightly less than 0.2%, which is a considerable improvement. The necessary circuit is shown in Fig. 5.

Now let's assume that the same circuit is loaded with 500 ohms. Drawing a vertical load line through the 170-volt operating point, we can consider an excursion from −0.5 to −2.5 volts on the grid. This will produce a current swing from 2.5 ma to 0.1 ma, or 2.4 ma overall across 500 ohms. This produces a swing of 1.2 volts from cathode to ground for the 2-volt swing between

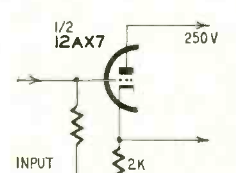


Fig. 5—Basic circuit for cathode follower represented in Fig. 4. For simplicity, coupling capacitor is not shown. The dotted line shows an alternate output, which gives 2% less voltage on open circuit and a source resistance about 2,000 ohms higher than the solid line connection.

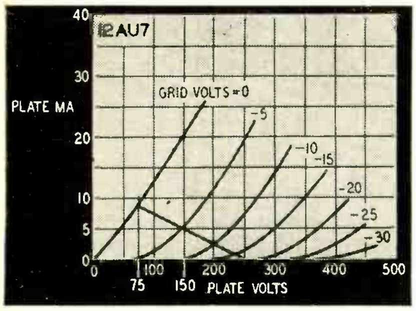


Fig. 6 — Characteristics of a 12AU7, showing cathode follower operation using a 20,000-ohm load.

grid and cathode, or a total of 3.2 volts swing at the input from grid to ground.

The 2.4-ma swing is made up of 0.7 ma negative from 0.8 and 1.7 ma positive. This represents 15% distortion. However, the feedback, which reduces gain by a ratio of 2/3.2, the difference in the input required to give 1.2 volts out, brings the distortion down to slightly less than 10%.

This is for a peak-to-peak output of 1.2 volts, or an rms of not much more than 0.4 volt. So, for working into a loaded circuit, use of a larger cathode resistance has made our position worse —we cannot get as much output for the same amount of distortion.

Back to the 12AU7

Now let's return to my friend's first choice, the 12AU7. Its characteristics are shown in Fig. 6 and a 20,000-ohm load line is drawn from a 250-volt operating point. For convenience in assessing distortion, we'll assume the bias is −5 volts. This gives an operating point of 150 volts at the plate. So the bias resistor has to be 1,000 ohms as shown in Fig. 7.

To assess operating conditions without an external load, assume a 5-volt excursion each way: the plate voltage swings from 75 to 150 to 200. This again represents 10% distortion, but the overall swing of 125 volts cathode to ground is achieved with a grid-to-cathode swing of 10 volts, or 135 volts from grid to ground. This means that the gain is reduced by a factor of 13.5, so that the resulting distortion will be 10/13.5, or about 0.75%.

This is at an output of 125 volts peak to peak or 45 volts rms. As practical levels would be a lot lower than this, we can expect less distortion than with the 12AX7.

Now consider what happens when we load the output with 500 ohms. Drawing a vertical line through the 150-volt point on the 5-volt bias curve, we find that the current excursion is now from 0 to 5 to 20 ma. This represents 25% distortion. A swing of 20 ma in 500 ohms will produce 10 volts output swing for 10 volts from grid to cathode. So feedback will just halve the distortion, reducing it to 12.5%.

But notice that here we have a swing of 10-volts peak to peak available, or about 3.5 rms with 12.5% distortion. So it should be possible to produce an output of about 1 volt rms with not much more than 1% distortion, which is a considerable improvement on the possibility with the 12AX7.

Source resistance

But, using this method, how can we assess the output source resistance? We could, of course, use the formula again but it is simpler, as we are using tube characteristics to assess distortion, to use the same characteristics to assess source resistance produced.

Reverting to the 12AX7 with a 100,000-ohm load resistor (see Fig. 4), we observe the slope of the −1.5-volt characteristic where it intersects the load line. This we can judge by noticing the voltage change corresponding to a given

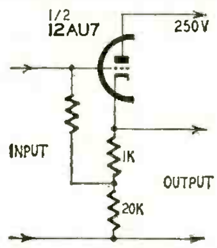


Fig. 7—Basic circuit of cathode follower represented in Fig. 6.

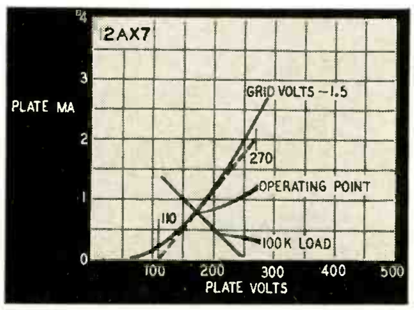


Fig. 8—Finding the working value of a tube's plate resistance—a 12AX7—at the operating point of Fig. 4.

current. Drawing a tangent to the 1.5-volt line (dashed line in Fig. 8), we get 0 ma at 110 volts and 2 ma at 270 volts, a difference of 160 volts for 2 ma or 80 volts for 1 ma. This represents a plate resistance of 80,000 ohms which is effectively in parallel with the 100,000-ohm coupling resistor, giving a source resistance, without feedback, of 45,000 ohms.

You will recall that feedback reduces gain by 51 times, so the plate resistance or source resistance is also reduced 51 times. So 45,000 ohms becomes about 880.

Using the same method with the 12AU7 tube and drawing a tangent to the curve, we find the working plate resistance to be about 10,000 ohms—there is a 100-volt change for 10 ma. The coupling resistor was 20,000 ohms, so the source resistance without feedback is about 6,700 ohms. The gain reduction was 13.5 to 1 so the source resistance is 6,700 ohms divided by 13.5, or about 500 ohms.

This is the desired figure of 500 ohms. There is no margin for adjustment. If the 500-ohm figure is important, a load resistor of less than 20,000 ohms can be used. Try, for example, 10,000 ohms. The load line for this is shown in Fig. 9. Using a bias of −5 volts, we require a 620-ohm bias resistor.

The output swing is 100 volts for a grid swing of 10 volts. The distortion is about 5% and, with feedback reducing the gain at 11 to 1, distortion is less than 0.5%. This is probably a little more than the other load line gave *for the same output level*, but is a big improvement over the original values obtained. At an output of a few volts instead of 35 volts rms (at which the 0.5% is obtained), distortion should be very small.

At this point on the −5-volt curve, plate resistance is about 8,000 ohms, which in parallel with 10,000 ohms gives 4,500 ohms. This divided by 11 gives an output resistance of about 410 ohms. This result has been confirmed in practice. Lower values of plate resistance can be used, but they cause further increases in distortion. For achieving a reasonable distortion figure 10,000 ohms is about a minimum value.

If the source resistance is reduced below the design figure, it can be padded out with series resistance, as shown in Fig. 10. There is no need to go in search of a negative resistance for the load circuit!

The procedure in designing a cathode-follower output is to find a suitable load line in the same way as designing an ordinary plate-coupled output.

If the cathode follower is to be matched-loaded, distortion will be inevitably high unless the levels are kept very low. The more practical use of a cathode-follower output is to provide a low *source* resistance, so the connect-

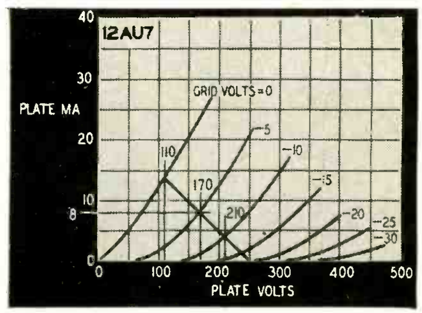


Fig. 9—Using a lower value load for the 12AU7—10,000 ohms—produces a lower source resistance, with slightly more distortion for the same output level.

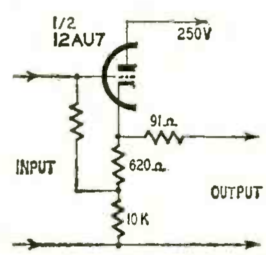


Fig. 10—Instead of looking for a negative resistor, the desired source resistance can be padded out as shown here. The values indicated give a source resistance of 410 ohms, which can be padded to 500 ohms by the 91-ohm resistor. In practice a coupling capacitor is needed.

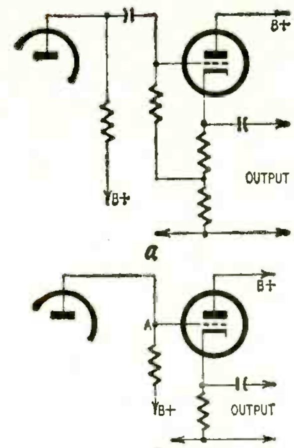


Fig. 11—Practical considerations: a—the traditional way of connecting a cathode follower to get correct operating conditions and block dc components: b—a practical method that eliminates one coupling capacitor and two resistors, but requires careful control of the dc potential at point A on the previous stage.

ing link between a preamp and power amplifier is nonsusceptible to loading effects due to cable capacitance or static pickup. The low impedance presented, looking back into the cathode follower, effectively short-circuits any kind of static pickup that might otherwise occur. The load to which the cathode follower is connected can then be large compared to R_s with no ill effects.

While a high-slope triode, such as the 12AX7, *can* be used to provide a low source resistance at low signal levels, low-impedance tubes like the 12AU7 are more flexible in this application. When working into open circuit or high impedance, the coupling resistance in the cathode circuit should be more than the plate resistance of the tube—preferably at least 1½ times. Above this value, further increase does not make much difference in performance, provided suitable operating conditions are chosen. Below it, distortion begins to increase rapidly. For working into a matched load, the best coupling resistor is, more critical and should be in the region of the tube's plate resistance.

But the ideal purpose of a cathode-follower output stage is not for matching a low resistance. It is for *providing* a low source resistance.

If a number of power amplifiers are connected in parallel, or fed through frequency-selective networks for separate channel amplification, a cathode follower is ideal to prevent interaction between the different inputs.

The practical circuits shown in this article use a return point for the bias obtained by calculating and employ a coupling capacitor to isolate the plate voltage from the previous stage. An alternative method of design is to work out the cathode-follower details in conjunction with the preceding stage.

If the operating voltage drop, as in this example, is 105 from cathode to ground, then the plate voltage of the preceding stage can be designed to operate around 100 volts—the cathode-to-ground voltage plus the bias voltage of 5. Then the output can be direct-coupled, as shown in Fig. 11.

This obviates the necessity for a coupling capacitor, a grid-to-bias-point resistor and a separate bias resistor. So we save a coupling capacitor and two resistors by using this method!

In this article I have gone into the question of what value capacitor to use. This will be determined, in the usual way, by low-frequency response consideration. An important point that should be mentioned, though, is that matching into a 500- or 600-ohm load necessitates a very large output coupling capacitor, about 100 times the value necessary when working from a cathode follower into a high impedance. END

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Final Touchup For Your Amplifier

By HAROLD REED

Some simple methods for correcting an audio amplifier's frequency response

IN designing and building audio amplifiers, known and proven practices must be followed to obtain the best possible frequency response. This, of course, includes careful selection of resistive and capacitive components used in the amplifier's circuitry, and high-quality transformers. But, when the amplifier is complete, it may still be desirable to apply frequency correction for one reason or another. Let us first consider a simple method to provide some high-frequency boost.

The cathode resistor in a voltage-amplifier stage provides correct dc operating bias for the tube. The audio signal voltage also appears across this resistor and the voltage drop developed is in opposition to the input signal voltage. This results in inverse or negative feedback, causing a reduction in gain. It is customary, therefore, to bypass the cathode resistor with a large capacitor, presenting a low impedance to the signal current and reducing the audio voltage drop to a negligible value. However, beneficial results may often be obtained by not bypassing the cathode resistor heavily. Let us consider the voltage-amplifier stage in Fig. 1.

High-frequency boost

Without any bypass capacitor across cathode resistor, R_x, feedback voltage reduced stage gain by about 5 db. A 20-μf capacitor shunted across this resistor ended this loss in gain, boosting the voltage 5 db from 20 to 15,000 cycles and 4 db at 20,000 cycles.

Suppose your amplifier is dropping off at the higher frequencies. We may be able to obtain just the desired boost with a small capacitor across the cathode resistor. As an example, the 20-μf capacitor shown in Fig. 1 was removed and replaced by a .05-μf unit, C_x. This results in a boost of about 2 db at 10,000 cycles, 3 db at 15,000, and 4 db at 20,000 cycles. The small value of capacitance has high reactance to the lower frequencies and causes little or no change in the feedback voltage. At the higher frequencies, the capacitor's reactance becomes relatively small, causing a reduction in the signal-voltage drop in the cathode circuit and a corresponding reduction in negative feedback. In the example just cited, capacitive reactance X_c equals the 1,800-ohm resistor at about 17,000 cycles. This correction may be applied to the preamp if a large cathode bypass is not needed to reduce hum. If a bypass is needed, the alteration should be applied to a later voltage-amplifier stage.

Another convenient method that can be used to increase gain at the higher frequencies is shown in Fig. 2. A capacitor and resistor in series are placed between cathode and ground. Feedback from the amplifier output is brought back to this cathode circuit. The reactance of the .01-μf capacitor C_x equals the 1,000-ohm resistor R_x at 16,000 cycles.

The capacitor couples 1,000 ohms in parallel with 2,200 ohms, reducing the

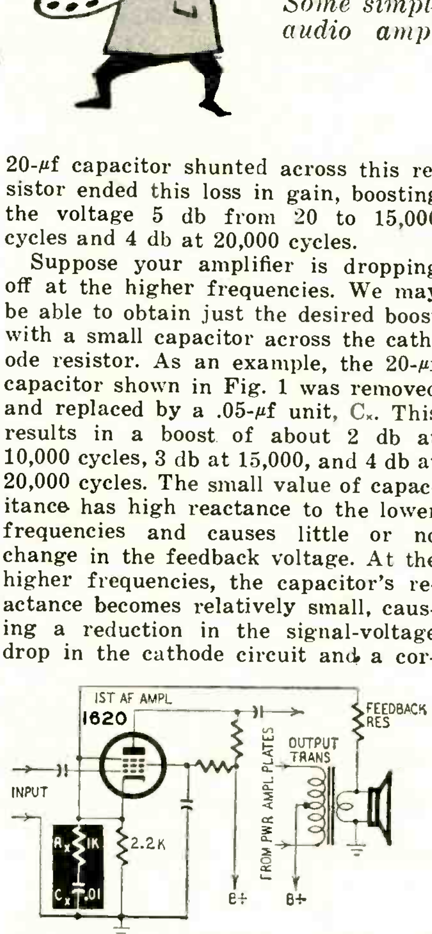


Fig. 2—Another method of increasing high-end boost.

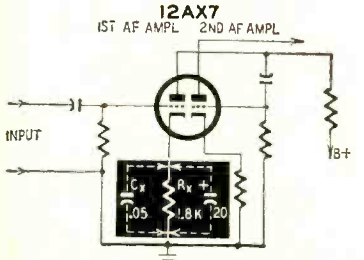


Fig. 1—Bypassing the cathode resistor resulted in high-frequency boost.

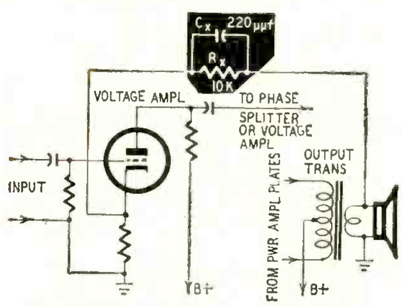


Fig. 3—High-frequency attenuation attained by shunting the feedback resistor.

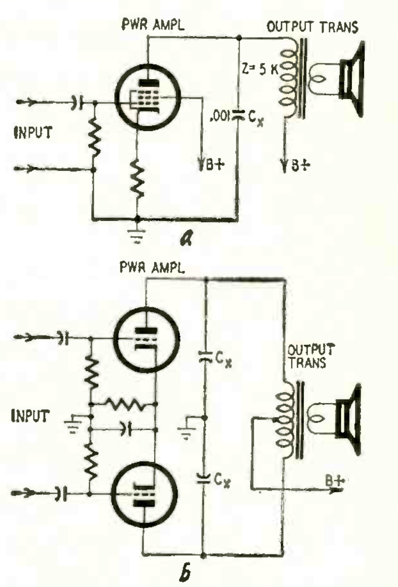


Fig. 4—Suppressing ultrasonic oscillations: a—in a single-ended output stage; b—in a push-pull output stage.

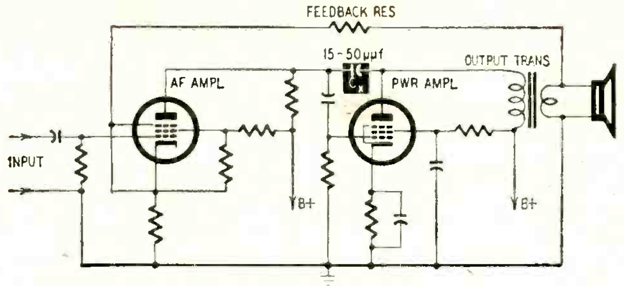


Fig. 5—A one-stage feedback loop also helps avoid ultrasonic oscillation.

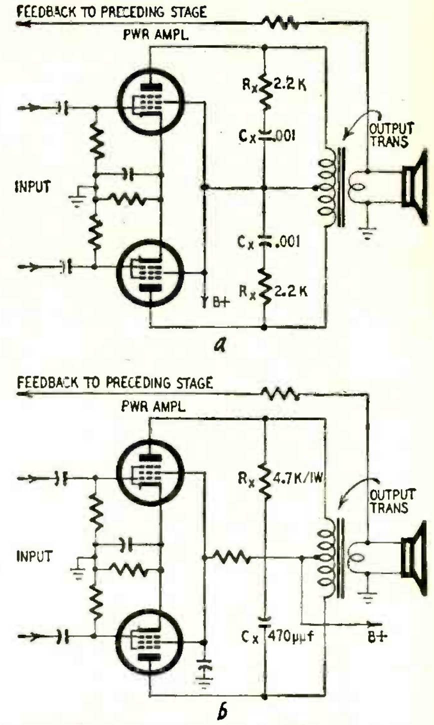


Fig. 6—Neutralizing audio-frequency phase shift.

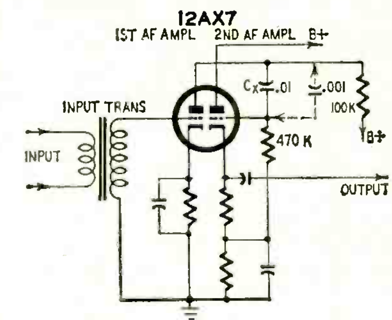


Fig. 7—Reducing the value of the coupling capacitor attenuates the lower frequencies.

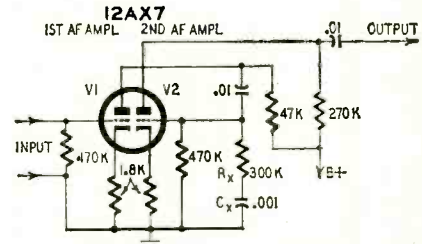


Fig. 8—Bass boost with a simple R-C network.

combined value to about 690 ohms. A change from 2,200 to 690 ohms will give about a 10-db boost, most of which will occur by 16,000 cycles—theoretically about 7.3 db. Other factors adjust this to a 6-db overall rise in gain at 16,000 cycles with the particular values given for R_x and C_x. The reactive value of C_x increases with decreasing frequency and has negligible effect at the lower half of the audio band.

In a specific case, an amplifier was flat when designed and tested in the experimental breadboard manner. After being dressed up and packaged relatively long shielded leads in the grid circuit, including the gain control, resulted in a high-frequency drop. The simple R-C network shown provided a remedy with negligible effect on other characteristics.

Suppressing ultrasonics

It may be desirable to attenuate certain audio frequencies. One useful arrangement for high-frequency attenuation is presented in Fig. 3. The feedback resistor is shunted by a suitable capacitor. This is often helpful in suppressing ultrasonic frequencies or reducing gain at the upper limit of the audio band.

Suppose we are concerned with a parasitic oscillation above 20,000 cycles. In Fig. 3 the feedback resistor (R_x) is 10,000 ohms. Shunting it with a 220-μμf capacitor delivers an attenuation of 1 db at 20,000 cycles. The capacitive reactance X_c becomes smaller as frequency increases, introducing more feedback and reducing gain above the audio range. An even smaller capacitor, causing less than 1-db attenuation at 20,000 cycles, may be enough to suppress the parasitic, depending of course on the frequency of oscillation. Larger capacitor values can be used to reduce gain in the upper part of the audio band. However, this cannot be carried too far. Increasing the feedback beyond a certain value at the high frequencies will result in the amplifier breaking into oscillation.

There are other ways to suppress ultrasonic oscillations. A small capacitor may be connected from the plate of the output tube to ground. Its value will depend on the output load impedance and usually can be small enough to have negligible effect on the amplifier frequency response. (See Fig. 4-a.) Measurements in the circuit with indicated values of output load and C showed 0.1-db attenuation at 20,000 cycles and 6-db attenuation at 44,000 cycles. This method may also be applied to a push-pull output stage as shown in Fig. 4-b. Larger capacitor values may be used if attenuation of the upper audio frequencies can be tolerated.

Another simple treatment often found effective is shown in Fig. 5. A small amount of feedback at high frequencies is introduced around one stage by a small capacitor, say between 15 and 50 μμf. This is inside the normal feedback loop.

Audio-frequency phase shift in a negative-feedback amplifier prevents the use of maximum feedback voltage. Neutralization of high-frequency phase shift can be obtained with an R-C network in the output stage as shown in Fig. 6-a. Resistor (R_x) and capacitor (C_x) in series are placed across the plate of each stage of the push-pull circuit; that is, across each half of the transformer winding. This is a typical output stage often found in hi-fi amplifiers and uses tubes like the 6V6 with an 8,000-ohm-to-voice-coil output transformer. The capacitive reactance X_c at 20,000 cycles is 8,000 ohms. This, in series with the 2,200-ohm resistor, places an impedance of about 8,300 ohms across each half of the transformer primary at the top of the audio band. X_c, then, increases or decreases inversely with frequency. Another circuit arrangement is given in Fig. 6-b, using a single resistor and capacitor.

Low-frequency alterations

You may want to make some minor alterations at the lower audio frequency. The reactance of the coupling capacitor between the plate of one stage and grid of the next is usually negligible at the middle and high frequencies of the audio band. At the lower frequencies its reactance can be come appreciable and some of the signal voltage will appear across it, resulting in loss of low-frequency gain. Therefore, the coupling capacitor is made relatively large. However, if you want to attenuate the lower ferquencies, you may deliberately reduce the capacitive value of the coupling capacitor. Consider the circuit in Fig. 7. The frequency response was flat within 0.5 db using the .01-μf capacitor C_x. By replacing this with a .001-μf unit, the frequency response became −4 db at 30 cycles and zero db at 1,000 cycles This attenuation decreases with progressively larger values of the coupling capacitor. Some interesting data on bass attenuation in R-C-coupled pentode stage by variation of the screen bypass capacitor are given in the *Radiotron Designer's Handbook.*[1]

Bass can be boosted with a simple R-C network as shown in Fig. 8. R_x and C_x are shunted across the plate circuit of V1. If C_x is .001 μf, its reactance is equal to R_x, 300,000 ohms at approximately 550 cycles. As the frequency of the audio signal decreases, the reactance of C_x increases, and a

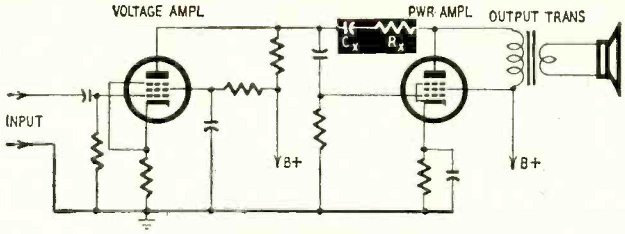


Fig. 9—Another bass-boost network.

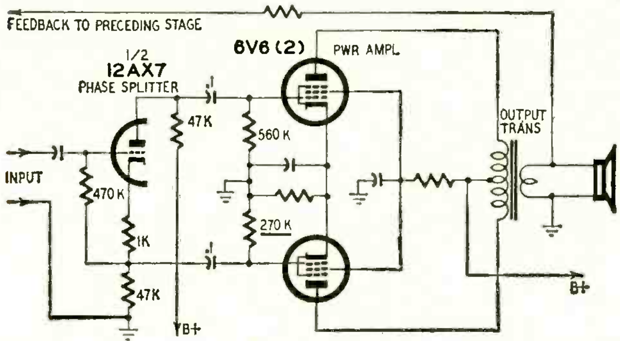


Fig. 10—Changing grid-resistor values can end high-frequency oscillation.

larger signal is available at the grid of V2. Using the circuit and values indicated, response was 5 db at 30 cycles and zero db at the reference frequency, 1,000 cycles. The response was within 1 db across the band prior to connecting the R-C network. The value of the grid resistor for the stage following the R-C network must be as high as possible with respect to R_x. Also the value of R_x should be at least twice the plate resistance of V1 to prevent plate loading of the tube.

Another handy network for bass boost is presented in Fig. 9. A capacitor is inserted in series with the feedback resistor. As frequency decreases, the reactance of C_x increases, resulting in reduced feedback and greater gain. *Caution:* Negative feedback is reduced at the low end where it is most needed to control distortion. Increasing gain in this manner may also increase distortion.

When using the phase-splitter type of phase inverter, balance at the lower frequencies is usually good. Shunt capacitances across the plate and cathode outputs of the inverter, however, are different at the high frequencies and unbalance may result. High-frequency response is better through the cathode side of the inverter than through the plate side as the grid input capacitance of the output tubes has less effect on the cathode side of the phase splitter than on the high-impedance plate side. With increased feedback, instability may be a problem.

Where very-high-frequency oscillation exists in an amplifier, varying the values of the grid resistors, lowering the resistance in the grid circuit opposite the cathode side of the inverter, is helpful. This may best be done by temporarily inserting a 500,000-ohm potentiometer in place of the fixed resistor shown in Fig 10.

This differential in the grid resistors results in considerable attenuation at the lower frequencies if small coupling capacitors, say .01 μf, are used. In Fig. 10 these capacitors are 0.1 μf and there is negligible effect on the low-frequency response even when the potentiometer is reduced to 270,000 ohms, or half the value of the other grid resistor. (But, in feedback circuits, check for instability!)

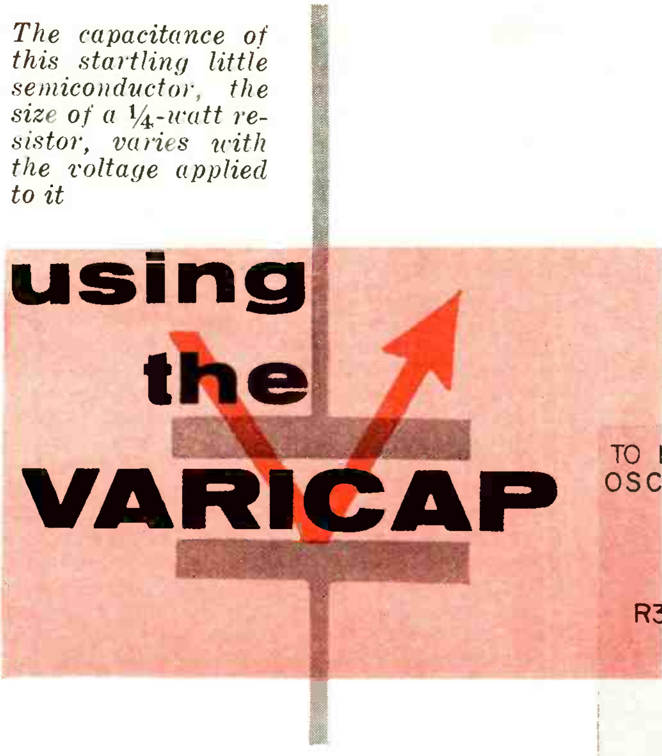
Another method of obtaining balance is to apply some negative feedback to one side of the circuit. If feedback is provided by a small capacitor on the side of the circuit with the greatest response to the higher frequencies, then balance can be effected due to the reduction in gain on this side of the circuit. Since the response is greater on the cathode side of the inverter, negative feedback should be introduced on this side of the circuit. A good arrangement for applying this method in the 50-watt amplifier circuit is given by David Hafler.[2] A 390-μμf capacitor is connected from the screen of the output stage, situated on the inverter cathode side of the circuit, to the cathode circuit of the amplifier input tube, thus reducing high-frequency gain on this side of the circuit.

The db loss or gain figures given in the foregoing discussion were measured values with the configurations employed. The audio amplifier constructor should use these merely as a guide and select R and C values best suited for his needs and in accordance with his particular amplifier circuitry. While these procedures worked with the particular amplifier tested, you may not get the same results with every amplifier. However, these suggestions are useful and the examples show what has been done. END

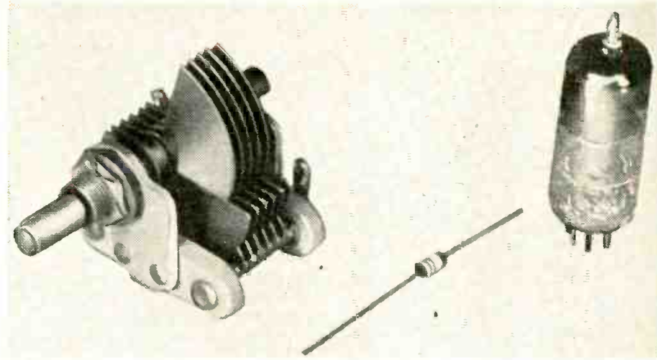
REFERENCES

[1]*Radiotron Designer's Handbook*, 4th Edition, Radio Corporation of America.
[2]David Hafler, "A 50-Watt Power Amplifier," *Radio and Television News*, June, 1956.

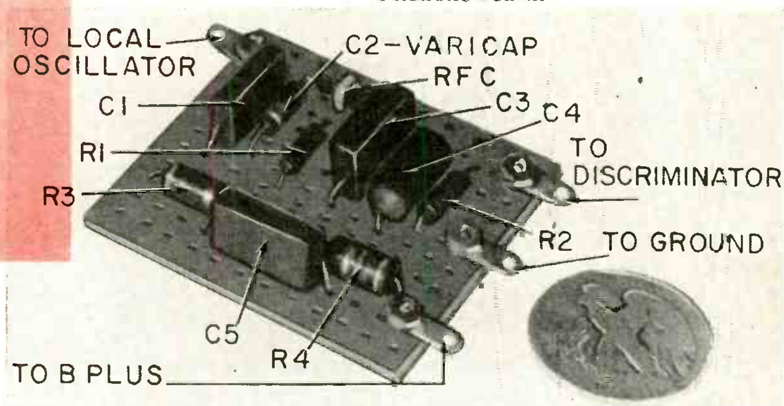
The capacitance of this startling little semiconductor, the size of a ¼-watt resistor, varies with the voltage applied to it



using the VARICAP



(Above) a Miniature tuning capacitor and reactance tube dwarf Varicap which may replace them. (Below) Afc circuit which you can add to FM receiver fits on 2⅛ x 2⅜-inch Phenolic board.



By RUFUS P. TURNER

THE capacitance of a reverse-biased semiconductor junction varies with the reverse dc voltage—capacitance decreases as voltage is increased. This effect has been noted in both diodes and power rectifiers. In selenium rectifier plates, for example, the capacitance is comparatively large, often reaching 0.25 μf or more. Attempts to use this voltage-sensitive capacitance have been thwarted by the comparatively low reverse resistance of the junction—rather high currents are needed to effect the capacitance changes, and the Q is too low for most practical applications. Also, both the capacitance and reverse resistance are extremely temperature-sensitive in ordinary diodes and rectifiers.

An important milestone was reached with development of the silicon junction diode. This semiconductor device has capacitance in small but useful amounts readily varied by the reverse bias. And the reverse resistance of the silicon p-n junction is so high (often 10,000 megohms at −1 volt) that almost no current at all is required to do the job. Essentially a high-Q component, the silicon junction is noted for the stability of its capacitance over a wide temperature range. In research laboratories during the past 2 years, the voltage-sensitive capacitance of the silicon p-n junction has been used in experimental voltage-operated tuning, frequency modulators, automatic frequency control, capacitor type amplifiers, tunable filters and numerous sensitive remote-control devices. Workers who had been intrigued by the earlier dielectric amplifier (using voltage-sensitive ceramic capacitors), only to be frustrated by their severe temperature drift, have had their interest restimulated by the silicon junction.

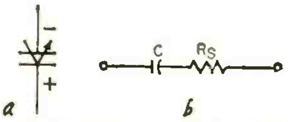


Fig. 1—Schematic symbol and equivalent circuit of the Varicap.

Now, a useful new semiconductor component, the Varicap (see RADIO-ELECTRONICS, January, 1958, page 45) has become commercially available. This simple, two-terminal, p-n junction device, designed for use as a voltage-variable capacitor, opens new vistas for the simplification of many electronic circuits. The number of applications to old circuits and the possibilities for new circuits will be limited only by the experimenter's imagination and ingenuity. No larger than most ¼-watt resistors and resembling a miniature crystal diode, the Varicap will do the work of a reactance modulator tube or of a variable capacitor, both of which are many times its size.

Varicap characteristics

Fig. 1 shows the schematic symbol and equivalent circuit of the Varicap. The markings in Fig. 1-a indicate the dc bias voltage polarity. The positive end of the unit is marked with a painted black band.

Fig. 1-b shows the equivalent circuit. Capacitance C varies approximately as $1/\sqrt{V}$, where V is the reverse bias voltage, and is practically constant (for any given value of V) from −65°C to 150°C. Both capacitance and the series resistance (R_s) are substantially independent of the operating frequency. The maximum frequency at which the equivalent circuit remains as shown in Fig. 1-b is 500 mc.

Varicaps are available in six capacitances, as shown in the chart. These capacitances are obtained with a dc bias of −4 volts. Capacitance tolerance is ±20%. A Varicap costs about $1.50.

Fig. 2 shows the capacitance variation with reverse dc bias voltage. This curve applies to all types of Varicaps, regardless of their nominal capacitance, and shows that each has 100% of the rated capacitance when the bias is −4 volts. Only a few millimicroamperes of

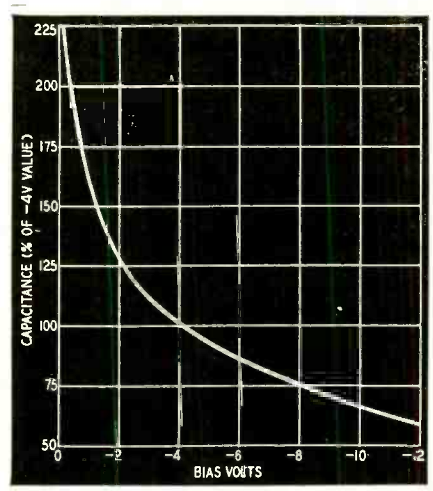


Fig. 2—How capacitance varies with bias voltage.

ELECTRICAL CHARACTERISTICS OF THE VARICAP

Varicap Type Number	Capacitance @ −4 v[1] (μμf)	Maximum Operating Voltage[2]	Series Resistance Maximum (ohms)	Series Resistance Typical (ohms)	Typical Q @ 50 mc
V20	20	−20	18	8.5	18.7
V27	27	−20	14	7.5	15.7
V33	33	−20	12	6.6	14.6
V39	39	−20	10	5.4	15.1
V47	47	−20	7.5	4.4	15.4
V56	56	−15	7.0	4.2	13.5

[1]Tolerance ±20%.
[2]The bias voltage plus the signal voltage peak should not exceed the maximum operating voltage. Also, the bias voltage should not be set so low that the signal voltage will swing the Varicap into the forward, or conducting, direction.

current flow when bias is applied to the Varicap. Thus, virtually no power is required to vary the capacitance of this very-high-resistance device.

Since the bias signal may be either steady or fluctuating, a variety of control signals may be employed. The frequency range exends from dc to more than 500 mc.

In any application, the total voltage applied to the Varicap (that is, the dc bias voltage plus the signal-voltage peak when there is an alternating component) must not exceed the unit's maximum operating voltage. Also, since the Varicap is a diode operated in the reverse direction, the dc bias voltage should not be set so low that the signal-voltage peak will swing operation into the forward, or conducting, region.

The Varicap actually utilizes the *capacitance* of the p-n junction to do its job. Why capacitance exists in the junction won't be rehashed here. Junction capacitance in semiconductor devices is familiar to the reader; collector capacitance, for example, is well known for its role in limiting the high-frequency response of transistors.[1,2]

In a conventional capacitor, a small leakage current flows through the dielectric because it is not a perfect insulator. The higher the insulation resistance, the lower this current. In a mica capacitor in good condition, dielectric resistance may be 100,000 megohms or more, and the leakage current at low dc voltages so tiny that it can be ignored completely. In a tubular paper capacitor, the dielectric resistance may be as low as 1,000 megohms; therefore leakage current is much higher than in a mica unit. The leakage current is highest of all in an electrolytic capacitor; it may be an appreciable part of a milliampere. Because of leakage current, the equivalent circuit of a capacitor shows a leakage resistance in parallel with the capacitor plates.

The leakage resistance is so high in a mica capacitor that its shunting effect is negligible. The dielectric between the plates approaching a perfect insulator, there is (to all practical intents and purposes) no appreciable leakage path between the plates, and the parallel resistance may be erased from the equivalent circuit. Similarly, in the Varicap, the leakage resistance is extremely high (in the order of tens of thousands of megohms) since the reverse-biased silicon p-n junction passes only a few thousandths of a microampere. As in the mica capacitor, the parallel resistance may be ignored and the junction considered a capacitance, since its reactance is many orders of magnitude lower than the shunting resistance. The situation is much the same as having a very good dielectric between the "plates" of the junction. This capacitance varies, as explained earlier, with the impressed dc reverse voltage.

A conventional capacitor also has a series resistance component R_s. At high frequencies, the magnitude of this resistance is due to the resistance of plates, leads and various in-phase components of current. The Q of the capacitor is affected by this series resistance. The Varicap also has an R_s component. It is shown in Fig. 1-b and is specified for each type in the chart. The Q of the Varicap (but not its capacitance) similarly depends upon this series component. As mentioned earlier, however, this series resistance component is independent of frequency up to 500 mc.

It is well to reflect that other semiconductor junctions, such as germanium diodes and selenium rectifiers, pass much higher reverse (leakage) currents. These leakages are not only higher than those of high-quality silicon junctions but increase markedly with increased reverse voltage. In these units, because the leakage resistance is often of the same order of magnitude or even lower than the capacitive reactance, the useful change produced by changing the voltage on these devices is not exclusively a capacitance change but rather a change in the impedance of the equivalent R-C circuit. In this respect, the selenium rectifier somewhat resembles the electrolytic capacitor with its high leakage. Quite to the contrary, the extremely high leakage resistance of the silicon p-n junction and its useful capacitance identify it as a high-quality capacitor.

Tuning effect

One of the first applications that comes to mind is use of the Varicap as a voltage-variable tuning capacitor in an L-C circuit. Fig. 3 shows the author's test setup to demonstrate this effect and to check the tuning range for one set of operating conditions.

In this arrangement, C2 is a type V56 Varicap which serves as the tuning capacitor of the L-C circuit, L2–C2. Capacitor C1 blocks direct current flow from the coil. This capacitance is very large with respect to C2. Adjustable dc bias is supplied by a battery through potentiometer R2. The bias level is indicated by the dc voltmeter. Isolating resistor R1 blocks rf flow into the dc circuit but introduces no appreciable dc voltage drop because of the negligible direct current flowing through the Varicap. An rf choke can be used in place of R1. The rf vtvm acts as a high-impedance resonance indicator. The test signal is supplied by a conventional rf signal generator link-coupled to the L-C circuit through coil L1. Coil L2 has been wound for resonance with C2 in the vicinity of 2 mc.

Near zero dc voltage, the Varicap has its highest capacitance (nominally greater than 100 μμf) and the L-C circuit therefore is tuned to its lowest frequency. At −9 volts, the capacitance is low (approximately 39 μμf) and the circuit is tuned to its highest frequency. To keep within operating ratings of the Varicap, the dc voltage should not be set to less than 1, nor the rf voltage, indicated by the vtvm, to more than 0.5 volt rms.

To demonstrate the effectiveness of the Varicap as a voltage-variable tuning capacitor: (1) Set the dc voltage to −1. (2) Tune the rf signal generator for resonance, as indicated by peak deflection of the vtvm. Set the generator output control to hold this deflection to 0.5-volt rms. (3) Record the generator frequency as f1. (4) Set the dc voltage

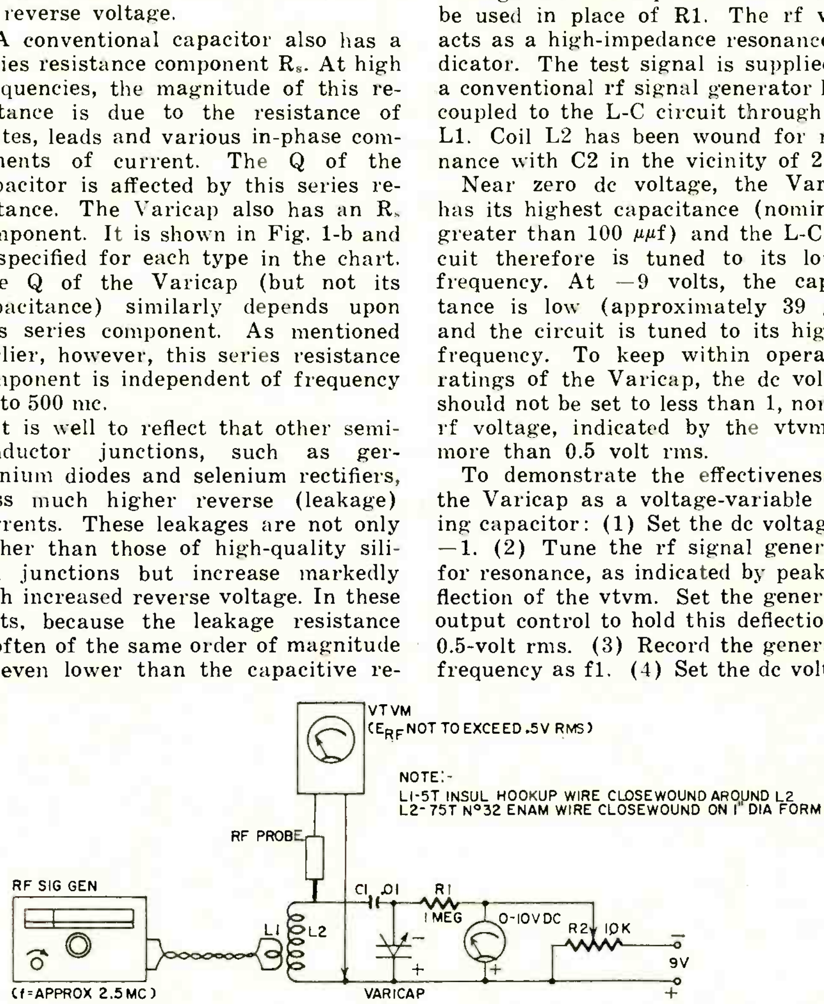


Fig. 3—Test setup to demonstrate Varicap performance.

[1]William Shockley, *Electrons and Holes in Semiconductors*, D. Van Nostrand Co., 1950, page 100.
[2]D. C. Brown and F. Henderson, "The PN Junction on a Variable Reactance Device for FM Production," *Electronic Engineering*, (London) November, 1957, page 556.

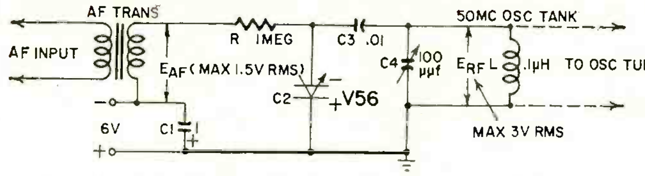
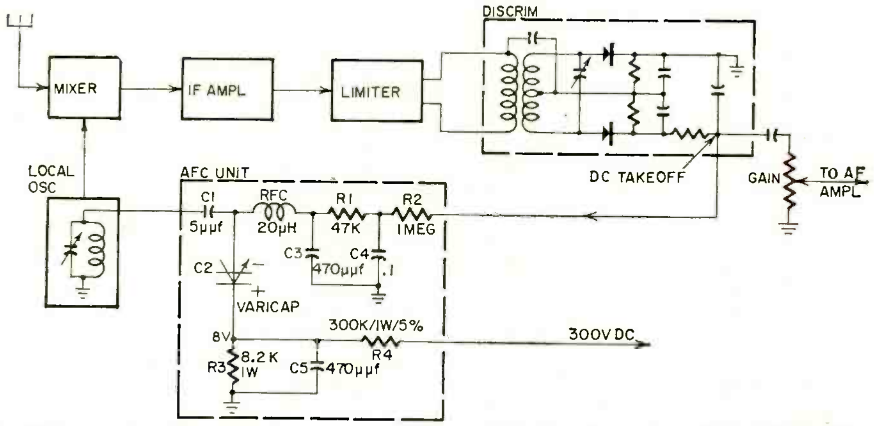


Fig. 4—Circuit of a Varicap frequency modulator circuit.



R1—47,000 ohms, 1/2 watt
R2—1 megohm, 1/2 watt
R3—8,200 ohms, 1 watt
R4—300,000 ohms, 1 watt, 5%
C1—5 µµf, silver mica
C2—Varicap (any type) (Pacific Semiconductors Inc., 10451 W. Jefferson Blvd., Culver City, Calif.)
C3, 5—470 µµf, silver mica
C4—0.1 µf, metallized tubular, miniature
RFC—20 µh, rf choke (Miller 6152 or equivalent)
Chassis, 2⅜ x 2⅛-inch perforated phenolic board
Miscellaneous hardware

Fig. 5—A Varicap afc circuit for your FM receiver.

to −9, noting that the vtvm deflection falls indicating detuning of the circuit. (5) Retune the generator to locate the new, higher resonant frequency and record this as f2. The tuning range afforded by the 8-volt bias change is equal to f2 − f1.

In the test setup shown in Fig. 3, the circuit was tuned from 1400 kc at −1 volt to 2250 kc at −9 volts, a tuning range of 850 kc. A wide frequency band may be covered with the same capacitance change if L2's inductance is made smaller to increase the operating frequency. In some applications of this principle, it will be desirable to use the Varicap as a voltage-variable trimmer in parallel with an air tuning capacitor.

Many applications of this principle suggest themselves. Examples are the voltage tuning of rf test oscillators, local oscillators in radio and TV receivers (especially in remote control operation), self-excited oscillators in transmitters and absorption wavemeters.

Frequency modulator

In the experimental circuit shown in Fig. 4, the Varicap (C2) is shunted (through .01-µf blocking capacitor C3) across the tank circuit (L–C4) of a self-excited 50-mc oscillator. An audio-frequency voltage (E_{af}) is applied to the Varicap in series with the 6-volt dc bias supplied by the battery. This ac fluctuates the bias at the audio-frequency rate. The capacitance of the Varicap accordingly fluctuates about its mean −6-volt value, frequency-modulating the oscillator. The center frequency is determined by the setting of the 100-µµf air capacitor (C4) and the −6-volt bias level.

Sweep width is proportional to the amplitude of E_{af} and is adjusted by varying this audio voltage. In Fig. 4, the rf oscillator is tuned to the center frequency of 50 mc when C4 is set to 50 µµf, the dc bias to −6 volts and E_{af} to zero. A 0- to 4-mc sweep is obtained when E_{af} is varied from 0 to 1.5 volts rms.

To prevent exceeding the Varicap voltage ratings in this kind of FM oscillator, the sum of the dc, peak af and peak rf voltages must not exceed the maximum voltage shown in the chart. Also, the dc bias must not be set so low that the sum of E_{af} peak and E_{rf} peak will drive the Varicap into its forward, or conducting, region. In Fig. 5, these conditions are met when E_{dc} = −6 volts, E_{af} does not exceed 1.5 volts rms and E_{rf} does not exceed 3 volts. While the latter is a relatively low rf tank voltage for tube type oscillators, it is reasonable for high-frequency transistor oscillators with which the Varicap frequency modulator is a natural companion.

Although the tank circuit shown in Fig. 4 has been designed for 50-mc operation, it is not imperative that this frequency be used. The same FM scheme may be used at other center frequencies by properly proportioning the L-C circuit. The lower the center frequency, the lower the sweep width obtained with a given Varicap capacitance swing, and vice versa. The transformer shown in Fig. 4 is not critical. Any audio unit whose secondary will deliver a maximum of 1.5 volts rms audio from a given af source is usable if it has a satisfactory audio response.

Automatic frequency control

The voltage-variable capacitance of the Varicap and its temperature stability suit it for use as a simple, highly sensitive, afc device which performs better than some reactance tube circuits. The small size of an afc unit, containing a Varicap, four small capacitors, four resistors and an rf choke, lets you tuck it into a receiver with a minimum of disturbance to the set's circuitry. This should be welcome news to hi-fi enthusiasts whose FM receivers have no automatic frequency control.

Fig. 5 shows an afc circuit developed by Pacific Semiconductor engineers, which I adapted for bias from the 300-volt dc supply of an FM receiver. The photos show the complete unit ready for wiring into the receiver. Any type of Varicap may be used. The receiver's local oscillator is simply realigned to compensate for the shunting capacitance introduced by the biased Varicap C2 which functions as a frequency-controlled trimmer across the local oscillator tank.

The Varicap is referred to a dc bias of −8 volts obtained from the receiver's 300-volt supply through the voltage divider R3, R4. The afc dc voltage is obtained from one side of the discriminator. For other than 300-volt supplies, the values of R3 and R4 will not be the same as mine but must be worked out for an output of −8 volts from the particular supply voltage of the set that you are adding this afc circuit to.

The completed afc unit is built on a perforated phenolic board 2⅜ inches long and 2⅛ inches wide. The pigtails of the components are passed through the holes in the board and interconnected underneath to complete the wiring. Printed circuitry may be used. The four connections to the receiver circuit are made at solder lugs mounted along the edge of the panel. The completed unit should be mounted as close as possible to the local oscillator so that the lead from the tank to C1 will be short.

(Certain silicon diodes can also be used as variable capacitors in such applications as this. In the February–March, 1958, issue of *Rectifier News*, published by the International Rectifier Corp., El Segundo, Calif., a circuit is shown for using their 3DS1 silicon diode as an afc control device for an FM tuner.—*Editor*)

Other applications

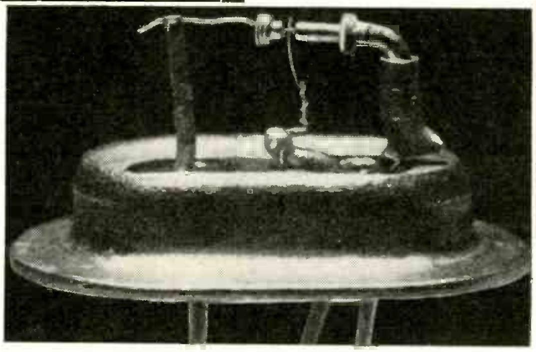
Other suggested uses for the Varicap include all-electronic dc-to-dc and dc-to-ac choppers, amplitude modulators, alignment sweep generators, capacitor type amplifiers (both ac and dc), ac type flip-flops, automatic amplitude control in rf oscillators, FM telemetering and elimination of the fine-tuning control in TV receivers.

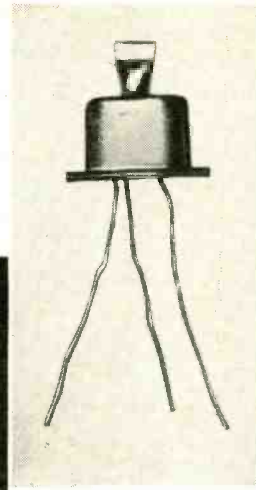
In some applications, Varicaps, like capacitors, may be operated in parallel for increased capacitance and in series back to back for increased voltage-handling capability. END

the TECNETRON

Competitor to the TRANSISTOR?

Neither spacistor nor transistor, this new semiconductor triode shows great promise for the ultra-high frequencies





Left—Closeup of Tecnetron; above—a unit in its case.

By E. AISBERG*

HARDLY a month passes nowadays without the announcement of some "sensational" new amplifying device. The great majority of these startling inventions, after their brief flurry in the popular and technical press, disappear into oblivion. But we believe that the *Tecnetron*, just announced in France, has a brilliant and enduring future.

The most remarkable feature of this device is that its transconductance *increases with frequency*, unlike more common semiconductor amplifiers whose performance falls off as frequency increases and becomes very low as the cutoff frequency is approached. Up to the present, frequencies in the order of 500 mc have been attained with the Tecnetron. And, as further work and research make it possible to reduce the capacitances of the contacts and other parts of the montage, there seems to be nothing to prevent it from functioning at 1,000 mc or even higher.

It has been possible—with a Tecnetron working in class A at 500 mc—to obtain a power output of 30 mw, with a dissipation of 125 mw. Since the characteristics of individual Tecnetrons are very consistent, one can envision the paralleling of several identical units to obtain watts—or even kilowatts—of power. This may make it possible to use Tecnetrons in applications requiring heavy currents.

In addition, the Tecnetron—though using germanium—is less sensitive to high temperatures than the transistor. It will operate at temperatures 20°C higher than will transistors. This should extend its field of applications considerably.

Neither is it a fragile experimental device that works only under laboratory conditions. Pilot production by regular industrial methods had begun on a small scale at the time of its announcement. About 700 units per month are being produced, and indications are that production could quickly be increased to the thousands.

*Publisher, *Toute la Radio, Television, Radio Constructeur et Depanneur, Electronique Industrielle* (Paris).

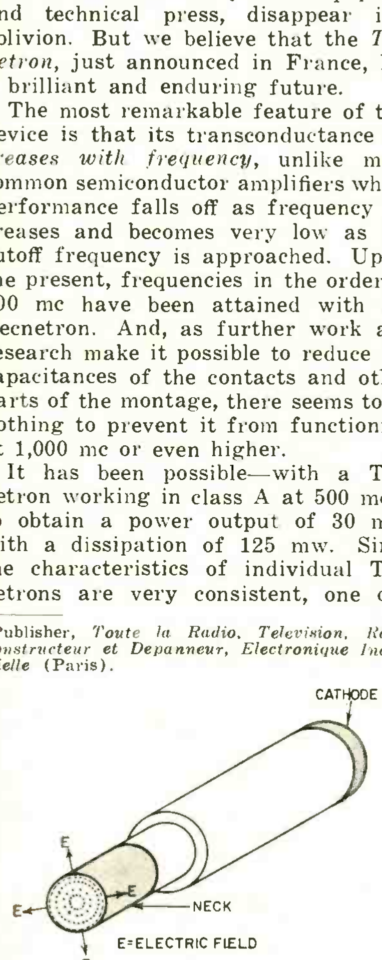


Fig. 1—Tecnetron cut to show cross-section of neck. The space charge E tends to drive the conducting area toward the center of the rod.

What is the Tecnetron?

First, why is it the Tecnetron? The first syllable of the name begins as does that of its inventor, S. Teszner. The initials CNET follow. These stand for the Centre National d'Etude des Telecommunications (National Center for the Study of Telecommunications), that great ensemble of research laboratories sponsored by France's Ministry of Posts, Telegraphs and Telephones. And of course the final syllable is the conventional one for such electronic devices.

Now, how is the Tecnetron constructed? It is a small rod of n-type germanium, 2 mm in length and 0.5 mm in diameter, provided with two contact electrodes at the ends. These must be of such material that they act solely like electrical conductors and not like transistor junctions.

The germanium rod is reduced in diameter at its center (Fig. 1) to form a "bottleneck" of very small diameter (about 30 microns). Around this neck is placed a cylinder of indium. This makes a metal-to-semiconductor barrier-layer contact of excellent characteristics. The ratio of forward-to-back resistance is greater than a million to one.

A relatively high potential (50 volts or more) is applied to the electrodes at the end of the rod. These may be called the cathode and anode. The cylinder of indium might be called a grid, for it plays exactly that role. The inventor prefers to call it the "bottleneck" or simply the "neck" to indicate its method of action better. The neck is polarized negatively with respect to the cathode, and the circuit of a stage of amplification (Fig. 2) is like that of a tube triode, with the load resistance placed in the anode circuit in series with the supply voltage.

A field-effect transistor?

Is this device not essentially that which Shockley called a "field-effect transistor" which he described in the *Proceedings of the IRE* (November, 1952; Vol. 40, pp 1365–76) and with which he was not able to obtain appreciable gains above 2 mc? Like Shockley, Teszner has turned to the field effect, discovered by Lilienfeld in 1928. Here the resemblance ends. Whereas Shockley worked with plane surfaces (or a parallelepiped), Teszner has utilized the cylindrical configuration, transforming a linear effect to a quadratic one by applying a *radial* electric field.

What is the field effect? Our readers know of the Hall effect, due to which

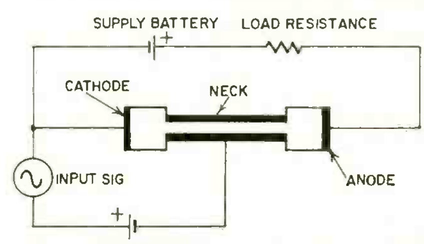


Fig. 2—Schematic of Tecnetron hookup.

charge carriers in semiconductors can be deflected from their paths under the action of a magnetic field. The Lilienfeld effect is analogous to the Hall effect, but is based on the action of the electric instead of the magnetic field. In semiconductors such as germanium, charge carriers (electrons or "holes") can be deflected from their paths by the action of such an electric field.

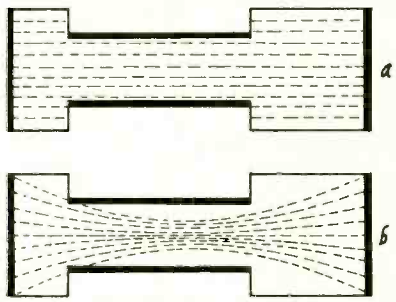


Fig. 3-a—Distribution of charge carriers (electrons) with neck unbiased; 3-b—reduction of current path caused by negative bias on neck.

The Tecnetron action

The neck of the indium cylinder creates a concentrated electric field in the interior of the rod, depending on the charge on the cylinder. With no charge whatever, the current is propagated evenly through the whole area of the neck. As one applies a negative voltage to the cylinder, the electrons are deflected toward the center, occupying only a reduced section of the rod (Fig. 3). Thus the apparent resistance of the rod increases as the active section—through which electrons pass—decreases. This action is proportional to the square of the radius.

Note well that this is a variation in the total resistance, not in the specific resistivity which remains constant.

The voltage applied to the indium cylinder causes the neck to act as if its diameter were decreased. Thus the cathode–anode current is varied, causing the voltage across the load resistor to reproduce faithfully the changes in the voltage applied to the neck, but at a greater amplitude.

The best analogy of the Tecnetron is without doubt a flexible rubber hose through which flows a current of water. If the hose is compressed more or less by the hand, the flow decreases in the same ratio. If the hose is compressed circularly—from all sides toward the center, as by an encircling thumb and forefinger—the diminution of current will follow the square law. This centripetal constriction is an essential characteristic of the Tecnetron.

Effects of capacitance

If we analyze these actions carefully, we note that the variation in resistance is accompanied by a variation in capacitance between the part of the germanium occupied by the electrons and the indium cylinder. As the cylinder becomes more negative, it drives the electrons further from it and toward the center of the rod, thus reducing the capacitance between the current-carrying portion of the rod and the cylinder. As the voltage becomes less negative, the electrons flow through a larger section of the germanium and the capacitance increases. The Tecnetron acts like the equivalent circuit of Fig. 4.

These variations of capacitance, which are increased by the cylindrical configuration of the device, have an effect on the current through the external circuitry similar to that which the variations of resistance have on the flow of electrons through the germanium. These two actions are synchronous and reinforce each other, thus increasing the gain. There is of course a very slight detuning effect in resonant circuits due to the instantaneous variations in capacitance produced by the signal. These are very small, since the total input capacitance is a fraction of a micromicrofarad and the detuning is proportional to the square root of the capacitance change. Practically, according to the inventor, it manifests itself as a slight enlargement of the passband.

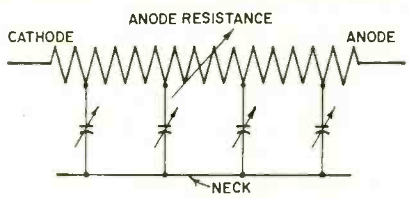


Fig. 4 — The Tecnetron can be considered as a variable resistance and a distributed variable capacitance.

The capacitance effect, with its reduction of impedance as frequency increases, is one of the reasons for the high transconductance at high frequencies (Fig. 5) and the fact that the Tecnetron's *figure of merit* continues to increase with frequency. The figure of merit is the product of the gain by the width of the passband over which the gain is maintained at ±3 db.

Tecnetron as amplifier

We have seen that the neck which acts as a control electrode is polarized negatively with respect to the cathode. Thus no appreciable direct current can flow in the cathode–neck circuit, because of the extension of the barrier layer into the n-type germanium.[1]

Under these conditions, the input resistance is several megohms. The input capacitance is in the order of 2 $\mu\mu$f.

The output impedance is generally higher than 1 megohm, and the load resistance thus may be chosen as high as it is practically permissible to set it; usually between 2,500 and 250,000 ohms.

If we plot the characteristics of the Tecnetron by measuring the anode current as a function of the anode–cathode voltage at various values of neck voltage, we obtain a family of curves which resemble strikingly those of a pentode tube (Fig. 6). Which is to say, that we have here an excellent voltage amplifier. The chart shows experimental results obtained at various frequencies.

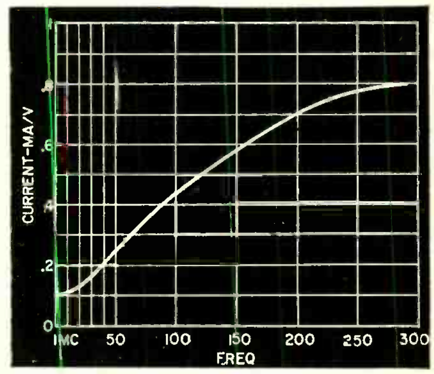


Fig. 5—Variation of the transconductance as a function of the signal frequency.

Manufacturing the Tecnetron

It was necessary to develop special technical methods to manufacture the Tecnetron. This was one of the major achievements of M. Teszner and the CNET researchers who aided him. For part of the work, the classic procedures of transistor production could be followed. Then a whole series of new mechanical operations intervened: cutting the refined crystals into plates, then into little rods. This last operation was performed with ultrasonic cutting apparatus. The constriction for the neck was made by a procedure of electrolytic etching perfected especially for the purpose. The indium was also deposited by electrolysis, with the rod in continuous rotation during the process. More conventional techniques could be used in applying the terminal (cathode and anode) contacts.

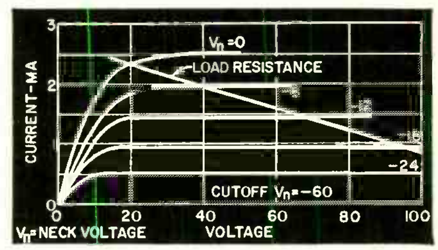
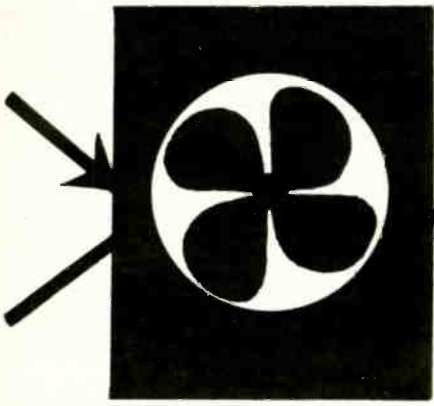


Fig. 6—These Tecnetron static characteristic curves show the variation of anode current as a function of anode voltage, for several neck voltages.

Freq. (mc)	Gain (db)	Voltage ratio	Passband (mc)	Figure of Merit
110	22	12.9	1.7	21
200	16	6.31	6	37
460	9	2.818	29	80

Up to the present, procedures already developed permit manufacture on a large scale. Research is continuing, however, and the next step is the creation of a power Tecnetron and another model especially for ultra-high frequencies. Special arrangements which will permit continuing still further up the frequency spectrum are also under study. And, as always, as the area of actual accomplishment is increased, the greater become the prospects of future progress. END

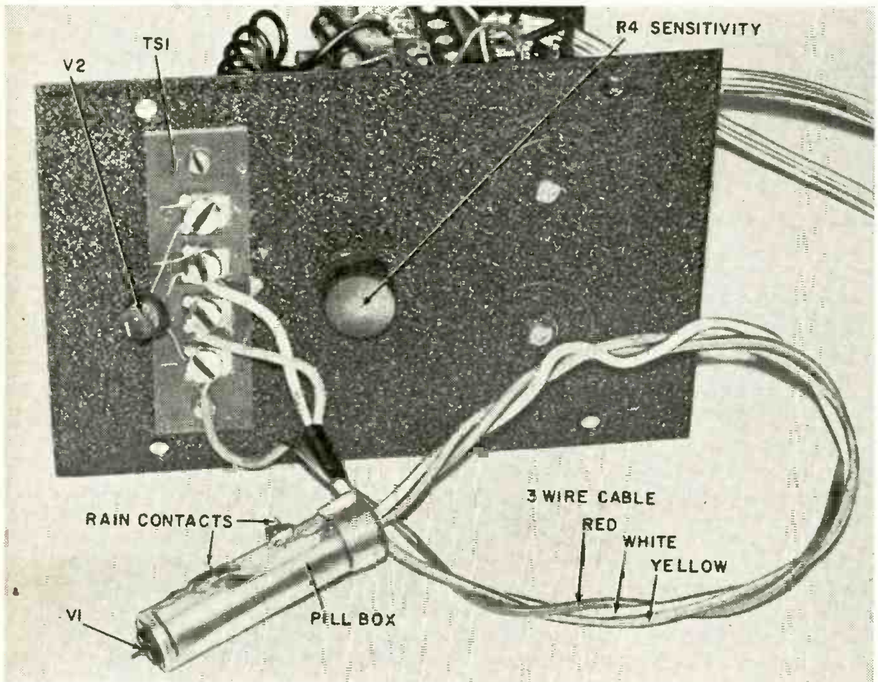
[1] M. Teszner, *Revue Générale d'Electricité,* June, 1954.



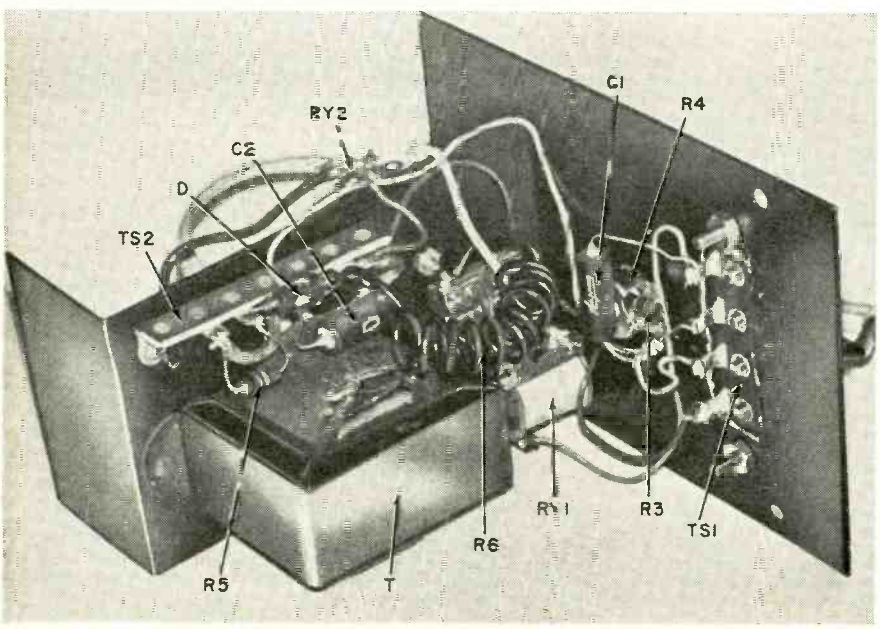
Construct a temperature-sensing unit to operate your fan or air-conditioner automatically

Train your fan with TRANSISTORS

By JAMES A. McROBERTS



The control unit with the outside sensor connected.



Inside the main control unit. Handle the chassis carefully or it may break loose from the front panel.

LOW-COST transistors can perform heat-sensing duties almost as well as their more conventional electronic jobs. Two are employed here in a device to sense very small temperature differences. It checks to see if it is cooler outdoors than inside. If so, it turns on a fan. If not, the fan stays off. If it is raining, another brain cell prevents the fan from going on, so rain will not be pulled into the house when the owner is away fishing.

The device can also be set to turn on an air conditioner whenever the difference between inside and outside temperatures exceeds a certain amount.

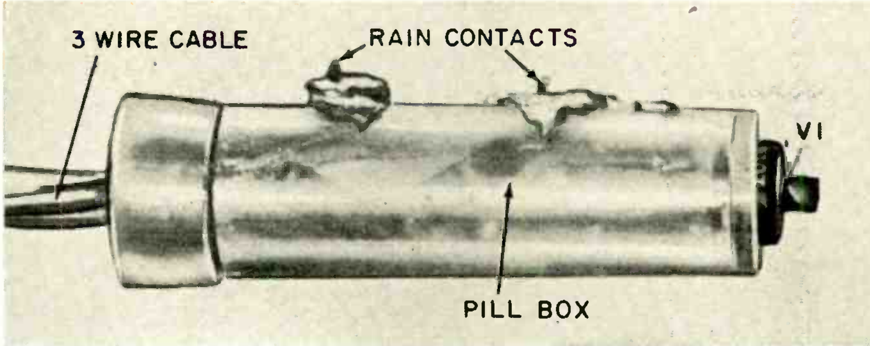
The device is simple and easy to construct, with the added advantage of being easy on the pocketbook.

Circuit description

Fig. 1 helps explain these sensing, memory and control functions. With proper circuit components, transistors V1 and V2 behave like thermal resistances—their collector currents increase as their temperature rises. V2 is mounted on the control-unit panel to sense inside temperature. Its collector current passes through the coil of relay RY1. As inside temperature rises, the increased current closes the relay.

Outside sensing transistor V1 counterbalances this action of V2 for similar increases or decreases of temperature. For example, as V1 becomes warmer, its collector current also rises. This current passes through R3 and R4, creating a voltage drop which makes V2's base less negative. Consequently, V2's collector current decreases. As a result, the relay's coil current remains relatively steady during even heating or cooling of both transistors.

A cooling fan is effective only when the outside temperature is lower than the inside, as at night. When the inside temperature is lower, V1 (outside sensor) draws more collector current relative to V2 (inside sensor), regardless of the actual value of the current. There is proportionately a greater voltage drop across its load, R3 and R4. V2's base voltage and collector current are lowered. Hence, current through relay RY1 is less than the



Closeup of the sensor. Keep rain contacts facing up.

even-temperature value for that particular temperature range. The fan remains off.

As outside temperature falls, V1 draws proportionately less current and relay RY1's current rises. Eventually RY1 is energized and the fan is turned on. Due to a difference in the turn-on and drop-out points of the relay, the fan remains on until the outside temperature rises above the inside. If you wish, you can install a switch in the power supply to break the circuit and release the relay. Only a momentary off–on is wanted so the transistors do not cool. This added feature may not be necessary since outside and inside temperatures are both rather low at this time, and a slight rise in outside temperature shuts off the fan. A thermostat may be included to shut off the fan at some comparatively low temperature. Install its contacts in the control unit's power supply line.

If it is raining, the fan sucks in rain unless its intake is well sheltered. A house full of water could result. An auxiliary rain lockout circuit supplies more base current to transistor V1 when water is present across the rain contacts (see photos). This decreases relay coil current. When the space between the rain contacts is wet (water, not just moisture from dew), the relay coil's voltage is about 2 volts less than otherwise. The fan cannot go on. Omit this circuit if the rain lockout feature is not wanted.

The power supply is conventional except that the center tap of the transformer supplies ac through a 2-ohm resistor to the auxiliary 6-volt relay.

Sensitivity controls

If other than even temperature is desired, the SENSITIVITY CONTROL (R4) is adjusted for the desired difference of temperature for turn-on or turn-off. However, V1's base resistor must be altered if the differential exceeds about 10°F. Less than this value does not require any change, just a new setting of R4. Fig. 2 shows the modification for a large temperature differential. R1 is split into two parts, a protective resistor R1-a and an adjustable element R1-b. R1-b is set for uniform relay coil current (RY1) or voltage across it (monitor with high-resistance voltmeter) with ambient temperature changes. Both transistors are kept at the same temperature. Be careful in such work—the heat from a hand or a nearby lamp will upset the compensation. If either transistor is handled, allow about 3 minutes for it to cool before making any further adjustment.

Rain lockout sensitivity can be doctored too by adding a potentiometer (R3) in series with a protective resistor (R4) as shown in Fig. 2. It can be made sensitive to the slightest amount of moisture by lowering the resistance of potentiometer R2-b. Added pots may be panel-mounted or left inside the control unit as factory adjustments.

Construction hints

The control unit and its power supply are housed in a 4 x 5 x 6-inch metal utility cabinet with the built-in chassis. The photos give an idea of parts placement.

A three-wire cable in the standard fan model connects the external sensor to screw terminals mounted on the front panel of the control unit.

In practice a long three-wire cable is employed. The tiny amount of current flow permits lengths up to 1,000 feet without appreciable voltage drops.

In this model, transistor V1 is mounted on the end of a pillbox. (You can get one at the drug store.) A hole is drilled in the end to permit the transistor to pass through. Transistor leads are clipped for mounting in a socket, thereby simplifying installation. The rain contacts are small metal tabs sealed in place with Duco cement.

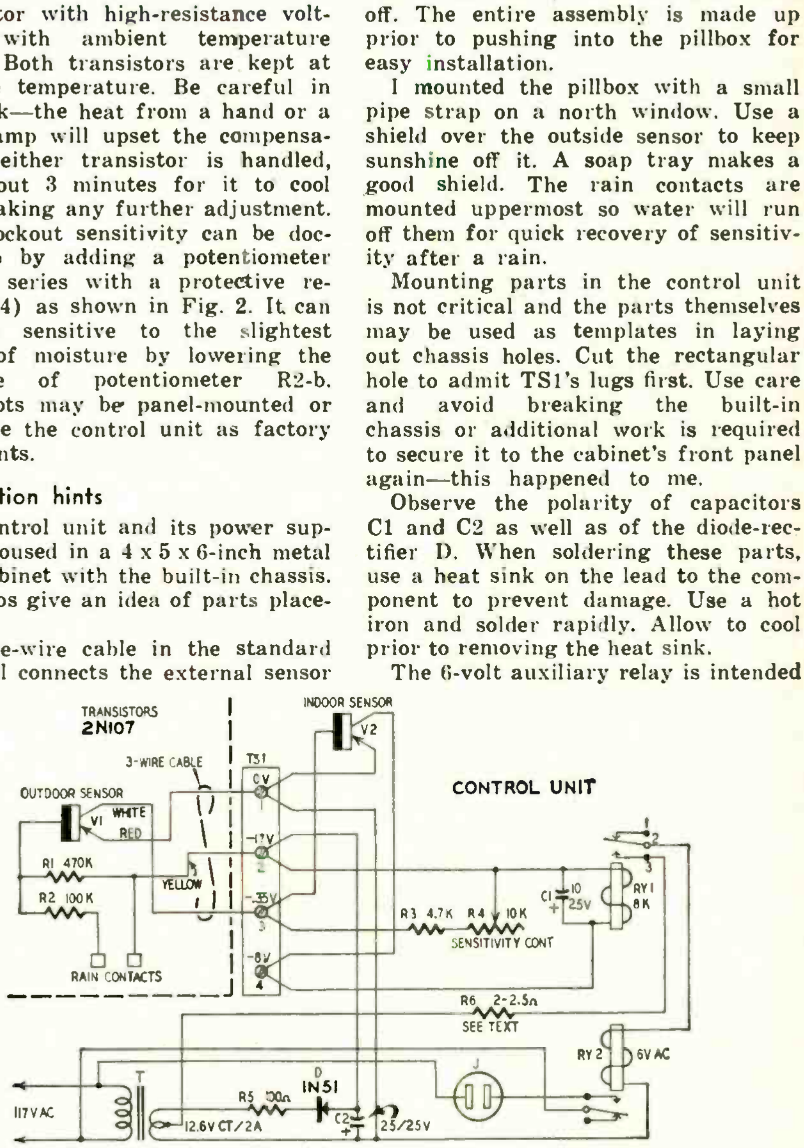
This cement also makes a watertight seal between the transistor's case and the pillbox. A hole in the pillbox cover admits the cable, which is also sealed off. The entire assembly is made up prior to pushing into the pillbox for easy installation.

I mounted the pillbox with a small pipe strap on a north window. Use a shield over the outside sensor to keep sunshine off it. A soap tray makes a good shield. The rain contacts are mounted uppermost so water will run off them for quick recovery of sensitivity after a rain.

Mounting parts in the control unit is not critical and the parts themselves may be used as templates in laying out chassis holes. Cut the rectangular hole to admit TS1's lugs first. Use care and avoid breaking the built-in chassis or additional work is required to secure it to the cabinet's front panel again—this happened to me.

Observe the polarity of capacitors C1 and C2 as well as of the diode-rectifier D. When soldering these parts, use a heat sink on the lead to the component to prevent damage. Use a hot iron and solder rapidly. Allow to cool prior to removing the heat sink.

The 6-volt auxiliary relay is intended



R1—470,000 ohms
R2—100,000 ohms
R3—4,700 ohms
R4—pot, 10,000 ohms, miniature (Lafayette VC-34 or equivalent)
R5—100 ohms
R6—2–2.5-ohm strip of Nichrome wire (see text)
All resistors ½ watt unless noted
C1—10 µf, 25 volts, electrolytic
C2—25 µf, 25 volts, electrolytic
D—1N51
J—ac receptacle
RY1—sensitive relay, 8,000-ohm coil (Sigma 4F-8000 or equivalent)
RY2—midget power relay, 6-volt ac coil (advance GH/1C/6VA or equivalent)
T—power transformer: primary, 117 volts; secondary, 12.6 volts ct, 2 amps (Thordarson 26F67 or equivalent)
V1, 2—2N107
TS1—4-lug screw terminal strip
TS2—5-lug terminal strip
Cabinet, 4 x 5 x 6 inches with built-in chassis (ICA 3819 or equivalent)
Pillbox, plastic, ½-inch diameter, 2 inches long.
Miscellaneous hardware

Fig. 1—Complete circuit of the sensing and control units. They are connected by a three-wire cable.

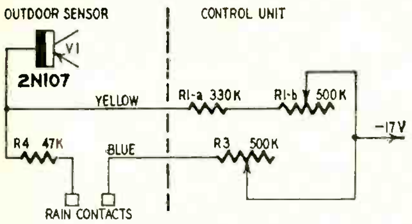


Fig. 2—Modifying the control system to handle air conditioners.

for intermittent duty only. A length of Nichrome heater wire (R6) is cut to 2 ohms (use an ohmmeter to measure). It is straightened out and slipped into a length of spaghetti (see photos). This added resistance permits continuous duty without overheating the relay. The Nichrome wire is readily obtained at neighborhood hardware stores.

Final adjustments

Test and adjust the unit on the bench before putting it into use. A lamp may be plugged into the outlet receptable J for this check. (J is an ordinary cube tap for smaller fans. For heavy power fans leave it out and wire direct via BX cable.) The external sensor unit may be used with a short cable length for testing and later spliced at the window.

Hook up the external sensor and mount V2 as shown in the photos. Turn on the power. Rotate the SENSITIVITY CONTROL. The lamp should light and a relay click heard at some setting of this control. This is the turn-on point. A little more counterclockwise rotation will extinguish the light and the relays will click off at the same time.

Now let the transistors warm up from current passage through them. Keep the SENSITIVITY CONTROL at about the drop-out point. Leave the unit on overnight to age the transistors and the diode rectifier as well as to form capacitors C1 and C2. The relay pull-in and drop-out points will be relatively stable thereafter. The unit may now be connected for steady operation.

The sensitivity setting for even inside and outside temperature turn-on is that obtained on the bench test. A little more counterclockwise (toward turn-off) is the setting for a slightly lower outside temperature turn-on. This is the setting usually used.

Air-conditioner control

For controlling an air conditioner, the object is the opposite of fan cooling. We wish to maintain a temperature differential between inside and outside temperatures. Consequently we make a minor change in the relay contact wiring. On Fig. 1 the wire to contact 3 of relay RY1 is connected to contact 1.

Sensitivity is adjusted for the required temperature differential in this type of service.

As an alternative to the change in relay wiring, V1 and V2 may be interchanged, making V1 the inside sensor. Rain lockout, if still wanted, would be extended outside by a pair of wires. END

A–Z TRANSISTOR DICTIONARY

By H. BARR

COMPILED from several sources and presented here are over 150 terms unique to the transistor field. General radio–electronic–television terms that are not directly related to transistors are excluded, as well as specialized scientific terms we are not likely to run across. Many of the terms defined have several meanings. Only the particular meaning appropriate to the transistor field is given. Also, many of the words have various spellings and no attempt has been made to list all possible variations.

—A—

Acceptor Impurity used to produce *p*-type semiconductor.
Alloy–diffused transistor Transistor in which the base is diffused in, and the emitter alloyed.
Alloy process Process for making junctions by melting an acceptor or donor on the surface of the semiconductor and letting it refreeze.
Alloy transistor Transistor made by the alloy process.
Alpha Emitter-to-collector current gain. For a junction transistor alpha is less than one.
Alpha-cutoff frequency The high frequency at which the value of alpha is down to 0.7 of its low-frequency value.

—B—

Back bias See *reverse bias.*
Barrier See *junction.*
Barrier capacitance See *depletion-layer capacitance.*
Barrier layer, barrier region See *depletion layer.*
Barrier-layer capacitance See *depletion-layer capacitance.*
Base Electrode on a transistor.
Base resistance Resistance in series with the base lead in the common T equivalent circuit of a transistor.
Base ring Ohmic contact to the base region of power transistors, made in the shape of a ring.
Beta Base-to-collector current gain of a transistor.
Bonded-barrier transistor Transistor made by alloying when the alloying material is on the end of a wire.
Boundary, p-n See *p-n junction.*
Button Piece of metal for alloying onto the base wafer in making alloy transistors.

—C—

Carriers Particles which carry current, specifically either electrons or holes.
Collector Electrode on a transistor.
Collector capacitance Depletion-layer capacitance associated with the collector junction.

Collector efficiency Ratio of useful power output to final stage power supply power input, usually expressed in percentage.

Collector family Set of characteristic curves for a transistor, in which collector current and collector voltage are used as variables.

Collector junction On junction transistors, the junction between the collector and the base.

Collector resistance Resistance in series with the collector lead in the common-T equivalent circuit of a transistor.

Common base Configuration for amplifiers, in which the base is common to both input and output circuits.

Common collector Configuration for amplifiers, in which the collector is common to both input and output circuits.

Common emitter Configuration for amplifiers, in which the emitter is common to both input and output circuits.

Complementary symmetry Any of several types of circuits using both p-n-p and n-p-n transistors in a symmetrical arrangement.

Conductivity A property of a semiconductor expressing how easily current may flow through it; the reciprocal of resistivity.

Configuration Type of amplifier circuit, depending on which electrode is common to input and output; for example, common-emitter configuration.

Coupling Method of passing the signal from one stage to another; for example, *capacitor coupling*, *transformer coupling*.

Crossover distortion Harsh type of distortion produced by incorrectly biased class-B amplifiers.

Crystal Regular array of atoms in a solid; for example, *single-crystal germanium*.

Current amplification, current gain Ratio of output to input current.

Cutoff current Collector current with no emitter current and normal collector-to-base bias.

Czochralski technique Method of growing large single crystals by pulling them from a molten state; usually used to grow germanium and silicon single crystals.

—D—

Depletion layer Region near a junction without current carriers, on reverse bias.

Depletion-layer capacitance Capacitance of the depletion layer, which is a function of reverse voltage.

Depletion-layer transistor Any of several types of transistors which rely directly on motion of carriers through depletion layers for their operation; for example, spacistor.

Derating Reducing ratings on a transistor, especially the maximum power dissipation rating at higher temperatures.

Diamond lattice The crystal structure of both germanium and silicon as well as diamond.

Diffused-base transistor Any of several types of drift transistors in which the base is diffused in.

Diffused emitter-collector transistor, diffused E-C transistor Transistor in which both the emitter and collector are made by the diffusion process.

Diffusion Movement of carriers from heavily populated regions to regions without as many carriers, similar to slow diffusion of ink through a still glass of water; also similar movement of donors and acceptors at high temperatures.

Diffusion process Method for making junctions by diffusing acceptors or donors into a semiconductor at a high temperature.

Diffusion transistor Transistor relying on diffusion for carrying current; for example, ordinary junction transistor.

Diode Two-terminal semiconductor device that rectifies.

Dissipation Loss of electrical energy into heat.

Donor Impurity used to produce n-type semiconductor.

Doping Adding impurities to change the resistivity of semiconductors and to make n-type or p-type.

Dot See *button.*

Double-base diode See *Unijunction transistor.*

Double-diffused transistor Junction transistor in which both the emitter and the base are diffused in.

Drain Electrode on a field-effect transistor.

Drift Movement of carriers because of applied voltage.

Drift transistor Transistor relying on drift for carrying current; compare diffusion transistor.

—E—

Electroforming Process of creating p-n junctions by passing current through point contacts.

Electrons Negatively charged current carriers.

Emitter Electrode on a transistor.

Emitter junction On junction transistors, the junction between the emitter and the base.

Emitter resistance Resistance in series with the emitter lead in the common-T equivalent circuit of a transistor.

Equivalent circuit A circuit which approximates the actual transistor under some conditions.

—F—

Field-effect transistor Type of transistor relying on movement of a depletion layer to vary the conduction between two electrodes, the source and the drain.

Floating junction Junction through which no net current flows.

Forward bias Large-current bias as applied to a diode; opposite to reverse bias.

Fused-junction transistor See *alloy transistor.*

Fused transistor See *alloy transistor.*

—G—

Gate Electrode on a field-effect transistor.

Germanium Common semiconductor material, usually used for making transistors.

Grounded base See *common base.*

Grounded collector See *common collector.*

Grounded emitter See *common emitter.*

Grown-diffused transistor Junction transistor with junctions formed by diffusion of impurities near a grown junction.

Grown-junction transistor Junction transistor with junctions formed by adding impurities to the melt while the crystal was being grown.

—H—

Hall effect Transverse voltage produced by current travelling at right angles to a magnetic field; especially prominent in semiconductors.

Header Part of a transistor which the leads pass through to get outside.

Heat sink Something that will absorb and dissipate a large amount of heat without getting hotter.

Holes Positively charged current carriers in semiconductors.

Hook transistor Four-layer transistor with a built-in hook amplifier for a collector.

***h*-parameters** Four commonly used parameters for specifying the small-signal behavior of a transistor.

Hybrid parameters See *h-parameters.*

—I—

Impurity Small addition to a semiconductor, especially a donor or an acceptor.

Injector Electrode on a spacistor.

Intrinsic-region transistor Four-layer transistor with an intrinsic region between the base and the collector.

Intrinsic semiconductor Neither n-type nor p-type, containing roughly equal numbers of electrons and holes.

***i*-type** Intrinsic semiconductor

—J—

Junction Region separating two different types of semiconductor, especially p-n junction.

Junction diode A diode which uses a junction to get a rectifying characteristic.

Junction transistor Most common type of transistor, using two junctions with the base region between them.

—L—

Large-signal analysis Consideration of large excursions from the no-signal bias, so that the nonlinear, switching properties of the transistor are important.

Leakage current That portion of cutoff current due to surface effects.

—M—

MADT transistors Micro-Alloy Diffused-base Transistors.

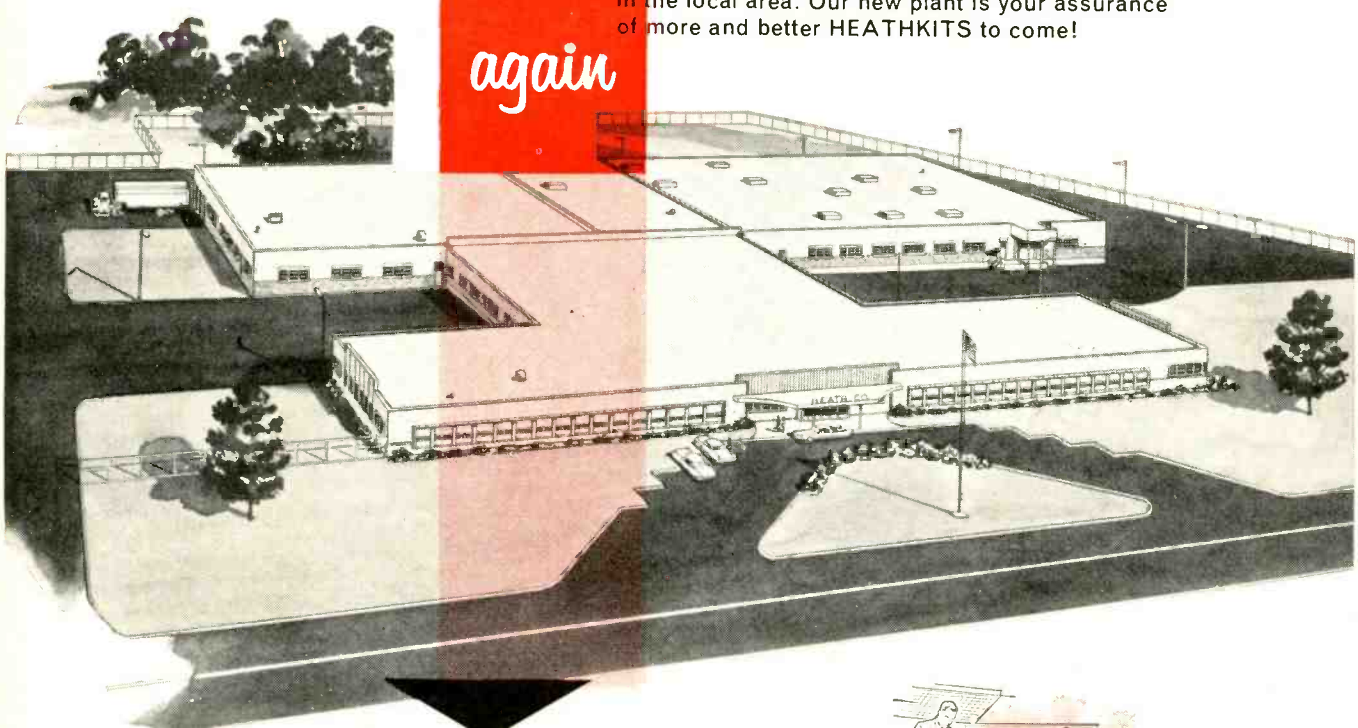
Majority carriers Whichever type is more plentiful, i.e. electrons in n-type and holes in p-type.

Meltback process Method of making

(*Continued on page* 82)

here we grow again

With this issue we introduce our new building—over 140,000 sq. ft. of modern plant equipment under one roof, the largest in the nation devoted to direct mail selling of electronic kits. To you, in the field, goes the credit for the tremendous growth of the electronic industry over recent years. Your imagination, courage and resourcefulness have moved America into the electronic age at a breath-taking pace. A pioneer in "do-it-yourself" electronic kits, Heath Co. has always endeavored to stay out in front. As a result we have grown too—from one small building to a point where we occupied seven buildings in the local area. Our new plant is your assurance of more and better HEATHKITS to come!



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MODEL W-6M **$109.95**

HEATHKIT HIGH FIDELITY FM TUNER KIT

This tuner can bring you a rich store of FM programming, your least expensive source of high fidelity material. It covers the complete FM band from 88 to 108 mc. Stabilized, temperature-compensated oscillator assures negligible drift after initial warmup. Features broadbanded circuits for full fidelity, and better than 10 uv sensitivity for 20 db of quieting, to pull in stations with clarity and full volume. Employs a high gain, cascode RF amplifier, and has AGC. A ratio detector provides high-efficiency demodulation without sacrificing hi-fi performance. IF and ratio transformers are prealigned, as is the front end tuning unit. Special alignment equipment is not necessary. Edge-lighted glass dial for easy tuning. Here is FM for your home at a price you can afford. Shpg. Wt. 8 lbs.

MODEL FM-3A **$25.95** (with cabinet)

HEATHKIT BROADBAND AM TUNER KIT

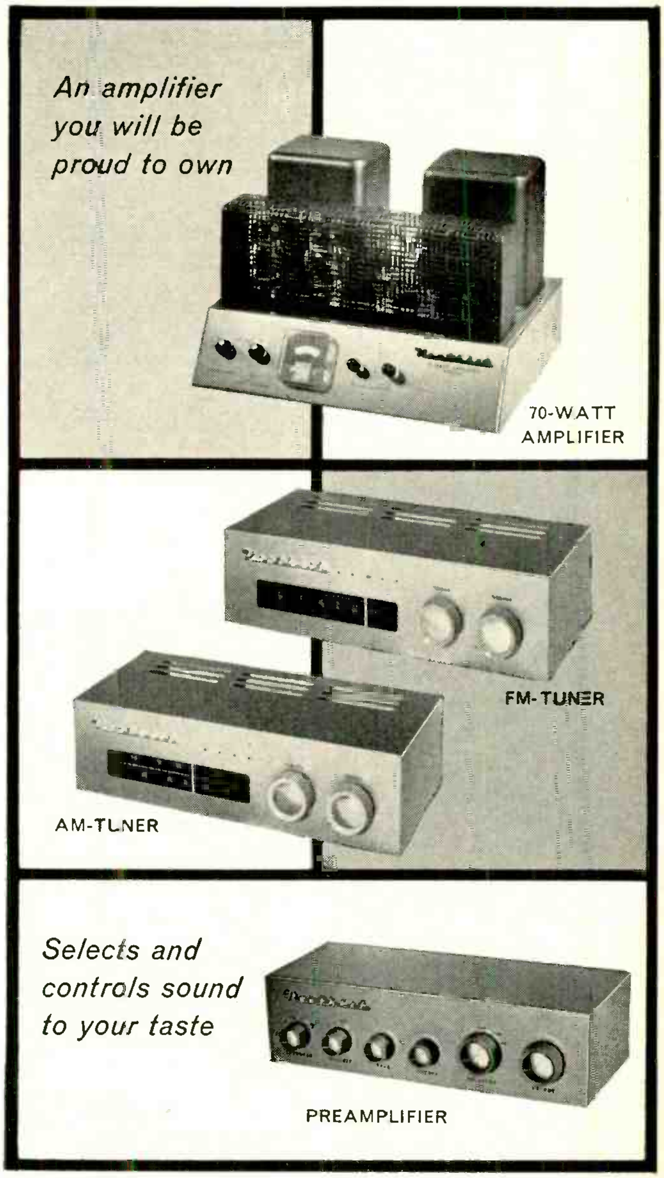
This AM tuner was designed especially for high fidelity applications. It incorporates a special detector using crystal diodes, and the IF circuits feature broad band-width, to insure low signal distortion. Audio response is ±1 db from 20 cps to 9 kc, with 5 db of preemphasis at 10 kc to compensate for station rolloff. Sensitivity and selectivity are excellent, and tuner covers complete broadcast band from 550 to 1600 kc. Quiet performance is assured by 6 db signal-to-noise ratio at 2.5 UV. Prealigned RF and IF coils eliminate the need for special alignment equipment. Incorporates AVC, two outputs, two antenna inputs, and built-in power supply. Edge-lighted glass slide-rule dial for easy tuning. Your "best buy" in an AM tuner. Shpg. Wt. 8 lbs.

MODEL BC-1A **$25.95** (with cabinet)

HEATHKIT MASTER CONTROL PREAMPLIFIER KIT

Designed for use with any of the Williamson-type amplifiers, the WA-P2 has five switch-selected inputs, each having its own level control to eliminate blasting or fading while switching through the various inputs, plus a tape recorder output. A hum control allows setting for minimum hum level. Frequency response is within ±1½ db from 15 to 35,000 cps. Equalization provided for LP, RIAA, AES, and early 78's. Separate bass and treble controls. Low impedance cathode follower output circuit. All components were specially selected for their high quality. Includes many features which will eventually be desired. Shpg. Wt. 7 lbs.

MODEL WA-P2 **$19.75** (with cabinet)



HEATH COMPANY *A Subsidiary of Daystrom, Inc.* **BENTON HARBOR 20, MICH.**

ADVANCED-DESIGN
25-WATT AMPLIFIER

Top performance in its power class!

SINGLE-CHASSIS
20-WATT AMPLIFIER

Hi-Fi equipment for your listening pleasure!

DUAL-CHASSIS
20-WATT AMPLIFIER

GENERAL-PURPOSE
20-WATT AMPLIFIER

HEATHKIT ADVANCED-DESIGN 25-WATT HIGH FIDELITY AMPLIFIER KIT

Designed especially to satisfy critical audio requirements, the W-5M incorporates the extra features needed to compliment the finest in program sources and speaker systems. Faithful sound reproduction is assured with a frequency response of ±1 db from 5 to 160,000 cps at 1 watt, and harmonic distortion is less than 1% at 25 watts, with IM distortion less than 1% at 20 watts. Hum and noise are a full 99 db below rated output, assuring quiet, hum-free operation. Output taps are 4, 8 and 16 ohms. Exclusive Heathkit features include the "tweeter saver", and the "bas-bal" balancing circuit, requiring only a voltmeter for indication. Years of reliable service are guaranteed through the use of conservatively rated, high quality components. KT66 tubes and Peerless output transformer are typical. Shipped express only. Shpg. Wt. 31 lbs.

MODEL W-5: Consists of W-5M kit above plus model WA-P2 preamplifier. Express only. Shpg. Wt. 38 lbs. $79.50

MODEL W-5M **$59.75**

HEATHKIT SINGLE-CHASSIS 20-WATT HIGH FIDELITY AMPLIFIER KIT

The model W4-AM Williamson-type amplifier will amaze you with its outstanding performance. A true Williamson circuit, featuring extended frequency response, low distortion, and low hum levels, this amplifier can provide you with many hours of listening enjoyment with only a minimum investment compared to other units on the market. 5881 tubes and a special Chicago-standard output transformer are employed to give you full fidelity at minimum cost. Frequency response extending from 10 cps to 100 kc within ±1 db at 1 watt assures you of full coverage of the audio range, and clean clear sound amplification takes place in circuits that hold harmonic distortion at 1.5% and IM distortion below 2.7% at full 20 watt output. Hum and noise are 95 db below full output. Taps on the output transformer are at 4, 8 or 16 ohms. Shipped express only. Shpg. Wt. 28 lbs.

MODEL W-4A: Consists of W-4AM kit above, plus model WA-P2 preamplifier. Express only. Shpg. Wt. 35 lbs. $59.50.

MODEL W4-AM **$39.75**

HEATHKIT DUAL-CHASSIS 20-WATT HIGH FIDELITY AMPLIFIER KIT

The model W3-AM is a Williamson-type amplifier built on two separate chassis. The power supply is on one chassis, and the amplifier stages are on the other chassis. Using two separate chassis provides additional flexibility in installation. Features include the famous acrosound model TO-300 "ultralinear" output transformer and 5881 tubes for broad frequency response, low distortion, and low hum level. The result is exceptionally fine overall tone quality. Frequency response is ±1 db from 6 cps to 150 kc at 1 watt. Harmonic distortion is less than 1% and IM distortion is less than 1.3% at 20 watts. Hum and noise are 88 db below 20 watts. Designed to match the speaker system of your choice, with taps for 4, 8 or 16 ohms impedance. A very popular high fidelity unit employing top quality components throughout. Shipped express only. Shpg. Wt. 29 lbs.

MODEL W-3A: Consists of W-3AM kit above plus model WA-P2 preamplifier. Express only. Shpg. Wt. 37 lbs. $69.50

MODEL W-3AM **$49.75**

Heathkits...

By DAYSTROM

bring you the lasting satisfaction of personal accomplishment

HEATHKIT GENERAL-PURPOSE 20-WATT HIGH FIDELITY AMPLIFIER KIT

The model A-9C will provide you with high quality sound at low cost. Features a built-in preamplifier with four separate inputs, and individual volume, bass and treble controls. Frequency response covers 20 to 20,000 cps within ±1 db. Total harmonic distortion is less than 1% at 3 db below rated output. Push-pull 6L6 tubes are used, with output transformer tapped at 4, 8, 16 and 500 ohms. A true hi-fi unit using high-quality components throughout, including heavy-duty "potted" transformers. Shpg. Wt. 23 lbs.

MODEL A-9C **$35.50**

HEATHKIT "BASIC RANGE" HI-FI SPEAKER SYSTEM KIT

The extremely popular Heathkit model SS-1 Speaker System provides amazing high fidelity performance for its size. Features two high-quality Jensen speakers, an 8" mid-range woofer and compression-type tweeter with flared horn. Covers from 50 to 12,000 CPS within ±5 db, in a special-design ducted-port, bass reflex enclosure. Impedance is 16 ohms. Cabinet measures 11½" H x 23" W x 11¾" D. Constructed of veneer-surfaced plywood, ½" thick, suitable for light or dark finish. All wood parts are precut and predrilled for easy, quick assembly. Shpg. Wt. 30 lbs.

MODEL SS-1

$39.95

HEATHKIT "RANGE EXTENDING" HI-FI SPEAKER SYSTEM KIT

Extends the range of the SS-1 to ±5 db from 35 to 16,000 CPS. Uses 15" woofer and super-tweeter both by Jensen. Kit includes crossover circuit. Impedance is 16 ohms and power rating is 35 watts. Measures 29" H x 23" W x 17½" D. Constructed of veneer-surfaced plywood ¾" thick. Easy to build! Shpg. Wt. 80 lbs.

MODEL SS-1B

$99.95

HEATHKIT "LEGATO" HIGH FIDELITY SPEAKER SYSTEM KIT

The quality of the Legato, in terms of the engineering that went into the initial design, and in terms of the materials used in its construction, is matched in only the most expensive speaker systems available today. The listening experience it provides approaches the ultimate in esthetic satisfaction. Two 15" theater-type Altec Lansing speakers cover 25 to 500 CPS, and an Altec Lansing high-frequency driver with sectoral horn covers 500 to 20,000 CPS. A precise amount of phase shift in the crossover network brings the high frequency channel into phase with the low frequency channel to eliminate peaks or valleys at the crossover point, by equalizing the acoustical centers of the speakers. The enclosure is a modified infinite baffle type, especially designed for these speakers. Cabinet is constructed of veneer-surfaced plywood, ¾" thick, precut and predrilled for easy assembly. Frequency response 25 to 20,000 CPS. Power rating, 50 watts program material. Impedance is 16 ohms. Cabinet dimensions 41" L x 22¼" D x 34" H.

Choice of two beautiful cabinets. Model HH-1-C in imported white birch for light finishes, and HH-1-CM in African mahogany for dark finishes. Shpg. Wt. 195 lbs.

MODEL HH-1-C
MODEL HH-1-CM

$299.95
EACH

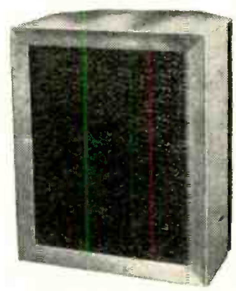
Heathkits...

By DAYSTROM

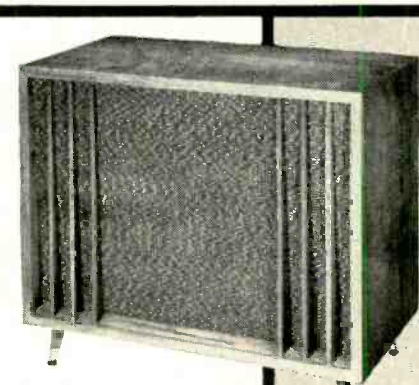
let you save up to ½ or more on all types of electronic equipment.

"BASIC RANGE" HI-FI SPEAKER SYSTEM

Superlative sound reproduction through the speaker system of your choice



"RANGE EXTENDING" HI-FI SPEAKER SYSTEM



"LEGATO" HI-FI SPEAKER SYSTEM

SINE-SQUARE GENERATOR

AUDIO ANALYZER

Sine and square waves for countless applications.

HEATHKIT SINE-SQUARE GENERATOR

The new AG-10 provides high quality, sine and square waves over a wide range, for countless applications. Some of these are; radio and TV repair work, checking scope performance, as a variable trigger source for telemetering and pulse work, and checking audio, video and hi-fi amplifier response. Frequency response is ±1.5 db from 20 CPS to 1 MC on both sine and square waves, with less than .25% sine wave distortion, 20 to 20,000 CPS. Sine wave output impedance 600 ohms, square wave output impedance 50 ohms, (except on 10v ranges). Square wave rise time less than .15 usec. Five-position band switch—continuously variable tuning—shielded oscillator circuit—separate step and variable output attenuators in ranges of 10, 1, and .1 volts for both sine and square wave, with extra range of .01 volt on sine wave. Both sine and square wave can be used at the same time without affecting either wave form. Power supply uses silicon-diode rectifiers. Shpg. Wt. 12 lbs.

MODEL AG-10

$49.95

HEATHKIT AUDIO ANALYZER KIT

The AA-1 is actually three instruments in one compact package. It combines the functions of an AC VTVM, an audio wattmeter, and an intermodulation analyzer. Input and output terminals are combined, and high and low frequency oscillators are built in. VTVM ranges are 0-.01, .03, .1, .3, 1, 3, 10, 30, 100 and 300 volts (RMS). Wattmeter ranges are .15 mw, 1.5 mw, 15 mw, 150 mw, 1.5 w, 15 w and 150 w. IM scales are 1%, 3%, 10%, 30% and 100%. Provides internal load resistors of 4, 8, 16 or 600 ohms. A tremendous dollar value. Shpg. Wt. 13 lbs.

MODEL AA-1

$49.95

HEATH COMPANY *A Subsidiary of Daystrom, Inc.* **BENTON HARBOR 20, MICH.**

HEATHKIT "GENERAL PURPOSE" 5" OSCILLOSCOPE KIT

The model OM-2 Oscilloscope is especially popular with part-time service technicians, students, and high fidelity enthusiasts. It features good vertical frequency response ±3 db from 4 cps to over 1.2 mc. A full five-inch crt, and sweep generator operation from 20 cps to over 150 kc. Stability is excellent and calibrated grid screen allows precise signal observation. Extra features include external or internal sweep and sync, 1-volt peak-to-peak calibrating reference, 3-position step-attenuated input, adjustable spot shape control, push-pull horizontal and vertical amplifiers, and modern etched-metal circuits. Easy to build and a pleasure to use. Ideal for use with other audio equipment for checking amplifiers. Shpg. Wt. 21 lbs.

MODEL OM-3

$39.95

HEATHKIT AUDIO WATTMETER KIT

The AW-1 Audio Wattmeter can be used in any application where audio power output is to be measured. Non-inductive LOAD resistors are built in for 4, 8, 16 or 600 ohms impedance. Five power ranges cover 0-5 mw, 50 mw, 500 mw, 5 w, and 50 w full scale. Five switch-selected db ranges cover −10 db to +30 db. All indications are read directly on a large 4½" 200 microampere meter. Frequency response is ±1 db from 10 cps to 250 kc. Precision type multiplier resistors used for high accuracy, and crystal diode bridge for wide-range frequency response. This meter is used in many recording studios and broadcast stations as a monitor as well as servicing. A fine meter to help supply the answers to your audio operating or power output problems. Shpg. Wt. 6 lbs.

MODEL 'W-1

$29.50

HEATHKIT AUDIO SIGNAL GENERATOR KIT

The model AG-9A is "made to order" for high fidelity applications, and provides quick and accurate selection of low-distortion signals throughout the audio range. Three rotary switches select two significant figures and a multiplier to determine audio frequency. Incorporates step-type and a continuously variable output attenuator. Output indicated on large 4½" panel meter, calibrated in volts and db. Attenuator system operates in 10 db steps, corresponding to meter calibration, in ranges of 0-.003, .01, .03, .1, .3, 1,3 and 10 volts RMS. "Load" switch permits use of built-in 600-ohm load, or external load of different impedance. Output and frequency indicators accurate to within ±5%. Distortion less than .1 of 1% between 20 and 20,000 cps. Total range is 10 cps to 100 kc. Shpg. Wt. 8 lbs.

MODEL AG-9A

$34.50

HEATHKIT HARMONIC DISTORTION METER KIT

All sounds consist of dominant tones plus harmonics (overtones). These harmonics enrich the quality and brightness of the music. However, additional harmonics which originate in the audio equipment, represent distortion. Used with an audio signal generator, the HD-1 will accurately measure this harmonic distortion at any or all frequencies between 20 and 20,000 cps. Distortion is read directly on the panel meter in ranges of 0-1, 3, 10, 30 and 100% full scale. Voltage ranges of 0-1, 3, 10 and 30 volts are provided for the initial reference settings. Signal-to-noise ratio measurements are also permitted through the use of a separate meter scale calibrated in db. High quality components insure years of outstanding performance. Full instructions are provided. Shpg. Wt. 13 lbs.

MODEL HD-1

$49.50

Heathkits...

By DAYSTROM

are well known for their high quality and reliability.

HEATHKIT AUDIO VTVM KIT

This new and improved AC Vacuum Tube Voltmeter is designed especially for audio measurements and low-level AC measurements in power supply filters, etc. Employs an entirely new circuit featuring a cascode amplifier with cathode-follower isolation between the input and the amplifier, and between the output stage and the preceding stages. It emphasizes stability, broad frequency response, and sensitivity. Frequency response is essentially flat from 10 cps to 200 kc. Input impedance is 1 megohm at 1000 cps. AC (RMS) voltage ranges are 0-.01, .03, .1, .3, 1, 3, 10, 30, 100 and 300 volts. Db ranges cover −52 db to +52 db. Features large 4½" 200 microampere meter, with increased damping in meter circuit for stability in low frequency tests. 1% precision resistors employed for maximum accuracy. Stable, reliable performance in all applications. Shpg. Wt. 5 lbs.

MODEL AV-3

$29.95

HEATHKIT TUBE CHECKER KIT

Eliminate guesswork, and save time in servicing or experimenting. The TC-2 tests tubes for shorted elements, open elements, filament continuity, and operating quality on the basis of total emission. It tests all tube types encountered in radio and TV service work. Sockets are provided for 4, 5, 6 and 7-pin, octal, and loctal tubes, 7 and 9 pin miniature tubes, 5 pin hytron miniatures, and pilot lamps. Tube condition indicated on 4½" meter with multi-color "good-bad" scale. Illuminated roll chart with all test data built in. Switch selection of 14 different filament voltages from .75 to 117 volts. Color-coded cable harness allows neat professional wiring and simplifies construction. Very easy to build, even for a beginner. Shpg. Wt. 12 lbs.

MODEL TC-2

$29.50

HEATHKIT HANDITESTER KIT

The small size and rugged construction of this tester makes it perfect for any portable application. The combination function-range switch simplifies operations. Measures AC or DC voltage at 0-10, 30, 300, 1000 and 5000 volts. Direct current ranges are 0-10 ma and 0-100 ma. Ohmmeter ranges are 0-3000 (30 ohm center scale) and 0-300,000 (3000 ohm center scale). Very popular with home experimenters, electricians, and appliance repairmen. Slips easily into your tool box, glove compartment, coat pocket, or desk drawer. Shpg. Wt. 3 lbs.

MODEL M-1

$17.95

HEATHKIT PICTURE TUBE CHECKER KIT

The CC-1 can be taken with you on service calls so that you can clearly demonstrate the quality of a customer's picture tube in his own home. Tubes can be tested without removing them from the receiver or cartons if desired. Checks cathode emission, beam current, shorted elements, and leakage between elements in electromagnetic picture tube types. Self-contained power supply, and large 4½" meter. CRT condition indicated on "good-bad" scale. Relative condition of tubes fluorescent coating is shown in "shadowgraph" test. Permanent test cable with CRT socket and anode connector. No tubes to burn out, designed to last a lifetime. Luggage-type portable case. Shpg. Wt. 10 lbs.

MODEL CC-1

$24.95

HEATHKIT ETCHED-CIRCUIT VTVM KIT

This multi-purpose VTVM is the world's largest selling instrument of its type—and is especially popular in laboratories, service shops, home workshops and schools. It employs a large 4½" panel meter, precision 1% resistors, etched metal circuit board, and many other "extras" to insure top quality and top performance. It's easy to build, and you may rely on its accuracy and dependability. The V7-A will measure AC (RMS) and DC voltages in ranges of 0-1.5, 5, 15, 50, 150, 500 and 1500. It measures peak-to-peak AC voltage in ranges of 0-4, 14, 40, 140, 400, 1400 and 4000. Resistance ranges provide multiplying factors of X 1, X 10, X 100, X 1000, X 10k, X 100k, and X 1 megohm. Center-scale resistance readings are 10, 100, 1000, 10k, 100k, 1 megohm and 10 megohms. A db scale is also provided. The precision and quality of this VTVM cannot be duplicated at this price. Shpg. Wt. 7 lbs.

MODEL V7-A

$24.50

Heathkits...

By DAYSTROM

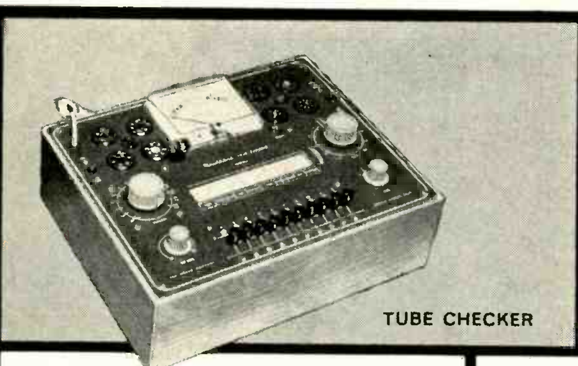
let you fill your exact needs from a wide variety of instruments

HEATHKIT 20,000 OHMS/VOLT VOM KIT

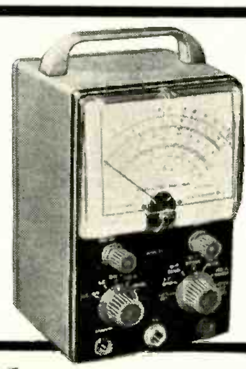
This fine instrument provides a total of 25 meter ranges on its two-color scale. It employes a 50 ua 4½" meter, and features 1% precision multiplier resistors. Requires no external power. Ideal for portable applications. Sensitivity is 20,000 ohms-per-volt DC and 5000 ohms-per-volt AC. Measuring ranges are 0-1.5, 5, 50, 150, 500, 1500 and 5000 volts, AC and DC. Measures direct current in ranges of 0-150 ua, 15 ma, 150 ma, 500 ma and 15 a. Resistance multipliers are X 1, X 100 and X 10,000, with center-scale readings of 15, 1500 and 150,000 ohms. Covers −10 db to +65 db. Easy to build and fun to use. Attractive bakelite case with plastic carrying handle. Shpg. Wt. 6 lbs.

MODEL MM-1

$29.95



TUBE CHECKER



ETCHED CIRCUIT VTVM

High quality test gear you will be proud to own

HANDITESTER

Priced low to fit your budget

PICTURE TUBE CHECKER

20,000 OHMS/VOLT VOM

HEATHKIT RF SIGNAL GENERATOR KIT

Even a beginner can build this prealigned signal generator, designed especially for use in service work. Produces RF signals from 160 kc to 110 mc on fundamentals in five bands. Covers 110 mc to 220 mc on calibrated harmonics. Low impedance RF output in excess of 100,000 microvolts, is controllable with a step-type and continuously variable attenuator. Selection of unmodulated RF, modulated RF, or audio at 400 CPS. Ideal for fast and easy alignment of radio receivers, and finds application in FM and TV work as well. Thousands of these units are in use in service shops all over the country. Easy to build and a real time saver, even for the part-time service technician or hobbyist. Shpg. Wt. 8 lbs.

MODEL SG-8 — $19.50

HEATHKIT LABORATORY RF GENERATOR KIT

Tackle all kinds of laboratory alignment jobs with confidence by employing the LG-1. It features voltage-regulated B+, double shielding of oscillator circuits, copper-plated chassis, variable modulation level, metered output, and many other "extras" for critical alignment work. Generates RF signals from 100 kc to 30 mc on fundamentals in five bands. Meter reads RF output in microvolts or modulation level in percentage. RF output available up to 100,000 microvolts, controlled by a fixed-step and a variable attenuator. Provision for external modulation where necessary. Buy and use this high-quality RF signal generator that may be depended upon for stability and accuracy. Shpg. Wt. 16 lbs.

MODEL LG-1 — $48.95

HEATHKIT DIRECT-READING CAPACITY METER KIT

Here's a fast, simple capacity meter. A capacitor to be checked is merely connected to the terminals, the proper range selected, and the value read directly on the large 4½" panel meter calibrated in mmf and mfd. Ranges are 0 to 100 mmf, 1,000 mmf, .01 mfd, .1 mfd full scale. Not affected by hand capacity. Shpg. Wt. 7 lbs.

MODEL CM-1 — $29.50

Heathkits...

By DAYSTROM

are educational
as well as functional

HEATHKIT "IN-CIRCUIT" CAPACI-TESTER KIT

With the CT-1 it is no longer necessary to disconnect one capacitor lead to check the part, you can check most capacitors for "open" or "short" right in the circuit. Fast and easy—to save your valuable time in the service shop or lab. Detects open capacitors from about 50 mmf up, so long as the capacitor is not shunted by excessively low resistance value. Will detect shorted capacitors up to 20 mfd (not shunted by less than 10 ohms). (Does not detect leakage.) Employs 60 cycles and 19 megacycle test frequencies. Electron beam "eye" tube used as indicator. Compact, easy-to-build, and inexpensive. Test leads included. Shpg. Wt. 5 lbs.

MODEL CT-1 — $7.95

HEATHKIT CONDENSER CHECKER KIT

This handy instrument uses an electron beam "eye" tube as an indicator to measure capacity in ranges of .00001 to .005 mfd, .5 mfd, 50 mfd and 1000 mfd. Also measures resistance from 100 ohms to 5 megohms in two ranges. Checks paper, mica, ceramic and electrolytic capacitors. Selection of five polarizing voltages. Shpg. Wt. 7 lbs.

MODEL C-3 — $19.50

HEATHKIT VISUAL-AURAL SIGNAL TRACER KIT

Although designed originally for radio receiver work, the T-3 finds application in FM and TV servicing as well. Features high-gain channel with demodulator probe, and low-gain channel with audio probe. Traces signals in all sections of radio receivers and in many sections of FM and TV receivers. Built-in speaker and electron beam eye tube indicate relative gain, etc. Also features built-in noise locator circuit. Provision for patching speaker and /or output transformer to external set. Shpg. Wt. 9 lbs.

MODEL T-3 — $23.50

HEATH COMPANY *A Subsidiary of Daystrom, Inc.* **BENTON HARBOR 20, MICH.**

HEATHKIT IMPEDANCE BRIDGE KIT

The model IB-2A employs a Wheatstone Bridge, a Capacity Comparison Bridge, a Maxwell Bridge, and a Hay Bridge in one compact package. Measures resistance from 0.1 ohm to 10 megohms, capacitance from 100 mmf to 100 mfd, inductance from 0.1 mh to 100 h, dissipation factor (D) from 0.002 to 1, and storage factor (Q) from 0.1 to 1000. A 100-0-100 ua meter provides for null indications. The decade resistors employed are of 1% tolerance for maximum accuracy. Completely self-contained. Has built in power supply, 1000-cycle generator, and vacuum-tube detector. Special two-section CRL dial insures convenient operation. Instruction manual has entirely new schematic that clarifies circuit functions in various switch positions. A true laboratory instrument, that will provide you with many years of fine performance. Shpg. Wt. 12 lbs.

MODEL IB-2A

$59.50

HEATHKIT "LOW RIPPLE" BATTERY ELIMINATOR KIT

This modern battery eliminator incorporates an extra low-ripple filter circuit so that it can be used to power all the newest transistor-type circuits requiring 0 to 12 volts DC, and the new "hybrid" automobile radios using both transistors and vacuum tubes. Its DC output, at either 6 or 12 volts, contains less than .3% AC ripple. Separate output terminals are provided for low-ripple or normal filtering. Supplies up to 15 amps on 6 volt range or up to 7 amps on 12 volt range. Output is variable from 0 to 8 or 0 to 16 volts. Two meters constantly monitor output voltage and current. Will also double as a battery charger. Shpg. Wt. 23 lbs.

MODEL BE-5

$39.95

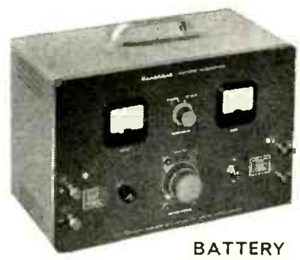
HEATHKIT ISOLATION TRANSFORMER KIT

The model IT-1 is one of the handiest units for the service shop, home workshop or laboratory. Provides complete isolation from the power line. AC-DC sets may be plugged directly into the IT-1 without the chassis becoming "hot". Output voltage is variable from 90 volts to 130 volts allowing checks of equipment under adverse conditions such as low line voltage. Rated for 100 volt amperes continuously or 200 volt amperes intermittently. Panel meter monitors output voltage. Shpg. Wt. 9 lbs.

MODEL IT-1

$16.50


IMPEDANCE BRIDGE


BATTERY ELIMINATOR


ISOLATION TRANSFORMER


Q METER


REGULATED POWER SUPPLY

Laboratory facilities at low cost

Heathkits...

By DAYSTROM

are designed with high-quality, name-brand components to insure long service life

HEATHKIT "Q" METER KIT

At this price the laboratory facilities of a Q Meter may be had by the average service technician or home experimenter. The Q Meter permits measurement of inductance from 1 microhenry to 10 milihenry, "Q" on a scale calibrated up to 250 full scale, with multipliers of 1 or 2, and capacitance from 40 mmf to 450 mmf ± 3 mmf. Built in oscillator permits testing components from 150 kc to 18 mc. Large 4½" panel meter is featured. Very handy for checking peaking coils, chokes, etc. Use to determine values of unknown condensers, both variable and fixed, compile data for coil winding purposes, or measure RF resistance. Also checks distributed capacity and Q of coils. No special equipment is required for calibration. A special test coil is furnished, along with easy-to-follow instructions. Shpg. Wt. 14 lbs.

MODEL QM-1

$44.50

HEATHKIT REGULATED POWER SUPPLY KIT

Here is a power supply that will provide DC plate voltage and AC filament voltage for all kinds of experimental circuits. The DC supply is regulated for stability, and yet the amount of DC output voltage available from the power supply can be controlled manually from 0 up to 500 volts. At 450 volts DC output, the power supply will provide up to 10 ma of current, and provide progressively higher current as the output voltage is lowered. Current rating is 130 ma at 200 volts output. In addition to furnishing B+ the power supply also provides 6.3 volts AC at up to 4 amperes for filaments. Both the B+ output and the filament output are isolated from ground. Ideal unit for use in laboratory, home workshop, ham shack, or service shop. A large 4½" meter on the front panel reads output voltage or output current, selectable with a panel switch. Shpg. Wt. 17 lbs.

MODEL PS-3

$35.50

Terrific values

in amateur

equipment!

DX-100 TRANSMITTER

DX-20 TRANSMITTER

DX-40 TRANSMITTER

HEATHKIT DX-20 CW TRANSMITTER KIT

The Heathkit model DX-20 "straight-CW" transmitter features high efficiency at low cost. It uses a single 6DQ6A tube in the final amplifier stage for plate power input of 50 watts. A 6CL6 serves as crystal oscillator, with a 5U4GB rectifier. It is an ideal transmitter for the novice, as well as the advanced-class CW operator. Single-knob band switching is featured to cover 80, 40, 20, 15, 11 and 10 meters. Pi network output circuit matches various antenna impedances between 50 and 1000 ohms and reduces harmonic output. Top-quality parts are featured throughout, including "potted" transformers, etc., for long life. It has been given full "TVI" treatment. Access into the cabinet for crystal changing is provided by a removable metal pull-out plug on the left end of the cabinet. Very easy to build from the complete step-by-step instructions supplied, even if you have never built electronic equipment before. If you appreciate a good, clean signal on the CW bands, this is the transmitter for you! Shpg. Wt. 18 lbs.

MODEL DX-20 **$35.95**

Heathkits...

By DAYSTROM

are designed by licensed ham-engineers, especially for you

HEATHKIT DX-40 PHONE AND CW TRANSMITTER KIT

A most remarkable power package for the price, the new DX-40 provides both phone and CW facilities for operation on 80, 40, 20, 15, 11 and 10 meters. A single 6146 tube is used in the final amplifier stage to provide full 75 watt plate power input on CW, or control carrier modulation peaks up to 60 watts for phone operation. Modulator and power supplies are built right in and single knob bandswitching is combined with a pi network output circuit for complete operating convenience. The tight fitting cabinet presents a most attractive appearance, and is designed for complete shielding to minimize TVI. A 4-position switch provides convenient selection of three different crystals or a jack for external VFO. The crystals are reached through access door at rear of cabinet. You can build this rig yourself and be proud to show it off to your fellow hams. Get your DX-40 now for many hours of operating enjoyment. Shpg. Wt. 25 lbs.

MODEL DX-40 **$64.95**

HEATHKIT DX-100 PHONE AND CW TRANSMITTER KIT

Listen to any ham band between 160 meters and 10 meters and note how many DX-100 transmitters you hear! The number of these fine rigs now on the air testifies to the enthusiasm with which it has been accepted by the amateur fraternity. No other transmitter in this power class combines high quality and real economy so effectively. The DX-100 features a built in VFO, modulator and power supplies, complete shielding to minimize TVI, and pi network output coupling to match impedances from approximately 50 to 600 ohms. Its RF output is in excess of 100 watts on phone and 120 watts on CW, for a clean strong signal on all the ham bands from 10 to 160 meters. Single-knob band switching and illuminated VFO dial and meter face add real operating convenience. RF output stage uses a pair of 6146 tubes in parallel, modulated by a pair of 1625's. High quality components are used throughout, such as "potted" transformers, silver-plated or solid coin silver switch terminals, aluminum heat-dissipating caps on the final tubes, copper plated chassis, etc. This transmitter was designed exclusively for easy step-by-step assembly. Shpg. Wt. 107 lbs.

MODEL DX-100 **$189.50**

FUNCTIONAL DESIGN . . .

The transmitters described on this page were designed for the ham, by hams who know what features are desirable and needed. This assures you of the best possible performance and convenience, and adds much to your enjoyment in the ham shack.

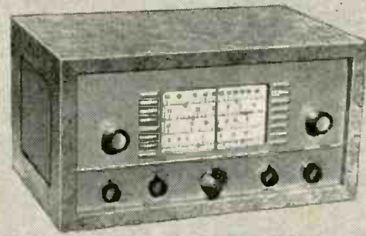
HEATH COMPANY *A Subsidiary of Daystrom, Inc.* **BENTON HARBOR 20, MICH.**

Automatically turns off transmitter and gives visual signal

"AUTOMATIC" CONELRAD ALARM

GRID DIP METER

"Q" MULTIPLIER



COMMUNICATIONS-TYPE RECEIVER

An ideal receiver for the beginning ham or short wave listener

HEATHKIT "AUTOMATIC" CONELRAD ALARM KIT

This conelrad alarm works with any radio receiver; AC-DC-transformer operated—or battery powered, so long as the receiver has AVC. Fully complies with FCC regulations for amateurs. When the monitored station goes off the air, the CA-1 automatically cuts the AC power to your transmitter, and lights a red indicator. A manual "reset" button reactivates the transmitter. Incorporates a heavy-duty six-ampere relay, a thyratron tube to activate the relay, and its own built-in power supply. A neon lamp shows that the alarm is working, by indicating the presence of B+ in the alarm circuit. Simple to install and connect. Your transmitter plugs into an AC receptacle on the CA-1, and a cable connects to the AVC circuit of a nearby receiver. A built-in sensitivity control allows adjustment to various AVC levels. Receiver volume control can be turned up or down, without affecting alarm operation. Build a Heathkit CA-1 in one evening and comply with FCC regulations now! Shpg. Wt. 4 lbs.

MODEL CA-1
$13.95

HEATHKIT "Q" MULTIPLIER KIT

The Heathkit Q Multiplier functions with any AM receiver having an IF frequency between 450 and 460 KC, that is not "AC-DC" type. It derives its power from the receiver, and needs only 6.3 volts AC at 300 ma (or 12 VAC at 150 ma) and 150 to 250 volts DC at 2 ma. Simple to connect with cable and plugs supplied. Adds additional selectivity for separating signals, or will reject one signal and eliminate heterodyne. A tremendous help on crowded phone and CW bands. Effective Q of 4000 for sharp "peak" or "null". Tunes any signal within IF band pass without changing the main receiver tuning dial. A convenient tuning knob on the front panel with vernier reduction between the tuning knob and the tuning capacitor gives added flexibility in operation. Uses a 12AX7 tube, and special high-Q shielded coils. Instructions for connecting to the receiver and operation are provided in the construction manual. A worthwhile addition to any communications, or broadcast receiver. It may also be used with a receiver which already has a crystal filter to obtain two simultaneous functions, such as peaking the desired signal with the crystal filter and nulling an adjacent signal with the Q Multiplier. Shpg. Wt. 3 lbs.

MODEL QF-1
$9.95

HEATHKIT GRID DIP METER KIT

A grid dip meter is basically an RF oscillator for determining the frequency of other oscillators, or of tuned circuits. Extremely useful in locating parasitics, neutralizing, identifying harmonics, coil winding, etc. Features continuous frequency coverage from 2 mc to 250 mc, with a complete set of prewound coils, and a 500 ua panel meter. Front panel has a sensitivity control for the meter, and a phone jack for listening to the "zero-beat." Will also double as an absorption-type wave meter. Shpg. Wt. 4 lbs.

Low Frequency Coil Kit: Two extra plug-in coils to extend frequency coverage down to 350 kc. Shpg. Wt. 1 lb. No. 341-A. $3.00

MODEL GD-1B
$21.95

HEATHKIT ALL-BAND COMMUNICATIONS-TYPE RECEIVER KIT

This communications-receiver covers 550 kc to 30 mc in four bands, and provides good sensitivity, selectivity, and fine image rejection. Ham bands are clearly marked on an illuminated dial scale. Features a transformer-type power supply—electrical band spread—antenna trimmer—headphone jack—automatic gain control and beat frequency oscillator. Accessory sockets are provided on the rear of the chassis for using the Heathkit model QF-1, Q Multiplier. Accessory socket is handy, also, for operating other devices that require plate and filament potentials. Will supply +250 VDC at 15 ma and 12.6 VAC at 300 ma. Ideal for the beginning ham or short wave listener. Shpg. Wt. 12 lbs.

Cabinet: Fabric covered cabinet with aluminum panel as shown. Part no. 91-15A. Shpg. Wt. 5 lbs. $4.95.

MODEL AR-3
$29.95
(Less cabinet)

Heathkits...

By DAYSTROM

are outstanding in performance and dollar value

HEATHKIT REFLECTED POWER METER KIT

The Heathkit reflected power meter, model AM-2, makes an excellent instrument for checking the match of the antenna transmission system, by measuring the forward and reflected power or standing wave ratio. The AM-2 is designed to handle a peak power of well over 1 kilowatt of energy and may be left in the antenna system feed line at all times. Band coverage is 160 meters through 2 meters. Input and output impedances for 50 or 75 ohm lines. No external power required for operation. Meter indicates percentage forward and reflected power, and standing wave ratio from 1:1 to 6:1. Another application for the AM-2 is matching impedances between exciters or R.F. sources and grounded grid amplifiers. Power losses between transmitter output and antenna tuner may be very easily computed by inserting the AM-2 in the line connecting the two. No insertion loss is introduced into the feeder system, due to the fact that the AM-2 is a portion of coaxial line in series with the feeder system and no internal connections are actually made to the line. Complete circuit description and operation instructions are provided in the manual. Cabinet size is 7-3/8" x 4-1/16" x 4-5/8". Can be conveniently located at operating position. Shpg. Wt. 3 lbs.

MODEL AM-2

$15.95

HEATHKIT VARIABLE FREQUENCY OSCILLATOR KIT

Enjoy the convenience and flexibility of VFO operation by obtaining the Heathkit model VF-1 Variable Frequency Oscillator. Covers 160-80-40-20-15-11 and 10 meters with three basic oscillator frequencies. Better than 10 volt average RF output on fundamentals. Plenty of output to drive most modern transmitters. It features voltage regulation for frequency stability. Dial is illuminated for easy reading. Vernier reduction is used between the main tuning knob and the tuning condenser. Requires a power source of only 250 volts DC at 15 to 20 miliamperes and 6.3 volts AC at 0.45 amperes. Extra features include copper-plated chassis, ceramic coil forms, extensive shielding, etc. High quality parts throughout. VFO operation allows you to move out from under interference and select a portion of the band you want to use without having to be tied down to only two or three frequencies through use of crystals. "Zero in" on the other fellow's signal and return his CQ on his own frequency! Crystals are not cheap, and it takes quite a number of them to give anything even approaching comprehensive coverage of all bands. Why hesitate? The model VF-1 with its low price and high quality will add more operating enjoyment to your ham activities. Shpg. Wt. 7 lbs.

MODEL VF-1

$19.50

Heathkits...

By DAYSTROM

are the answer for your electronics hobby.

REFLECTED POWER METER

Insure your "on the air" performance with these fine accessories.

VARIABLE FREQUENCY OSCILLATOR

HEATHKIT BALUN COIL KIT

The Heathkit Balun Coil Kit model B-1 is a convenient transmitter accessory, which has the capability of matching unbalanced coax lines, used on most modern transmitters, to balance lines of either 75 or 300 ohms impedance. Design of the bifilar wound balun coils will enable transmitters with unbalanced output to operate into balanced transmission line, such as used with dipoles, folded dipoles, or any balanced antenna system. The balun coil set can be used with transmitters and receivers without adjustment over the frequency range of 80 through 10 meters, and will easily handle power inputs up to 250 watts. Cabinet size is 9" square by 5" deep and it may be located any distance from the transmitter or from the antenna. Completely enclosed for outdoor installation. Shpg. Wt. 4 lbs.

MODEL B-1

$8.95

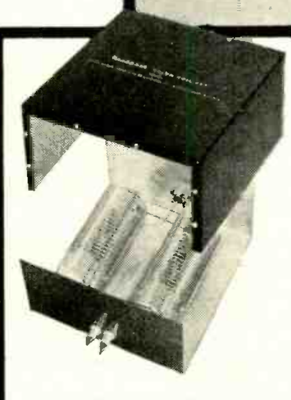
HEATHKIT 6 OR 12 VOLT VIBRATOR POWER SUPPLY KITS

These little power supply kits are ideal for all portable applications with 6 volt or 12 volt batteries, when you are operating electronic equipment away from power lines. By replacing the power supplies of receivers, small public address systems, or even miniature transmitters with these units, they can be used with conventional 6 or 12 volt batteries. Use in boats, automobiles, light aircraft, or any field application. Each unit provides 260 volts DC output at up to 60 miliamperes. More than one power supply of the same model may be connected in parallel for increased current capacity at the same output voltage. Everything is provided in the kit, including a vibrator transformer, a vibrator, 6X4 or 12X4 rectifier, and the necessary buffer capacitor, hash filter, and output filter capacitor. Shpg. Wt. 4 lbs.

6 VOLT MODEL VP-1-6
12 VOLT MODEL VP-1-12

$7.95 Each

VIBRATOR POWER SUPPLY



BALUN COIL SET

HEATH COMPANY *A Subsidiary of Daystrom, Inc.* **BENTON HARBOR 20, MICH.**

HEATHKIT ELECTRONIC IGNITION ANALYZER KIT

Previous electronic experience is not necessary to build this fine ignition analyzer. The construction manual supplied has complete step-by-step instructions plus large pictorial diagrams showing the exact placement and value of each component. All parts are clearly marked so that they are easily identified. The IA-1 is an ideal tool for engine mechanics, tune-up men, and auto hobbyists, since it traces the dynamic action of voltage in an ignition system on a cathode-ray tube screen. The waveform produced is affected by the condition of the coil, condenser, points, plugs, and ignition wiring, so it can be analyzed, and used as a "sign-post" to ignition system performance. This analyzer will detect inequality of spark intensity, a poor spark plug, defective plug wiring, breaker-point bounce, an open condenser, and allow setting of dwell-time percentage for the points. An important feature of this instrument is its ability to check dynamic performance, with the engine in operation (400 to 5000 RPM). It will show the complete engine cycle, or only one complete cylinder. Can be used on all types of internal combustion engines where breaker-points are accessible. Use it on automobiles, boats, aircraft engines, etc. Shpg. Wt. 18 lbs.

MODEL IA-1
$59.95

HEATHKIT PROFESSIONAL RADIATION COUNTER KIT

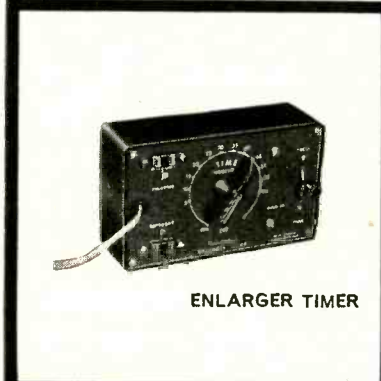
This Heathkit professional-type radiation counter is simple to build successfully, even if you have never built a kit before. Complete step-by-step instructions are combined with giant-size pictorial diagrams for easy assembly. By "building it yourself" you can have a modern-design, professional radiation counter priced far below comparable units. Provides high sensitivity with ranges from 0-100, 600, 6000 and 60,000 counts-per-minute, and 0-.02, .1, 1 and 10 miliroentgens-per-hour. Employs 900-volt bismuth tube in beta/gamma sensitive probe. Probe and 8-foot expandable cable included in kit price, as is a radiation sample for calibration. Use it in medical laboratories, or as a prospecting tool, and for civil defense to detect radioactive fallout, or other unknown radiation levels. Features a selectable time constant. Meter calibrated in CPM or mR/hour in addition to "beep" or "click" from panel-mounted speaker. Prebuilt "packaged" high voltage power supply with reserve capacity above 900 volt level at which it is regulated. Merely changing regulator tube type would allow use of scintillation probe if desired. Employs five tubes (plus a transistor) to insure stable and reliable operation. Kit price includes batteries. Shpg. Wt. 8 lbs.

MODEL RC-1
$79.95

IGNITION ANALYZER

Kit includes everything you need for construction — even batteries!

RADIATION COUNTER



ENLARGER TIMER

BATTERY TESTER

Heathkits...

By DAYSTROM

are supplied with comprehensive instructions that eliminate costly mistakes and save valuable time

HEATHKIT ENLARGER TIMER KIT

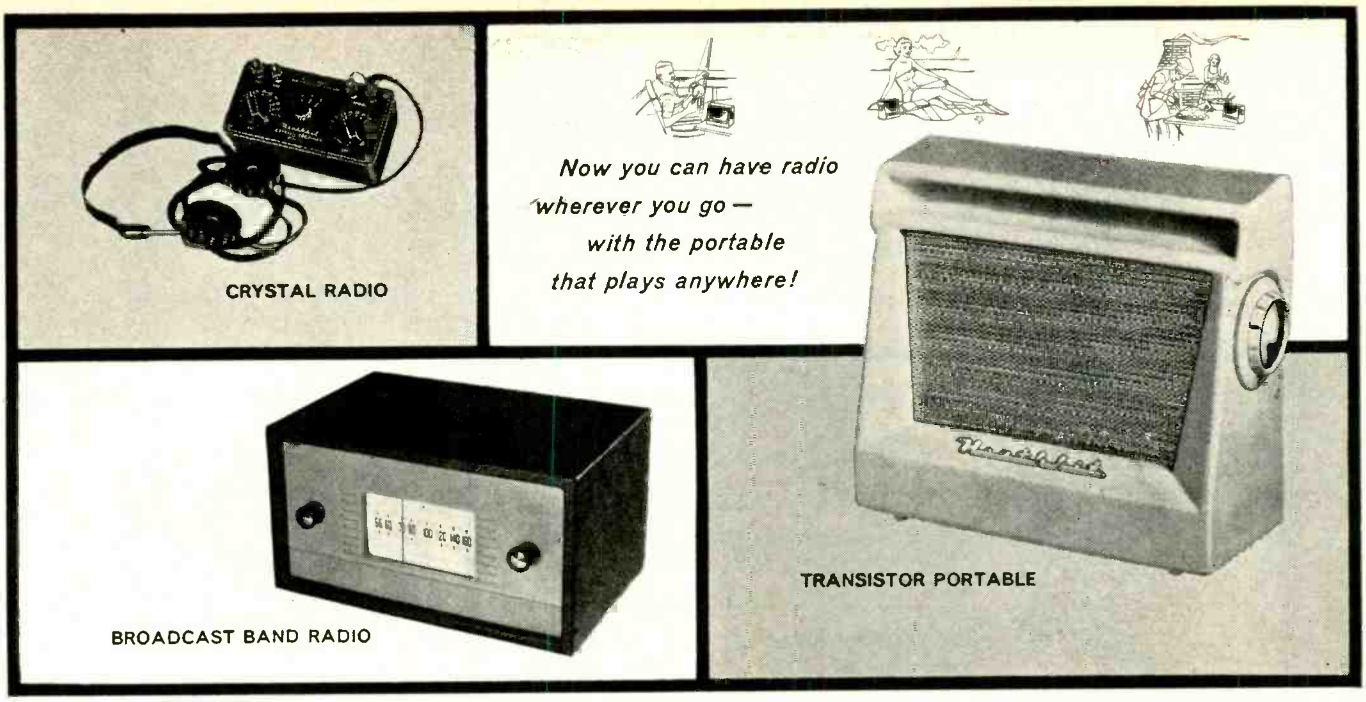
The ET-1 is an easy-to-build electronic device to be used by amateur or professional photographers in timing enlarger operations. The calibrated dial on the timer covers 0 to 1 minute, calibrated in 5-second gradations. The continuously variable control allows setting of the "on" cycle of your enlarger, which is plugged into a receptacle on the front panel of the ET-1. A "safe light" can also be plugged in so that it is automatically turned "on" when the enlarger is turned "off." Handles up to 350 watts with built-in relay. All-electronic timing cycle insures maximum accuracy. Timer does not have to be reset after each cycle, merely flip lever switch to print, to repeat time cycle. A control is provided for initial calibration. Housed in a compact plastic case that will resist attack of photographic chemicals. A fine addition to any dark room. Shpg. Wt. 3 lbs.

MODEL ET-1
$11.50

HEATHKIT BATTERY TESTER KIT

The BT-1 is a special battery testing device that actually "loads" the battery under test (draws current from it) while it is being tested. Weak batteries often test "good" with an ordinary voltmeter but the built-in load resistance of the BT-1 automatically draws enough current from the battery to reveal its true condition. Simple to operate with "good-weak-replace" scale. Tests all kinds of dry cell batteries within ranges of 0-15 volts and 0-180 volts. Slide switch provides for either 10 ma or 100 ma load, depending on whether you're testing an A or B battery. Not only determines when battery is completely exhausted, but makes it possible to anticipate failure by noting weak condition. Ideal for testing dry cell hearing aid, flashlight, portable radio, and model airplane batteries. Test batteries in a way your customers can understand and stimulate battery sales. Shpg. Wt. 2 lbs.

MODEL BT-1
$8.50



HEATHKIT CRYSTAL RADIO KIT

The Heathkit model CR-1 crystal radio is similar to the "crystal sets" of the early radio days except that it has been improved by the use of sealed germanium diodes and efficient "high-Q" coils. The sealed diodes eliminate the critical "cats whisker" adjustment, and the ferrite coils are much more efficient for greater signal strength. Housed in a compact plastic box, the CR-1 uses two tuned circuits, each with a variable tuning capacitor, to select the local station. It covers the broadcast band from 540 to 1600 kc. Requires no external power whatsoever. This receiver could prove valuable to emergency reception of civil defense signals should there be a power failure. The low kit price even includes headphones. Complete step-by-step instructions and large pictorial diagrams are supplied for easy assembly. The instruction manual also provides the builder with the basic fundamentals of signal reception so that he understands how the crystal receiver functions. An interesting and valuable "do-it-yourself" project for all ages. Shpg. Wt. 3 lbs.

MODEL CR-1
$7.95

Heathkits...

By DAYSTROM

are easy and fun to build,
and they let you learn
by "doing-it-yourself"

HEATHKIT TRANSISTOR PORTABLE RADIO KIT

Heath engineers set out to develop a "universal" AM radio, suitable for use anywhere. Their objective was a portable that would be as much "at home" inside as it is outside, and would feature top quality components for high performance and long service life. The model XR-1 is the result of these efforts. Six name-brand (Texas Instrument) transistors were selected for extra good sensitivity and selectivity. A 4" by 6" PM speaker with heavy magnet was chosen to insure fine tone quality. The power supply was designed to use six standard size "D" flashlight cells because they are readily available, inexpensive, and because they afford extremely long battery life (between 500 and 1000 hours). Costs you no more to operate from batteries than what you pay for operating a small table-model radio from the power line. An unbreakable molded plastic was selected for cabinet material because of its durability and striking beauty. Circuit is compact and efficient, yet components are not excessively crowded. Transformers are prealigned so it is ready for service as soon as construction is completed. Has built in rod-type antenna for reception in all locations. Cabinet dimensions are 9" L x 8" H x 3¾" D. Comes in holiday gray, with gold-anodized metal speaker grille. Compare this portable, feature by feature, to all others on the market, and you'll appreciate what a tremendous dollar value it represents! Shpg. Wt. 4 lbs.

MODEL XR-1
$34.95
(Less batteries)
(With cabinet)

HEATHKIT BROADCAST BAND RADIO KIT

This table-model broadcast radio is fun to build, and is a fine little receiver for your home. It covers the standard broadcast band from 550 to 1600 kc with good sensitivity and selectivity. The 5½" PM speaker provides surprisingly good tone quality. High-gain IF transformers, miniature tubes, and a rod-type built in antenna, assure good reception in all locations. The power supply is transformer operated, as opposed to many of the economy "AC-DC" types. It's easy to build from the step-by-step instructions, and the construction manual includes information on operational theory, for educational purposes. Your success is assured by completely detailed information which also explains resistor and capacitor color codes, soldering techniques, use of tools, etc. A signal generator is recommended for final alignment. Shpg. Wt. 10 lbs.

Cabinet: Fabric covered cabinet with aluminum panel as shown. Shpg. Wt. 5 lbs. Part no. 91-9A. $4.95.

MODEL BR-2
$18.95
(Less cabinet)

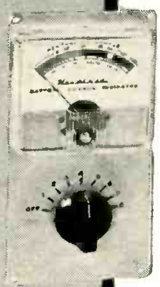
HEATH COMPANY *A Subsidiary of Daystrom, Inc.* **BENTON HARBOR 20, MICH.**

protects against possible explosion and fire from undetected fuel vapor

FUEL VAPOR DETECTOR

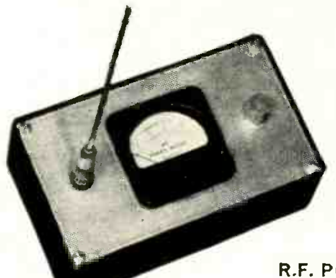
detects electrolysis currents which cause deterioration of underwater metal fittings on your boat

ELECTROLYSIS DETECTOR



indicates condition and charge of batteries for safe cruising

BATTERY CHARGE INDICATOR



R.F. POWER METER

HEATHKIT FUEL VAPOR DETECTOR KIT

Protect your boat and its passengers against fire or explosion from undetected fuel vapor by building and using one of these fine units. The Heathkit Fuel Vapor Detector indicates the presence of fumes on a three-color "safe-dangerous" meter scale and immediately shows if it is safe to start the engine. A pilot light on the front panel shows when the detector is operating, and it can be left on continuously, or just used intermittently. A panel control enables initial calibration of the detector when installed. Features a hermetically-sealed meter with chrome bezel, and a chrome-plated brass panel. It is very simple to build and install, even by one not having previous experience. Models FD-1-6 (6 volts DC) and FD-1-12 (12 volts DC) operate from your boat batteries. The kit is complete in every detail, even to the inclusion of a spare detector unit. Shpg. Wt. 4 lbs.

6 volt MODEL FD-1-6
12 volt MODEL FD-1-12
$35.95 EACH

HEATHKIT BATTERY CHARGE INDICATOR KIT

The Heathkit model CI-1 Marine Battery Charge Indicator has been designed especially for the boat owner, although it has found use in service stations, power stations, and radio stations where banks of batteries are kept in reserve for emergency power. It is intended to replace the hydrometer method of checking storage batteries, and to eliminate the necessity for working with acid in small, below-decks enclosures. Now it is possible to check as few as one, or as many as eight storage batteries, merely by turning the switch and watching the meter. A glance at the meter tells you instantly whether your batteries are sufficiently charged for safe cruising. Dimensions are 2-7/8" W x 5-11/16" H x 2" D. Operates on either 6 or 12 volt systems using lead-acid batteries, regardless of size. Simple installation can be accomplished by the boat owner in fifteen minutes. Shpg. Wt. 3 lbs.

MODEL CI-1
$16.95

HEATHKIT ELECTROLYSIS DETECTOR KIT

The Heathkit model ED-1 Electrolysis Detector indicates the extent of electrolysis currents between the boat's common ground and underwater fittings, except on boats having metal hulls. These currents, undetected, could cause gradual corrosion and deterioration of the propeller or other metal fittings below the water line. It is particularly helpful when installing electrical equipment of any kind, or to determine proper polarity when power is obtained from a shore supply. Easy-to-build, the model ED-1 consists of a hermetically-sealed, waterproof meter, special sensing plate, and sufficient wire to install, including the necessary hardware. Mounts on instrument panel where it can be easily seen. Requires no power for operation, and gives instant warning to guard your boat for a lifetime. Shpg. Wt. 2 lbs.

MODEL ED-1
$9.95

HEATHKIT RF POWER METER KIT

The Heathkit RF Power Meter Kit is designed to sample the RF field in the vicinity of your transmitter, whether it be marine, mobile, or fixed. Output meter is merely placed in some location close to the transmitter, to pick up RF radiation from the antenna. Requires no batteries, electricity, nor direct connection to the transmitter. It provides you with a continuing indication of transmitter operation. You can easily detect if power is dropping off by comparing present meter readings with past ones. Operates with any transmitter having output frequencies between 100 kc and 250 mc, regardless of power. Sensitivity is 0.3 volts RMS full scale, and a special control on the panel allows for further adjustment of the sensitivity. Meter is a 200 ua unit, mounted on a chrome-plated brass panel. The entire PM-1 measures only 3¾" W x 6¼" L x 2" D. An easy way to put your mind at ease concerning transmitter operation. Shpg. Wt. 2 lbs.

MODEL PM-1
$14.95

Heathkits...

By DAYSTROM

now offer you completely modern marine equipment with outstanding design features

HEATHKIT TRANSISTOR RADIO DIRECTION FINDER KIT

The Heathkit Transistor Radio Direction Finder model DF-1 is a self-contained, self-powered, 6-transistor super heterodyne broadcast radio receiver incorporating a directional loop antenna, indicating meter, and integral speaker. It is designed to serve primarily as an aid to navigation when out of sight of familiar landmarks. It can be used not only aboard yachts, fishing craft, tugs, and other vessels which navigate either out of sight of land or at night, but also for the hunter, hiker, camper, fisherman, aviator, etc. It is powered by a 9-volt battery. (A spare battery is also included with the kit). The frequency range covers the broadcast band from 540 to 1600 kc and will double as a portable radio. A directional high-Q ferrite antenna is incorporated which is rotated from the front panel to obtain a fix on a station and a 1 ma meter serves as the null and tuning indicator. The controls consist of: tuning, volume and power (on-off), sensitivity, heading indicator (compass rose) and bearing indicator (antenna index). Overall dimensions are 7½" W x 5⅞" H x 5⅜" D. Supplied with slip-in-place mounting brackets, which allow easy removal from ship bulkheads or other similar places. Shpg. Wt. 5 lbs.

MODEL DF-1

$54.95

use it for a radio-compass or as a portable radio

TRANSISTOR
RADIO DIRECTION FINDER

Heathkits...

By DAYSTROM

are sold only by direct mail, passing middleman profits on to you

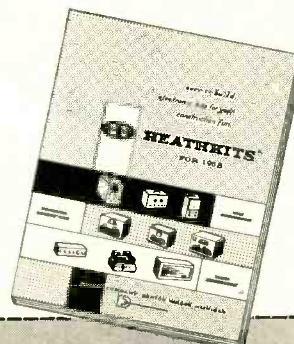
Pioneer in "do-it-yourself" electronics

HOW CAN YOU MISS?

The Heath Company maintains a technical consultation service, should you experience some sort of difficulty in construction or operation. Although only a very small percentage of our customers ever have occasion to use this service (usually only beginners in electronics) it is still reassuring to know that technical help is available when needed. A service department is also available, should you wish a complete factory check of operation and alignment or repair. After you build your first Heathkit you'll realize how easy it is.

Free Catalog

Send for this informative booklet listing more than 100 "do-it-yourself" kits.



HEATH COMPANY A Subsidiary of Daystrom, Inc. **BENTON HARBOR 20, MICH.**

ORDER BLANK

NOTE: All prices subject to change without notice.

Enclosed find ( ) check ( ) money order for________ Please ship C.O.D. ( ) postage enclosed for________ pounds.

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ON PARCEL POST ORDERS include postage for weight shown. ORDERS FROM APO'S must include full remittance. All prices F.O.B. Benton Harbor, Mich.

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SHIP VIA
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- ☐ Best Way

QUANTITY	ITEM	MODEL NO.	PRICE
		POSTAGE	
	☐ SEND FREE Heathkit Catalog	TOTAL	

(*Continued from Page* 65)
junctions by melting a correctly doped semiconductor and allowing it to refreeze.

Meltback transistor Junction transistor made by the meltback process.

Melt-quench transistor Junction transistor made by quickly cooling a melted-back region.

Microalloy transistor Transistor using very thin alloyed collector and emitter, usually made in the same shape as a surface-barrier transistor.

Minority carriers Whichever type is less plentiful, i.e. electrons in p-type and holes in n-type.

Modulator Electrode on a spacistor.

—N—

Noise figure The ratio of actual equivalent noise input to thermal noise input, usually expressed in decibels.

n-p-i-n transistor Intrinsic-region transistor with p-type base and n-type emitter and collector.

n-p-n-p transistor Hook transistor with p-type base, n-type emitter, and hook collector.

n-p-n transistor Junction transistor with p-type base and n-type collector and emitter.

***n*-type** Semiconductor doped with a donor so that electrons are more plentiful than holes.

—P—

Parameters Set of numbers which characterize a device, especially a transistor.

Peak inverse voltage Maximum reverse voltage rating for a diode or a transistor.

Photodiode Semiconductor diode whose reverse current increases upon illumination.

Photoresistor Semiconductor resistor whose resistance drops when illuminated.

Phototransistor Photodiode with a built-in hook amplifier; physical construction is the same as a junction transistor.

Pinch-off In a field-effect transistor, the effect of having reduced source-to-drain current as far as possible.

Pinch-off voltage The voltage at which pinch-off occurs.

p-n-i-p transistor Intrinsic-region transistor with n-type base and p-type emitter and collector.

p-n junction Junction between p-type and n-type areas of a semiconductor.

p-n-p-n transistor Hook transistor with n-type base, p-type emitter, and hook collector.

p-n-p transistor Junction transistor with n-type base, and p-type collector and emitter.

Point contact A sharp point placed on a semiconductor for making point-contact devices.

Point-contact diode A diode which uses a point contact to get a rectifying characteristic.

Point-contact transistor Old-style transistor made by forming junctions by the unpredictable process of electroforming.

Power gain Ratio of output power to signal input power, not to be confused with *collector efficiency*.

Power transistor A transistor, usually an alloy-junction type, made to handle high currents and high power.

***p*-type** Semiconductor doped with an acceptor so holes are more plentiful than electrons.

—R—

Rate-grown transistor Junction transistor with junctions formed by varying the rate of the crystal's growth.

Recombination Simultaneous elimination of both an electron and a hole.

Rectifier Any device which has a nonsymmetrical volt-ampere curve, and which therefore can be used to rectify a.c.; for example, *junction diode*.

Resistivity A property of a semiconductor directly related to the resistance to electricity; the reciprocal of conductivity.

Reverse bias Small-current, high-voltage bias as applied to a diode; opposite to forward bias.

Reverse current The small current that flows in a diode under reverse bias.

—S—

Saturation The low-resistance condition in a transistor when the collector voltage is very small.

Saturation current That portion of cutoff current not due to surface effects; do not confuse with *saturation*.

Saturation resistance The ratio of voltage to current in saturation.

Seed Special single crystal used to start the growth of large single crystals by the Czochralski technique.

Selenium Semiconductor used mainly in rectifiers.

Semiconductor Material which conducts by both electrons and holes.

Silicon Common semiconductor, used in transistors and diodes.

Small-signal analysis Consideration of only small excursions from the no-signal bias, so that the transistor can be represented by a linear equivalent circuit.

Source Electrode on a field-effect transistor.

Space-charge layer See *depletion layer*.

Spacistor Type of transistor relying on modulation of carriers injected into a depletion layer.

Stability Lack of tendency toward thermal runaway.

Stability factor A number which measures the stability of a transistor stage.

Stabilization Process of introducing stability into a circuit.

Surface barrier A barrier formed automatically at a surface due to trapped electrons held at the surface.

Surface-barrier transistor Transistor using surface barriers instead of p-n junctions.

Symmetrical transistor Transistor in which collector and emitter are made identical, so either can be used for either purpose.

—T—

Tandem transistor Two transistors in one package, internally connected together.

Tetrode transistor Any of several types of transistors with four electrodes.

Thermal runaway Condition in which the dissipation in the transistor increases with higher temperature so fast that the temperature keeps rising.

Thermistor Temperature-sensitive resistor, usually made from a semiconductor.

Transistor Semiconductor device with three or more electrodes used for amplification.

Transistor action The physical mechanism of amplification in a junction transistor.

Transition layer, transition region See *depletion layer*.

Transition-layer capacitance See *depletion-layer capacitance*.

Transit time Average time it takes a minority carrier to diffuse from emitter to collector in a junction transistor.

Trapping Holding of electrons or holes by any of several mechanisms in a crystal, preventing the carriers from moving.

Traps Any of several imperfections in a crystal which can trap carriers.

—U—

Unijunction transistor Transistor made for switching circuits, having only one junction.

—V—

Varistor A semiconductor device with a symmetrical but nonlinear volt-ampere characteristic.

Voltage amplification, voltage gain Ratio of output voltage to input voltage.

—W—

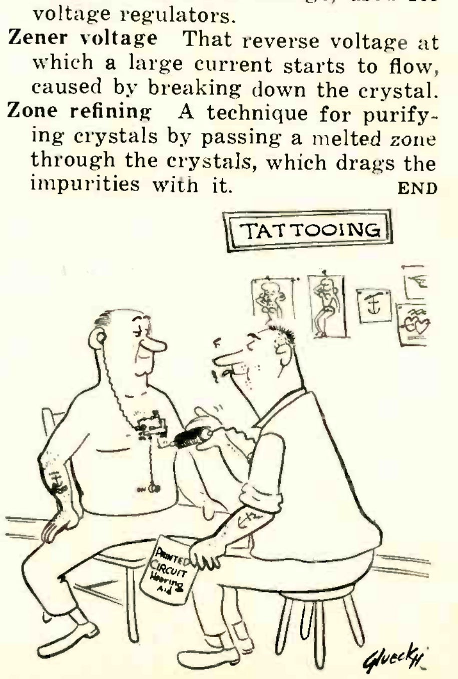
Whisker A point contact.

—Z—

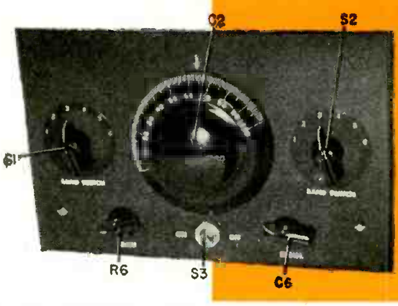
Zener diode A diode which breaks down at the Zener voltage, used for voltage regulators.

Zener voltage That reverse voltage at which a large current starts to flow, caused by breaking down the crystal.

Zone refining A technique for purifying crystals by passing a melted zone through the crystals, which drags the impurities with it. END



6-Band Portable TRANSISTOR



This 4-transistor trf receiver brings you the radio world between 100 kc and 20 mc

By J. E. PUGH, JR.

A TRF amplifier combined with a class-B detector and a bit of controlled regeneration makes possible a wide-range all-transistor portable receiver that is hard to beat in overall performance.

A tuning range of 100 kilocycles to 20 megacycles is broken into six steps. The lower limit of this range is determined by the physical size of the necessary coils and their Q. The upper limit is determined by the alpha-cutoff frequency of the rf transistors.

The long-wave band is a feature not ordinarily found in radios, and it will provide many hours of pleasure for anyone who enjoys getting off the conventional path occasionally.

The trf stage uses an rf transistor connected in a common-base circuit (see diagram) biased for class-A operation. Although the gain of the common base is less than that of the common-emitter circuit, it was selected because of its marked advantages in other respects. One of the most important advantages is its better frequency response compared with the common-emitter circuit—important for more uniform response over a wide range of frequencies. Also this circuit does not need neutralization while the common-emitter amplifier does. This results in a circuit that is stable, very simple and easy to align.

The common-base circuit has an additional advantage in that it has a much higher output impedance. This makes it possible to connect the collector directly to the top of rf transformer T2. In a common-emitter circuit the collector must be tapped down from the top of the coil for best results, complicating the band-switching problem.

A class-B detector is used because it is simple and has a high degree of sensitivity. A 2N112 was used in this circuit and in the photographs, and a 2N114 was in the trf stage. However the recently introduced 2N247 drift transistor was substituted when I found that it gave considerable improvement in performance at a much lower cost.

Regeneration is obtained by feeding some of the rf energy at the base of V2 back to V1's emitter through C6, a variable capacitor. This feedback reduces the rf resistance of the resonant circuits and increases their effective Q, improving the selectivity and sensitivity. Therefore, the actual circuit, so far, consists of an rf amplifier and a class-B detector having variable selectivity and sensitivity. The degree of the detector's selectivity and sensitivity above the normal point is determined by the amount of feedback. When feedback is set at minimum, the receiver can be used as a normal nonregenerative receiver with medium sensitivity and selectivity. When feedback is great enough, V1 oscillates, making CW reception possible.

The emitter voltage for V1 and V2 is set slightly above 3 volts by R13. This improves performance on the low-frequency end of the tuning range but also lowers the highest frequency at which regeneration can be obtained. Regeneration is smooth with *no dead spots up to the upper frequency limits.*

Capacitor C1 is a 9–180-$\mu\mu$f trimmer used to compensate for different antenna lengths. Once set, it need not be touched unless the antenna length is changed.

Band switching

Two two-pole six-position rotary switches handle the band switching. Separate switches are used so transformers T1 and T2 can be separated enough to prevent feedback. Six transformers are used at T1 and six at T2 to cover the tuning range. Each transformer at T1 and T2 has its own trimmer capacitor (C3 and C5, respectively), making a total of 12 trimmers for the two groups of transformers. Separate trimmers are used to permit best alignment for each band.

The circuit diagram shows only one transformer for T1 and one for T2. Trimmer capacitors C3 and C5 are in-

TRANSFORMER WINDING CHART

Transformer	Freq Range	Primary	Secondary*
T1-a	100 to 215 kc	Miller 6322	80 turns No. 32 either direction
T1-b	215 to 550 kc	Miller 6318	27 turns No. 32 either direction
T1-c	530 to 1400 kc	Miller 4513	9 turns No. 32 either direction
T1-d	1.4 to 4.0 mc	Miller 4508	12 turns No. 32 either direction
T1-e	4.0 to 10.0 mc	Miller 4504	5 turns No. 22 either direction
T1-f	10.0 to 20.0 mc	Miller 4501	4 turns No. 22 either direction
T2-a	100 to 215 kc	Miller 6322	145 turns No. 32 opposite T1-a secondary
T2-b	215 to 550 kc	Miller 6318	48 turns No. 32 opposite T1-b secondary
T2-c	530 to 1400 kc	Miller 4513	16 turns No. 32 opposite T1-c secondary
T2-d	1.4 to 4.0 mc	Miller 4508	16 turns No. 32 opposite T1-d secondary
T2-e	4.0 to 10.0 mc	Miller 4504	3 turns No. 22 opposite T1-e secondary
T2-f	10.0 to 20.0 mc	Miller 4501	2 turns No. 22 opposite T1-f secondary

NOTE: All secondaries except T1-d and T2-d are wound on the outer surface of the primary winding. The primaries of these two coils are wound in two sections spaced about 1/16 inch apart. The secondaries are wound in this spacing between the two sections. For further details see text.
*All secondaries enameled wire

dicated in the same manner. This is done to make the schematic easy to follow. The additional units would add no information since they are schematically identical. In the description that follows, the transformers will be called T1-a to T1-f and T2-a to T2-f, and the capacitors C3-a to C3-f and C5-a to C5-f.

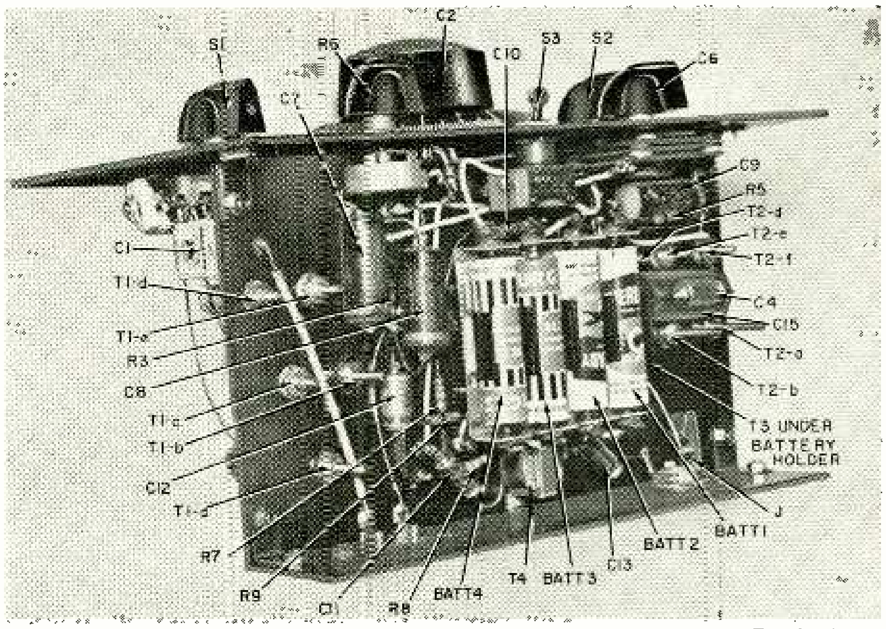
The audio section of the receiver is entirely conventional and needs no explanation.

Bias stabilization is used in all stages to minimize transistor variations due to temperature changes. This is especially important in the rf circuits because a temperature change will cause a shift in the resonant response of the circuits if stabilization is not used. It also makes it possible to substitute transistors of a similar type without changing other component values.

Building the receiver

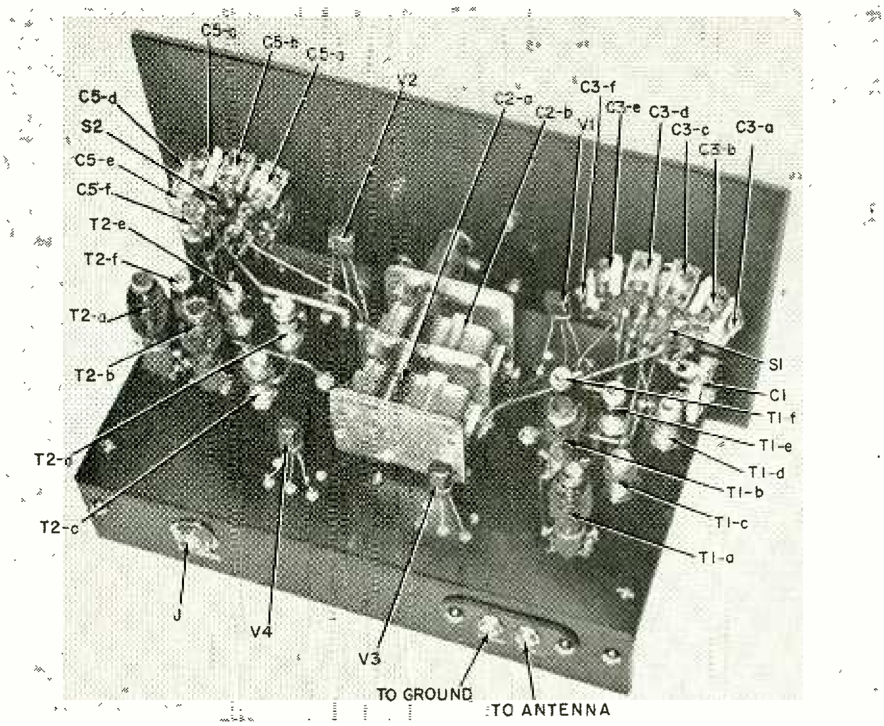
The front and back panels and the chassis are all made of XXP-26—a high-grade paper-base phenolic material—and are fastened together with ⅝-inch angle brackets. Large plastic supply houses carry this material. If you wish,

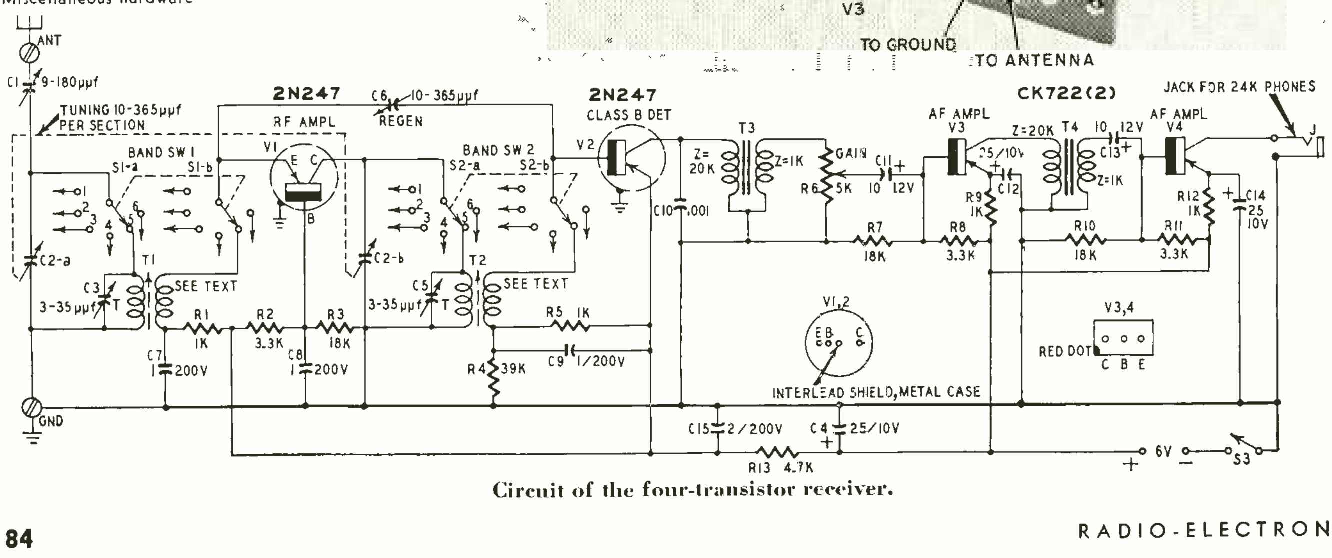
R1, 5, 9, 12—1,000 ohms
R2, 8, 11—3,300 ohms
R3, 7, 10—18,000 ohms
R4—39,000 ohms
R6—pot, 5,000 ohms, audio taper
R13—4,700 ohms
All resistors ½-watt 10%
BATT 1, 2, 3, 4—1.5-volt cells, penlight, flashlight D cell, or mercury cell (see text)
C1—9-180 μμf, trimmer
C2—10-365 μμf, 2-gang tuning capacitor
C3-a–C3-f, C5-a–C5-f—3-35 μμf, trimmer (El Menco type 403 or equivalent) (12 needed)
C4, 12, 14—25 μf, 10 volts, miniature electrolytics
C6—10-365-μμf tuning capacitor (Lafayette MS-215 or equivalent)
C7, 8, 9—1 μf, 200 volts, metallized paper, miniature
C10—.001 μf, tubular ceramic
C11, 13—10 μf, 12 volts, miniature electrolytics
C15—2 μf, 200 volts, metallized paper, miniature
J—phone jack
S1, 2—2-pole 6-position rotary, shorting type (Mallory 3126J)
S3—spst toggle
T1-a–T1-f, T2-a–T2-f—see transformer winding chart
T3, 4—audio driver transformers: primary, 20,000 ohms; secondary, 1,000 ohms (Argonne AR-104 or equivalent)
V1, 2—2N247 (RCA)
V3, 4—CK722 (Raytheon)
Dial, 5:1 ratio, 3-inch diameter (National Velvet Vernier or equivalent)
Chassis—see text
Bar knobs (2)
Dial plates, 1-6 (2) (Mallory 376 or equivalent)
Terminal strip, 2 screw lugs
Battery holder
Miscellaneous hardware



(Above) The underchassis may look crowded, but it really isn't. Don't forget, transformer T3 is mounted under the battery holder.

(Below) Careful layout makes the set easy to wire. Headphone jack and antenna and ground connections are on the receiver's back panel.





Circuit of the four-transistor receiver.

the front and back panels can be metal, such as aluminum, and the chassis can be made of Bakelite. The front panel is about 1 inch wider than the chassis and back panel so the entire receiver can be housed in a wooden case. The front panel is 8¾ x 5½, the chassis 7¾ x 4½, and the back panel is 4½ x 1⅝ inches. However, you can follow your own ideas on these dimensions and on the exact layout of parts.

Turret type terminal lugs are used for all connections on the chassis. All of these are USECO type 1290 except the two large ones used for ground terminals. These large lugs are USECO type 1320 and are located on both sides of the tuning capacitor between it and the coils (see photos). Swaging tools are needed to fasten both types of lugs and, if you want to avoid this investment, the USECO type 1300T lug, which is fastened with 4-40 nuts, can be used. These lugs and the swaging tools are available at Newark Electric Co., Chicago; Burstein-Applebee Co., Kansas City, Mo., and the Radio Shack, Boston, and others. A cheaper but not-as-neat terminal can be made from 4-40 x ¼-inch screws, nuts and solder lugs.

A tuning dial with a drive ratio of about 5 to 1 should be used to aid in separating signals in the higher frequency range. I used a 3-inch diameter National *Velvet Vernier*. When buying the tuning capacitor, note the direction of rotation so that dial calibration (clockwise or counterclockwise) will be correct. Also note the shaft diameter as some capacitors have a ⅜-inch diameter while most dials take a ¼-inch shaft. This problem can be solved by using a ⅜- to ¼-inch shaft extender.

Trimmer capacitors C3-a to C3-f have their lower end (the end connected to the adjustment screw) soldered to a short length of No. 16 bus wire that circles about halfway around the bandswitch housing and connects to a shaft grounding lug. This lug is one of the type supplied with volume controls. Another length of No. 16 bus wire connects from this lug to the type 1320 ground lug next to the tuning capacitor. The other group of trimmers, C5-a to C5-f, is mounted in a similar manner on the other bandswitch. Both assemblies can be seen in the photos. These groups of trimmers replace the trimmers usually mounted on the tuning capacitor, and if the tuning capacitor is equipped with them they should be removed.

Winding the secondaries

Transformer winding data is given in the chart. As noted the secondaries can be in either direction but the T2 group must be opposite the T1 group to obtain regeneration. For example, the T1 group can spiral upward in a clockwise direction and this would make it necessary for the T2 group to spiral upward in a counterclockwise direction.

The Miller 6300 series of coils (used for T1-a, T1-b, T2-a, T2-b) have both ends of the existing winding connected to lugs on a fiber sleeve close to the base of the winding. Carefully unsolder the outer end from its lug and remove a few turns to provide enough lead to reach the bandswitch. The unused lug is now used as a tie point for the hot end of the secondary. The lower ends of the secondaries of the T1 group all connect to a single lug located between V1 and the front panel, and the lower ends of the T2 group connect to a lug between V2 and the front panel.

When fastening the Miller 4500 series coils to the chassis, use a wrench to hold the hex nut on the top side of the coil form as the coil will not take any rough handling. After the coil is fastened to the chassis a very small triangular spring, found among the hardware supplied with each coil, is put into position to put tension on the core-adjusting screw.

An easy way to do this is first to turn the adjustment screw up until it is flush with the threaded housing. Then lay the wide side of the spring in the slot in the side of this housing and push the other sides of the spring over the end of the housing. After this, the adjustment screw can be backed out of the housing and oiled with a light oil.

Shaft grounding lugs can be used on the regeneration and gain controls where a nonmetallic front panel is used. Otherwise they will not be needed.

A convenient method for mounting the battery box is to fasten four ⅝-inch threaded posts to it, using existing holes near the corners of the box. These posts are mounted on the receiver chassis with 6-32 flat-head screws in countersunk holes so that the heads of the screws clear the underside of the tuning capacitor's frame.

Before soldering any parts into place, mark the terminal lug to which each transistor collector will be connected with a small dab of paint on both sides of the chassis. This makes wiring easier and helps prevent mistakes.

Before soldering the transistors in place check carefully to see that no mistakes have been made because the rf transistors can easily be ruined.

Alignment procedure

Connect a short antenna, about 10 feet long, and a ground to the set. Now back off capacitor Cl about 1½ turns from full capacitance. The signal generator should be the modulated type with a frequency range covering 100 kc to 20 mc but, if one is not available, the harmonics of a low-frequency generator can be used to cover the higher frequencies.

Loosely couple the generator to the antenna by attaching a short length of wire to its hot terminal.

The output meter can be any ac voltmeter with an impedance of 1,000 ohms per volt or more and a 0-to-5- or 10-volt scale. This meter can be connected across the headphone terminals.

Now adjust the signal generator to 100 kc, set the bandswitches to position 1, set the tuning capacitor for maximum capacitance, and adjust T1-a and T2-a cores for maximum output. Next set the signal generator to the upper frequency for band 1, set the tuning capacitor for minimum capacitance and adjust the C3-a and C5-a for maximum output. Repeat these adjustments until maximum output is obtained at each end of band 1.

Switch to band 2 and adjust transformers T1-b and T2-b and trimmers C3-b and C5-b in the same manner, allowing a small frequency overlap for the two bands. In a similar manner adjust the corresponding coils and trimmer capacitors for the remaining bands.

It is not necessary to switch the battery off when changing bands. The switches are the shorting (make-before-break) type and do not open any circuits, therefore there is no chance of damaging the transistors when switching.

When aligning the receiver keep the signal generator adjusted for minimum usable signal to prevent overloading. Also keep the REGENERATION control set close to the oscillation point to obtain best alignment. This is done because this control has a slight detuning effect on the resonant circuits as it is varied.

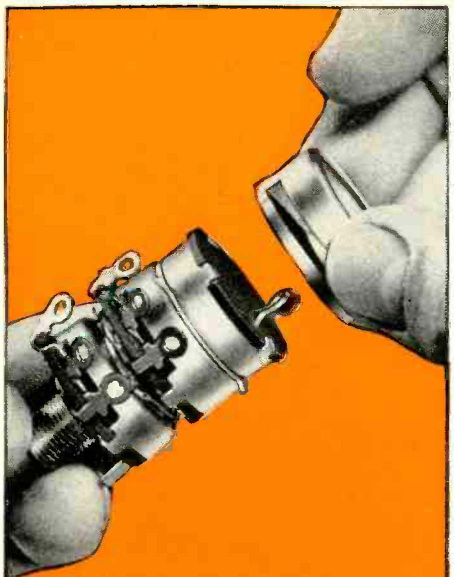
After alignment is completed obtain the dial reading for some known station, such as one of the WWV frequencies or a broadcast station, on the high end of one of the bands. Now, if the antenna length is ever changed, simply set the dial to this predetermined reading and adjust antenna trimmer C1 until the station falls at the correct dial reading. All bands will be corrected automatically without further adjustment.

This receiver is suitable for use during a Conelrad alert. Mark the dial at 640 and 1240 kc for easy adjustment during such an alert. END

AES LECTURE NOTES

A volume containing detailed notes on the first half of the Audio Engineering Society's (AES) 1957–58 lecture series on "Principles and Practices of Tape and Disc Recordings" is now available.

The book covers the 15 autumn and winter lectures by authorities in the audio field and can be ordered from Sumner Hall, Lecture Series Chairman, Amityville, N. Y. The price of $5 for members and applicants of AES and $7.50 for nonmembers also includes a second volume of notes, on the present series of lectures, which will be published in June. Subscribers to the lecture series receive these notes at no charge.



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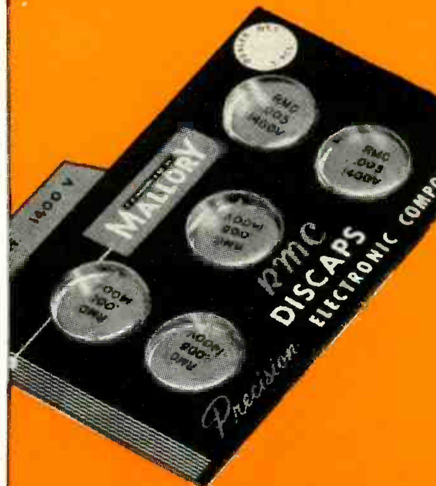

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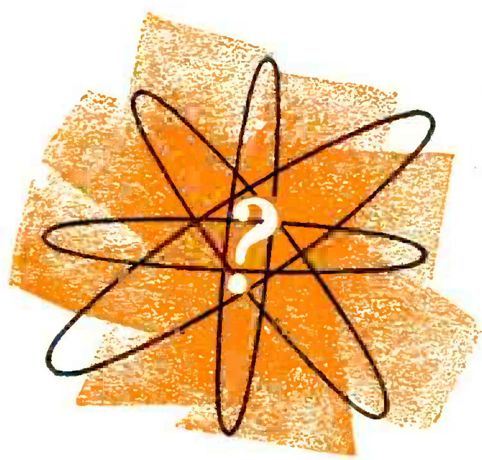

And in your future . . . who knows what electronic marvels will become reality, and thus become new service business for you. Mallory will continue to develop components for new circuits, and replacement parts to service these new needs. You can continue to depend on Mallory leadership, ingenuity, and your Mallory Distributor.

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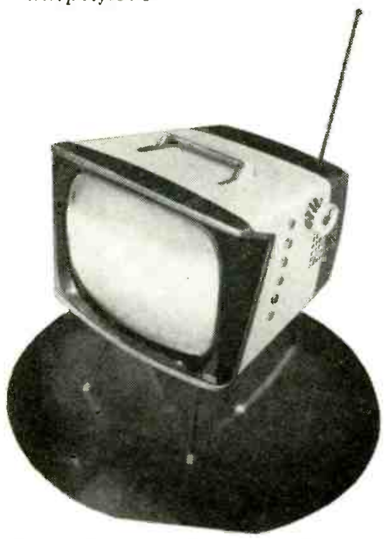
Transistors in the TV set

Part I:—Been wondering what transistor TV circuitry looks like? Here are the first sections of such a receiver—the front end, video if strip, video detector and video amplifiers



By LOUIS E. GARNER, JR.

SEVERAL years ago one of our leading electronic manufacturers, RCA, designed, assembled and demonstrated an all-transistor (except for the CRT) television receiver. This early set used a comparatively small picture tube and was put in a clear plastic case for demonstration and display purposes. It employed a number of specially selected types of the now nearly obsolete point-contact transistor.

RCA was (and is) not the only firm interested in transistor TV receivers. Nearly every major television receiver manufacturer, as well as most semiconductor manufacturers, has investigated transistor TV circuits, and a number of firms have assembled their own sets. A few months ago, for example, Motorola placed on display two prototypes of a fully transistorized portable TV receiver (see What's New, RADIO-ELECTRONICS, March, 1958). The Motorola receiver uses a 14-inch picture tube and is powered by a set of self-contained rechargeable nickel-cadmium batteries. Its performance equals that of conventional (vacuum-tube) line-operated portables.

While no major television receiver manufacturer is producing an all-transistor set today, such receivers will be manufactured in the future and transistor designs will, one day, become standard for all portable receivers. In fact, due to their low power consumption and long life, there is the real possibility that they will eventually replace vacuum-tube sets in home as well as portable applications. The 31-transistor Motorola prototype, for example, requires only 12 watts for operation, compared to a minimum of 105 watts for a conventional portable.

In addition to their low power requirements, transistors offer many advantages over vacuum tubes in TV receiver design. They are smaller, lighter, more rugged and more efficient than tubes, and they operate at much lower temperatures. Thus, the interior of a transistor TV receiver will run *much cooler* than a comparable vacuum-tube set. This is extremely important in determining the service life of electronic components. As every service technician knows, one of the major factors contributing to component breakdown is the high temperatures developed within a set. Excessive heat causes electrolytic capacitors to dry out, certain types of insulation to melt or deteriorate, and other components to operate above their normal ratings.

Three barriers have limited the use of transistors in TV circuits in the past: the lack of suitable types for vhf and high-power applications, lack of circuit design knowledge and the high cost of transistors compared to vacuum tubes. The first two have been overcome for practical purposes. Vhf and power transistors are, today, readily available from major manufacturers in production quantities, and the design experience obtained in transistorizing military electronic equipment where cost is not a factor (such as airborne radar equipment) can be applied directly to the design of transistor TV sets.

The remaining barrier, cost, is being whittled down rapidly. With improved production techniques, the transistor yield rate has been going up and production figures have soared. As a result, transistor prices have dropped continuously—almost on a month-to-month basis. There is good reason to believe that ultimately they will drop *below* those of vacuum tubes with corresponding characteristics. After all, as far as internal construction is concerned, a transistor is simpler than a vacuum tube.

The home experimenter and electronics hobbyist interested in new circuits, the service technician who may be called on to repair transistor TV receivers, and the technically minded consumer who may one day buy such a set, all have an interest in the circuitry and performance of transistor TV receivers.

As far as general circuitry is con-

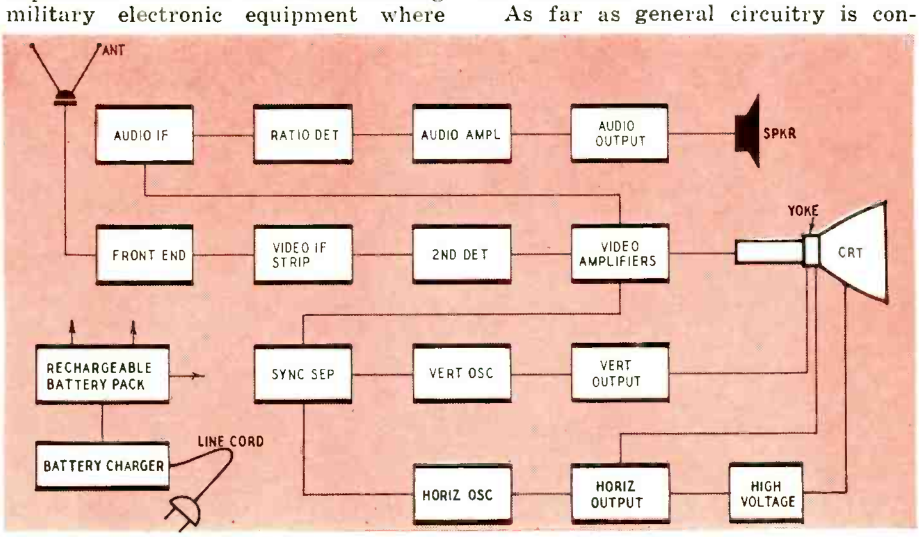


Fig. 1—Block diagram of an all-transistor TV receiver.

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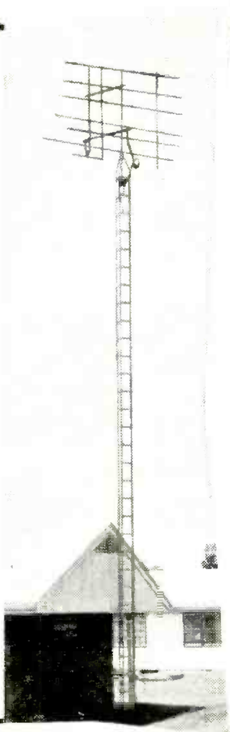

2 COMMUNICATIONS

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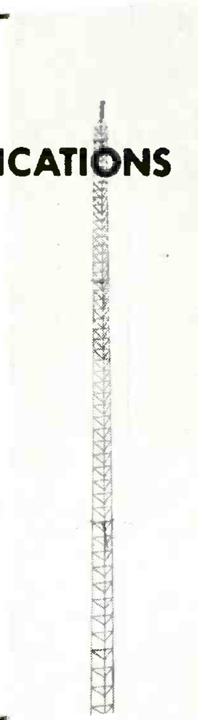

3 AMATEUR USE

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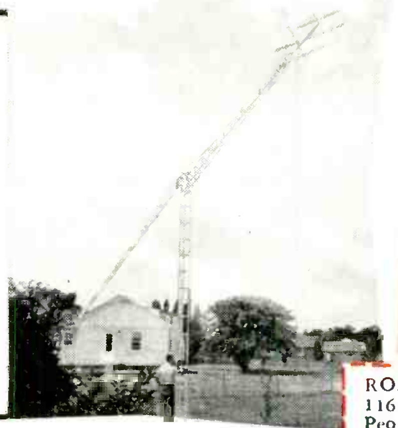

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cerned, the block diagram of a typical transistor TV receiver (Fig. 1) is not much different from that of a tube set. Nor should there be much difference in overall performance. A commercially manufactured transistor TV receiver, to compete with vacuum-tube sets, must perform as well as (if not better than) they do. Price-wise, the first transistor TV receivers will be more expensive than vacuum-tube sets but, eventually, should be competitive.

With similar block diagrams and comparable performance, the real differences between tube and transistor-operated TV receivers will be found in the actual circuitry used in each section of the sets. Let us examine some of the circuits that well may be used in future TV receivers.

The front end

The receiver's rf section (front end) receives, selects and converts the incoming TV sound and picture carriers into if signals carrying the full audio and video modulation of the original rf carriers. In addition, it *may* amplify the original signals prior to conversion to if signals.

If the receiver is designed to operate only in the vhf band (through channel 13), we know that the transistors will have to handle signals up to about 216 mc. This means that the front end will have to use vhf units. Currently, the only vhf transistors in full production are the MADT's produced by Lansdale Tube Co. (Philco), the junction tetrode transistors made by G-E and Texas Instruments and the drift transistors introduced by RCA. Any of these types might be used in the front end.

A Philco 2N502, an MADT type, can supply a power gain of about 10 db as an rf amplifier at 200 mc. Similar gain should be possible if it were used as a converter.

At present, vhf transistors are harder to manufacture and hence are much more expensive than lower-frequency units. Therefore, in an economy TV receiver, there might be a certain amount of skimping in front-end design to compensate for the comparatively higher prices of such transistors. Thus, the front end in such a set may consist of little more than a vhf local oscillator, a diode mixer and appropriate tuned circuits to select the incoming signal and to set oscillator frequency. In a more expensive receiver, and in later models, the front end might include one or more stages of rf amplification and a converter, or a mixer with a separate local oscillator. The schematic diagram for such a front end is shown in Fig. 2.

Vhf p-n-p transistors V1 and V2 are, respectively, the rf amplifier and converter. The common-emitter configuration is used for both stages. To simplify the circuit, I have assumed that the unit uses a continuous-tuning arrangement on each band. The high–low bandswitch has been omitted. In many commercial receivers, however, separate

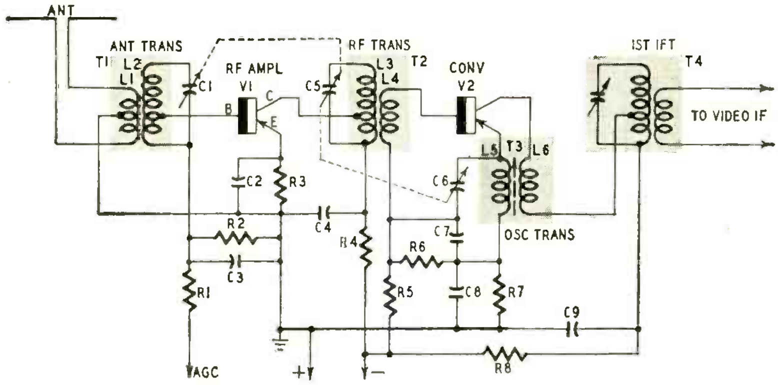

Fig. 2—A transistor front end. In some receivers, rf stage may be omitted and front end may consist of only a local oscillator and diode mixer.

coils (or separate tuning capacitors) may be switched into the circuit for each channel.

In operation, rf signals picked up by the antenna are fed over a conventional transmission line to the center-tapped primary winding (L1) of the antenna transformer. Secondary winding L2 is tuned to the desired channel by variable capacitor C1. A tap on L2 provides an impedance match to V1's input circuit. Base bias current is obtained from the agc system and is supplied to the stage through voltage divider R1–R2, bypassed by C3. The dc voltage developed across emitter resistor R3 (bypassed by C2) helps stabilize stage operation. Collector current is supplied through R4, bypassed by C4—these two components form a stage isolation filter.

The amplified rf signal in the primary winding (L3) of transformer T2 is coupled to secondary winding L4. The turns ratio between L3 and L4 is chosen to provide a good impedance match to V2's input circuit. Tuned to channel frequency by variable capacitor C5, L3 is tapped to provide the best compromise between circuit Q and circuit loading to insure adequate stage bandwidth as well as to provide a good impedance match to V1's collector circuit. L3's tap also minimizes the effect of V1's interelectrode capacitances on circuit tuning. These capacitances may vary with changes in V1's base bias current, due to agc action.

Transistor V2 serves as a converter—that is, as a combination local oscillator and mixer. Base bias current is supplied by voltage divider R5–R6, with the stage stabilized by emitter resistor R7, bypassed by C8. Oscillator transformer T3, connected between V2's collector and emitter circuits, provides the feedback necessary to start and maintain oscillation. The transformer's secondary winding, L5, is tuned by variable capacitor C6. C7 serves both as a padder capacitor for the tuned circuit and as a bypass for R6. Resistor R8 and bypass capacitor C9 form an isolating network for the stage.

Rf tuning capacitors C1 and C5 and oscillator tuning capacity C6 normally would be ganged in a receiver using continuous tuning. In a set with a channel switching system, these capacitors, with their corresponding coils, would be switched.

The video and audio if carrier signals resulting from the mixing of the local oscillator's signal with the amplified rf carrier signals in V2 are selected by the broad-band if transformer (T4) serving as V2's collector load, and fed to the video if strip. A tap on T4's primary provides a match to V2's collector circuit.

Video if strip

Probably designed to operate at the now standard intermediate frequency of about 40 mc, the video if strip supplies most of the set's high-frequency gain. Considering the relative gain of tube and transistor circuits, chances are the if strip will have not less than four and possibly as many as five or six cascaded stages. The transistors will be high-frequency units but need not be vhf types. Suitable types would include surface-barrier transistors, medium-frequency tetrodes and drift units. The if strip's overall bandwidth will be comparable to—perhaps slightly better than—that of a corresponding vacuum-tube strip. In many cases, the gain of a transistor if strip will be *greater* than that of a similar vacuum-tube if section to compensate for the somewhat lower gain obtained from a transistor front end.

A typical four-stage transistor if amplifier is shown in Fig. 3. Stagger-tuning is used to obtain the necessary bandwidth and overall gain, with interstage if transformers T4, T5, T6, T7, T8 tuned to different frequencies. All four stages use p-n-p tetrode transistors in the common-emitter configuration.

The if carrier signals obtained from the front end are delivered through T4 to V3, the first stage in the strip. This stage differs from the succeeding stages in several respects. First, its base bias current is obtained from the agc system and is supplied through voltage divider R9–R10, bypassed by C10. Second, its collector load, if transformer T5, is shunted by capacitor C11. This capacitor swamps V3's interelectrode capacitances and thus minimizes their effect on stage tuning. V3's collector-to-ground capacitance may change with changes in base bias cur-

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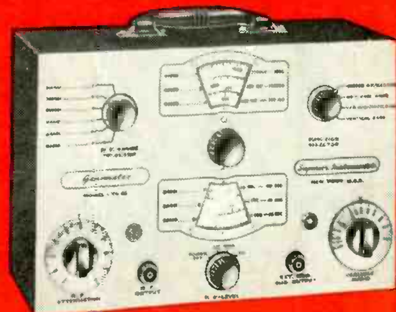

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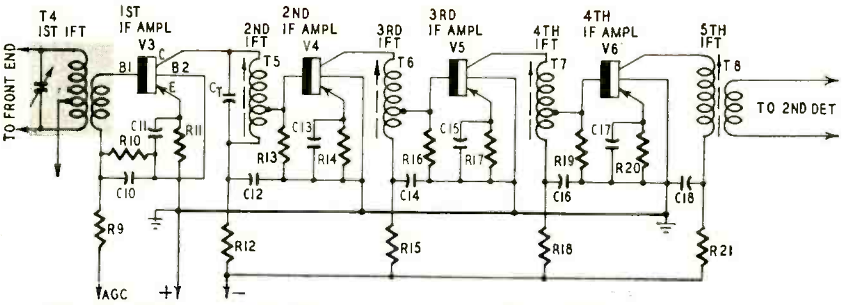

Fig. 3—Video if strip. Four stagger-tuned if amplifier stages are used.

rent due to agc action and, if C_T were not included in the circuit, this could result in circuit detuning.

Interstage if transformers T5, T6 and T7 are stepdown autotransformers. They are tapped down to provide an impedance match between the high-impedance collector circuit of one stage and the low-impedance base circuit of the succeeding one. Thus, T5 provides a match between V3's output and V4's input circuit, T6 provides an impedance match between V4 and V5, while T7 is tapped to provide a match between V5's collector and V6's base circuits.

Capacitors C12, C14, C16 and C18 operate with resistors R12, R15, R18 and R21, respectively, to form decoupling networks for their corresponding stages. Three of these decoupling resistors also have a secondary function. V4's base bias is supplied through a voltage divider made up of V3's collector decoupling resistor (R12) and V4's base resistor R1. In the same way, V4's decoupling resistor (R15) and V5's base resistor R16 supply base bias current for V5. And, finally, V6's base bias is supplied by a voltage divider made up of V5's decoupling resistor R18 and V6's base resistor R19.

In each stage, the emitter resistor and its appropriate bypass capacitor serve the dual function of stabilizing stage operation and of supplying the reverse bias for each transistor's second base connection (B2) necessary for true tetrode operation. R11 and C11 do this job for V3, R14 and C13 for V4, R17 and C15 for V5, and R20 and C17 for V6.

Individual stage gain could be controlled by varying the amount of reverse bias applied to the second base electrode in each stage. Thus, an effective overall gain control could be achieved by applying a separate controllable bias to the transistors' second base connections (B2). In some receivers, a similar arrangement also could be used for agc action. The agc control voltage could be fed to the second base connections.

The amplified if carrier signals appearing across the last if transformer (T8) are coupled to the second detector.

Video detector and amplifier

The video second detector strips the video modulation from the video if carrier and, at the same time, mixes the audio and video if carriers to provide a new audio if carrier at 4.5 mc. Both vacuum-tube and semiconductor diodes are used as second detectors in present-day (vacuum-tube) TV receivers. A semiconductor diode could be used in a similar application in an all-transistor set. However, second-detector action also can be obtained from a transistor amplifier stage biased almost to cutoff—that is, biased for class-B operation. Such a detector might be preferred because it supplies higher gain than a simple diode detector.

The video amplifier must be reasonably flat to better than 4 mc and should provide good gain with minimum phase shift. A two-stage transistor amplifier could be expected to yield a gain comparable to (or slightly better than) that obtained from a single pentode vacuum-tube stage. Therefore, we can expect the video amplifier to be a two- or three-stage circuit.

If present-day cathode-ray tubes are used in a transistor receiver, chances are that the video amplifier output stage would have to use a high-voltage transistor—one that can safely withstand a collector–emitter voltage of 80 to 100—to supply a big enough video signal to drive the C-R tube and produce a picture of normal contrast. However, some work has been done toward developing a special picture tube for transistor TV applications. This tube requires relatively little signal drive and can be used with low-voltage transistors. There is a good chance that such tubes will be available by the time full-scale receiver production has started. Still later, we may expect to see flat semiconductor picture "tubes."

Since the video second detector and video amplifiers must handle a fairly broad band of frequencies, good-quality rf transistors will be used in them. High-frequency junction transistors, tetrodes, surface-barrier units or drift types may be used.

The circuit of a video detector and two-stage video amplifier is given in Fig. 4. An n-p-n transistor is used as the detector (V7), while the video amplifier consists of p-n-p junction triode (V8) and tetrode (V9) transistors. The common-emitter configuration is used in all three stages.

In the detector stage, the small base bias current necessary for detector action is supplied by voltage divider R23–R24, bypassed by C20. Emitter resistor R25, bypassed by C21, insures stable operation. V7's collector load consists of peaking coil L7 and resistor R26. C22 serves as an rf bypass capacitor.

In operation, V7 is biased almost to cutoff, and only the positive half-cycles of the applied signal are effective in controlling collector current. As the amplitudes of the if carrier signals applied to V7 by T8 increase, V7's collector current increases. The pulsating dc voltage appearing on V7's collector electrode is a composite signal which includes: rf components of the amplified if carrier signals, the modulation of the video if carrier, and a new signal at 4.5 mc representing the beat between the audio and video if carriers. (This 4.5-mc signal becomes the new audio if carrier and contains both the amplitude modulation of the original video if carrier and the frequency modulation of the audio if signal.) The rf components of the detected signal are bypassed by C22. The dc component of this composite signal is fed back to the agc-controlled rf and if stages through filter R22–C19.

The bias applied to the agc-controlled stages depends on the current fed through R27 and on V7's dc collector voltage. As stronger rf signals are picked up, the amplitudes of the if

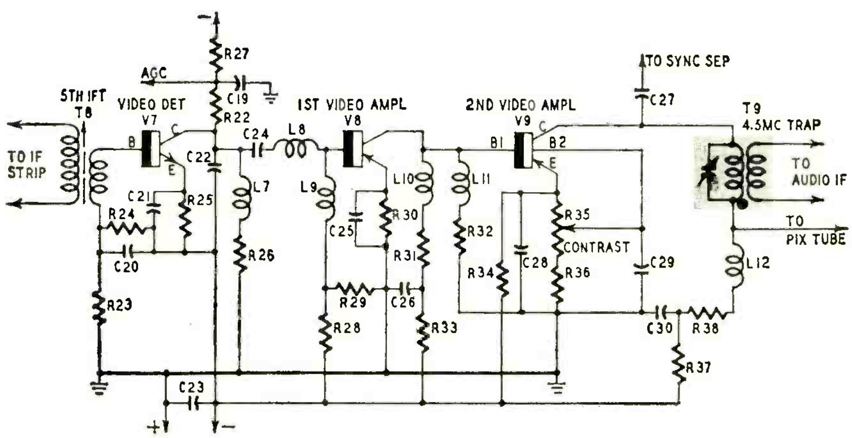

Fig. 4—Video detector and amplifier stages. In some sets a conventional diode detector might be used. Agc voltage is taken from detector, sync output from first video stage, and 4.5-mc audio if signal from trap in output stage.

carriers increase and V7's collector current increases. This results in a greater dc voltage drop across collector load resistor R26, reducing V7's collector voltage and allowing the bias applied through R27 to increase. This, in turn, reduces the gain of the agc-controlled stages.

Both the 4.5-mc audio if carrier and the detected video signal are fed through dc blocking capacitor C24 to V8, the first video amplifier stage. L8 and L9 are peaking coils in V8's base circuit and serve to improve this stage's high-frequency response. V8's base bias current is supplied through voltage divider R28–R29, while stage stabilization is insured by emitter resistor R30, bypassed by C25. V8's collector load consists of peaking coil L10 and resistor R31. R33 and C26 form a decoupling filter for the stage.

The first and second video amplifier stages (V8 and V9) are direct-coupled to minimize low-frequency phase shift. Thus, V8's collector connects directly to V9's control base (B1). V9's base bias current is determined by a voltage divider made up of R33, R31 and R32. L11 serves as a peaking coil in the base circuit. V9's collector load consists of a 4.5-mc trap (T), peaking coil L12 and resistor R38. R33 and C30 form a decoupling filter.

Emitter resistor R36 and potentiometer R35, bypassed by C28 and C29, have a dual job. First, the dc voltage developed across these resistors helps stabilize the stage. Second, the reverse bias voltage between R35's arm and ground is fed to V9's second base connection (B2) to insure tetrode operation. B2's bias can be varied by adjusting R35 and this, in turn, varies V9's stage gain. Thus, R35 serves as a CONTRAST CONTROL. Adequate bias for gain control is assured by bleeder resistor R34, connected to the junction of resistor R35 and V9's collector electrode.

The amplified audio if and video signals appearing in V9's collector circuit are fed to different sections of the TV receiver. The 4.5-mc audio if signal is trapped by a tuned resonant circuit in T9, and coupled by the transformer's secondary to the audio if amplifier. A portion of the amplified video signal is fed through blocking capacitor C27 to the sync separator section, while the video signal itself is applied to the picture tube.

There is one remaining component in this circuit—C23. This capacitor is used as a bypass across the section's power supply connections and thus serves as a decoupling filter for these three stages.

So far we have taken a detailed look at a transistor TV receiver's front end, video if strip, and video detector and amplifier. Next month we will continue our tour of the all-transistor TV receiver and travel through the audio if strip, audio amplifier, ratio detector, sync separator and sweep and high-voltage circuits. TO BE CONTINUED

TV Service CLINIC

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By ROBERT G. MIDDLETON
TELEVISION CONSULTANT

We pick up again with receiver quick checks in this issue. These are of primary importance in preliminary work, both on the bench and in the set-owner's home.

When the complaint is *weak picture* and new tubes do not cure the trouble, we must find out where the circuit trouble is. We have either of two situations:

1. Weak (or no) picture, *with* snow.
2. Weak (or no) picture *without* snow. (This is generally agc trouble.)

Consider No. 1: *Snow* and *audio noise* come from the receiver's front end. For example, there is no snow or noise when the second if stage is dead and there is only a little snow when the first if stage is dead.

Here are the points to keep in mind:

1. The mixer–oscillator stage generates the most snow in normal operation.
2. The antenna contributes the next largest amount of snow.
3. The rf amplifier contributes the next largest amount of snow.
4. The first if stage contributes just a little snow, in normal operation.

Now let us see how this helps us in quick checks. Let's tackle a receiver with snow in the picture. Where is the trouble? Maybe it's in the antenna—could be the lead-in is broken off. So we remove the lead-in from the receiver, meanwhile watching the snow in the picture and listening to the noise in the sound.

If there is practically no change in the snow level, don't waste time with the *receiver*. The trouble is in the *antenna*. To confirm this connect a pair of rabbit ears to the receiver. (Hold the ears out of the window if in a steel building.)

But, on the other hand, if there is a marked reduction of snow when the lead-in is disconnected, the trouble is in the receiver. Leave the lead-in disconnected and pull the rf amplifier tube. No change in snow level means that the trouble is in this or a nearby succeeding stage. (NOTE: In a series-string set, we have to use a dummy tube, with all but heater pins cut off.)

Trouble in the rf stage is often caused by a short in the tube, which overheats the plate resistor and changes its value. However, make another check to see if the trouble could be in the mixer. With any kind of a picture on the screen, we know that the oscillator is working.

Unplug the oscillator–mixer tube. There must be a great reduction in snow if this stage and the first if stage are OK. This tells us whether the trouble is in the rf stage.

If the chassis is on the bench, there is a valuable quick test that you can make with a voltmeter. Connect the meter at the output of the picture detector. Then lift the shield over the mixer tube, but keep your fingers in contact. This couples stray fields to the mixer's plate. A reading on the meter shows that the mixer and all if stages are in working order. No picture in this case generally points to a dead oscillator.

The oscillator can also be quickly checked from the same floating tube shield. Use a good detector probe with your meter. Apply the probe between shield and chassis. A reading of 0.5 to 2 volts means the oscillator is running. Zero reading means a dead oscillator.

Raster blooming

I am having trouble with raster blooming in a Philco 51-T1634. Numerous checks have been made, with little success.—P. V., S. Peabody, Mass.

The trouble can be localized by dc voltage measurements. First see if the high voltage is up to par. This is very likely low. Then check the other picture-tube voltages. Normal voltages are: pins 1 and 2, 0 volt; 10, 300 volts; 11, 120 volts; 12, 6.3 volts ac. The trouble will be found in the circuit with incorrect voltage.

Circuit ghost

We have trouble with what looks like a ghost here. In a test pattern, there is a white circle showing next to the black circle. It is about the same in all locations and with various receivers. Could the trouble be in the sets?—G. McP., Renfrew, Ont.

This is not a multipath ghost which you describe, but a circuit ghost. Sometimes high video peaking is used at the TV camera, especially when old films are televised. This gives greater snap

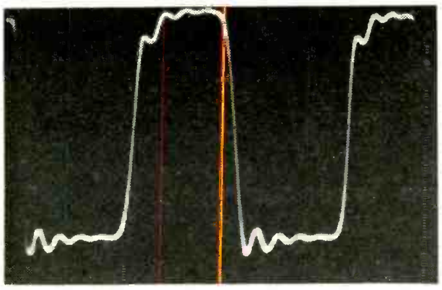

Fig. 1—High video peaking (high-frequency peaking) causes rapid signal changes to overshoot and ring. This gives rise to circuit ghosts.

to the picture, but also causes a spurious transient response (see Fig. 1), which gives the effect of close-in negative ghosts in the picture. Of course, if video peaking in the receiver is also high, the negative ghost will be intensified.

Larger screen?

I have a Wilcox-Gay chassis 439 and would like to change from the 19- to a 21-inch picture tube. What would you suggest?—M. H. W., Brooklyn, N. Y.

The most practical conversion is to a 21EP4. This tube can be swept almost as easily as the 19AP4, and will require no change in output transformers. The difficulties will all be mechanical.

21-inch conversion

I would like to use the all-glass 21CPY22 in place of a 19VP22 picture tube. Is this conversion feasible?—R. F. P., Toledo, Ohio

It is definitely easier to convert from the 19VP22 to the 21CPY22 than to a 21AXP22, for example. The lower anode voltage for the 21CPY22 is an advantage. The dynamic convergence voltages used by the 19VP22 should serve satisfactorily, also. The mechanical details will not be simple but, if you have the time available, the conversion is practical.

Horiz sync on the blink

I am having trouble with a 21-inch Philco model 22B4002, chassis R-191, code 140. It has good picture and sound but loses horizontal sync intermittently and folds over. This can be corrected with a slight touch of the hold control. The horizontal output transformer tests 69 ohms low between terminals 2 and 4. Could this cause the intermittent loss of sync?—E. H. B., West Palm Beach, Fla.

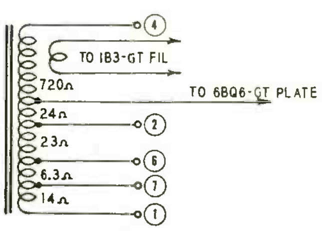

Fig. 2—The windings of a flyback transformer have a manufacturing tolerance. An error of less than 10% indicated on an ohmmeter is not evidence of trouble.

As shown in Fig. 2, the rated resistance between the flyback terminals noted is 744 ohms. An error of 69 ohms is small (less than 10%) and within the manufacturing tolerance, plus the tolerance of a service ohmmeter. You are more likely to find this trouble in a defective ringing coil (L800), or in the time-constant circuits of the horizontal multivibrator. Check R809, R810, R811 and possibly R806, R807. If stable, then check C815-a for leakage.

Rf radiation

A Sylvania color TV receiver has been causing interference on black-and-white receivers in the same building. A bar floats back and forth on one channel only. It appeared first on channel 7 but when the 6BQ6's were changed, it moved to channel 9. I am also having difficulty converging the color dots.—W. E., Chicago, Ill.

The interference is due to rf radiation. It can come from the antenna and lead-in of the color receiver, or is sometimes conducted by the power line. If the latter, installing rf filters in the line will help. If the antenna and lead-in are radiating strongly, try to reroute the lead-in away from others. Also install the antenna as far from the other antennas as possible.

Lack of convergence is caused by misadjustment of the static and dynamic convergence controls. One or more of the beam magnets may be reversed. A complete step-by-step convergence will be required.

Weak blues

An RCA 21-CT-660U color receiver has weak blue hues, and snow appears in the blue parts of the picture. I have changed the (B — Y) amplifier plate-peaking coil, which reduced the snow to a certain extent. How should I adjust the new bandpass transformer?—R. W., Philadelphia, Pa.

If you get a normal black-and-white picture, the picture tube is not at fault. The trouble is caused by low gain in the (B — Y) signal channel. Hence, you will not correct the trouble by adjusting the bandpass transformer. This transformer affects the entire chroma signal. The trouble will probably be found between the demodulator driver and the picture tube. A wide-band scope and low-capacitance probe should be used to find out where the signal loss occurs. This will permit you to close in on the fault.

Fuse blowing

An RCA 24D7545, chassis KCS-104A has had repeated fuse failures. Slow-blow fuses do not help. The receiver has a 0.3-amp rating. I have tried tube substitution. In my own shop, the fuse does not blow.—J. T., East Chicago, Ill.

Since the fuse blows in the customer's home but not in your shop, it indicates that the line voltage is different. Check to see whether the line voltage is high in the set-owner's home, and if an occasional surge occurs. A receiver usually requires higher starting current when it has been standing idle for a long period. This is because the electrolytics become partially unformed when idle. Fuse blowing caused by heavy starting current can often be eliminated by using a surgistor, which consists of a small wirewound resistor and a bimetallic relay strip. I assume you have tried replacing the horizontal output tube, an occasional offender.

Audio hum

A Westinghouse V-2311-45 2L48, model H-14T170 has a loud hum in the sound. The hum changes pitch and grows louder or weaker with changes in picture scenes.—M. N. B., Southampton, N. Y.

The hum that you report is video signal, and vertical sync pulses in particular, getting into the sound signal. There are several possible points of entry. A scope and low-capacitance probe will give a definite answer, showing the vertical sync mixed with the sound. The possible points of entry are: (1) Overload of the first video output tube. Such overload occurs because of low plate voltage, low screen voltage, leaky grid capacitor C313 (Fig. 3) or wrong value of R315. A short in C315 will cause the same trouble. A lesser possibility is leakage

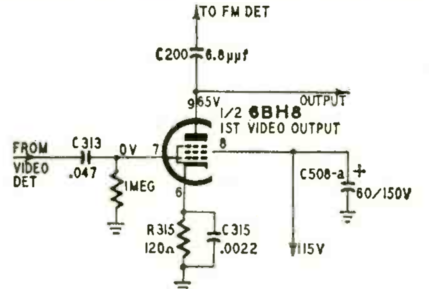

Fig. 3—Video overload and sync buzz can be caused by faulty C313, C200 or C315. Low plate or screen voltage or a change in the value of R315 can also be the fault.

in C200. (2) Poor decoupling of the video-amplifier output circuit from the audio circuits. Capacitor C508-A performs this function. It should be checked. (3) Overload in an if stage. Clamp the agc to see if the sound interference disappears. If it disappears look for agc trouble, such as a leaky delay capacitor. (4) Incorrect voltages on the 3BN6, intercarrier audio detector tube. Correct voltages are: pin 1, 1.5 volts; 2, 0; 5, 70; 6, 0; 7, 65. (5) Misalignment of sound if input coil (L200) or quadrature coil L201. END

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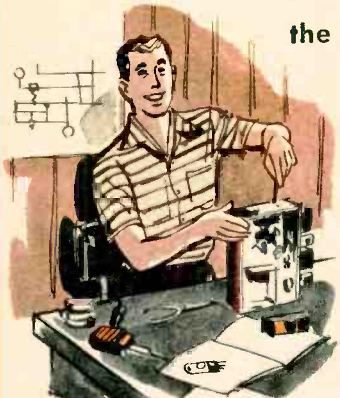

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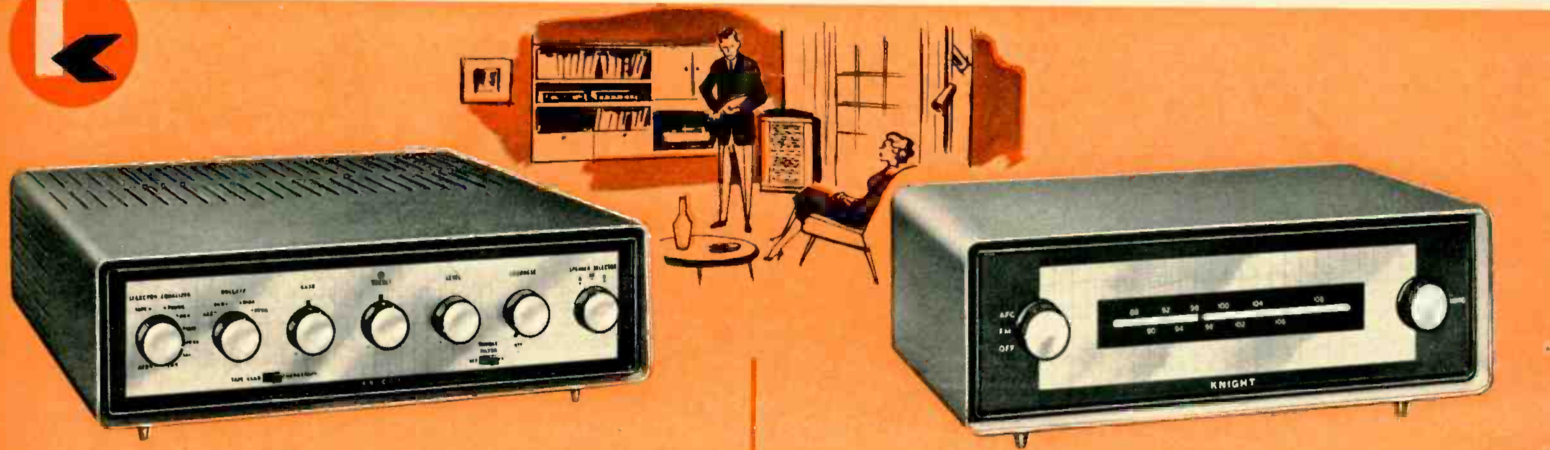

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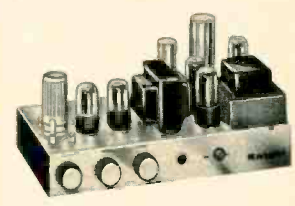

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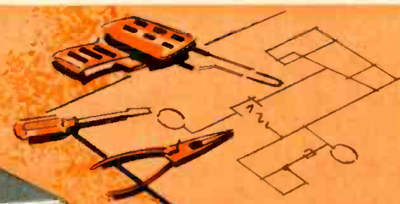

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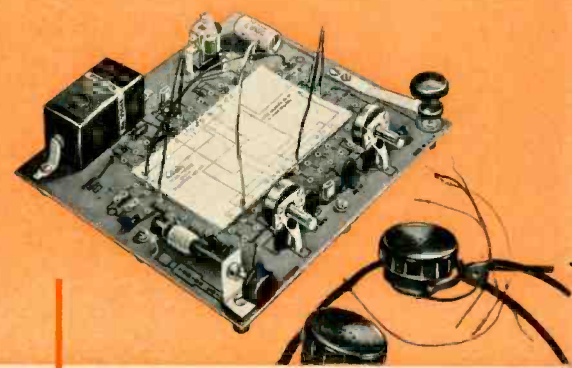

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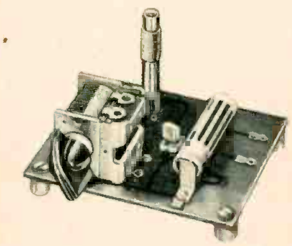

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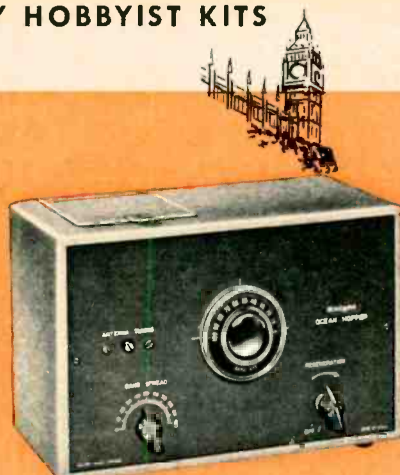

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Model Y-740 **$11.95** This top-performing regenerative receiver puts a world of listening pleasure at your finger-tips. Tuning range (using coils listed below) is virtually world-wide; covers 155 kc to 35 mc, including every type of radio transmission: AM broadcast, marine, aircraft, distress channels, direction-finding, Amateur, frequency standard, foreign broadcast, and police. With bandspread tuning. For use with headphones or 3-4 ohm PM speaker. Kit is supplied with standard broadcast band coil and all tubes and parts. (Less extra coils, headphones, speaker and cabinet.) Shpg. wt., 5 lbs.

Model Y-740. Net only **$11.95**

Y-746. Cabinet for above. 1½ lbs. Net **$2.90**

Extra coils available: Long Wave Coil (155-470 kc), Net 79c. Short Wave (1.65—4.1 mc; 2.9—7.3 mc; 7—17.5 mc and 15.5—35 mc). Each 65c.

knight-kit "Space-Spanner" Bandswitching World-Wide Radio Kit

Model Y-243 **$15.95**

- Broadcast or Short Wave Reception
- Sensitive Regenerative Circuit
- Convenient Bandspread Tuning
- Built-In Loudspeaker

Imagine the thrill of hearing overseas broadcasts on a precision receiver you've built yourself—and then, at the flip of a switch, being able to tune to your favorite local broadcast station! Bandswitch selects exciting short wave, including foreign broadcasts, amateur calls, aircraft, police and marine radio on the 6.5 to 17 mc range, as well as standard 540-1700 kc broadcasts. Features highly sensitive regenerative circuit. Includes built-in 4" PM speaker and beam-power tube for strong volume and clear tone. Headphone connectors are available for private listening; switch cuts out speaker. Controls: Bandspread, Main Tuning, Antenna Trimmer, Bandswitch, Regeneration, Volume. 7x10x6". Easy to build from step-by-step instruction manual. For 110-120 v., 50-60 cy. AC or DC. (Less cabinet.) Shpg. wt., 5 lbs.

Model Y-243. Net only **$15.95**

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$17.25 Popular Broadcast band receiver built and enjoyed by thousands. Features built-in antenna, automatic volume control, ball-bearing tuning condenser, PM dynamic speaker. Handsome plastic cabinet. Easy to assemble. AC or DC operation. Shpg. wt., 8 lbs.

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- Handsome Metal Cabinets
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Easy to build at lowest cost—ideal for home, office, shop or school. Consists of Master unit and Remote unit. Remote unit may be left "open" for answering calls from a distance, for "baby sitting", etc. Remote also may be set for "private" operation—cannot be "listened-in" on, but it can be called and can originate calls. Master unit includes high-gain 2-stage amplifier, combination volume control and on-off switch, plus pilot light. Each unit has 4" PM dynamic speaker. System responds to even a whisper. Handsome Antique white cabinets, each 4¾x6½x4⅜". With all parts, tubes and 50-ft. cable (up to 200-ft. may be added). For 110-120 v., AC or DC. 8 lbs.

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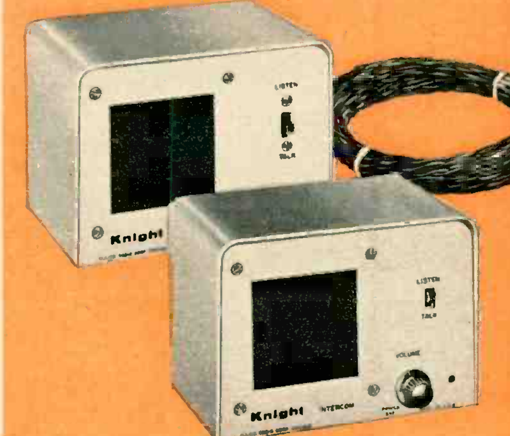

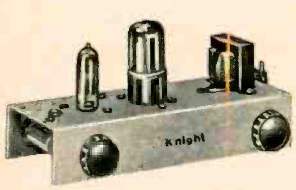

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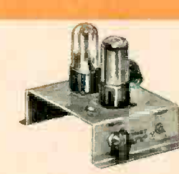

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- With 16 Filament Voltages
- 600 Latest Tube Types Listed
- Easy-to-Read 4½" Meter
- Tests Series-String TV Tubes

Expertly designed for complete, up-to-date coverage of tube types. Tests *series-string TV tubes;* tests 4, 5, 6 and 7 pin large, regular and miniature types, octals, loctals, 9-pin miniatures and pilot lamps. Tests for open, short, leakage, heater continuity and performance (by amount of cathode emission). Big 4½" square meter has clear "GOOD-?-REPLACE" scale. With line-voltage indicator and line-adjust control. Choice of 16 filament voltages from 0.63 to 117 volts to check virtually all receiving tubes; blank socket for future type tubes. Universal-type selector switches permit selection of any combination of pin connections. Single-unit, pre-assembled 10-lever function switch simplifies and speeds assembly. Up-to-date illuminated roll chart lists over 600 tube types. Counter model case, 5 x 14 x 10". Easy to build. 14 lbs.

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Build this wide-range, extremely stable RF signal generator—save two-thirds the cost of a comparable wired instrument! Large, semi-circular dial is clearly calibrated; range is covered in 5 separate bands for close accuracy in setting individual frequencies. Ideal for aligning RF and IF stages in radio and TV sets and for troubleshooting audio equipment. Delivers output on fundamentals from 160 kc all the way out to 112 mc; useful harmonics to 224 mc. Has built-in 400-cycle sine-wave audio oscillator for modulating RF; audio is also available externally. Features high-stability Colpitts circuit. Convenient jack for external modulation. Maximum audio output 10 volts; RF output over 0.1 volt on all ranges. Step and continuous-type attenuator controls. Supplied with precision-wound coils that require no adjustment. 7 x 10 x 5". Shpg. wt., 11 lbs.

Model Y-145. Net only **$19.75**

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Model Y-128

$16^{95}

Exceptional accuracy and versatility at amazing low cost. Ideal for service shop, lab or Amateur use. Large 4½", 400 microamp meter with separate scales for AC and DC voltage and current, decibels and resistance. *Uses 1% precision resistors;* has 3-position function switch and 12-position range switch. *38 ranges* include: AC, DC and output volts, 0-1-5-10-50-500-5000 (1000 ohms/volt sensitivity); Resistance, 0-1000-100,000 ohms and 0-1 meg (center scale readings of 60, 150 and 1500 ohms); Current, AC or DC, 0-1-10-100 ma and 0-1 amp; Decibels, −20 to +69 in 6 ranges. Precision resistors are used as shunts and multipliers to assure exceptional accuracy of measurements. With all parts, battery, test leads and black bakelite case with convenient carrying handle, 6¾ x 5¼ x 3¾". A great value in an easy-to-build quality instrument. Shpg. wt., 2½ lbs.

Model Y-128. Net only **$16.95**

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Model Y-125

$24^{95}

- 200 µa Movement, 4½" Meter
- Includes AC, Peak-to-Peak
- Balanced-Bridge, Push-Pull Circuit
- 1% Film-Type Resistors

Top buy in an extremely stable, highly accurate VTVM. Easy to assemble—entire chassis is printed circuit board. Perfect for radio-TV service work, lab and Amateur use. Features low-leakage type switches; 1% film-type precision resistors; balanced-bridge, push-pull circuit (switch to any range without readjusting zero set); zero center scale and direct-reading db scale; polarity reversing switch. Ranges: Input Resistance, 11 megs; DC and AC rms, 0-1.5-5-15-50-150-500-1500; AC Peak-to-Peak, 0-4-14-40-140-1400-4000; Response, 30 cycles to 3 mc; Ohms, 0-1000-10K-100K and 0-1-10-100-1000 megs; db, −10 to +5. Includes all parts, tubes, battery, test leads and portable case, 7¾ x 5¼ x 4-5/16". Easy to assemble. Shpg. wt., 6 lbs.

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$32^{95}

High current rating; continuously variable filtered output; delivers 15 amps at 6 volts, 10 amps at 12 volts. May be used as battery charger. Two meters provide simultaneous current and voltage readings. Shpg. wt., 18 lbs.

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$12^{50}

Tests capacitors while in the circuit! Has widest range—20 mmf to 2000 mfd. Exclusive circuit for cancelling lead capacity. "Magic Eye" indicator. Save 60% over factory-wired units. 5 lbs.

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knight-kit High-Gain Signal Tracer Kit

Model Y-135

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A remarkable value in an easy-to-build instrument which permits visual and aural signal tracing of RF, IF, video and audio circuits. Has *highest gain in its price class.* Traces signal from antenna to speaker. Reproduces signal at plate or grid connection of any stage. Identifies and isolates "dead" stages. Features: usable gain of *91,000;* "magic eye" with calibrated attenuators for signal presence indication and stage-by-stage gain measurements; built-in 4" PM speaker; combination 2-position probe, one for RF (6 mmf. input), the other for audio. Provides noise test; built-in watt-meter calibrated from 25 to *1000 watts;* provision for external scope or VTVM. Binding posts provide output transformer and speaker substitution test, plus external 280 volts B+. With all parts, tubes and probe. 7x10x5". 12 lbs.

Model Y-135. Net only **$26.50**

knight-kit 5" Wide-Band Oscilloscope Kit

Model Y-144

$69^{00}

Only $6.90 down

- 5 mc Width for Color TV
- Horizontal Sweep to 600 kc
- 25 mv/inch Sensitivity
- Z-Axis Input
- Printed Circuit Construction

Equals or betters the performance of commercially wired scopes costing far more. Two printed circuit boards and laced wiring harness assure wiring accuracy and cut assembly time. Ideal for lab use, color TV servicing and high frequency applications. Wide sweep range—*15 to 600,000 cps.* Vertical response, ± 3 db, 5 cps to 5 mc; only 1 db down at 3.58 mc color burst. High vertical sensitivity of .025 rms v/inch. Input capacity, 20 mmf. Outstanding features: cathode follower inputs; 2nd anode provides 1400 volts high-intensity trace; push-pull amplifiers; positive and negative locking; frequency-compensated attenuator; Z-axis input; one volt P-P calibrating voltage; astigmatism control; retrace blanking circuit; DC positioning control. Includes CRT. 14½ x 9½ x 16". 40 lbs.

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Model Y-146

$42^{00}

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- Phantastron Linear Sweep
- 25 mv/inch Sensitivity
- Printed Circuit Board
- Retrace Blanking Circuit

Feature for feature the world's best oscilloscope kit value. A standout in its class with all these fine features: *Printed Circuit* wiring board and laced harness for quick, error-free assembly. *Phantastron Sweep Circuit* for high linearity of sweep from 15 to 150,000 cps. *25 Millivolts Per Inch Sensitivity*—3 times that of similarly priced scope kits. *Calibration Voltage*—1 volt peak-to-peak square wave, fully regulated. *Vertical Amplifier*—frequency response ± 3 db, 3 cps to 1.5 mc (± 6 db to 2.5 mc). Includes: Directly coupled positioning controls; retrace blanking circuit; frequency-compensated vertical input attenuator; positive and negative internal sync; high 2nd-anode voltage for high-intensity trace; input capacity, 45 mmf. Kit includes CRT. 9½ x 13¾ x 17¾". 26 lbs.

Model Y-146. Net only **$42.00**

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$5^{95}

Easily determines resistor values required in a circuit. Makes available 36 standard 1-watt resistance values in 2 ranges between 15 ohms and 10 megohms, with 10% accuracy. Slide switch selects range; 18-position switch for value selection. Shpg. wt., 2 lbs.

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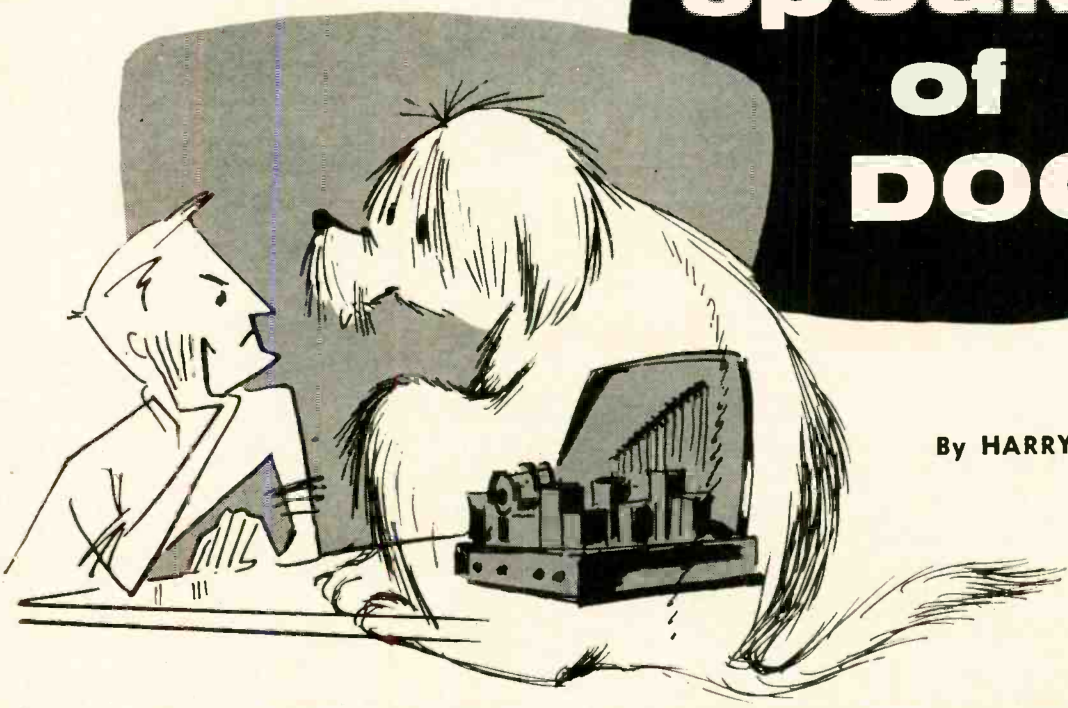
Take advantage of the most liberal Easy Pay plan in electronics. On Knight-Kit orders totaling $45 or more—just 10% down, small monthly payments thereafter. Low carrying charges—no "red tape."

According to Hank, you can save a lot of work by "fixing the audio first!"

speaking of DOGS



By HARRY M. LAYDEN

As usual, whenever technicians get together, the conversation took off on a single track. These two had scarcely greeted each other before the talk turned to shop. Hank, the older of the two, couldn't get a word in edgewise, as Bob, a youth of 20, yakked about a job that was giving him fits. After patiently listening to the woes of the youngster for all of 5 minutes, Hank finally got in a word.

"You may be making the job tougher than it really is. I can recall that very thing happening to me a couple of times, before I got wise to what I was doing wrong. I think you'll find out that it pays off in the long run to fix the sound first."

Bob was all ears as Hank cleared his throat to go on. "I recall a Du Mont RA-302 that was a dilly! It came in with a case of audio buzz and a picture with white lines spaced about 2 inches apart throughout the frame. Here, let me sketch the circuit so you'll be able to follow better." Hank pulled out a pencil and traced a schematic on the back of an envelope (see Fig. 1).

"Notice," the veteran continued, pointing to a network connected to the C-R tube's grid, "how retrace blanking is provided for. I sized up the problem as a defect somewhere in the vertical-retrace blanking section. The scope showed that the blanking spike was apparently OK but it certainly wasn't doing its job. I went through the circuit as carefully as a miser counts his money.

"Every part was tested, but I couldn't find anything wrong. One at a time I substituted every part, but it was no soap. By this time I was a little groggy. Boy, was I but thoroughly pooped!"

Did you give up?

As Hank paused to get his second wind, Bob prodded him. "What happened then—did you give up?"

"You don't give up in this business, Bob! You may execute what is known in military circles as a strategic withdrawal to pull yourself together and regain your self-esteem, but you never give up.

"No, I didn't quit. But I did take a 5-minute break, off by myself, with a coke and a cigarette. That always helps.

"Then I got a bright idea. Why not, I asked myself, work on that other problem, the buzz? I'll have to fix it anyway, why not now? So, I shifted the attack and began investigating the buzz. This proved brilliant!"

"How come?" Bob wanted to know. "I don't see . . ."

"You will!" Hank cut in. "You will! I knew that buzz usually comes from either the sync pulses or the vertical sweep. It's easy to identify which is which. Simply kill the vertical oscillator. If the buzz persists it's not the source.

"In my case, the buzz disappeared the instant the vertical oscillator was pulled! Replacing the tube brought back the buzz. There couldn't be any doubt now about where the buzz was originating. Somewhere, somehow, the vertical sweep was getting into the audio."

Hank paused to light a cigarette before continuing. "It didn't take long to find the answer. The scope showed the spike at the B-plus point feeding the

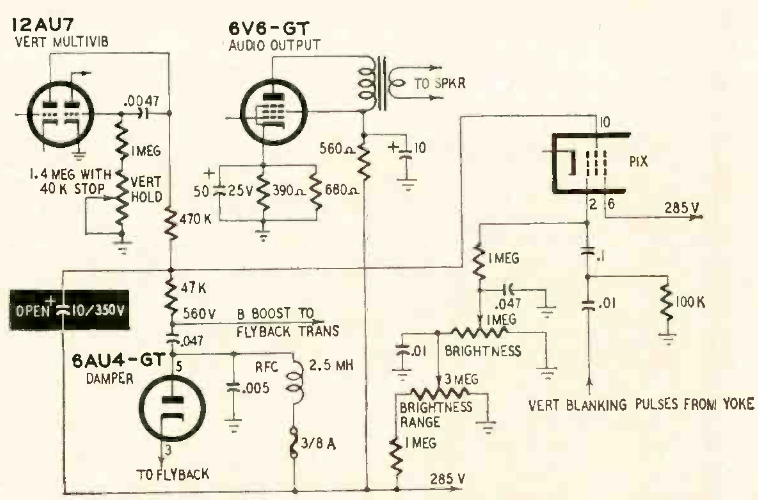


Fig. 1—Partial circuit of the Du Mont RA-302.

audio output tube, even with the output tube out of its socket!

"This B-plus point is at 285 volts and is the negative return for this boost supply filter capacitor," Hank said, pointing at a 10-μf electrolytic in the drawing.

"It's a semipolarized unit and filters and decouples the boost voltage. As long as it does its job, there's no problem. But let it develop a high power factor or lose its capacitance, then you're in trouble!

"Look here," Hank said, pointing to a spot on the schematic, "the boost voltage is the feed source for the vertical oscillator. I figured that vertical spikes would be transferred to the 280-volt B-plus if this decoupling capacitor had given up the ghost. It would then be working as a coupling device rather than the decoupler it was intended for. In less time than it takes to tell, I bridged it with a test capacitor, and both retrace lines and buzz vanished."

"The problem was licked, and was I relieved!" Hank heaved a sigh of relief, as if he had been reliving the experience all over again.

A matter of logic

"But those retrace lines," Bobby persisted, "what about them? How did they get into the picture?"

Hank smiled a bit, as he rejoined, "I was afraid you'd ask that. The answer is so ridiculously simple that I guess you'll put me down as a real boob for not realizing it sooner.

"But that's the trouble with second-guessing. The second time around, things get so simple we begin to suspect that the simplicity was in our own mental chemistry," Hank mused out loud.

"If you trace out the first anode circuit, you can't miss the answer to your question. It's connected directly to the boost voltage! See what I mean! The first anode voltage containing the unfiltered vertical spikes was intensity-modulating the C-R tube's beam at the spike repetition rate.

"It never occurred to me to check the first anode with the scope. It's rarely suspect in retrace problems and we humans are creatures of habit. I just didn't associate the two. The point that has stuck with me," Hank went on, "is that I could have spared myself a lot of grief by fixing the audio first. There's good logic behind it!"

Bob was visibly incredulous. "I don't get it. It just happened to work out that way. Why do you say fixing the sound first has logic behind it?"

"For two very good reasons," Hank replied. "First, and you'll probably agree, the sound section of a TV set is usually more straightforward and less complicated than the video section. Consequently, it's easier to troubleshoot than the more complicated picture circuits. And second, TV sets as a general rule come into the shop with one defect at a time. There may be multiple symptoms, but there is usually

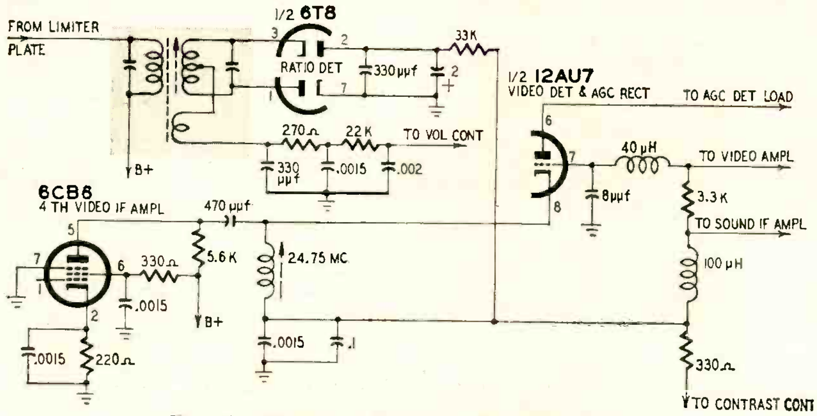


Fig. 2—Circuitry between the ratio detector and video detector in a Philco 52-T2157.

only one major defect in the cause of them all.

"Even where the symptoms stem from separate and distinct causes, it's no harder to attend to the sound first. It will have to be fixed before the job is finished anyways, and, as it may save you trouble, why not do it first?

"I think you'll be playing the game with the odds in your favor since curing the sound symptom sometimes cures the video symptoms automatically."

Conquering a monster

"You may be right," Bob conceded. "But I don't think it will work out that way with the job I've got on the bench now." The doubt in his mind showed itself in his tone.

Hank looked at his watch, and said, "I've got a few minutes. Let's go by the shop and look at this monster."

A Philco 52-T2157 was set up on the bench for a sweep inspection of the if curve. Bob turned the equipment on, and a nice if curve was displayed on the scope.

"My trouble," Bob explained, "is that sound is getting into the picture, and the sound itself seems to have a high noise level." He manipulated the marker generator to show Hank that the clean bill of health he had given to the if circuits was justified.

Hank asked to see the service literature, and went into a huddle with it for a few moments. "Now, Bob, let's see what we can do about cleaning up the sound. As a first step, let's redraw the ratio detector circuit for quick reference (see Fig. 2).

"From what we know about the quieting action in ratio detectors (they depend on the relatively long time constant provided by the electrolytic and the load resistor), it would appear that something is wrong right here," Hank said, indicating the 2-μf electrolytic and the 33,000-ohm resistor connected to the ratio detector.

"Remove the sweep and scope equipment and tune in a station," he requested. Bob's description of the symptoms coincided with the facts; the noise level was high and sound was definitely getting into the picture. Seeing a vtvm right at his elbow, Hank set it up for minus dc on the 10-volt range. When the meter was applied across the electrolytic, instead of a normal steady dc reading, the pointer fluctuated in step with the sound!

"I thought so!" Hank exclaimed. "Bridging the electrolytic with a test capacitor cleared up the trouble." The noise was gone but, more amazingly, there was no sign of sound interference in the picture!

Bob stood there speechless. "I don't get it," he stammered. "How, why, this just can't be! Where's the connection? . . ."

Hank left him in the dark for a few moments, enjoying his evident discomfort. "It's like I told you before, Bob, fix the sound first," Hank pointed out. "With this electrolytic open, quieting action was lost and the sound was getting into the picture circuits by way of the video detector.

"As you can see from the diagram, the video detector's cathode returns through the coil and the 33,000-ohm resistor to the ratio detector. If this point isn't tied down to ground through the electrolytic, it floats and the unsuppressed audio modulates the video detector."

The explanation evidently rang a bell as Bob's face lit up with a giant smile. "Well, what do you know," was all he could think of. Then he was quiet for a few minutes. At last he broke the silence with, "You know, Hank, I think you have something there in that idea to fix the sound first.

"Last week I had a job in here, where there was neither picture or sound. There was a raster, but that was about all. I spent a lot of time in the video and tuner circuits and didn't find the trouble there. It was the audio output tube. It had gone dead. The cathode was the B-plus source for the if strip."

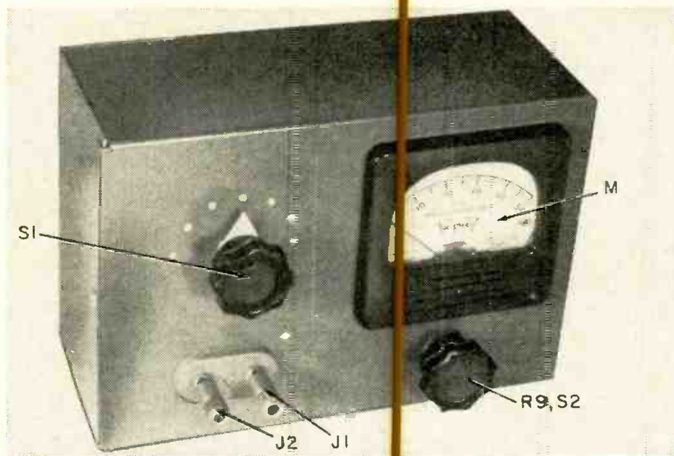
"I could have saved a lot of time if I had started the probing in the sound section. Well, we live and learn," was his sage conclusion.

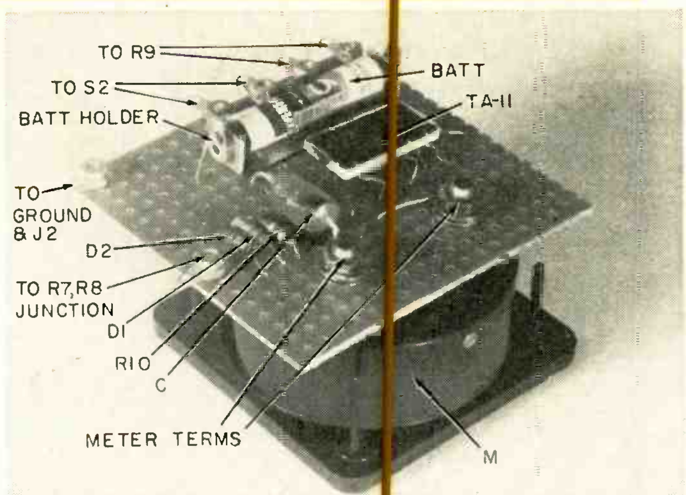
Hank nodded in agreement, and added, "You'll find out, as I did, that a lot of those so-called tough dogs are really only as tough as we make them."

"I know what you mean," Bob answered, and then, with a twinkle in his eye, added, "Especially the ones that bark the loudest!" END

Battery-powered unit is also a voltmeter and ammeter

TRANSISTOR NULL DETECTOR and SENSITIVE INDICATOR





(Above) Completed instrument.

(Right) Closeup of layout on phenolic board. Board is held in place by meter terminals.

By TED LADD

A BATTERY-powered null detector for ac bridges is very desirable from the standpoint of complete isolation from the power line. This type of instrument is free from the hum and interaction troubles common to line-operated devices, and requires no warmup time. However, a null detector employing battery type tubes will be microphonic unless extraordinary precautions are taken in its mechanical design. Also, such a unit is expensive to operate. Both A and B batteries are required and because of the high current drain, long life cannot be expected. The B battery type tubes will be microphonic overnight if the instrument is left running when not in use. These factors result in rather expensive upkeep. A further disadvantage is the relatively large size and weight of the batteries.

The shortcomings of the tube type null detector can be overcome by using a transistor circuit. A transistor type instrument can operate from one small, cheap 1.5-volt cell. It is nonmicrophonic, light, rugged, and requires no warmup. Its current drain is so low that no disaster results from forgetting to turn the instrument off— even if it is left on for long periods. You may accidentally leave it on overnight.

The all-transistor null detector described here is designed for economical and reliable operation. It is self-contained, small (only 7 x 5 x 3 inches), weighs 1.5 pounds, and its dc requirements are low (4.4 ma maximum at 1.5 volts). In addition to its intended use as a balance indicator for ac bridges, it has numerous applications where sensitive ac indicators are required.

Instrument circuit

Fig. 1 is the complete circuit of the null detector. This is seen to be similar to the amplifier–rectifier type of vacuum-tube voltmeter. There are three major sections: an input-signal voltage divider (R1 to R8); a four-stage R-C-coupled, high-gain, low-noise transistor amplifier (TA-11); and an indicator circuit (C, D1, D2 M, R10). The indicating meter is a 0–50 dc microammeter.

The Centralab TA-11 is a factory-made miniature unit. It is 1.175 inches long, 0.665 inch wide and 0.250 inch thick. The complete circuit of the TA-11 can be found on page 106 of the January, 1958, issue of RADIO-ELECTRONICS. Seven pigtails, numbered as in Fig. 1, are provided for external connections. This completely fabricated amplifier saves most of the assembly and wiring time required to build the null detector—46 soldered connections are reduced to the 7 pigtail connections. All capacitors, fixed resistors and low-noise transistors that make up the four-stage amplifier are in the sealed package. Fig. 2 shows the frequency response of the TA-11.

The input voltage divider (R1 to R8 together with RANGE switch S1) provides a coarse gain control, while potentiometer R9 provides fine control. The voltage-divider resistance values specified in Fig. 1 limit the maximum input signal to 10 volts rms. A voltage-divider resistor string may be worked out for higher voltages, if desired. I needed small variations of voltage range between steps A and E of switch S1 and a large reduction between F and G. The use of 5% resistors resulted in the odd voltages shown in Fig. 1. However, you may prefer to work out a divider giving integral voltage values and even steps (such as 10 to 1), particularly if the instrument is to be used also as an ac voltmeter–millivoltmeter.

The instrument has an input resistance of approximately 81 megohms on the 10-volt range, 71 megohms for 9.1 volts, [illegible]1 megohms for 7.3 volts, 41 megohms for 4.2 volts, 21 megohms for 1.75 volts, 1 megohm for 115 mv and 91,200 ohms for 11 mv. These high input resistances, uncommon in most transistor devices, make loading by the

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ILLUMINATED CLOCK, electric. Both useful and advertises your business. Easily read—16" diameter—with long-life bulbs. Hang on a wall, or mount on a counter (easel is provided).

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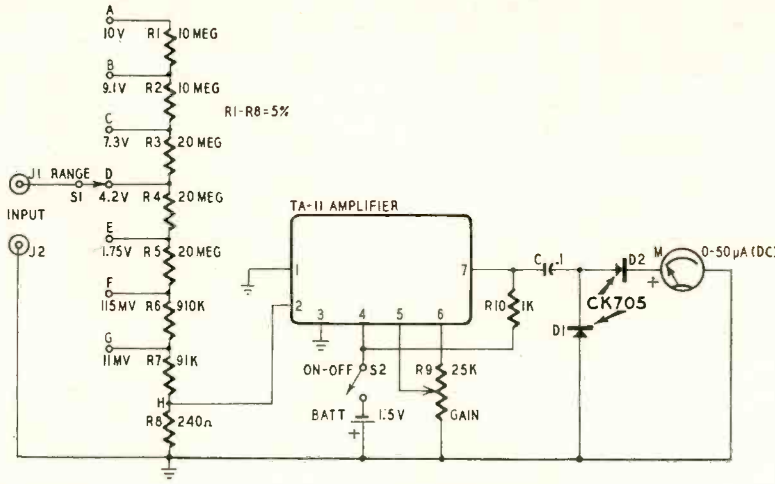
METAL TACK-ON SIGN. Narrow, smart dimensions—14" by 42". Fasten against building, or mount as a free-standing display.



R1, 2—10 megohms
R3, 4, 5—20 megohms
R6—910,000 ohms
R7—91,000 ohms
R8—240 ohms
R9—pot, 25,000 ohms, linear taper, 10%
R10—1,000 ohms, 10%
All resistors ½-watt 5% unless noted
BATT—1.5 volts, penlight D-cell or mercury cell
C—0.1 μf, metallized tubular, miniature
D1, 2—CK705 (Raytheon)
J1, 2—3-way binding posts (see text)
M—0-50 dc microammeter
S1—single-pole 11-position, nonshorting rotary switch (see text)
S2—spst switch on pot R9
TA-11—Centralab 4-stage R-C-coupled transistor amplifier
Chassis box, 7 x 5 x 3 inches
Perforated phenolic board, 3½ x 3½ inches
Battery holder, for battery used
Miscellaneous hardware

Fig. 1—Circuit of the handy test instrument. Use of a TA-11 printed circuit amplifier makes it easy to build.

instrument negligible.

The amplifier's output-signal voltage is developed across a 1,000-ohm resistor, R10. This voltage is coupled to the meter circuit through a 0.1-μf capacitor, C. The meter rectifier consists of two germanium diodes, D1 and D2. In the absence of an input signal, there is no deflection of microammeter M, hence no zero-set adjustment is required and the instrument is ready for operation as soon as it is switched on. The unit's voltage response is very nearly linear.

The miniature amplifier requires connections only to the input, output, ground, battery and gain control through its seven pigtails. The total current drain is between 3.6 and 4.4 ma dc, depending upon individual transistor parameters and resistor values within the amplifier. Since the current drain is so low and the instrument is usually used intermittently, I use a penlight cell to power it. This cell is seen in place in the photos. However, a larger, size-D flashlight cell or a 1.5-volt mercury cell might be preferrable in more rugged service because of their greater milliampere-hour capacity.

With an input-signal voltage corresponding to a particular setting of RANGE switch S1, the meter will be deflected to full scale when GAIN control R9 is set for maximum resistance between its arm and ground and will be at zero when R9 is set for minimum resistance between arm and ground. Thus, by adjusting S1 and R9, the operator has excellent control of detector sensitivity during bridge-balancing adjustments.

Maximum amplifier gain, which I did not need, may be obtained by applying the input signal to point H on the voltage-divider string. Full-scale deflection of meter M then is obtained with an input signal of only 30 mv rms.

Construction kinks

No attempt was made to subminiaturize this instrument, although you could easily make it smaller. My instrument is built into an aluminum chassis box 7 x 5 x 3 inches. It could be fitted into a meter box and, if a 1- or 1.5-inch diameter microammeter, a miniature selector switch and a dime-size potentiometer are used, it can be made pocket-size. Photos show construction.

All circuit components except the RANGE switch (S1), input voltage-divider resistors (R1 to R8), ON-OFF switch (S2), potentiometer (R9) and the input binding posts are mounted on a 3½-inch-square panel of perforated phenolic held by the microammeter terminal screws. The leads from the TA-11 capacitor C, resistor R10 and diodes D1 and D2 are passed through nearby perforations in the board and are interconnected underneath to complete the wiring. This is a labor-saving arrangement somewhat similar to a printed circuit. Solder lugs, held by ¼-inch 6-32 screws and nuts, are provided for connections to the external components (see photos).

The battery is held in a bracket type holder mounted on the circuit board. Select this holder for the battery you intend to use. Leads from the holder are passed through the nearest perforations and connected under the board. Leads from the meter terminal screws are also passed through perforations in the board.

The INPUT terminals are three-way binding posts on a phenolic strip (National FWH assembly). However, conventional insulated binding posts may be used. They should be spaced on ¾-inch centers to accommodate standard plugs and patch-cord assemblies.

The ON–OFF switch (S2) is attached to the GAIN control potentiometer (R9). This potentiometer is mounted on the front panel below the meter.

Since a 7-position selector switch is not easy to get, a standard 11-position switch is employed with a removable stop placed at the seventh position. Resistors R1 to R8 are soldered directly between the lugs of this switch.

Use the shortest practicable leads in making connections under the circuit board. Be careful when soldering the leads from the amplifier and diodes. To prevent heat damage to these components, hold the lead with long-nose pliers during the soldering operation and until the joint has cooled.

Observe battery, meter and diode polarity. Failure to do so will cause downward deflection of the meter and may damage the amplifier. Also, be sure to follow the manufacturer's number coding of the TA-11 amplifier leads.

Standard ½-watt carbon resistors are specified for the input voltage divider (R1 to R8). The tolerance of these resistors is entirely satisfactory when the instrument is used as a null detector and the RANGE switch serves only as an uncalibrated coarse gain control. However, precision resistors are required when the instrument is also used as an electronic ac voltmeter–millivoltmeter and a voltage divider is worked out for standard full-scale voltage ranges.

Final check

Check all wiring carefully before clipping the battery into its holder and closing the ON–OFF switch. Incorrect connections can damage the amplifier if the battery is connected.

After verifying that all wiring is correct, run a complete check on the instrument: Throw switch S2 to OFF. Set potentiometer R9 to zero-gain position. Set switch S1 to position A (10 volts). Connect an audio oscillator to the INPUT terminals. Set the oscillator to 1,000 cycles. Set the oscillator's output control to zero position. Switch on the oscillator and allow a 5-minute warm-up. Turn on switch S2. Set potentiometer R9 to maximum-gain position. Advance the oscillator output until full-scale deflection of microammeter M is obtained. Run potentiometer R9 up and down to check for smooth control of gain. Reset this control for full-scale deflection of the meter. Check operation at each of the settings of the RANGE switch, using correspondingly lower output voltages from the oscillator. A voltage calibration of the microammeter scale may be made (against an ac vtvm connected in parallel with the

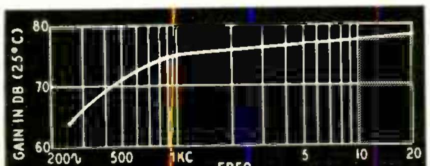


Fig. 2—Frequency response of the 4-stage amplifier.

oscillator at the INPUT terminals) at any desired setting of S1—with potentiometer R9 set for maximum gain.

Other uses

In addition to its intended use as a bridge null detector, this transformerless instrument may be employed for other purposes requiring a sensitive ac indicator with high input impedance:

Af signal tracer. With its negligible loading of a circuit under test, the instrument is well suited to signal tracing in audio amplifiers and other audio systems. For this purpose, connect a shielded probe to the high INPUT terminal and connect the low INPUT terminal to the chassis (or B-minus) of the system under test. The meter gives visual indications of signal strength and, if potentiometer R9, range switch S1, and the meter scale are voltage-calibrated, gain and loss may be determined from the deflections obtained at successive test points.

Rf signal tracer. For this application, connect a shielded, crystal type demodulator probe to the high INPUT terminal. Connect the low INPUT terminal to the chassis (or B-minus) of the system under test. As in the preceding application, the meter gives a visual indication of signal strength. Gain and loss may be determined from successive deflections if the instrument has been voltage-calibrated.

Electronic ac voltmeter–millivoltmeter. If the instrument is used as a voltmeter, precision resistors will be required for R1 to R8 (1% or better), and the input voltage divider must be worked out in the conventional manner for the desired full-scale voltage ranges. The instrument must be voltage-calibrated. Voltage calibration and voltage measurements are made with potentiometer R9 in its maximum-gain position.

Ac ammeter. Here, the instrument is first calibrated as a direct-reading voltmeter. When a precision 1-ohm resistor is connected across its INPUT terminals, it then will indicate ac amperes. Ac milliamperes will be indicated on the millivolt ranges. A battery-operated electronic current meter of this type has the advantage that both input terminals can be above ground, as they frequently must be when measuring signal currents, without introducing the disturbances that line-operated instruments do when used in this manner.

Sensitive indicator. As a sensitive, high-impedance indicator, the instrument has various applications: Tuning indicator in filter adjustment and testing. Resonance and intensity indicator in field-strength meters utilizing modulated rf input. Output indicator for repetitively operated piezoelectric devices. Hum-field locator when used with an inductive probe. Leakage current checker in small-signal ac devices. In other words an extremely useful, general-purpose instrument you'll be glad to own. END

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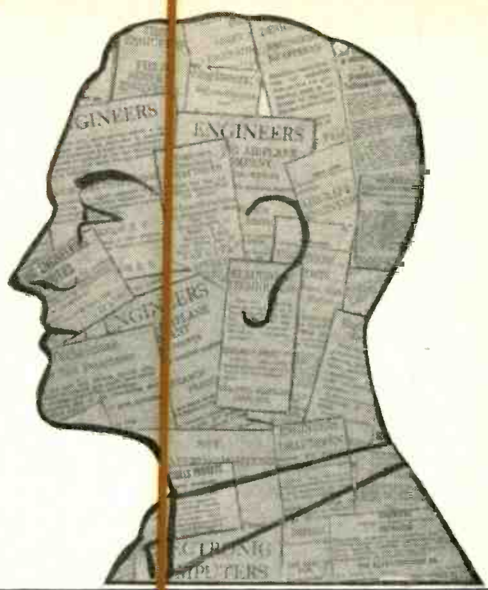

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VTVM Calibrator

Is the ac scale on your vtvm accurate? Here's a simple instrument to make and keep it so

By J. H. SUTTON

OF the thousands of vtvm kits currently being sold and assembled, probably very few have their ac calibration control adjusted accurately. This is in contrast to the probability that most dc calibration controls are accurately set.

Assuming that the kit is a good one and properly assembled, the builder can adjust the dc calibration control to near laboratory accuracy by using a 1.55-volt dry cell. However, the voltage for adjusting the ac calibration control usually comes from the power line, either directly or through a stepdown transformer, and here is the difficulty. What precise value is the line voltage?

The instruction book may say to assume that the line voltage is 117 or that a stepdown transformer delivers 6.3 volts. Either assumption can be wide of the mark. I figured on a 117-volt line while adjusting my meter but later found out, by reference to a laboratory meter, that line voltage was actually about 122. Here was an error of 4.5%, which might be additive to the rated 5% error of the instrument.

A similar check of my meter showed that the dc calibration control adjustment had been quite accurate—the deviation being less than 1%.

What is needed is a good, secondary method of calibration (primary method is with a laboratory standard meter) the accuracy of which depends upon the known value of a standard *dc* source (a mercury or dry cell), the accuracy of a dc meter calibrated by such a cell and a method of equating this dc calibration to an ac source.

Equating dc and ac voltages is achieved in the ordinary vom by rectifying the alternating voltage and indicating the direct voltage on an ac-equivalent scale. In a similar manner, most vtvm's equate ac to dc voltages derived from the same source.

If, with our vtvm connected across a given resistor, we can measure in sequence a half-wave pulsating voltage and a full-wave alternating voltage, both derived from the same source, then these voltages will be mathematically related to each other:

$$\frac{\text{rms value of alternating full wave}}{\text{average value of pulsating half wave}} = \frac{0.71}{0.32} = 2.2$$

or as mathematicians express the relation:

$$\frac{\pi}{\sqrt{2}} = 2.221$$

This relationship is used in the vom. The basic circuit employed is seen in Fig. 1. I have added an ac tap and variable resistor R3. M is the meter, for our purposes a vtvm. RECT 1 and RECT 2 are selenium rectifiers. When RECT 1 is connected to the dc tap, pulsating dc flows through resistor R1. When RECT 1 is connected to the ac tap, alternating current will flow through R1. As R1's precision does not enter into the accuracy of the result, it can be any resistor whose value is known within 10 or 20%. The only requirement is that its value remains constant. R3 is variable in order to adjust the voltage across R1 but it is a convenience, not a necessity.

Selection of R1 depends partly upon the calibrating voltage we wish to drop across it. This voltage should be the full amount, or nearly so, of the 12- or 15-volt ac scale since this is possibly the lowest ac scale which, around full value, is reasonably certain to have linear response. At and below 5 volts ac, the signal rectifier of most vtvm's has a nonlinear response and the more expensive meters have special scales to show this. By choosing the 12- or 15-volt scale we go above the area of signal-rectifier nonlinearity.

Building a calibrator

Since it is desirable to check the calibration of a vtvm periodically, the circuit was set up in permanent fashion as shown by Fig. 2 and the photos. The chassis is a transparent cake-slice box. This, like other plastics, can be drilled safely only with a hand drill while the plastic is backed by a wood block. Drill positions on this chassis can most easily be fixed by attaching a template with Scotch tape.

Potentiometer R3 is used to adjust the dc reading to 6.75 volts, from which the calibration voltage is 15 volts ac (6.75 × 2.22). The 6.75 volts can be easily interpolated as corresponding to

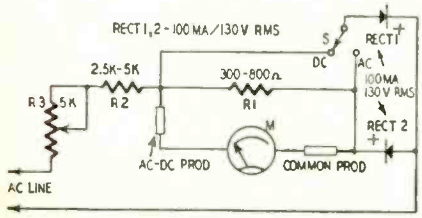
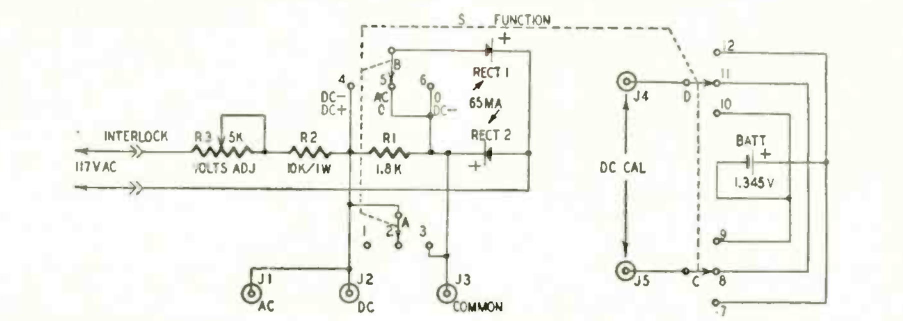


Fig. 1—Basic calibrator circuit.



R1—1,800 ohms, ½ watt, 10%
R2—10,000 ohms, 1 watt, 10%
R3—pot, 5,000 ohms, carbon, 1 watt
BATT—1.345 volts, mercury (Mallory RM625R or equivalent)
J1–J5—tip jacks
RECT 1, 2—selenium rectifiers, 130 volts rms, 65 ma
S—4-pole 3-position rotary, nonshorting (Mallory 3243J or equivalent)
Interlock receptacle and line cord, TV type
Case, wedge-shaped cake-slice box

Fig. 2—Calibrator for ac and dc ranges of your vtvm.

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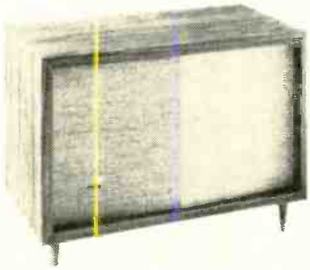

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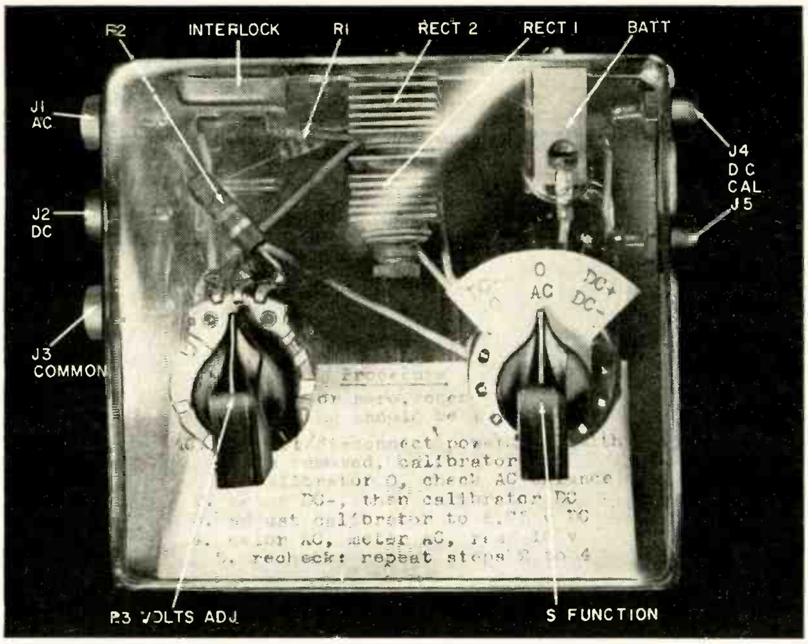
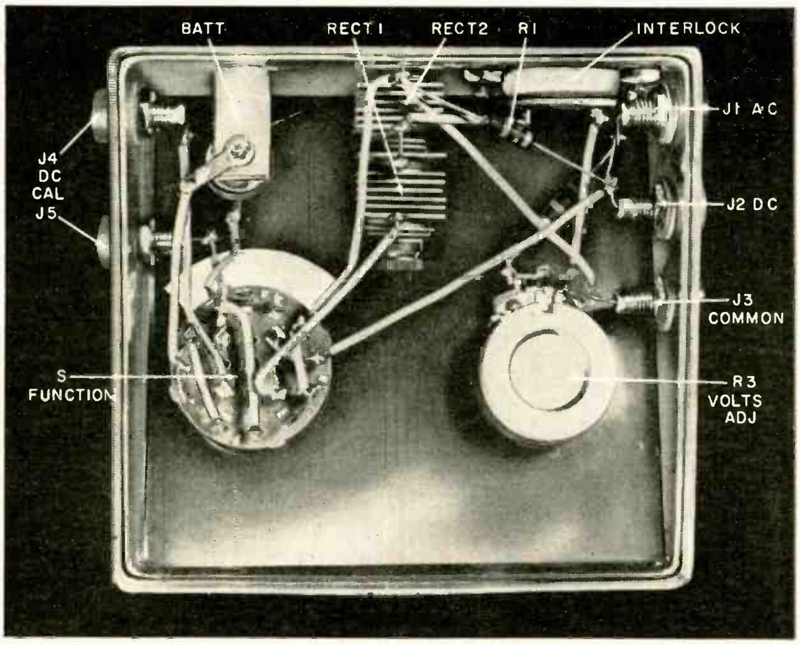


Top view of completed calibrator.



Bottom view shows simple layout of the few components.

2.25 volts on the 5-volt scale, provided your dial has 15- and 5-unit *linear* divisions.

The selenium rectifiers are fastened together and to the chassis with a common bolt through their center. The vtvm prods plug into tip jacks on the side. If the vtvm common prod is equipped only with a clip, a phone tip can be inserted in the common jack and the clip attached. The calibrator is connected to the ac line with a TV cheater cord and interlock receptacle.

Also incorporated in the device is a circuit for dc calibration from a 1.345-volt mercury cell, and switch S is wired so that the circuit for dc calibration is completely isolated from the circuit for ac calibration. In lieu of the mercury cell, you may wish to use an ordinary penlight cell—there is plenty of room.

Looking at the switch from the underside (Fig. 3), contacts 1–6 are for ac calibration while contacts 7–12 are for dc calibration. The latter connections are arranged so that the cell terminals reverse for easy comparison of the dc− and dc+ calibration readings. Because of the dc circuit, a nonshorting switch must be used.

The holder for the mercury cell is home-rolled and is detailed in Fig. 4. The mercury cell fits in the cup and is held in place by the tire valve spring which also furnishes contact pressure for both electrodes. The bottom of the cup is coated with solder to provide a bright surface for electrode contact.

It is possible to buy these cells with leads attached to *both* terminals (RM625RT). If you get one of these, the cell leads can be soldered directly into the circuit. In the absence of such leads, solder directly to the cell but be careful as heat may damage it.

Using the unit

To use the calibrator follow these instructions: Warm up the vtvm for an hour or more before starting and make sure that its zero adjust is properly set. Now set the vtvm for dc. Plug the meter leads into J4 and J5. Using the calibrator's top scale (DC−, 0, DC+), set at 0. The meter should read 1.345 volts dc.

Now set the vtvm on ac. Connect the calibrator to the ac line. Plug the meter leads into J1, J2 and J3. Using the calibrator's bottom scale (0, AC, DC−), set the calibrator at 0 and check ac balance. Switch the vtvm to dc−, and then the calibrator to DC−. Adjust R3 on the calibrator for a 6.75-volt dc reading on the vtvm. Next set the calibrator to AC and the meter to ac. Set the vtvm's ac calibration control to give a reading of 15 volts ac. Recheck once or twice.

With this switching system, the calibrator can be turned to zero without meter disturbance, whether the meter is in the ac or dc position. If the meter is set to dc, the momentary switching of RECT 1 out of the circuit will give the needle a minor upscale flick which will not upset the zero adjust. Note that this adjustment may be upset if the calibrator is connected or disconnected with the vacuum-tube voltmeter's prods in and the calibrator not set at 0. END

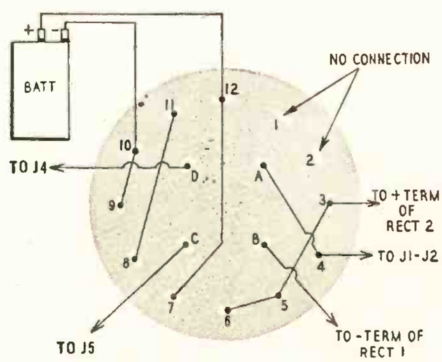


Fig. 3—Wiring the function switch.

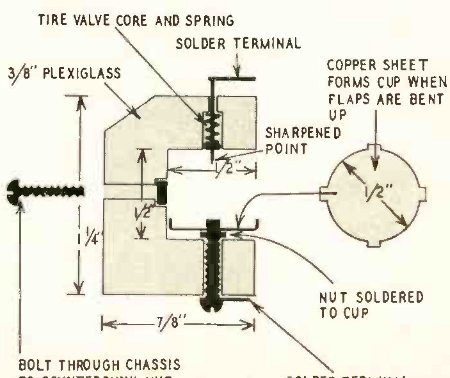


Fig. 4—Holder for the mercury cell.

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Technicians' News

VOTES IN SAN ANTONIO

The San Antonio Radio & Television Association (SARTA), San Antonio, Tex., held an election and voted the following persons into office: C. W. Schertz, Lone Star TV Center, president; O. O. Brigman, Brigman Radio & TV, vice president; Don Van Der Brugen, Sight & Sound of San Antonio, secretary; Tom Boyd, Boyd's Radio & TV Service, treasurer. Ralph McCoy, City-Wide TV Service, and Roland Mueller, M & M TV Service, became directors.

ARTSNY HOLDS ELECTION

Officers of the Associated Radio–Television Servicemen of New York Inc. (ARTSNY) for 1958 are: Marty Boxer, president; Max Leibowitz, executive secretary; Phil Goldfarb, treasurer. In the technical chapter: Peter La Presti, vice president; Jacob Allen, recording secretary; O. Capetelli, corresponding secretary; John Bush, sergeant at arms. In the business chapter: Charles Edward, vice president; Lou Gioa, recording secretary; Jack Sperling financial secretary; Bob Mulwitz, sergeant at arms. To the board of directors: Frank Joseph, Harry Magar, Harry Temler, John Wagonny, Harold Levinson, Harold Goodman, Harold Landfield, Henry Ruscoll, Charles Anglone, Jack Spegal, John Burns.

SERVICE GROUPS COMBINE

Three Philadelphia TV Service groups have combined to form a new association called the Television Service Association of Delaware Valley. The new association is made up of 300 members from the Northeast Service Dealers Association, the Philadelphia Radio Servicemen's Association, and the Television Dealers association of Philadelphia.

Officers of the new group are: Ray Cherrill, Cherrill Radio & TV Service, president; John S. McCloy, McCloy's TV Service, vice president; Harvey Morris, Harvey's Radio & TV Service, secretary; Louis J. Smith, corresponding secretary; Jack Rubin, Delaware Valley TV Service, treasurer.

On the board of directors are: Samuel Brenner, Ray Fink, Albert M. Haas, Charles Knoell and Ralph Newby.

NEW TESA OFFICERS

At a banquet held at the Chestnut Lodge in Buffalo, N. Y., the Television & Electronics Service Association (TESA) of Greater Buffalo installed Irving Toner as their president. Other

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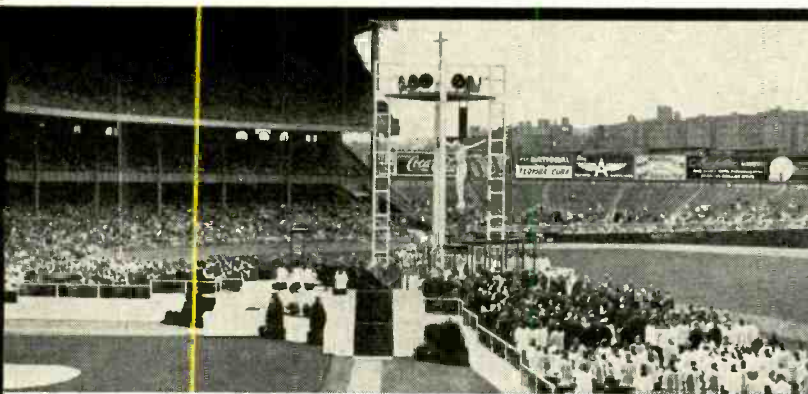

FOR UNUSUAL STADIUM FUNCTION The vast expanses of Yankee Stadium were converted to an open-air cathedral for the mass offered by Francis Cardinal Spellman, R.C. Archbishop of New York, to mark his 25th Anniversary as Bishop.

"The Yankee Stadium is well-known for its acoustic difficulties. The specific problem for this special event was to cover hundreds of thousands of square feet with true high fidelity reproduction of voice, organ and choir without reverberation and echo effects. With a single group of University speakers mounted over the altar, we were able to 'saturate' the stadium with highest quality sound that the N.Y. Times called 'cathedral-like' in its front page story. What's more, the high efficiency and distortion-free characteristics of the speakers enabled us to use remarkably low amplifier power."

Edward P. Casey, *President*
Edward P. Casey Sound Systems, Inc., New York

FOR PROFESSIONAL RECORDING STUDIO The Crew Cuts, well-known recording artists, are shown monitoring playback of the master tape to check over-all quality and fidelity of a new recording made at Universal Recording Corporation (the world's largest independent recording studio for all the leading artists and labels).

"For many years, we have used various speaker systems in our control rooms and studios. Recently, we installed the University 'Classic.' According to Mr. Mason Coppinger, our chief engineer, the 'Classic' has not only met the rigid power requirements of studio monitoring, but gives us a realistic picture in terms of the final reproduced balance. The favorable reaction from our clients, artists and our engineers especially, is unanimous!"

M. T. Putnam, *President*
Universal Recording Corporation, Chicago

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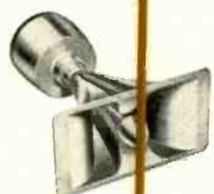
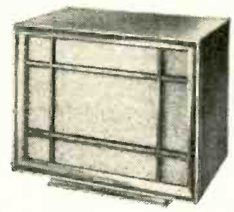


MID-RANGE

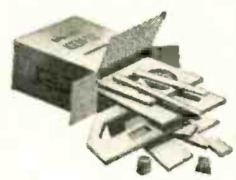
NETWORKS

DIFFAXIALS



SYSTEMS

ENCLOSURES



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officers installed were: Norm Telaak, J. Beitz, George Leffler, Joseph Adams, J. Opiela, Pat Pratt, Ralph D'Augustine, Nick Meltie and Edward Dannaher. NATESA president Russell Harmon administered the oath of office.

Among the out-of-town guests were Bert Bregenzer, Philadelphia, Pa., chairman of the Federation of TV and Radio Service Associations of Pennsylvania; Dan Hurley, Syracuse, president of ESFETA; Don Roberts, Syracuse, president of TESA-Syracuse and Middle Atlantic Governor of NATESA; Bert Lewis, Rochester, eastern vice president of NATESA; Malcom Nelson, president ETA, Jamestown, N. Y.; and Frank Kurkowski, president TESA-Mohawk Valley, Utica, N. Y.

RTA-SANTA CLARA NEWS

At a dinner and dance held at Mariani's Restaurant in Santa Clara, Calif., the Radio TV Association of Santa Clara Valley installed new officers.

Richard J. Kelso is the new president; W. I. Smith, vice president; Harold L. Kelley, Jr., secretary treasurer. Newly elected directors are: Quentin W. Muchow, James C. Davis, C. S. Dawson, Russell J. Ham, Jack Morrisroe and O. N. Timmons.

MIDWEST ELECTRONIC FORUM

A display of carefully planned educational exhibits and informative speakers made the second annual Midwest Electronic Forum, held at the Hotel Statler in Detroit, Mich., a success.

Keynote speaker was Edward Wimmer, vice president of the National Federation of Independent Business, who noted that independent businessmen will have to combine efforts to fight for their existence. He also suggested they brighten up their stores or shops with an eye to greater customer appeal.

William J. Nagey, general manager of Philco's accessory division, urged plus sales to increase profits. John Bennett, also of Philco presented a talk on Service Etiquette and stated that tools and appearance are great assets in building customer confidence.

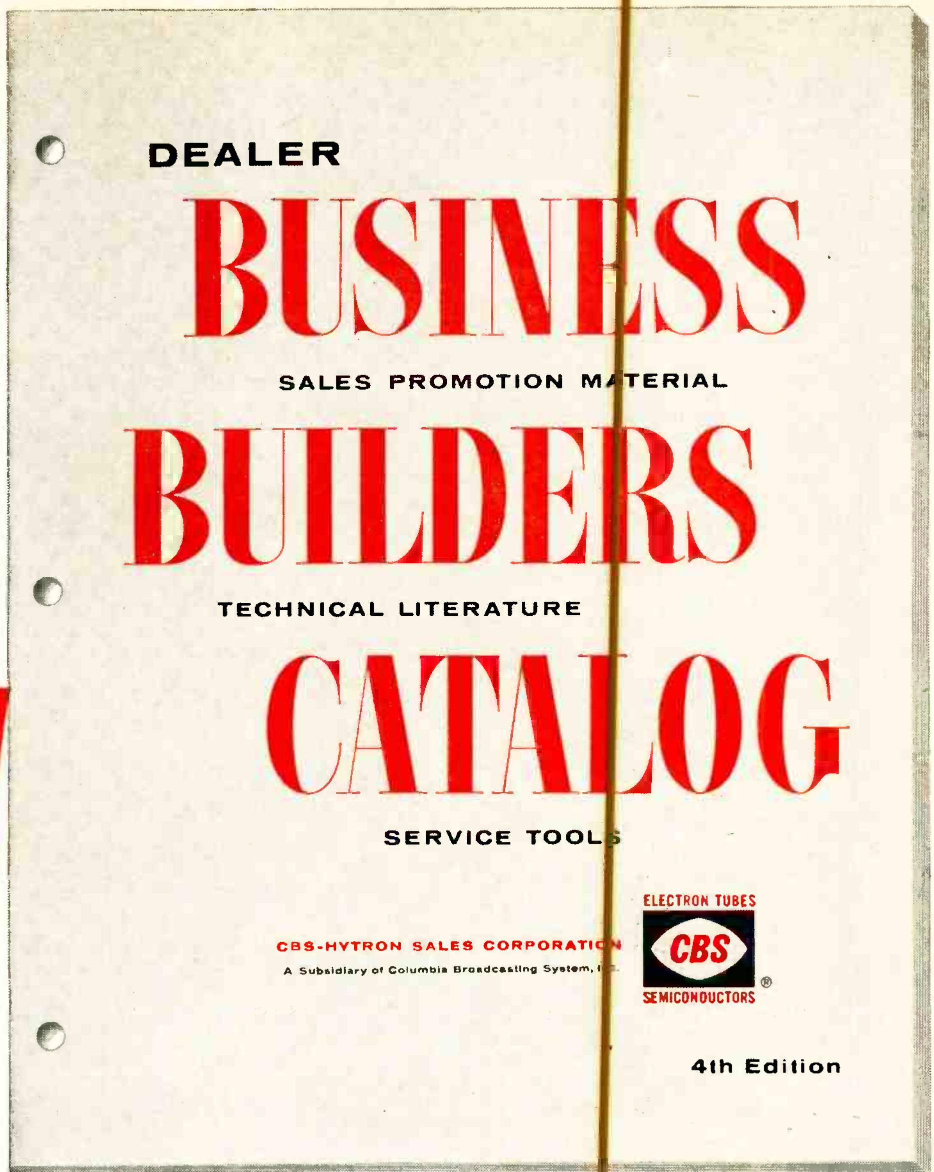
Stanly Bartlemen, a Zenith hi-fi specialist, spoke on demonstration selling of hi-fi. Stuart Greenly of Flint, Mich., told of his experiences in credit and collections.

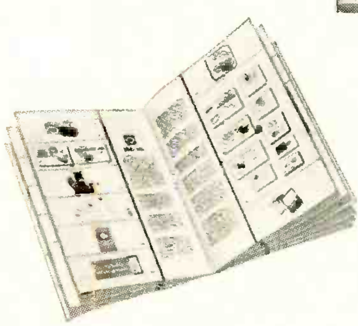
Others on the technical program included Robert G. Middleton of Radio Electronic Television Schools and John Meagher of RCA and Robert B. Tomer of CBS.

TESA-SC (Missouri) ELECTS

The Television & Electronics Service Association of south-central Missouri elected E. Cattoll of Cabool as its president for 1958. Other officers elected were James Rathbun of Sparta as vice president and Bill Pryer of Mountain Grove as secretary-treasurer of the group. END

NEW





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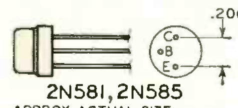
New Tubes & Semiconductors

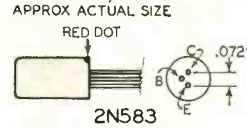
WARRANTING special attention this month is the MADT (*M*icro *A*lloy *D*iffused-base *T*ransistor). Three of these types are presented, and between them they have the unusual properties (for transistors) of acting as power oscillators at 100 and 200 mc, oscillating beyond 500 mc and providing 11 db of power gain at 100 mc. Some computer switching type transistors and plug-in silicon diodes also have their interesting points.

2N581, 2N583, 2N585

The 2N581 and 2N583 are germanium p-n-p alloy junction types while the 2N585 is a n-p-n type. All are specifically designed for use in medium-speed switching circuits. Max-



2N581, 2N585
APPROX ACTUAL SIZE



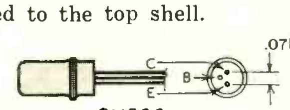
2N583
APPROX ACTUAL SIZE

imum tentative ratings of these RCA units are:

		2N581	2N583	2N585
V_{CB}		−18	−18	25
V_{CE}		−15	−15	24
V_{EB}		−10	−10	20
I_C (ma)		−100	−100	200
I_E (ma)		100	100	−200
P_c (mw)	(25°C)	80	80	120
	(55°C)	35	35	45
	(71°C)	10	10	10

2N500

A hermetically sealed germanium MADT field-flow transistor intended for use as a uhf power oscillator. A power output of over 20 mw at 200 mc and 40 mw at 100 mc can be expected. Polarities are similar to p-n-p junction transistors. For maximum performance the 2N500 should be attached to a heat sink such as a 2 x 2-inch copper fin clipped to the top shell.



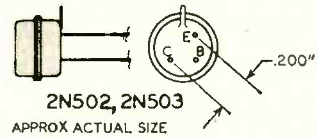
2N500
APPROX ACTUAL SIZE

Maximum ratings of the Philco 2N500 are:

V_{CB}	−20
V_{CE}	−15
V_{EB}	−0.5
P_c (mw) (25°C)	
in free air	75
with heat sink	100

2N502, 2N503

The 2N502 and 2N503 are hermetically sealed germanium MADT field-flow transistors. Their maximum ratings are identical to the 2N500 in all but collector dissipation. At 25° C the 2N502 and 2N503 have a collector dissipation of 60 mw.

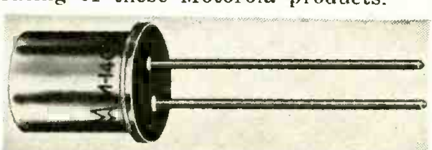


2N502, 2N503
APPROX ACTUAL SIZE

The 2N502 is designed for use as a vhf amplifier. Its maximum frequency of oscillation is over 500 mc and its power gain is at least 8 db at 200 mc. The 2N503 is designed for amplifier applications at frequencies up to 100 mc. Its gain at 100 mc is at least 11 db. Polarities of these Philco transistors are similar to those found in p-n-p junction transistors.

M14 SILICON RECTIFIERS

A series of medium-power rectifiers with a rectifying junction formed by diffusion. The case is selected to provide reliable, rugged units for use in both chassis and printed-circuit construction. This series is available with either the anode or cathode connected to the case. Units with the anode connected to the case are designated M14A and units with the cathode connected to the case are designated M14C. A numerical suffix indicates the peak inverse voltage rating of these Motorola products.



Peak inverse ratings are:

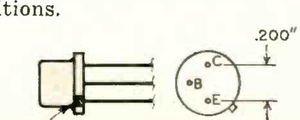
M14A1, M14C1—100 volts
M14A2, M14C2—200 volts
M14A3, M14C3—300 volts
M14A4, M14C4—400 volts
M14A5, M14C5—500 volts
M14A6, M14C6—600 volts

Other ratings that are identical for all units are:

Dc rectified current—0.5 amp
Surge current for 2-msec square wave —35 amps
Surge current, one-half 60-cycle sine wave—5 amps

2N460, 2N461

Intended for general purpose industrial applications, these are p-n-p alloy-function transistors. Effective hermetic sealing, close control of leakage current at high voltage and efficient thermal design (achieved in part by connecting the transistor base to the case) insure reliable operation at normally encountered environmental conditions.



2N460, 2N461
APPROX ACTUAL SIZE

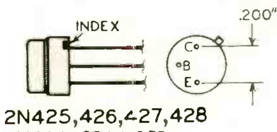
In a typical class-A audio amplifier circuit the only difference between these two units is in power gain. The 2N460 delivers 34 db while the 2N461 in the same circuit produces a 37 db power gain.

Other ratings of both Tung-Sol units are:

V_{CC}	−20
I_C (ma)	5
Frequency (test) (cycles)	1,000
R_L (ohms)	4,500
R_S (ohms)	500
P_C (mw)	40
Distortion (max) (%)	5

2N425, 426, 427, 428

These are p-n-p alloy-junction transistors designed for use in computer and switching applications. The transistors have very short "turn on" and "turn off" times. The case features a welded hermetic seal and a standard basing design.



2N425,426,427,428
APPROX ACTUAL SIZE

Maximum ratings of these Tung-Sol units at 25°C are:

	2N425	426	427	428
V_{CB}	−30	−30	−30	−30
V_{EB}	−20	−20	−20	−20
V_{CE}	−20	−18	−15	−12
I_C (dc) (ma)	−400	−400	−400	−400
I_C (peak) (amps)	−1	−1	−1	−1
Turn on time (μsec)	3	2	1.5	2.5
Turn off time (μsec)	2	1.5	1	1

END

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Short-Wave Craft	1930
Television News	1931

Some larger libraries still have copies of Modern Electrics on file for interested readers.

In May, 1908, *Modern Electrics*

A Silicon Detector, by A. C. Austin, Jr.
Wireless Telegraph Oddities, by Signor Marconi.
Construction of Wave Detectors.
The Dynamophone (voice-operated relay) by Hugo Gernsback.
Wireless Telephony, by Newell A. Thompson, Jr.
Wireless Around the World.
How to Remedy Troubles in Wireless Telegraph Instruments.

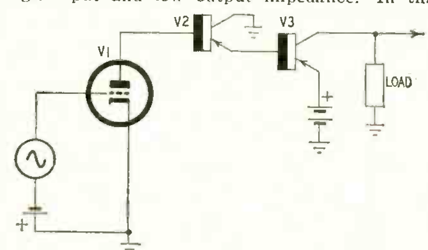
Patents

TUBE–TRANSISTOR AMPLIFIER

Patent No. 2,801,298

Roop Narayan Mital, Eindhoven, Netherlands (Assigned to North American Philips Co., Inc., New York, N. Y.)

One popular combination of transistors is that of a common collector followed by a common emitter. This combination results in good matching between stages so that transformers may be eliminated. Furthermore, it provides a relatively high input and low output impedance. In this



circuit the transistor pair is preceded by a tube amplifier. This gives good overall matching and, of course, very high voltage gain.

The big advantage of a tube input is its high input impedance, a value that cannot be approached by the usual transistor in any type of circuit.

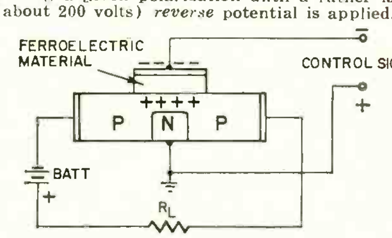
TRANSISTOR SWITCH

Patent No. 2,791,760

Ian M. Ross, New Providence, N. J. (Assigned to Bell Telephone Labs., Inc., New York, N. Y.

A specially prepared transistor becomes an efficient switch in this circuit. The body of the transistor is p-type, but there is a small n-conductive area. A battery connects across the ends of the p-type material. The battery circuit impedance remains low since there is no junction in its path.

Contacting the transistor is a ferroelectric capacitor. It has the unusual property of maintaining a given polarization until a rather large (about 200 volts) *reverse* potential is applied.



With a control signal or pulse connected with polarity shown, the bottom plate of the capacitor goes positive. Holes diffuse into the narrow channel above the n-area of the transistor. Thus the low impedance of the crystal remains. If the control signal were reversed, however (with sufficient amplitude), the ferroelectric polarization would also reverse. Now electrons would close the battery circuit above the n-area. The crystal impedance becomes very high due to the temporary n-p junction.

The device is an excellent memory unit as the capacitor's polarization is retained until a rather large reverse force is applied. Readout consists of simply testing the battery circuit for high or low impedance, so it does not weaken the polarization.

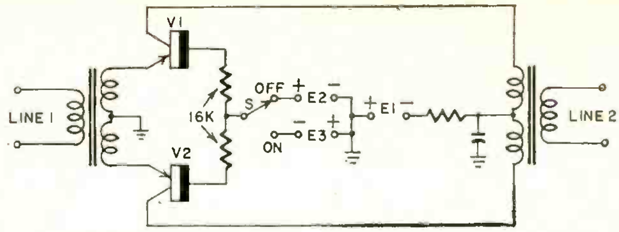
TRANSISTOR ATTENUATORS

Patent No. 2,816,238

George Elliott, Rochester, N. Y. (Assigned to General Dynamics Corp.)

Transistors are very efficient switches. They are excellent conductors when biased in the forward direction. Their resistance when blocked is high. Here a pair of transistors is used to pass or attenuate audio signals along telephone lines.

Both collectors return to the minus terminal of



E1. The emitters return through either E2 or E3 depending upon the position of switch S. When switched to E2, both emitters return to the minus terminal and are blocked. Thus no audio can flow through V1 or V2. When S is thrown to E3, positive bias permits conduction through V1 and V2.

Conventional p-n-p transistors conduct to some extent in either direction. For best results here, however, they should be processed for *bilateral* conduction.

DC TO AC CONVERTER

Patent No. 2,804,547

Harry T. Mortimer, Los Angeles, Calif. (May be used by the US Government without payment of royalty)

There are several ways of converting dc to ac. Among the most efficient circuits is a transistor oscillator that generates a square or pulse wave. In this converter (Fig. 1), the transformer core material has a rectangular hysteresis loop. As a result, the core can be saturated easily. Abrupt reversal of saturation (from one polarity to the other) provides maximum induced voltage with minimum power loss.

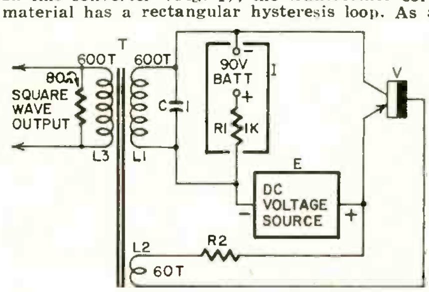


Fig.1

L1-C, the tuned circuit, is adjusted for a low audio frequency. L2 is the feedback coil. At some instant during a cycle, V conducts fully and becomes nearly a short circuit. This prevents flow from the constant-current source I through L1 At this time nearly the entire voltage E is available to saturate L1 with *positive* polarity. As V's conduction falls a smaller voltage is available from E across L1. Also, current from I now begins to flow and saturate L1 in a *negative* direction.

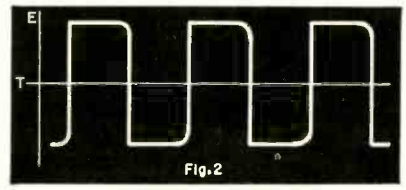


Fig.2

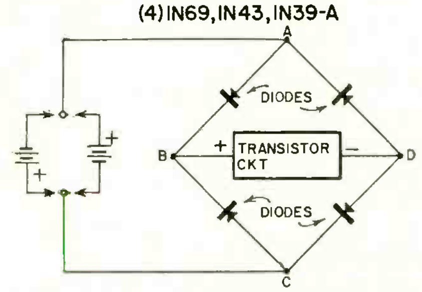
The hysteresis loop is such that magnetic switching is accomplished rapidly from one polarity to the other. Fig. 2 shows a typical waveform of the circuit's voltage output. END

radio-electronic Circuits

PROTECT YOUR TRANSISTORS

Most transistors and miniature electrolytics are highly sensitive to the wrong battery polarity. Few technicians or experimenters have escaped burning out at least one of these components by inserting a battery backward in some kind of transistor circuit. A foolproof protective circuit can be added, at small cost, to the transistor set which will guarantee the right polarity no matter how the battery is connected.

The protective circuit is a bridge rectifier type consisting of four germanium diodes, such as the 1N39-A, 1N43 or 1N69. Dc voltage from the battery is applied to the bridge circuit instead



of the usual ac, but the results are the same. The bridge allows current to flow only one way through the transistor circuit load. If the battery is reversed, the polarity across the load still remains the same.

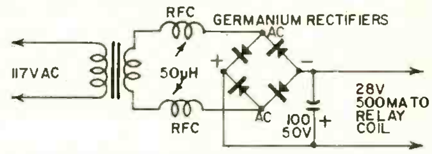
Construct the bridge shown in the schematic and connect the battery at points A and C. Using a voltmeter, measure the voltage and determine the polarity at B and D. Point B should be positive. Wire B and D permanently to the transistor circuit where the battery would normally go, with D to the negative connection and B to the positive. From then on, you can connect the battery to A and C without checking polarity or worrying about damaging the components.—*Dave Stone*

SEMICONDUCTOR RF NOISE

While cleaning some of the haywire out of my ARC-5 transmitter, I replaced my old selenium rectifier with four new, small-size germanium power diodes. This provided the 28 volts needed to operate the transmitter relays. The next time I turned on the equipment, I looked forward to an improved signal in keeping with the new neat arrangement. But the signal was worse. There was a good loud 50% modulation 60-cycle hum! After considerable musing, muttering and mumbling about leaving things alone once they're working, I began digging into my nice neat layout to chase the source of the 60 cycles.

As any of you fellows who are familiar with the ARC–5 transmitters know, the cathode and heater circuit of the oscillator are kept above rf ground. My first suspicion was a short in the coil or in one of its associated bypass capacitors, but no defect was found here or in any of the other logical sources in the oscillator, amplifier or modulator. Next, I thought that the common transformer for both the relay supply and the heaters was the cause, but a separate transformer for the relay supply did not eliminate the hum.

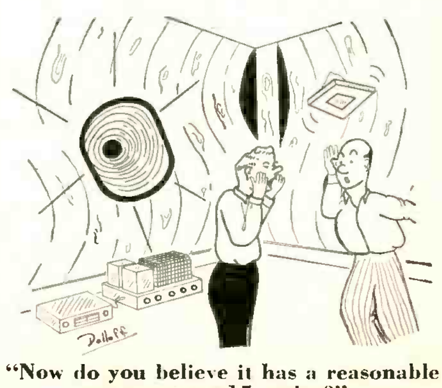
I noticed that the hum stopped when the transmitter relay was held manually closed. Further tests indicated that the hum originated in the germanium power rectifier and 100-μf filter circuit used to provide dc for the relays. The usual .001-μf bypass capacitors around the rectifiers to ground did not help. Two 50-μh chokes placed in the leads to the heater transformer did the trick (see diagram) and completely eliminated the trouble.



It seems that the very low forward resistance of the germanium rectifiers generated a very sharp current spike on each cycle. This showed up as a 60-cycle pulse which apparently modulated the oscillator circuit. Some TV germanium rectifier power supplies use a small bypass capacitor across the rectifier to eliminate a similar type of rf pulse. The higher-impedance 250-volt circuit used in the TV set may be the reason why the bypass worked in the TV circuit and not with 25-volt relay supply which I was using. A 50-ohm resistor would probably have eliminated the rf by rounding off the sharp spike. I did not use one because of the additional voltage drop it would cause.

In any event the point to remember is that these devices have good characteristics which may give trouble if not watched.—*Fred Lingel, K1CCW*.

END



"Now do you believe it has a reasonable response at 15 cycles?"

try This one

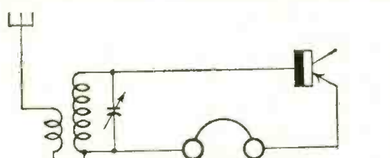
SOLDERING HINT

Here's a way to avoid overheating transistors or other delicate components while soldering. Fold a small piece of felt or cotton and dip it in a glass of water. Then, using an alligator clip to hold it in place, clip it to the lead between the component and the joint to be soldered. Due to the large amount of heat dissipated by the dampened cloth, this is better than holding the lead with pliers. It also leaves both hands free.—*Homer E. Hogue*

TRANSISTOR AS A DIODE

When no crystal diode is at hand for experiments, crystal radios, etc., a low-priced transistor will do the job. Don't throw away transistors which have been spoiled by incorrect battery polarity. Chances are, they can still be used as crystal diodes by using two of the three electrodes.

The diagram shows a 99-cent CK722 used as a crystal diode in a typical crystal radio. When using a CK722, best results were obtained by using



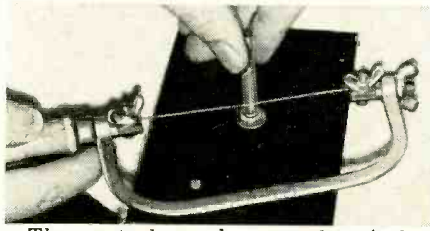
the base and emitter connections as shown. The emitter and collector connections also gave good results, but when base and collector connections were used, the sensitivity was poor. The interelectrode capacitance of a transistor is slightly higher than that of a crystal diode. When used as a diode, the transistor's sensitivity does not quite equal that of a 1N34, but it sure comes in handy in a pinch and the experiments should be interesting.—*Arthur Trauffer*

DETECTING MICROPHONIC TUBES

The usual method of locating a microphonic tube is to tap each in turn until a "boing" is heard in the speaker. However, some tubes are so microphonic that they sound off no matter what part of the chassis is tapped. One way of locating these tubes is to connect a voltmeter across the plate, screen or cathode resistor and then tap it. Microphonism is indicated when the meter flickers as the tube is tapped. When testing power output tubes, keep the volume turned down to eliminate the effects of microphonics in earlier stages. —*Charles Erwin Cohn*

JEWELER'S SAW CUTS CONTROL SHAFTS

The photo shows a jeweler's saw being used to cut a control shaft to length. The fine teeth of this saw make sharp, even cuts without binding and jamming to the extent experienced with a common hacksaw.



The control can be cut after it has been mounted without excessive vibration that might loosen the mounting nut. The subsequent hazard of moving the loose control and damaging wiring is also eliminated.

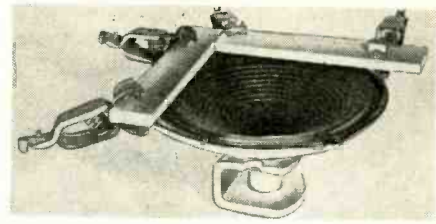
In sawing, hold one hand on the shaft as shown. This prevents any tendency toward binding.—*James A. McRoberts*

SOLDERING AID

We use modeling clay as a soldering aid in our shop. We shape it to hold small odd-shaped components and assemblies that cannot be clamped in a vise for soldering. This method of holding small parts has an added advantage. No outside metal contact dissipates the needed heat.—*Henry Josephs*

CLAMPS FROM BATTERY CLIPS

Thin strips of wood and large battery clips make excellent clamps when



recementing a speaker cone. If not enough clips are available to hold the entire cone, recement a half or a quarter section at a time.—*Carleton A. Phillips*

STOP THAT DRILL

When I accidentally drilled through a TV chassis and on into an electrolytic capacitor on the underside, I realized that one should always use a drill stop to restrict the travel of the drill. Looking around the shop I came up with some ideal drill stops—lengths of wire-insulating spaghetti.

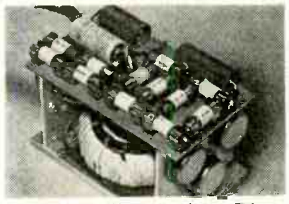
There are several sizes, so no matter what size drill you are using you can usually find a piece that makes a good snug fit. Since that little episode related above, I always use a length of spaghetti to stop the drill. It's considerably less expensive than a quad-section electrolytic.—*Scott Mack* END

new Devices

TRANSISTOR-LITE. Transistor-controlled neon lamp for use in computers, data processors, signal systems, keyboard equipment, and transistor automatic control devices. Housed in anodized aluminum tube 2 inches long. ½ inch in diameter. Requires 3.5-volt signal for control. *Echo-Lite*, pushbutton with NE-2 neon bulb enclosed.

Memo-Lite. subminiature thyratron indicator for transistor circuits.—**Transistor Electronics Co.**, 3357 Republic Ave., Minneapolis 26, Minn.

TRANSISTOR STATIC CONVERTERS. Transceiver and receiver supplies for 6- and 12-volt inputs. Typical transceiver, volts dc: 500 @ 165 ma; 270 @ 150 ma; −55 @ 10 ma. Receiver supply, 6-volt input; delivers 250 volts dc @ 80 ma or 290 @ 80 ma. 12-volt receiver supply delivers 250 volts dc @ 80 ma or 290 @ 80 ma or 250 @ 130

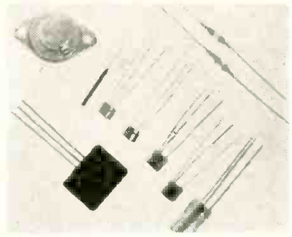


ma.—**UAC Electronics**, Div. of Universal Transistor Products Corp., 36 Sylvester St., Westbury, N. Y.

POWER MEGAPHONE, *Power Voice*. 6-transistor unit has 15-watt output. Powered by flashlight batteries. Range up to

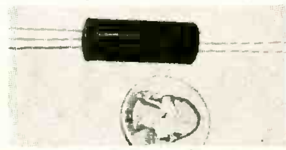
¾ mile. Weighs 8 pounds.—**Motorola Inc.**, Communications & Electronics Div., Technical Information Center, 4501 W. Augusta Blvd., Chicago 51, Ill.

SEMICONDUCTOR LINE. Power, small-signal, switching, special-purpose transistors; various types of crystal diodes



make up new *Gemco* line.—**Great Eastern Manufacturing Co.**, 165 Remson Ave., Brooklyn 12, N. Y.

SOLID-STATE CHOPPER, *model 50*. Encapsulated transistorized chopper or modulator alternately connects and dis-

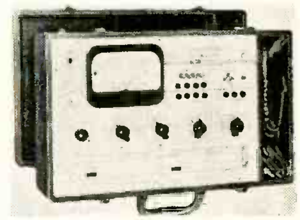


connects load from signal source. As demodulator, converts ac signal to dc. Driving voltage square wave—1–10 volts peak to peak. Driving source resistance. 600 ohms. Driving input resistance, 600 ohms. Input voltage, dynamic range from fraction of millivolt to more than 2 volts. Output voltage equals chopped input voltage. Chopping (driving) frequency dc–100 kc or higher.—**Solid State Electronics Co.**, 815[illegible] Orion Ave., Van Nuys, Calif.

DICTATING INSTRUMENT, *Audograph Key-Noter*. All-transistor unit works off 117-volt ac line only. Pushbutton operation. Record and playback. 6½ x 8½ x 2⅝ inches. 5 pounds 10 ounces.

Uses 20-minute disc. Embossing process. — **Gray Manufacturing Co.**, 20 Arbor St., Hartford, Conn.

TRANSISTOR TESTER, *model 960*. Portable unit tests for I_{CBO} gain, leakage, shorts of both p-n-p and n-p-n transistors. Checks low-, medium-, high-



power units. Test settings on roller chart.—**Precision Apparatus Co. Inc.**, 70-31 84th St., Glendale, N. Y.

TRANSISTOR CHECKER *conversion kit TCK-2*. Converts the Sencore TDC22 transistor checker to later type circuit used in

TRC4 tester which checks power transistors more thoroughly.—**Service Instruments Corp. (Sencore)**, 171 Official Rd., Addison, Ill.

POWER RESISTOR DECADE BOX, *model 240-C.* 6 resistance decades arranged to give any rating between 1 and 999,999

ohms in increments of 1 ohm. Maximum power capacity, 225 watts at 1,000 volts.—**Clarostat Manufacturing Co., Inc.,** Dover, N. H.

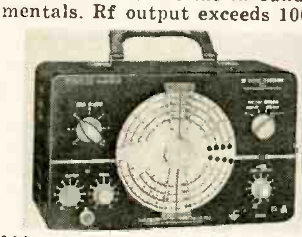
SUB CONNECTORS, *E-Z-Hook.* For substituting parts in circuit. Makes connections quickly,

positive contact. Hooks over wire and will not pull off.—**E-Z-Hook Test Products**, 1536 Woodburn, Covington, Ky.

TUBE TESTER, *model 500B Dyna-Quik.* Dynamic mutual-conductance type. Tests for shorts, grid emission, gas con-

tent, leakage and life expectancy.—**B & K Manufacturing Co.,** 3726 N. Southport Ave., Chicago 13, Ill.

RF SIGNAL GENERATOR KIT, *model G-30.* 8 bands cover 160 kc–240 mc. To 120 mc in fundamentals. Rf output exceeds 100,-

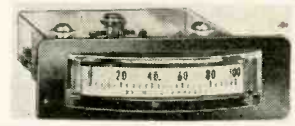


000 μv. 400-cycle audio output approximately 15 volts.—**Paco Electronics Co.,** Div. Precision Apparatus Co., Inc., 70-31 84th St., Glendale, Calif.

AC VTVM, *model WV-74A.* Measures ac voltages from .01 to 100. Decibels from −40 to +40. Also useful as wide-range audio preamplifier with approximately 38-db maximum gain.

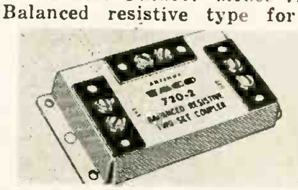
Frequency range on all measurement and amplifier functions is from 20–500,000 cycles. —RCA Electron Tube Division, Harrison, N. J.

EDGEWISE PANEL METERS. *Model 1502.* Dc voltmeters: 0–50, 0–150, 0–500. Dc ammeters: 0–5, 0–10. Dc milliammeters: 0–1, 0–10, 0–100, 0–500. Dc. microammeters: 0–50, 0–100. Accurate within 2% of full-scale deflection. *Model 1507* includes



VU meters and rectifier type ac voltmeters. — **Simpson Electric Co.,** 5200-18 W. Kinzie St., Chicago 44, Ill.

MULTISET COUPLERS. *Indoor model 720. Outdoor model 725.* Balanced resistive type for 2



TV receivers. Provide up to 25-db isolation between sets.—**Technical Appliance Corp.,** Sherburne, N. Y.

SCREW DRIVERS, *Red Cap* line. 7 models: *RC-1,* No. 1 Phillips, 3-inch blade. *RC-2,* No. 2 Phillips, 4-inch blade. *RC3,* 3/16

x 4-inch blade. *RC-5,* 3/16 x 5-inch blade. *RC-6,* ¼ x 4-inch blade. *RC-8,* ¼ x 6-inch blade. *RC-10,* 5/16 x 6-inch blade.—**Vaco Products Co.,** 317 E. Ontario St., Chicago 11, Ill.

UHF CONVERTER, *model BTU-2R Ultraverter.* Adds uhf chan-

nels 14–83 to standard vhf receivers. Uses 2 tubes, matches 300-ohm line.—**Blonder-Tongue Laboratories Inc.,** 9 Alling St., Newark 2, N. J.

LONG-NOSE PLIERS, shockproof. Made of high-impact plastic. Designed for high-voltage work. — **General Cement**

Manufacturing Co., Div. of Textron Inc., 400 S. Wyman St., Rockford, Ill.

INSULATION SPRAY, *No-*

Noise Rubber Coat Spray. Prevents arcing, shorting, corrosion due to moisture. Nonflammable and contains no plastic.—**Electronic Chemical Corp.**, 813 Communipaw Ave., Jersey City, N. J.

STEREO PHONO CARTRIDGE, for 45-45 stereo disc reproduction. Electrodynamic type uses twin D'Arsonval movements. Response from 20 to beyond 18.000 cycles. Output impedance

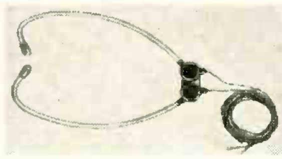
20 ohms at 1 kc. Crosstalk ratio 20 db. Output voltage 2 mv at 10 cm/sec. Fits standard arms.—**Electro-Sonic Laboratries Inc.**, 35-54 36th St., Long Island City 6, N. Y.

STEREO CARTRIDGE, *Ceramelex.* Single ceramic element. Frequency range from 50—15,000 cycles ±5 db into 3-megohm load. Typical channel separation 20 db. Output voltage at 1,000 cycles is 0.5 minimum. 6–8 grams tracking force.—**Erie Resistor Corp.**, Electronics Div., 644 W. 12 St., Erie, Pa.

CERAMIC CARTRIDGE, *Series 7.* Model *7T-S:* dual sapphire turnover unit. Model *7T-D:* a dual diamond model. Response flat within 2 db from 20–12,000 cycles plus smooth rolloff up to

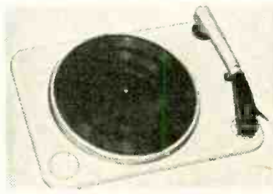
20,000 cycles.—**Sonotone Corp.**, Elmsford, N. Y.

BINAURAL HEADPHONES, *Model MS-431*, 6 ohms impedance, magentic. *Model MS-432*, 5,000 ohms. magnetic. *MS-433*, 100,000 ohms, crystal. Response 40–16,000 cycles. — **Lafayette**



Radio, 165-08 Liberty Ave., Jamaica 33, N. Y.

HI-FI RECORD PLAYER, *Model B-21.* 4 speeds, each may be varied within 5% range. 4-pole

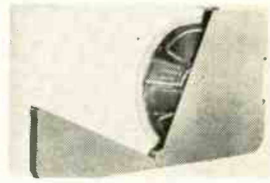


motor. Plug-in head. Turntable covered with serrated rubber pad.—**David Bogen Co.**, Div. of Siegler Corp., P. O. Box 500, Paramus, N. J.

4-SPEED RECORD CHANGER, *Garrard model RC121/II.* Plays as either an automatic-intermix changer or single-play unit with pickup arm completely free. 4-pole induction surge motor with dynamically balanced rotor. Turret drive. Cast-aluminum pickup arm with removable

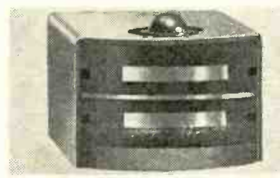
head. Stylus pressure and height adjustments. — **Garrard Sales Corp.**, 80 Shore Rd., Port Washington, N. Y.

DOUBLE-PLAY TAPE, *Sonoramic.* Uses DuPont Tensilized



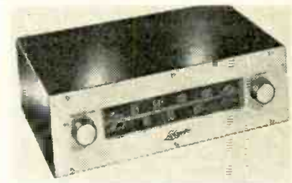
Double-Play Mylar as base. Comes in 2,400-foot 7-inch reels. —**Ferrodynamics Corp.**, Lodi, N. J.

4-CHANNEL TAPE HEAD,



model TR-48. Record–playback type. Has 2 tracks, each .031 inch wide and 0.119 inch apart. Permits recording or playback of 4 channels on one ¼-inch tape.—**Shure Brothers Inc.**, 222 Hartrey Ave., Evanston, Ill.

FM TUNER, *model LT-70.* Sensitivity 4 μv for 20-db quieting. Less than 1% distortion. Response 20–20,000 cycles within 1 db. Multiplex and tape recorder outputs as well as usual



audio output.—**Lafayette Radio**, 165-08 Liberty Ave., Jamaica 33, N. Y.

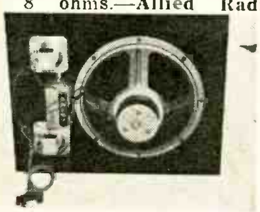
FM–AM TUNER–PREAMPLIFIER, *Knight KN-200.* Tuner section provides 3.5-μv sensitivity for 20-db quieting on FM and 10 μv for 20-db signal-to-noise ratio on AM. Tuner section has afc and EM 81 indicator tube.

Preamp has scratch filter, rumble filter; volume, loudness, bass, treble controls. Separate rolloff and turnover controls provide 12 record compensation positions. Inputs for magnetic and ceramic cartridges, mike, tape recorder, tape head or crystal phono. Two outputs—for amplifier and tape recorder.—**Allied Radio Corp.**, 100 N. Western Ave., Chicago 80, Ill.

STEREO PREAMP and control amplifier, *model SM-244*. 28 watts peak each channel, 14 watts rms continuous each channel. Harmonic distortion less than 1%. IM distortion less than 1.5% at full output. Hum and

noise 80 db below full output. Frequency response within 1 db from 20–20,000 cycles. Output impedances, 4, 8 or 16 ohms. Tape output, 500 ohms. Inputs for phono, tape head, mike, radio and auxiliary.—**Pilot Radio Corp.**, 37-06 36th St., Long Island City 1, N. Y.

HI-FI SPEAKER SYSTEM, *model W*. 12-inch woofer, two 3½-inch cone type tweeters with crossover network cover 40–15,000 cycles. Handles 24 watts. Fully wired, mounted on 16 x 20-inch plywood board. Impedance 8 ohms.—**Allied Radio Corp.**, 100 N. Western Ave., Chicago 80, Ill.



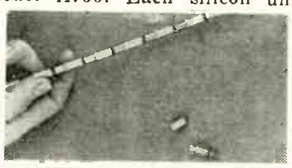
CERAMIC CAPACITORS, *Ultra-Kaps*. For transistor circuit applications. 0.22, 0.47, 1.0

and 2.2 μf. All rated at 3 volts dc. Size ranges from ¼–¾ inch diameter.—**Centralab**, Div. of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

TANTALUM SLUG CAPACITORS. Miniature units 15/32 inch long and 7/32 inch in

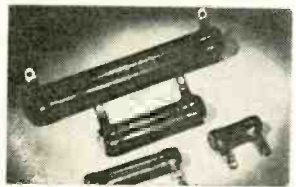
diameter. Range from 30 μf at 6 volts to 1.75 μf at 125 volts. Operate between −55 and 100°C without derating.—**Pyramid Research & Development Dept.**, Pyramid Electric Co., 1445 Hudson Blvd., N. Bergen, N. J.

EXPANDABLE RECTIFIER, *model A750*. Each silicon unit



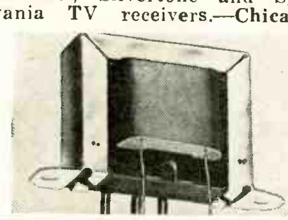
1-inch long and rated at 400 volts inverse with maximum forward current rating of 750 ma. Threaded on each end, units screw together to form high-voltage series chain. Also in units rated up to 5 amps.—**Audio Devices Inc.**, 620 E. Dyer Rd., Santa Ana, Calif.

VITREOUS-ENAMEL RESISTORS, *Greenohm V line*. Fixed and variable types. 5–200-watt ratings, resistance values 1–

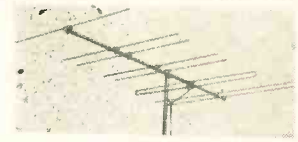


900,000 ohms, tolerances of ±5% for 50 ohms and up or ±10% for 49.9 ohms and under.—**Clarostat Manufacturing Co., Inc.**, Dover, N. H.

REPLACEMENT TRANSFORMER, *Stancor model VBO-201*. Replaces vertical blocking oscillator transformer used in models of Airline, Crosley, Hallicrafters, Hoffman, Hyde Park, Motorola, Sentinel, Silvertone and Sylvania TV receivers.—**Chicago Standard Transformer Corp.**, 3501 Addison St., Chicago 18, Ill.

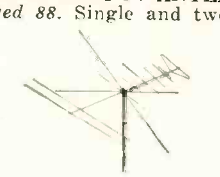


FM RADIO ANTENNAS, *model FMY-8* (illustrated). High gain, 8-element directional Yagi. Flat response over FM band with 10.2-db gain. *Model FM3A*: an-



tenna, mast, roof mount, fasteners, lead-in and set clip. Nondirectional. Preassembled.—**Winegard Co.**, 3000 Scotten Blvd., Burlington, Iowa.

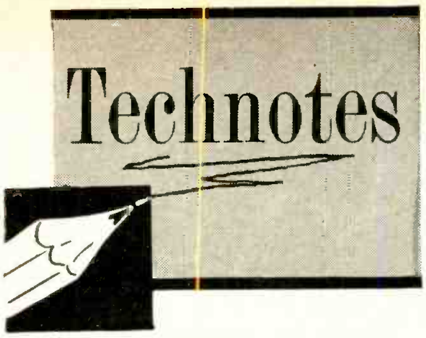
CONICAL-YAGI TV ANTENNA, *Winged 88*. Single and two-bay



models. Improved version of the *Sharpshooter 88*.—**Trio Manufacturing Co.**, Griggsville, Ill.

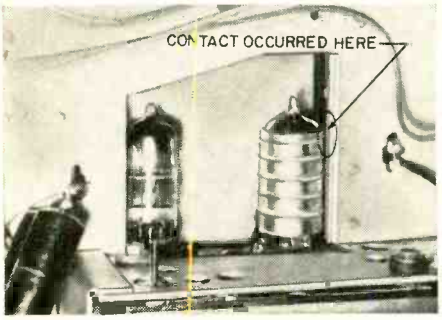
AUTO RADIO ANTENNA, *model JA-7 Bullet*. Chrome, die-cast swivels for vertical or 45°, angle mounting. 3-section telescoping mast extends to 57 inches.—**Tenna Manufacturing Co.**, 7580 Garfield Blvd., Cleveland 25, Ohio. END

All specifications given on these pages are from manufacturers' data.



MICROPHONIC JITTER

The photo illustrates an intermittent contact of a tube shield (over an oscillator tube) in a TV tuner. Jarring would cause the shield to contact the chassis, forming a new (and unwelcome) addition to the tuned-circuit



parameters of the local oscillator. The speaker vibrated the chassis, varying the fine tuning and detuning the set!

The remedy was simply to bend the chassis shield so that the tube shield would not contact it.—*James A. McRoberts*

RCA 21CS7815

We were called out to answer a complaint on wrong colors. Preliminary checks showed that both Y and chroma signals were coming through at satisfactory levels. However, color sync was uncertain, particularly at the counterclockwise end of the hue control, and no adjustment of the hue control would produce the proper sequence of colors.

Changing tubes in the chroma section had no effect on the picture, except to shift the range of the hue control. The maximum shift obtained by changing tubes still did not bring the range to normal.

Because of the uncertain color sync, we then assumed that the burst amplifier might have drifted in its tuning, so that the burst was being attenuated and shifted in phase.

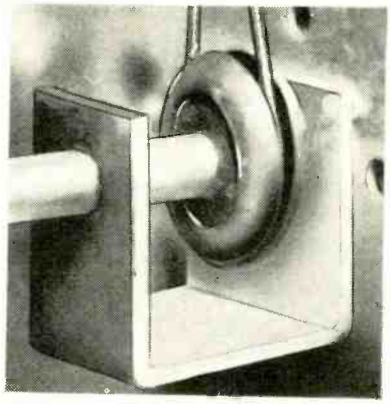
Noting carefully where the slug in the burst amplifier was set, we made a trial turn and lost color sync completely. Then we tried a turn in the opposite direction—the color dropped into tight lock and the correct color sequence was displayed at the center position of the hue control. Now the hue control could be turned through its complete range without loss of color sync.—*Robert G. Middleton*

SLOW TUNING

"It just won't select stations fast enough" was the complaint as the lady customer set the ivory table model down on the counter. "Isn't there something you can do about it?" she asked.

"Yes, ma'am, there sure is," I replied. "Come back in about a half hour and I'll have it fixed."

I expected the set to have a slipped dial cord but it didn't. It did, however, take more than a couple dozen turns to tune from one end of the dial to the other. I knew then that I would have to step up the ratio of the tuning shaft. I did this by slipping two tight-fitting rubber grommets over the shaft—one cemented inside the other. I then restrung the dial cord as shown in the photo.

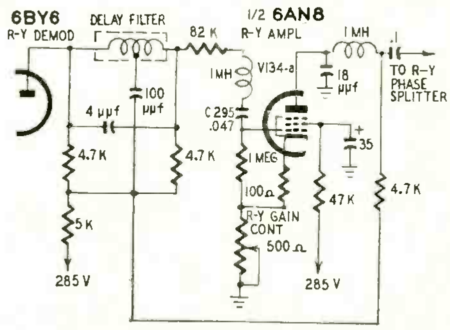


When Mrs. Housewife came to pick up the set, I had her try the dial. "It works fine now," she said. "You see, the reason it bothered me so much, I listen to a program at 650 on the dial and, right after it is over, Elvis Presley comes on at 1420. He's usually halfway through 'Don't Be Cruel' before I can turn from one end of the dial to the other."

The moral to the story?—Don't be cruel to housewives.—*John A. Comstock*

NO RED

Complaint: "Something wrong with the color." No red could be seen on the screen. After trying the usual tubes we pulled the chassis, an RCA CTC3. Circuit checks revealed loss of the R – Y signal. Voltage readings in the R – Y circuit disclosed a high voltage



on the grid of V134-a, the R – Y amplifier. Further checks showed that coupling capacitor C295 had shorted, allowing B-plus voltage to appear at the grid, paralyzing the R – Y amplifier. Capacitor and tube were replaced, set returned and everyone was satisfied.
—*B. Lawrence* END

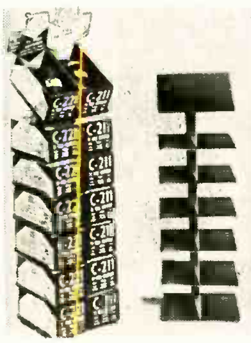
Business and People

Tobe-Deutschmann Corp., Distributor Div., Indianapolis, Ind., is promoting its service capacitors with a contest for service technicians. A Ford Ranch Wagon is the grand prize. Contest closes May 31.

CBS-Hytron, Danvers, Mass., is offering service technicians a series of

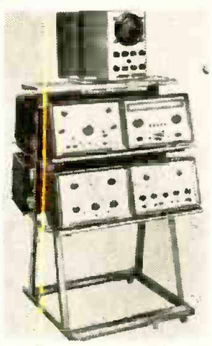
four new signs, including indoor clock, outdoor, flange and electric clock signs.

Perma-Power Co., Chicago, designed a new display rack to push sales of its



Tube Briteners and color TV service aids.

RCA Electron Tube Div., Harrison, N. J., introduced two new service-shop aids to service technicians as a bonus for purchases of RCA test equipment.



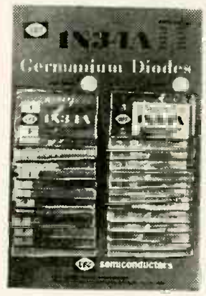
The Swivel-Scope provides a rotating base for the oscilloscope and the Porta-Rack will accommodate TV alignment equipment.

ORRadio Industries, Opelika, Ala., opened its new plant late in March. Sen. John Sparkman made the key address and many prominent guests including Peter L. Jensen watched a demonstration of the new Ampex TV video tape recorder.

Capitol Radio Engineering Institute,

Washington, D. C., established an advanced home-study course in nuclear engineering technology. It will be made available this fall by CREI Atomics, Inc., a newly formed subsidiary.

CBS Tube Div., Danvers, Mass., has expanded its display packaging program for germanium diodes with a new dispenser card for its popular 1N34-A. It lists the types the 1N34-A replaces.



Heath Co., Benton Harbor, Mich., moved to a new and greatly enlarged plant in the same city. The entire manufacturing operation, formerly in seven buildings, has been consolidated under one roof.

Merit Coil & Transformer Corp. got operations under way at its new plant in Merit Plaza, Hollywood, Fla., a full 2 weeks ahead of schedule. The company will continue to maintain regional offices in Chicago as well as headquarters in Florida.

Astron Corp., East Newark, N. J., increased its West Coast warehouse facilities managed by I. R. Stern & Co., Burbank, Calif.

Sylvania Electric Products switched its special tube operations headquarters from Woburn, Mass., to Williamsport, Pa.

David R. Hull, vice president and general manager of Raytheon's equipment operations, Waltham, Mass., was advanced to vice president for defense programs.

Donald W. Gunn, general sales manager of the Sylvania Electronic Tubes Div. since 1953, was appointed vice president—sales for the division. He will continue to maintain headquarters in New York. **W. Herbert Lamb** (left) and **Walter A. Weiss**, were appointed vice presidents for television picture tubes and radio tubes, respectively, for the Electronic Tubes Div. Lamb, who had been general manager of the TV Picture Tube Div.

in Seneca Falls, N. Y., will maintain his headquarters there. Weiss will remain at Emporium, Pa., where he had held the position of manager of the radio tube plant.

W. J. Zaun (left), former manager of quality control, was promoted to the


newly created position of manager–operations, Government service for the RCA Service Co., Camden, N. J. **T. Y. Flythe**, former administrator of technical products field quality succeeds him.

Arch Warden was elected a vice president of Xcelite Inc., Orchard Park, N. Y., manufacturer of hand tools. He will continue as sales manager. **A. J.**


(Arlie) Holmes, who joined the company last year, was named assistant sales manager.

Everett Leedom rejoined Electro-Voice, Inc., Buchanan, Mich., as advertising manager, a position he held previously for 2½ years. **Jay Carver,** whom he suceeds, becomes manager of the Wood Products Div. of Electro-Voice.

Edward H. Heller (left), prominent investment banker, and **Jan Oostermeyer,** former Shell Chemical Corp.


president, were elected to the board of directors of Siegler Corp., parent company of David Bogen Corp., Presto Recording Corp. as well as Olympic Radio & TV.

Henry G. Sellers, Jr., joined ORRadio Industries, Opelika, Ala., as assistant director of research. A chemist, he comes to the company from Newport Industries.

Robert G. Dailey, former vice president–sales, of Vokar Corp., Dexter, Mich., acquired full control of the company and moved its headquarters to Chelsea, Mich. END

technical Literature

Any or all of these catalogs, bulletins, or periodicals are available to you on request direct to the manufacturers, whose addresses are listed at the end of each item. Use your letterhead—do not use postcards. To facilitate identification, mention the issue and page of RADIO-ELECTRONICS on which the item appears. UNLESS OTHERWISE STATED, ALL ITEMS ARE GRATIS. ALL LITERATURE OFFERS ARE VOID AFTER SIX MONTHS.

PHYSICS AS A CAREER is a 16-page illustrated booklet describing what physics is and what the opportunities for new physicists are. Among the topics discussed are: physics—the science; physicists in industry and the training of the physicist.—**American Institute of Physics,** 335 E. 45 St., New York 17, N. Y.

ELECTRONICS COURSES, intended for home study, are offered in a 4-page bulletin. Radio, television and electronics are covered by the group.—**Supreme Publications,** 1760 Balsam Rd., Highland Park, Ill.

1958 STEREO TAPE CATALOG contains over 90 stereo titles in its 28 pages. The fields of classical, semiclassical, jazz, popular and folk music are represented. Also included are 150 monaural tapes. Stereo listings include all artists and selections on the tape. Individual sections are devoted to tape accessories and sampler and test tapes.—**Livingston Audio Products Corp.,** Box 202, Caldwell, N. J.

TAPE IT OFF THE AIR is a how-to-do-it pamphlet which aids you in making quality recordings of radio programs. Hints on how to set the correct volume level and where to hook up your tape recorder to a radio or TV set are also included. — **ORRadio Industries Inc.,** Shamrock Circle, Opelika, Ala.

HIGH-FIDELITY EQUIPMENT is described in several brochures and specification sheets announced by this firm.

The brochures: *EP-257*, a 3-color 10-section folder, with brief descriptions of hi-fi components and suggested home applications; *EP-243*, 12-page color booklet on diamond styli.

The specification sheets, all 4-page 4-color: *EP-235*, VR-II 4-gram cartridge and styli; *EP-234*, tone arms and replacement styli; *EP-237*, amplifier and preamps; *EP-238*, 12-inch wide-range speakers; *EP-233*, coaxial speakers; *EP-232*, woofers and tweeter, audio crossover network; *EP-239*, cabinets and enclosures.—**General Electric Hi-Fi,** Box 101, Liverpool, N. Y.

SYNTHETIC SAPPHIRE phono styli and an all-purpose dynamic microphone are described in catalog sheet *ASC-200*. The styli are intended for replacement and new equipment applications.—**Argonne Electronics Mfg. Corp.**, 165-11 South Rd., Jamaica 33, N. Y.

FLYBACK AND YOKE replacements are presented on a hardy wall chart, listing Stancor exact-replacement parts. The chart, printed on index cardboard, lists each TV set manufacturer alphabetically. All units for which there is an exact replacement are listed in numerical order by the manufacturer's part number.—**Chicago Standard Transformer Corp.**, 3501 W. Addison St., Chicago 18, Ill.

TWO-WAY RADIO and how it can save time and money for a service organization is the subject of an illustrated brochure *How Service Organizations Increase Efficiency With 2-way Radio*. Examples of how radio systems are used in auto emergency, ambulance, refrigeration repair, local delivery and other services are given.—**RCA**, Communications Equipment, Camden, N. J.

RADIO-PHONOGRAPH CATALOG contains complete information about this firm's 1958 line of high-fidelity consoles. A description of all models, including finishes and outstanding features, is offered.—**Fisher Radio Corp.**, 21-21 44th Dr., Long Island City 1, N. Y.

TANTALUM ELECTROLYTICS are detailed in a 4-page folder. Characteristics of a full line of these units are presented along with a brief description of the theory behind them—**Texas Instruments Inc.**, Semiconductor Components Div., P. O. Box 312, Dallas, Tex.

TRANSFORMER CATALOG TR-58 describes and illustrates hundreds of transformers. Toroid, pulse, transistor, hermetically sealed, geophysical, power, heater and audio transformers, chokes and television components are among the listings.—**Triad Transformer Corp.**, 4055 Redwood Ave., Venice, Calif. END

CORRECTIONS

In "Master Control Unit for Audio Tests" by Dr. L. B. Hedge, which appeared on page 54 of the March 1958 issue, reference 5 was omitted from the list at the end of the article. This should have read: L. B. Hedge, "The Long-Tailed Cascode Pair," RADIO-ELECTRONICS, October, 1956.

Mr. Wayne Lemons calls our attention to an error in his article "Taming The Horizontal Oscillator" which appeared in the April 1958 issue. The series resistor, from plate to ringing coil, should be 5.6K instead of 56K. Therefore the paragraph concerning R4 which states, "Temporarily shunt R4 with a resistor that will bring its value down to about 10,000 ohms" is also incorrect. In reality the technician will have to *increase* R4's value to 10,000 ohms by adding a series resistor.

Books

TV AND RADIO TUBE TROUBLES, by Sol Heller. Gernsback Library, Inc., 154 W. 14 St., New York 11, N. Y. 5½ x 8½ inches, 224 pages. $2.90.

It's strange nobody thought of it before, but here at last is a book on tubes and the troubles they cause. Tubes are responsible for most service calls. Furthermore, the picture tube needs special handling and adjustments. A tester does not completely solve the tube problem, because of its limited scope.

Logically, the book begins with safety: the proper handling of a picture tube and how to minimize danger of implosion, burn, shock, X-rays. There are six chapters on common and uncommon TV defects where tubes play a leading role. Eliminating corona and arcing, adjusting a yoke, ion trap, pincushion magnet, are some nontube, but associated, problems also discussed. A separate chapter covers radio tube troubles, and the final one deals with tube replacement.

The book contains a wealth of timesaving information for people who are looking for trouble—in radios and TV receivers.—*IQ*

WIRELESS SERVICING MANUAL, 9th Edition, by W. T. Cocking. Wireless World by Iliffe & Sons Ltd., Dorset House, Stanford Street, London S.E. 1, England. 5¾ x 8¾ inches, 268 pages, 17s. 6d.

This is the latest version of a British radio servicing text that first appeared in 1936. Completely revised to take into account all the latest developments, it presents useful techniques of testing and repairing radio receivers. It is written with a definite British slant and such terms as h.t. are used instead of high voltage, a feature which makes reading a little difficult at first.—*LS*

HOW TO READ SCHEMATIC DIAGRAMS, by David Mark. John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 5½ x 8½ inches, 147 pages. $3.50.

A pictorial diagram or parts layout can help when it is desirable to change tubes or resolder broken leads and can guide the nontechnical constructor in assembling very simple equipment. For major radio repairs, construction or study, nothing takes the place of a schematic. It conveys full technical information, is easiest to interpret and, therefore, the most common type of circuit representation. However, some knowledge of basic theory is required to get maximum benefit from a schematic. This book shows how to read wiring, pictorial and block diagrams as well as schematics. Along with the schematics the reader finds a simple discussion of the function of circuits and parts.

The author covers power supplies, amplifiers, oscillators, etc. By learning about these circuits and parts *separately*, the reader is soon able to identify them when combined in a complete schematic. The book is suitable for beginners who wish to learn the elements of radio, or workers in other fields who need to repair or adjust electronic instruments from time to time.

IDEAS, INVENTIONS, AND PATENTS, by Robert A. Buckles. John Wiley & Sons Inc., 440 4th Ave.. New York 16, N. Y. 9 x 6 inches, 270 pages. $5.95.

Have you built that better mousetrap? Perhaps it came in the form of a new video amplifier circuit or maybe you've come up with a new type of semiconductor. If you have and are thinking of taking out a patent on your new idea, this book should make interesting reading. In simple, nonlegal language you learn who is entitled to receive a patent, what happens in the patent office, what to do with the issued patent, and about designs, copyrights and trademarks. All in all, a detailed study of how to protect your invention.

ACOUSTICS, by Joseph L. Hunter. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y. 5¾ x 9 inches. 407 pages. $8.50.

Modern hi-fi and public-address setups utilize principles of acoustics and electronics. This book discusses the theory and practice of acoustics. Problems are given, and many worked-out examples appear. The book presupposes knowledge of physics and math to calculus.

The first half discusses theory, including vibrating strings, oscillators and waves. Chapters on applications with speakers, microphones, recording and room acoustics as well as ultrasonics and underwater sound follow.

FREQUENCY MODULATION ENGINEERING, by Christopher E. Tibbs and G. G. Johnstone. John Wiley & Sons, 440 4th Ave., New York, N. Y. 435 pages, 5½ x 8½ inches, $8.50.

This is a revised edition that speaks of receivers, transmitters, propagation, aerials and measurements. The author uses vectors, calculus and theory, but the practical side is not neglected. The book shows and describes modern commercial equipment and results of field tests. It is well illustrated with charts and circuit diagrams. References are made to both British and American works on the subject.—*RF* END

SCHOOL DIRECTORY

ADVERTISING INDEX

Radio-Electronics does not assume responsibility for any errors appearing in the index below.

SCHOOL DIRECTORY PAGE 148

BRANCH ADVERTISING OFFICES: Chicago: 600 Waukegan Road, Glenview, Ill., GLenview 4-6900. **Los Angeles:** Ralph W. Harker and Associates, 600 South New Hampshire. Tel. DUnkirk 7-2328. **San Francisco:** Ralph W. Harker and Associates, 444 Market St. Tel. GArfield 1-2481.
FOREIGN AGENTS: Great Britain: Atlas Publishing and Distributing Co., Ltd., 18 Bride Lane, London E.C. 4. **Australia:** McGill's Agency, Melbourne. **France:** Brentano's, Paris 2e. **Belgium:** Agence et Messageries de la Presse, Brussels. **Holland:** Trilectron, Heemstede. **Greece:** International Book & News Agency, Athens. **So. Africa:** Central News Agency, Ltd., Johannesburg, Capetown, Durban, Natal: Universal Book Agency, Johannesburg. **India:** Broadway News Centre, Dadar, Bombay #14. **Pakistan:** Paradise Book Stall, Karachi 3.

Lafayette Leaders In The Field of Transistors

Joins In The Tenth Anniversary Salute To The Transistor

NEW! 6 TRANSISTOR SUPERHET RECEIVER with LATEST NPN-PNP TRANSISTORS

- GE 2N188A AUDIO OUTPUT TRANSISTORS
- 100% SUBMINIATURE PARTS — NO COMPROMISES!
- CLASS B PUSH-PULL AMPLIFICATION-PLENTY OF POWER.
- FOR GROUP AND PRIVATE LISTENING
- LABORATORY DESIGNED — SENSITIVE, SELECTIVE, STABLE!

Superb Performance! Incomparable Value!

Transistor-wise Lafayette proudly presents its newly revised 6 Transistor Superhet Receiver Kit KT-119A. This improved model uses the latest GE NPN-PNP Transistors in an ingeniously engineered, laboratory tested circuit providing superb performance and an amazing superior commercial quality. The circuit features a specially matched set of 3 IF transformers, Oscillator Coil, High-Q Loop, Class B Push-Pull Audio Amplification and optimum Transformer Coupling in audio and output stages. Has efficient 2¾" speaker for exemplary reproduction and earphone jack for private listening. Complete with all parts, transistors, pre-punched chassis, but less battery and leather case. New 28 page easy-to-follow step-by-step instruction book. Size 6 x 3½ x 1½. Shpg. wt., 3 lbs.

KT-119A — Complete Kit-Less Case and battery.................Net **29.95**
BATTERY 9V BURGESS 2N6.................Net **1.30**
MS-339A — Sturdy attractive brown leather case with carrying strap for KT-119A. 6 x 3½ x 1½". Shpg. wt., 1 lb.................Net **2.95**
MS-366 — Sensitive matching earphone.................Net **1.29**

Dynamic Stereophonic Headphones

BINAURAL

- True Binaural Reproduction • Frequency Response 40-16,000 cps. • Matched Magnetic and Crystal Transducers • Exceptionally Lightweight • Six Types — Monaural and Binaural

Take your choice of six stethoscope type headsets. Binaural or Monaural! High impedance or low impedance! Magnetic or crystal! Only Lafayette offers a complete selection. Binaural units are equipped with two separate and individual transducers and cord sets for true dual channel reproduction. Long the most widely accepted means of stereophonic listening. Both monaural and binaural units are extremely sensitive to insure the desired response. Sound is carried through crystal clear plastic tubes tipped with removable, plastic earpieces. Ingenious hinge device permits adjustment to any desired spacing. Less than 2 ozs. total weight for the utmost in listening comfort. Binaural sets may be used for monaural listening. Shpg. wt., 6 ozs.

MONAURAL

BINAURAL MAGNETIC HEADPHONES

MS-431 Binaural-Magnetic-6 ohms impedance.........2.65
MS-432 Binaural-Magnetic-5000 ohms impedance.....2.95
MS-433 Binaural-Crystal-100,000 ohms impedance....2.25

MONAURAL-MAGNETIC HEADPHONES

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MS-430 Monaural-Magnetic-5000 ohms impedance.....1.95
MS-369 Monaural-Crystal-100,000 ohms impedance....1.65

HIGH SENSITIVITY 20,000 OHM PER VOLT DC 10,000 OHM PER VOLT AC MULTITESTER

LOOK AT THESE FULL SCALE RANGES!

D.C. Volts: 0-6; 0-30; 0-120; 0-600; 0-1200; 0-6000 Volts—**A.C. Volts**: 0-6; 0-30; 0-120; 0-600; 0-1200 Volts—**Resistance**: 0-10K; 0-100K; 0-1 Meg; 0-10 Megohms—**D.C. Current**: 0.60 Microamp; 0-6; 0-60; 0-600 Milliamps—**Decibel**: —20 to +17 db (0db—0.774V)—**Capacity**: .0001-.01; 005-.15 mfd—**Inductance**: 20-2000 millihenry—**Output Ranges**: 0-6; 0-30; 0-120; 0-600; 0-1200 Volts.

The new Lafayette high sensitivity Multitester is a complete instrument (not a kit). In addition to its unusual sensitivity of 20,000 OHMS PER VOLT ON D.C. AND 10,000 OHMS PER VOLT ON A.C., and the extraordinary number and scope of its ranges, it is packed with features that would make it cost at least twice as much if made in this country. Uses 1% precision resistors, silver contacts on selector switch, 35 ua 3" meter. Dependable, rugged and accurate. Even the test leads are heavy duty with high voltage insulation. Voltage source required for low capacity range is 120V for high range capacity and inductance scale is 6V A.C. Attractive plastic front with metal bottom. Size 6¼" x 4¼" x 2½". Complete with batteries and leads. Shipping weight 4½ lbs.

RW-30A .... in lots of 3, Each **19.25**....Singly, Each **19.95**

4 AND 6 TRANSISTOR SUPERHET KITS POCKET AND HOME RADIOS FOR SPEAKER AND EARPHONE OPERATION

Completely self-contained, pocket size portable set which operates a miniature earpiece so only you can hear. The circuit uses 4 transistors (2 high frequency and 2 audio) plus a germanium diode, 2 IF stages and built-in high gain ferrite core and antenna. The result is a sensitive, stable and selective receiver covering the entire broadcast band. It requires no outside antenna or ground connection. The kit is supplied complete with transistors and all parts, including battery, and drilled and punched chassis. Pictorial and circuit diagrams are included with simple, easy-to-follow instructions. (Note: Earpiece and carrying case are not supplied.)

KT-94 —Complete Kit. Shpg. wt., 2 lbs.........Net **19.95**
MS-311—Leather Carrying Case.................Net **1.95**
MS-260—Super Power Dynamic Earpiece..........Net **3.95**

2-TRANSISTOR PUSH-PULL OUTPUT KIT WITH SPEAKER SELF-CONTAINED IN BEAUTIFUL PLASTIC CASE.

Converts 4-Transistor Kit KT-94 into a 6-transistor home radio with speaker. Transitorized push-pull audio stage plugs into 4-transistor kit, suitable for group listening. Performance equal or superior to commercially wired sets selling at much higher prices. Kit includes 2 transistors, 2 transformers, 2½" PM speaker, pre-punched chassis, speaker case (holds all components), battery, hardware, instructions and diagrams.

KT-96—Shpg. wt., 1 lb.........................Net **11.50**

"SUNFLEX" 2 TRANSISTOR REFLEX RADIO RECEIVER KIT

- FOR SOLAR OR FLASHLIGHT BATTERY OPERATION
- NPN-PNP CIRCUIT REFLEXED FOR 3 TRANSISTOR PERFORMANCE

An efficient miniature receiver kit for earphone operation. Works on 2 inexpensive penlight cells (3 volts) or in sunlight using solar batteries (not supplied). 1 mil current drain. Complete kit with detailed instructions. Size 4¾ x 3⅝ x 1⅝". Shpg. wt., 1 lb.

KT-132—"SUNFLEX" KIT (less earphones)........Net **11.95**
MS-260—Super Power Dynamic Earphone...........Net **3.95**

"HELIODYNE" SUBMINIATURE SOLAR SILICON BATTERY

- MOST EFFICIENT TYPE OF SUN BATTERY

Generates electrical energy from sunlight or other light source. Rated 3.2 volts at 2 milliamps. Ideal for "Sunflex" receiver. 1-1/16 x 3/32".

MS-240—"HELIODYNE" SILICON SOLAR BATTERY Net **6.65**

4 TRANSISTOR TELEPHONE PICKUP AMPLIFIER KIT

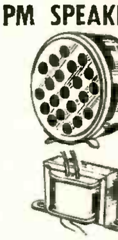
- FOR GROUP LISTENING OF PHONE CONVERSATIONS

Extra-sensitive 4 transistor telephone pickup amplifier with "class "B" push-pull output for efficient speaker operation. Merely requires pickup coil under or near phone. Also may be used as high gain amplifier for phono and mike. Easy-to-follow instructions. Size 4½ x 4¼ x 4¼". Shpg. wt., 3 lbs.

KT-131—Complete Kit less Battery & Pickup Coil..Net **17.95**
BATTERY RCA VS305 (9V).....................Net **1.30**
MS-16—Telephone Pickup Coil....................Net **2.95**

NEW! WORLD'S SMALLEST PM SPEAKER

1-3/16" DIAMETER — ONLY 9/16" THICK



- COMPLETE WITH MINIATURE TRANSFORMER
- HIGHLY EFFICIENT AS SPEAKER

1.95

Ideal for extremely thin transistor radios, miniature intercoms, telephone-type handsets, hearing aids and other miniature applications. As a dynamic mike delivers 0.5 millivolt output and may either be directly connected to high impedance amplifier input or transformer supplied may be used as matching transformer. Speaker handles up to 300 milliwatts and has response 550-5000 cps ± 10 db with resonant frequency 600-700 cps. Voice coil impedance is 14 ohms. The single ended miniature transistor output transformer has 8000 ohm primary, is [illegible] W x 11/16" D x ¾" H with 1-5/16" mtg. centers. Shpg. wt., ½ lb.

SK-96—Miniature PM Speaker & Output Transformer Net **1.95**

3 TRANSISTOR SUPERHET POCKET RADIO KIT

- A TRUE POCKET SUPERHET RECEIVER
- NO EXTERNAL ANTENNA
- NO EXTERNAL GROUND

A remarkable sensitive, super-selective pocket superhet receiver with astonishing performance over the complete broadcast band. Uses 2 high-frequency and one audio transistor plus efficient diode detector and features 2 specially matched IF transformers for maximum power transfer. The components are housed in a professional looking beige plastic case. The receiver's appearance enhanced by attractive maroon and silver station dial. Sensitive built-in ferrite antenna eliminates need for external antenna. A designer's dream in a true pocket superhet receiver! Complete with all parts, transistors battery, case, dial and easy to follow step-by-step instructions. 4⅛" x 2⅝" x 1-1/16". Shpg. wt., 1 lb.

KT-116 —Complete Kit, less earphone...............Net **16.95**
MS-260—Super Power Dynamic Earphone............Net **3.95**

Lafayette Radio 165-08 Liberty Ave. JAMAICA 33; N. Y.

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100 6th Ave.	110 Federal St.	542 E. Fordham Rd.	24 Central Ave.	139 W. 2nd St.
REctor 2-8600	HUbbard 2-7850	FOrdham 7-8813	MArket 2-1661	PLainfield 6-4718

LAFAYETTE PROFESSIONAL TURNTABLE with AUTHENTIC HYSTERESIS SYNCHRONOUS MOTOR

Value ~~129.50~~ Only 64.50
SAVE OVER 50%

PROFESSIONAL TURNTABLE WITH HYSTERESIS-SYNCHRONOUS MOTOR

The **Lafayette Model PK-225** is a true hysteresis-synchronous motor and is free from speed variations due to fluctuations in line voltage, load and temperature. It is the smoothest type known, completely free from "cogging" (the minute variations of speed which show up as wow and flutter)!

ONLY LAFAYETTE'S HYSTERESIS—SYNCHRONOUS MOTOR, in its price class, is made to extremely fine tolerances (on the order of .00001 inches)! Only Lafayette's motor has 16 cores; a high permeability rotor magnet, ball thrust bearings, oilite sleeve bearings plus felt oil reservoir, cooling fins as an integral part of the rotor and a hollow rotor core for maximum efficiency and minimum heat. Only Lafayette's motor can be oiled from above, without disassembly, through a unique oil feed system. Only Lafayette's motor has a self-aligning armature.

Here's THE turntable—the last word in professional high-fidelity performance! A fine precision instrument in every sense. Just look at some of these **OUTSTANDING FEATURES:- WOW AND FLUTTER:** Less than 0.2% • **TURNTABLE:** Heavy, diecast aluminum. Lathe-turned for perfect balance and concentricity. 12" diameter—weighs approx. 4 lbs. and provides amazingly constant speed; the extra-heavy rim acts just like a flywheel to prevent speed variations • **TRUE-HYSTERESIS-SYNCHRONOUS MOTOR:** For smooth, low-noise, wow- and flutter-free operation • **RUMBLE: AND NOISE:** 50db below average recorded level • **INTEGRATED SPEED CONTROL:** For all 3 speeds—78, 45 and 33⅓ rpm • **2 OVERSIZE, HEAVY DUTY IDLERS:** Precision-ground; provide positive constant-speed rim drive • **SINGLE BALL THRUST BEARING:** Turntable rides smoothly over ball bearing floating on thin film of oil • **FREE FLOATING, SHOCK-MOUNTED MOTOR** • **RUBBER CUSHION SHOCKMOUNTS** • **AUTOMATIC IDLER DISENGAGEMENT** • **CORK AND RUBBER MAT** • **STAINLESS STEEL PRECISION SPINDLE** • **POWER REQUIREMENTS:** For 105-130 volts, 60 cps AC; draws 16 V.A. • **ACCESSORIES SUPPLIED:** 45 RPM adapter, Strobe disc • **SIZE:** 2⅛" above and 4" below motor board; 14¾" deep x 12¼" wide • **SHIPPING WEIGHT:** 16 lbs.

LAFAYETTE MODEL PK-225 .... Net **64.50**
Deluxe Woodbase for PK-225 and 12" Tone Arm (Specify Finish). Shpg. wt., 13 lbs. .... Net **14.95**
Deluxe Woodbase for PK-225 and 16" Tone Arm (Specify Finish). Shpg. wt., 15 lbs. .... Net **15.95**

SPECIAL MONEY-SAVER COMBINATION
PK-225 Turntable, PK-90 12" Tone Arm, New GE VR-II Series Triple-Play Cartridge Model 4G-052 with Genuine GE Diamond and Sapphire Styli. *SPECIAL!* .... Net 81.50

VISCOUS DAMPED TRANSCRIPTION TONE ARMS

PK-90— **11.95** VISCOUS DAMPED ARM

LICENSED UNDER CBS U. S. PATENT NO. 2676806

PK-170— **17.95** VISCOUS DAMPED ARM

3 WAY SYSTEM WITH 15" WOOFER . . 8" MID-RANGE SPEAKER . . HORN TWEETER . . CROSSOVER NETWORK

PHANTOM VIEW SHOWS HOW SYSTEM MOUNTS IN CABINET

• 15-INCH WOOFER WITH 31.5 OZ. MAGNETIC (SK-67) • 8-INCH MID-RANGE SPEAKER (SK-74) • NEW HIGH FREQUENCY ACOUSTICAL LENS TWEETER (HW-7) • 3-WAY CROSSOVER NETWORK (LN-3)

Lafayette presents this outstanding 3-way speaker system designed for the high fidelity enthusiast who desires performance formerly possible in multi-speaker systems costing many times this price. You won't believe your ears when you hear the superb reproduction throughout the entire audio spectrum. The SK-67 15" woofer provides phenomenal bass response, the SK-74 8" speaker delivers full bodied, mid-range frequencies, and the HW-7 high frequency acoustical lens tweeter faithfully reproduces the highest audible frequencies. Crossover points at 350 and 5000 cycles are provided by the LN-3 3-way inductance-capacitance network with continuously variable presence and brilliance controls that adjust tone balance to personal taste. Shpg. wt., 25 lbs.

SY-93. Complete System as listed above .... Net **55.50**

2 WAY SPEAKER SYSTEM 40-16,000 CYCLES

• 25 WATT WOOFER • CROSSOVER NETWORK • IMPORTED HI-FI TWEETER • LEVEL BRILLIANCE CONTROL

This 2-way speaker system is another excellent buy for the moderate purse. It is basically the same as the SY-85 system described at the top of the page, but incorporates the deluxe SK-68 speaker with 21.5 oz. Alnico V magnet. This results in more efficient reproduction and extension of the lower register. Complete system includes the SK-68 12" 25 watt woofer, HK-3 cone type tweeter and LN-2 crossover network with level-brilliance control. Range of system 40-16,000 cycles. Shpg. wt., 18 lbs.

SY-87—Complete System .... Net **27.50**

NEW! POWER MEGAPHONE... Portable Sound Broadcaster

• Uses 8 Flashlight Cells • Completely Self-Contained • Weighs only 6½ lbs. with Batteries • High Efficiency Horn Projects Sound 1000 Ft. • Shoulder Strap for Portability and Ease of Use • Microphone Detachable On 10-Foot Cord • For Construction, Auctions, Carnivals, Fire & Police Use • Also Ideal for Marine, Railroad, Civil Defense, Sporting Events

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PA-12 — Power Megaphone, Less batteries .... Net **29.50**

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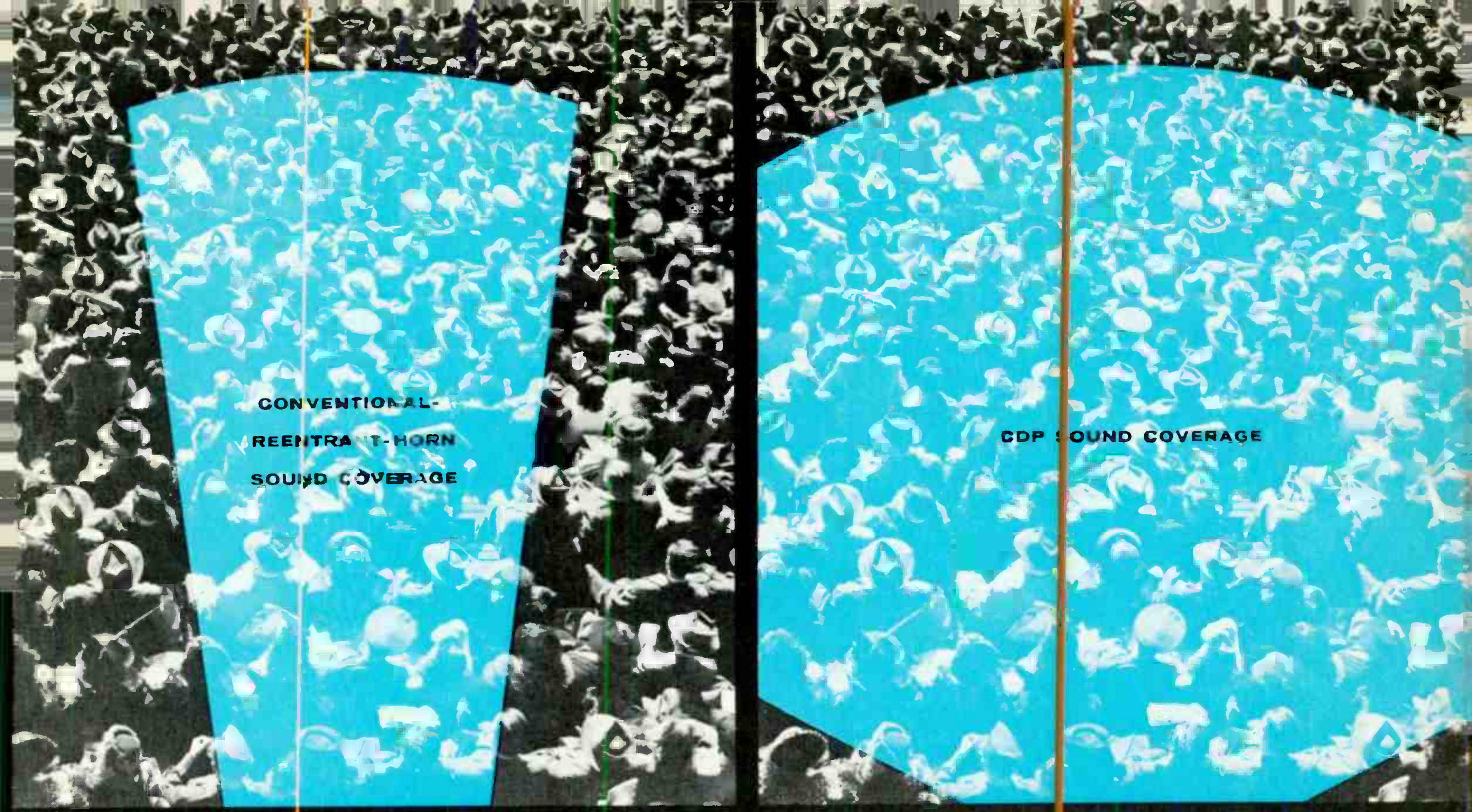

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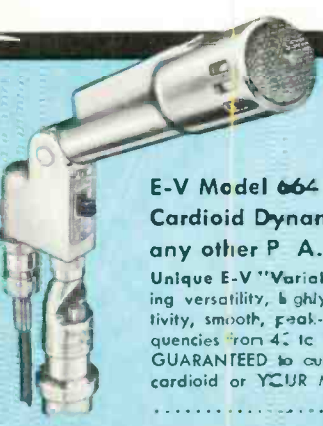

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