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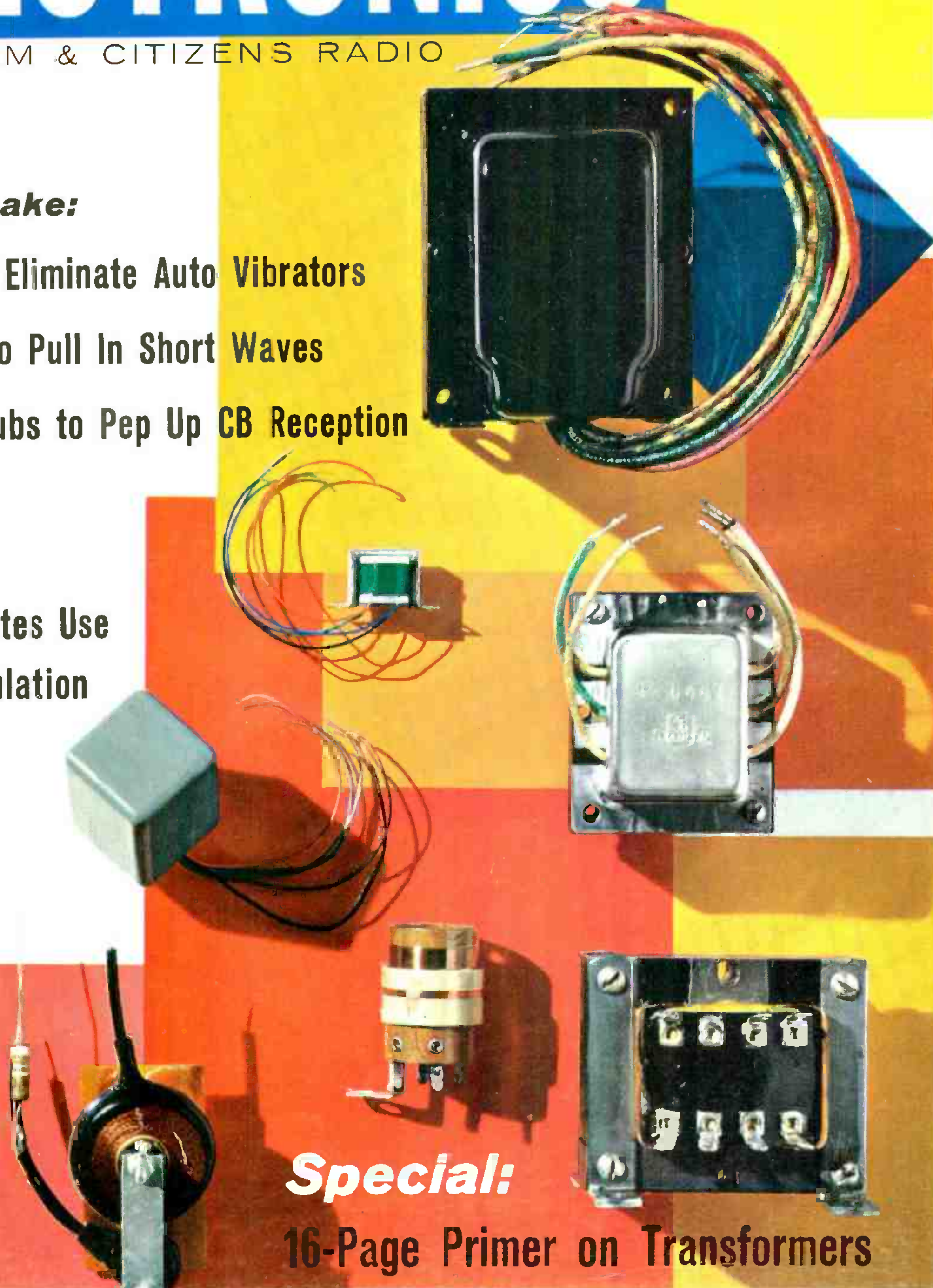

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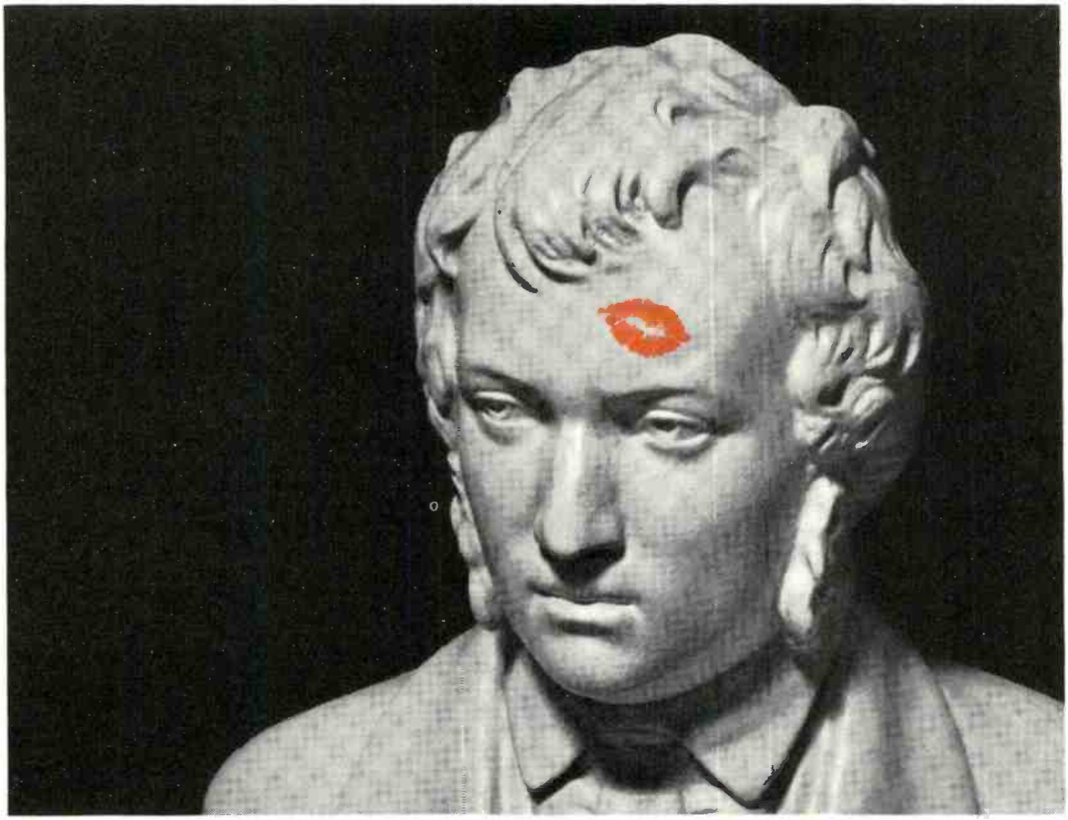

CLASSICS THAT MADE THE HIT PARADE

DETAILS OF THE PROGRAM

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Waldteufel	Espana Waltz (Hot Diggity)
Chopin	Polonaise No. 6, in Ab Major (Till the End of Time)
Tchaikovsky	Symphony No. 6 in B (The Story of a Starry Night)
Rachmaninoff	Piano Concerto No. 2 in C Minor (Full Moon and Empty Arms)
Chopin	Fantasie Impromptu in C# Minor (I'm Always Chasing Rainbows)
Tchaikovsky	Romeo and Juliet Overture (Our Love)

DETAILS OF THE OFFER

This exciting recording is available in a special bonus package at all Audiotape dealers. The package contains one 7-inch reel of Audiotape (on 1½-mil acetate base) and the valuable "Classics that Made the Hit Parade" program (professionally recorded on Audiotape). For both items, you pay only the price of two reels of Audiotape, plus $1. And you have your choice of the half-hour two-track stereo program or the 55-minute monaural or four-track stereo versions.

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POPULAR ELECTRONICS

OCTOBER 1960

VOLUME 13 NUMBER 4

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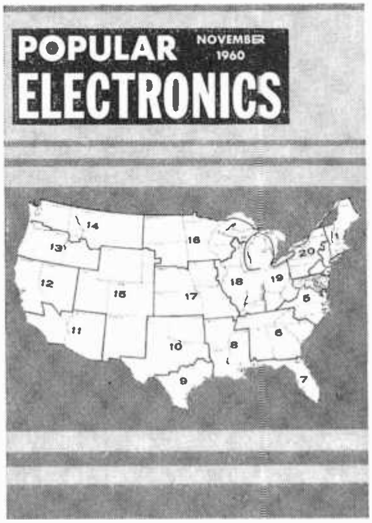

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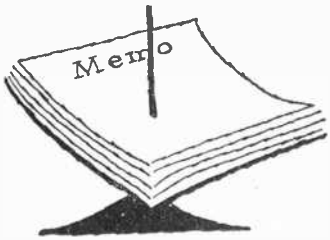


Notes from the Editor

READER SERVICES. My first month as editor of POPULAR ELECTRONICS has certainly not contained a dull moment. It has been a very busy month –during which the staff has lined up some marvelous things for the future. Among them are informative and newsworthy feature stories and some of the best do-it-yourself construction material I've ever seen. In this editorial, however, I want to concentrate on an important problem--the matter of reader inquiries and correspondence.

As last month rolled by, I was literally astounded at the mounting stack of reader inquiries that flooded the P.E. offices. In less than four weeks, nearly 600 cards and letters requiring an answer crossed my desk. Many of these inquiries were not simple and uninvolved by any stretch of the imagination. To answer them properly would have required exhaustive research. Approximately 80% did not even deal with material published in POPULAR ELECTRONICS, but instead ran the gamut of requests from career advice to how to repair TV receivers.

An editor would be the last NOT to expect reader mail, but I do think that this is an opportune moment for me to spell out just what we can, and cannot do, for our readers. It goes without saying that we will attempt to answer all inquiries pertaining directly to published material in any issue of our magazine. However, we cannot possibly answer requests for:

–new designs or original engineering involving material or ideas that have no direct bearing on articles which have been published in POPULAR ELECTRONICS

–information on material published in other magazines

–help in finding a job or planning your career in electronics

–help in selling your old equipment or estimating its value

–''advance'' information on one of next month's construction articles, so you can be first in your neighborhood to build it

–the design of a ''sure winner'' for the next science fair

If you write to POPULAR ELECTRONICS and your letter requires an answer, be sure to include your correct mailing address. If our reply to your letter seems unduly delayed, please understand that the pressure of putting out a monthly magazine consumes much of our time.

Oliver P. Ferrell

FCC Report

By ROBERT E. TALL
Washington Correspondent

CB and Amateur News

CITIZENS BANDERS who have been waiting anxiously for the FCC to raise the permissible power input for Class D stations to 25 watts can relax—at least for a while. So, too, can CB'ers looking forward to the day when FM transmissions will be permitted on the Citizens Band. The earliest the Commission can be expected to make any final changes in Class D regulations is two or three months after an initial notice of proposed rule-making—and then only if the agency feels that it can go along with the proposed changes.

The Commission has been receiving a hefty volume of correspondence concerning the possibility of such rule changes ever since a petition for a new 25-watt limit came in earlier this year from the Connelly Sales Co. of La Mirada, Calif. One big drawback to boosting the power of CB stations is the fact that any increase in permissible power would almost surely have to be accompanied by an increase in technical specifications for CB equipment. And this would almost certainly bring about an unwanted increase in the price of the units.

Prior to the August recess of the Commission, it appeared that favorable action —if any—on the Connelly request would not come before October. Allowing time for comments from interested CB'ers and other procedural steps, final action could not be expected before the end of the year.

The California company also posed the question of single-sideband operation in the Citizens Band. Since present regulations limit operation to double sideband (A1) only, this seems to be another matter for the Commission to consider.

Major revisions in application forms for the amateur radio fraternity—for renewal of licences with or without modifi-

cations—are to be put into effect by the FCC early next year. The Commission wants to abolish the present Form 405-A—used for renewal of an amateur operator license without modification, and the present Form 602—used for stations at military posts.

The reasons given for the change are that the 405-A renewal form has been improperly used in the past. In addition, it has been causing administrative difficulties, since sufficient information has not been included in many cases.

Both forms are to be replaced with new Form 610-A, which will cover additional stations, club stations, or stations for recreation under military auspices. The regular amateur application Form 610 will be retained.

A "Kilocycle Kops" episode concerning the FCC and CB'ers took place in Los Angeles recently. During the afternoon traffic rush, the Commission's district office there received a report that an unidentified Citizens Band station had been on the air continuously for some three hours. Although hampered by one-way streets, no turns, no stopping, no parking, and other traffic restrictions, an investigative car manned by an FCC engineer tried hard to determine where the signal was strongest.

As the search narrowed, according to the Commission, the FCC engineer heard a fragment of a conversation in which someone was telling a customer that his account with a certain piano company was overdue. After the engineer managed to find a parking space, he visited the piano company's office. There, a very flustered woman explained that she was confused by the controls on a Citizens Radio set and didn't know how to turn it off.

Courteously, the engineer flipped the switch for her, and the carrier left the air. The woman said she thought she could handle it in the future!

At the end of the FCC's 1960 fiscal year, on June 30, there was a total of 126,034 Citizens Radio station licenses on the Commission's books, representing an increase of 79,965 since the same date a year ago. Of the total, more than 105,000 are in the Class D service. Of the new stations added since July 1, 1959, more than 70,000 are Class D stations. The Commission has estimated that 90% of its incoming Citizens Band applications are now for Class D stations. —30—

Letters from our readers

Supersonic Presses

■ I am interested in some of the problems that the Tacoma Newprint Corporation must have had in learning how to run its printing presses at Mach 5! The brand of paper that can travel at that speed should be used for ICBM nose cones.

CHESTER E. CLAFF, JR.
Brockton, Mass.

The caption in Ken Gilmore's article on magnetic amplifiers (July, 1960, p. 71) pertaining to printing presses said 5000 feet per second—when it should have said 5000 feet per minute. *But the presses are still some of the fastest in the world.*

Rebuilding the Relics

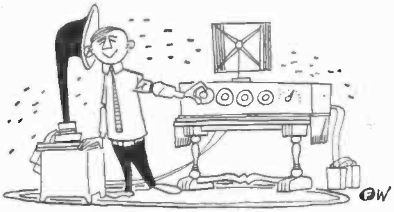
■ I found your article on rebuilding relics very informative. I have two such pre-war receivers that I now use for SWL'ing. In addition to your suggested alterations I have added an antenna tuner. One thing seems to be missing, though, and that is bandspread—what would be the easiest way to add it to one of these relics?

JOHN F. ZIMA, WPE2CAA
New Hyde Park, N. Y.

■ Mr. Wicks' article was one of the best I have ever read. I'm out looking for old relics that can be rebuilt.

NORMAN BANDER
New York, N. Y.

■ I fixed up an old RCA 17K and Philco 610; the 17K is now my main short-wave receiver. As you suggested, some old manuals *can* be



obtained from manufacturers—I got the RCA manual for 25 cents.

DAVID DRUCKER
Newport News, Va.

"Rebuild the Relics for SWL'ing" (August, 1960, p. 76) has been attracting considerable reader in-

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Letters

(*Continued from page 12*)

terest. If you missed this article, it tells how to pick out an old receiver worth rejuvenating, how to get the wiring schematic, and how to add a BFO and phone jack. Copies of this issue are available from our Circulation Department, 434 South Wabash Ave., Chicago 5, Ill., for 35 cents.

To answer reader John Zima's question, adding bandspread is very simple. You just wire a 15-μμf. variable capacitor in parallel with the oscillator tuning capacitor and attach a vernier dial. Keep in mind that the extra capacity will throw the main dial calibration off unless you realign the oscillator.

"Strange Inhabitants"

■ I enjoyed James Van Detta's article "The Strange Inhabitants of 75-Meter Phone" (July, 1960, p. 66), although I wondered why he restricted it to that band. Oddballs, such as the types described, can be found on all ham bands —phone and c.w. Personally, I think the most unusual characters are the CB'ers. Half of them don't seem to know the difference between a microphone input and an antenna output, yet they are on the air trying desperately to change frequencies with their send-receive switches.

STEVEN MELTZER
New York, N. Y.

Although we are inclined to agree with reader Meltzer, the caliber of the CB operator has been improving as the novelty of CB wears off. Characters we will always have on any band anywhere.

Power Line Grounding

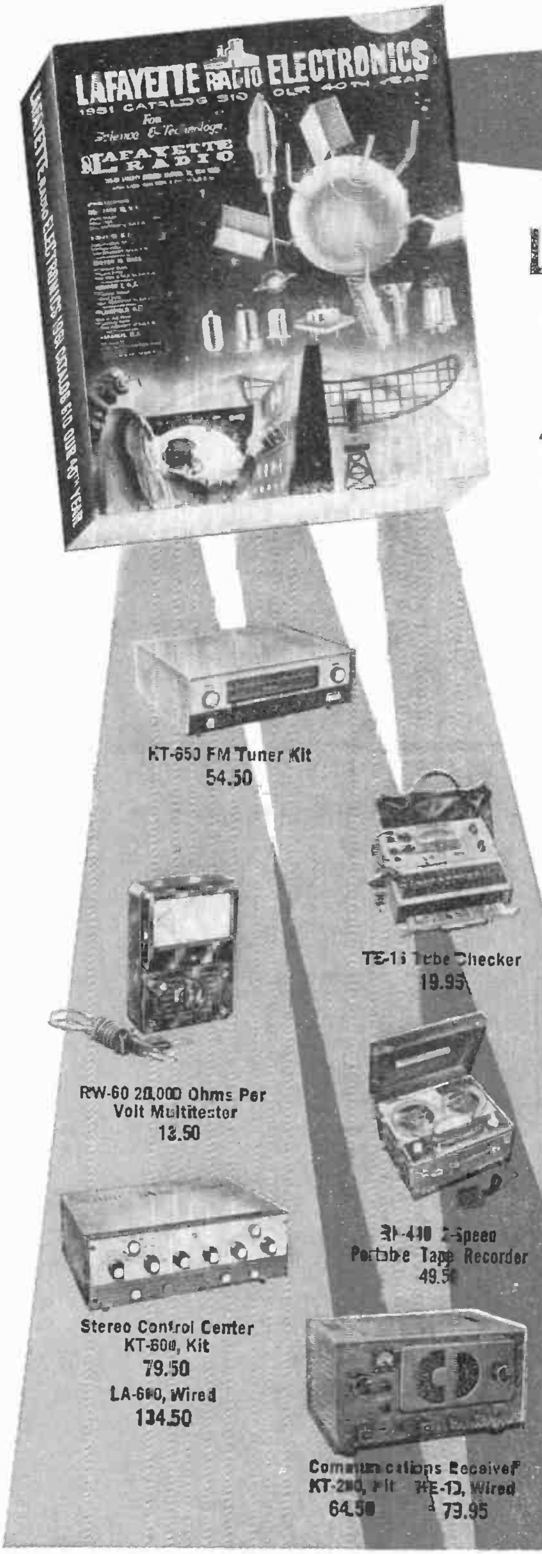
■ Harking back to your article in August 1959 titled "Shocking But True," it would seem to me that most people are electrocuted because they connect themselves between a hot power line and

ground. Why should the power companies ground one side of the power line? Why not completely isolate power lines, keeping both sides "above" ground?

ALLYN ROTHMAN
Syosset, L. I., N. Y.

Abbott's National Electrical Code Handbook: *states "Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage." In other words, power line circuits are safer when one side of the line is grounded than they would be if both*

(*Continued on page 18*)



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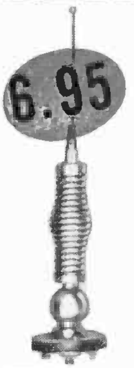

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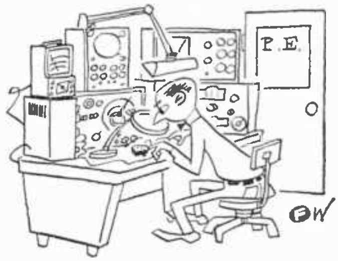
Letters

(Continued from page 14)

sides were "floating" or "isolated." Accidental grounding of the present distributing system is either harmless or blows a fuse; accidental grounding of a "floating" system could not be easily detected and could be very dangerous.

"Tiny Mite" Modifications

■ When I built the three-transistor miniature amplifier described in your June 1960 issue, I found that I could obtain better gain and low frequency



response by using a 10-μf. capacitor for *C1*. And instead of the dynamic microphone, I used a crystal equivalent with a miniature 200,000- to 1000-ohm matching transformer (Triad SP-7).

GARBIS SAATJIAN
Venice, Calif.

■ I built the "Tiny Mite" amplifier described in your June issue and am very happy with the results. I substituted 2N1265 transistors for the 2N207's suggested in the diagram and used a two-inch speaker in place of the microphone. The amplifier is so sensitive that I can hear a ball of cotton hit a table.

NORMAN B. WORTHEM
Chicago, Ill.

The "Tiny Mite" amplifier turned out to be one of our "Mighty Mite" projects—it seems that everyone was waiting for this circuit. If other readers have made modifications, we will be interested to hear about them.

The 240-Volt Problem

■ We have one problem here, "Down Under," that we'd like you to help us with. The voltage rating in Australia is 240 volts, unlike the 117 volts in the United States. How do we go about altering a circuit so it will work with 240 instead of 117 volts?

Y. SHALIA
Edgecliff, N.S.W.
Australia

Although our circuits are designed for American and Canadian readers, it's usually not much of a problem to convert to 240 volts. If there's a power transformer in the circuit, just obtain a similar unit with a 240-volt primary. Circuits without transformers can also be converted, but you'll need a suitable 240- to 117-volt step-down transformer which will increase the overall cost somewhat. —30—

POP'tronics Bookshelf

"RADIO SERVICING," Third Edition, by Abraham Marcus. Published by Prentice-Hall, Inc., Englewood Cliffs, N. J. 649 pages. Hard cover. $7.95.

As the author states in his introduction, he believes that a person is better equipped to trouble-shoot receivers if he has a good understanding of radio theory than if he simply studies individual sets in detail. Beginning with an intensive review of basic electrical and radio theory, Mr. Marcus follows through with an explanation of the electron tube and its many functions, plus specific service notes on possible defects. Servicing procedures, techniques, and instruments are covered. Numerous charts, diagrams, graphs, and other illustrations are provided, as are listings of electrical terms, and formulas, symbols, units and abbreviations. Recommended as a useful guide for budding servicemen and as a general reference book for the more established technician.

"TUBE SUBSTITUTION HANDBOOK," published by Howard W. Sams & Co., Inc., 2201 E. 46th St., Indianapolis 6, Ind. 96 pages. Soft cover. $1.50.

Substituting tubes, either American or European, in a variety of circuits is simplified by the data in this handbook. American substitutes for European tubes are listed, as are European substitutes for American tubes, industrial substitutes for receiving tubes, and possible picture-tube substitutions. Any serviceman or electronic experimenter will find the book of value and will probably make frequent reference to it.

"DIGITAL COUNTERS AND COMPUTERS" by Ed Bukstein. Published by Rinehart & Company, Inc., 232 Madison Ave., New York 16, N. Y. Hard cover. 248 pages. $7.00.

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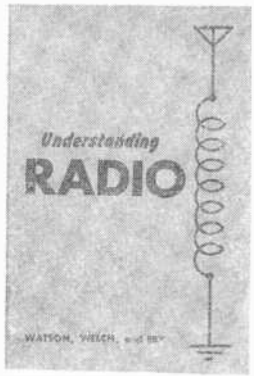
Bookshelf

(Continued from page 20)

telligible technical information in the growing field of computer technology, this book contains much information never before published in book form. Prepared in a clear, easily understandable style and supplemented with numerous illustrations and study questions for each chapter, it should fulfill the needs of the technically inclined layman, the student, and others interested in the science of computation.

"UNDERSTANDING RADIO," Third Edition, by Herbert M. Watson, Herbert E. Welch, and George S. Eby. Published by the McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y. 706 pages. Hard cover. $6.20.

Written for the student with little background in electronics, this revised textbook combines both the theoretical and practical aspects of radio. Several introductory chapters explaining sound, radio waves, electricity, and magnetism are followed by chapters on the theory, building, and operation of shortwave sets, transmitters, crystal receivers, and—new with this edition—a public address unit. Ending each chapter are two study aids: technical term definitions, and questions. Thoroughly illustrated with diagrams, pictorials, and schematics, the book also makes effective use of its inside covers and flyleaves. The latter contain charts which show the standard RETMA color code, drawings of resistors and capacitors, and a list of tube characteristics.



"PRACTICAL TRANSISTOR SERVICING," by William C. Caldwell. Published by Howard W. Sams & Co., Inc., 2201 E. 46th St., Indianapolis 5, Ind. 192 pages. Soft cover. $2.95.

(Continued on page 26)

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Bookshelf

(*Continued from page* 22)

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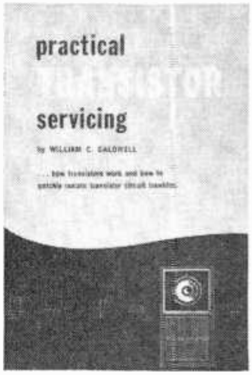

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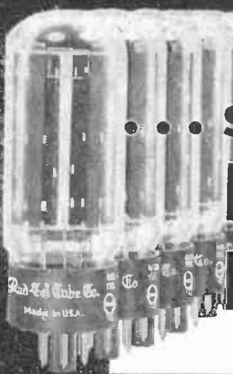
A 60-page handbook of data pertaining to space exploration, titled "Space Facts," can be obtained on request from Product Information, Missile and Space Vehicle Department, General Electric Company, 3198 Chestnut St., Philadelphia 4, Pa. —30—



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1DN5	.55	4DK6	.60	6AX7	.64	6DT5	.66	12AJ6	.46	12CX6	.54	17W6	.70
1G3	.73	4DT6	.55	6BA6	.49	6DT6	.53	12AL5	.45	12DB5	.69	19AU4	.83
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1U5	.50	5CL8	.76	6BH8	.87	6SK7	.74	12AV7	.75	12EZ6	.53	25DN6	1.42
1X2B	.82	5EA8	.80	6BJ6	.62	6SL7	.80	12AX4	.67	12F5	.66	25EH5	.55
2AF4	.96	5EU8	.80	6BK7	.85	6SN7	.65	12AX7	.63	12F8	.66	25L6	.57
...		5J6	.68	6BL7	1.00	6SQ7	.73	12AZ7	.86	12FM6	.45	25W4	.68
3AL5	.42	5T8	.81	6BN4	.57	6T4	.99	12B4	.63	12K5	.65	25Z6	.66
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3BU8	.78	6AC7	.96	6BY6	.54	6X8	.77	12BQ6	1.06	12W6	.69	50DC4	.37
3BY6	.55	6AF3	.73	6BZ6	.54	7AU7	.61	12BY7	.74	12X4	.38	50EH5	.55
3BZ6	.55	6AF4	.97	6BZ7	.97	7A8	.68	12BZ7	.75	17AX4	.67	50L6	.61
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4BQ7	.96	6AU4	.82	6CY5	.70	12A4	.60						
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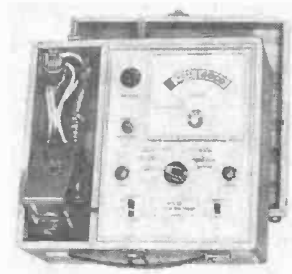


leakage. In addition, it can be used to reactivate either black and white or color picture tubes—a controlled high-voltage pulse is fed to the tube without "stripping" the emitting surface of the cathode. Shorts can be burned out and welds can be made with this special high-voltage pulse circuit. $49.95. (*Mercury Electronics Corp.*, 77 Searing Ave., Mineola, N. Y.)

FM CAR TUNER

Latest addition to the growing line of FM converters for cars is the Eric Model 100 FM tuner. Like other auto converters, the Model 100 feeds signals directly to your regular AM auto radio. Quite compact (it

measures 2⅞" x 8¼" x 7¾"), the Model 100 is claimed to have high sensitivity. An accessory FM antenna is available, although the converter will work with most automobile antennas if they are set to a height of about 30". Price, $79.95. (*Eric Engineering Co.*, 1823 Colorado Ave., Santa Monica, Calif.).

STEREO SPEAKER SWITCH

If you're wiring up another pair of stereo speakers, say in the den or patio, keep the

products

(*Continued from page* 28)

Centralab 1486 switch in mind. It permits operating either speaker pair individually, or simultaneously—a real switching convenience. Measuring approximately 1" x 1½", the switch is supplied with a push-on knob. (*Centralab,* 900 E. Keefe Ave., Milwaukee 1, Wis.)

TUBE TESTER

One of the smallest, lowest-priced tube testers on the market today, the EMC Model 211 checks all octal, loctal, 7- and 9-pin miniature tubes for shorts, leakages, opens, and intermittents as well as for emission. Magic eye and voltage regulator tubes can also be checked. Size, 6¾" x 5¼" x 2¼" deep. Price: $22.90 wired; $14.90 in kit form. (*Electronic Measurements Corp.,* 625 Broadway, New York 12, N. Y.)

ELECTRONIC ORGAN TUNER

Another gadget to ease the job of the radio/TV/hi-fi serviceman, the Schober "Autotuner AT-1" enables even a serviceman with a tin ear to tune electronic organs.

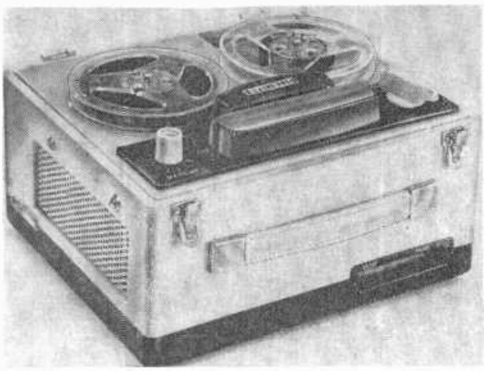
products

(*Continued from page* 30)

Picking up organ notes through a microphone, the "Autotuner" user varies 13 organ frequencies (in turn) until the appropriate built-in strobe disc pattern stands still. The gadget is usable with almost all electronic-oscillator organs; its cost is said to be less than one-third that of comparable models—$69.50 ($49.50 in kit form). (*The Schober Organ Corp.,* 43 West 61st St., New York 23, N. Y.)

DUAL TRACK TAPE RECORDER

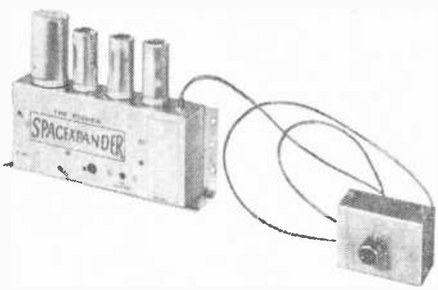
A dual-track, two-speed tape recorder introduced by *Radio Shack Corp.,* 730 Commonwealth Ave., Boston 17, Mass., will be marketed for less than $50. Operating at



either 3¾ or 7½ ips, it measures 11¾" x 10" x 7", weighs a full 17 lbs. There are external jacks for microphone, radio-phono and external speaker; accessories include a microphone, a radio cord, and a standard 5" reel.

REVERBERATION SYSTEM

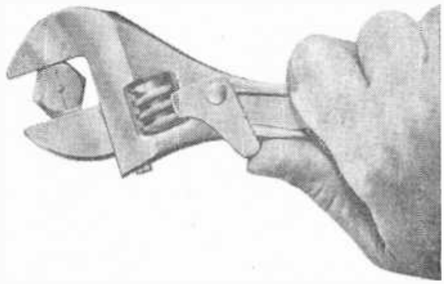
If you want to make your living room sound like Carnegie Hall, try the new



Fisher Model K-10 Dynamic "Spacexpander." Added to a stereo hi-fi system, the Spacexpander gives sparkle to "dead" recordings by introducing a small time delay or reverberation effect in one channel. It may also be connected to a stereo center-channel amplifier and speaker. $59.50. (*Fisher Radio Corp.,* 21-21 44th Drive, Long Island City 1, N. Y.)

ADJUSTABLE "LOCK" END WRENCH

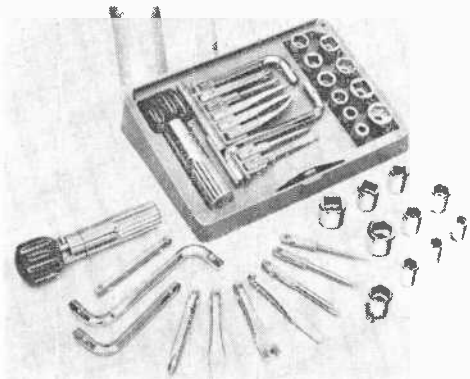
Have you ever felt frustrated because you accidentally changed the gap size on your adjustable end wrench? The "Select-O-



Lock" wrench is being offered by *Utica Drop Forge & Tool Division* (Kelsey-Hayes Co., Utica, N. Y.) to solve that problem. Built into the wrench is a device which guarantees no slipping or re-setting. The wrench is available in sizes ranging from 4 through 12 inches.

MULTI-PURPOSE TOOL KIT

Interested in a small tool kit that you can carry in a tackle box or glove compartment? The Shelton "Super Socketool" may

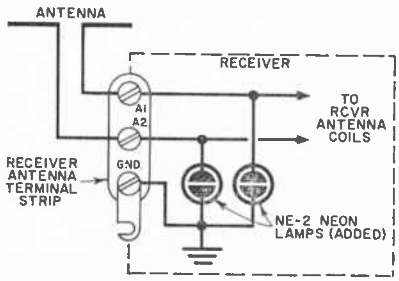


be the answer. Designed around a universal ratchet handle, the kit includes a wide variety of open-end sockets, screwdriver bits, awl attachments, and a handy tack lifter. It makes an ideal gift for any do-it-yourself'er. $4.98. (*Shelton Products Co.,* Shelton, Conn.) —30—

Tips and Techniques

ANTENNA COIL PROTECTOR

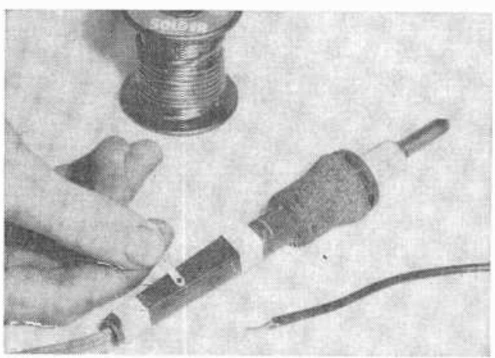
If you own both a receiver and a transmitter, you can prevent your receiver's antenna coils from going up in smoke because of stray r.f. from your transmitter. Simply connect two NE-2 neon lamps to your receiver as shown. Solder the lamps in place by their leads on the under-the-chassis side



of the receiver's antenna terminal strip; you will note that one lamp is connected between lug *A1* and *Gnd.*, the other between *A2* and *Gnd.* Although the lamps will not affect normal reception, they will fire and prevent damage to the antenna coil if you accidentally jolt your receiver with r.f. from your transmitter.—*Carl Wright, Tucson, Ariz.*

SOLDERING IRON FILE

Before soldering small parts such as terminal lugs, clean and brighten them with a small file taped to your soldering iron's



handle. Any small file will do, but an old nail file is ideal. Don't rub the file against the part as you might accidentally burn

(*Continued on page* 35)

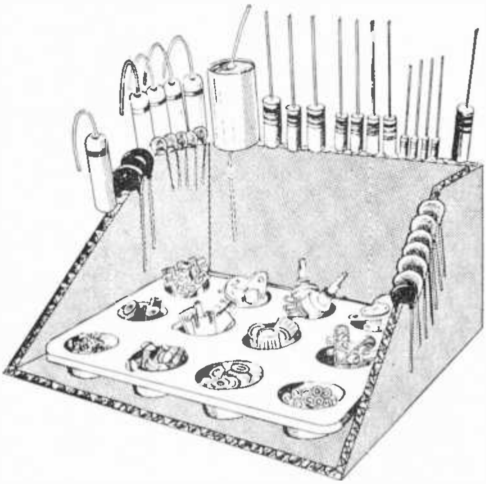
SEE OTHER SIDE

(*Continued from page* 32)

yourself on the iron. Instead, rub the part against the file as shown.—*Jerome Cunningham, Chicago, Ill.*

KIT BUILDING AID

To speed up the building of kits and other construction projects, take a few minutes to arrange all parts in a corrugated cardboard carton, as shown, separating the various parts into convenient categories. Resistor and capacitor leads can be inserted in the edge of the cardboard with values written on the cardboard next to each component. Muffin tins or molded egg cartons make handy trays for smaller parts.—*Courtesy of the Heath Company, Benton Harbor, Mich.*

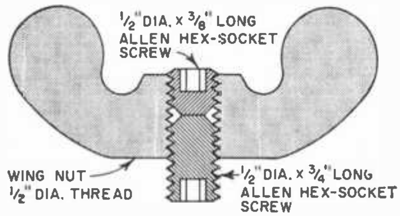


TROUBLE-SHOOTING PRINTED CIRCUITS

Tracing the printed wiring on a circuit board can be difficult if the board must be turned over constantly to follow the wiring. If you place a strong light behind the board, the shadow of the printed wiring will show through the board and eliminate the necessity of turning it over. The reduced handling will also prevent unnecessary wear and tear on leads connected to the circuit board.—*Ernie Harrison, Tuscaloosa, Ala.*

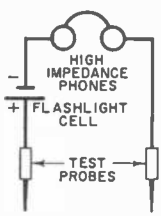
MINIATURE HEX-HEAD WRENCH

You can easily make a miniature hex-head wrench out of a wing nut and a pair of recessed hex-socket screws. For a ¼" socket wrench, simply take a wing nut with a ½"-diameter threaded opening and screw in two Allen-type, ½"-diameter recessed head screws as shown. When both Allen screws are in place, their bottoms will lock so that they won't turn when used as a wrench. Other size wing nuts and recessed Allen screws can be used in the same way. —*Sam Lissauer, Los Angeles, Calif.*



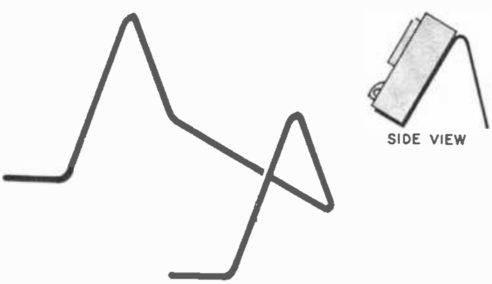
EMERGENCY CONTINUITY CHECKER

A pair of high-impedance headphones can be used as a continuity checker by simply connecting a 1½-volt flashlight cell and a couple of test probes to the phones as shown. Unless the circuit is open, you'll hear a loud click in the phones whenever the probes are effectively short-circuited. You'll find this checker helpful for testing continuity of vacuum-tube filaments, switches, fuses, household appliances, etc.—*Robert McFeely, Indianapolis, Ind.*



COAT-HANGER INSTRUMENT STAND

A convenient stand for a multimeter or vacuum-tube voltmeter can be easily formed from a wire coat hanger. Shape the wire to fit the meter, and tape the ends of the wire to prevent scratching or marring the meter. The stand will hold the meter securely and at a convenient reading angle. —*Rudolf F. Graf, New York, N. Y.* —30—



Hi-Fi Showcase

THINGS are hopping at hi-fi salons these days as a result of some exceptional hi-fi/stereo demonstrations during recent audio shows. Here are short descriptions of a few new products that may capture your interest. Further information is generally obtainable at any store handling hi-fi components; you can also write the individual manufacturers—see addresses on page 38.

Birmingham Sound Reproducers Ltd. prefers to call itself BSR and reckons that in a few years this abbreviation will be as familiar as RCA, GE, IRC, etc. Its stock in trade is record changers and it claims that 25% of all stereo phonograph combinations now being sold use its "Monarch" changers. BSR is currently emphasizing the UA14 model which has been life-tested to exceed 550,000 plays . . . *Eric Sound,* only a few years back, was a small producer of FM tuners. Although its prices were low, quality and workmanship seemed to be above average and the tuners sold well in west coast markets. Eric continues to expand and now offers a variety of hi-fi/stereo components. Its most recent addition is a stereo receiver/amplifier with 10 watts output per channel; the west coast price of $169.50 is $5.00 cheaper than the east coast price—quite a switch!

The *Gray Manufacturing Co.* has had a rebirth of interest in the hi-fi field. To refresh your memory, the Gray people are best known for a viscous-damped tone arm that gained considerable recognition in the days prior to stereo discs. Now they are back with a re-engineered model of the same arm but one that does not interfere with the vertical compliance requirements of stereo discs. Both kit and pre-wired versions are available . . . *Lafayette Radio* continues to offer a variety of unusual hi-fi products under its own brand name. Our attention has been drawn to a "Trihelix" 10-inch 3-way speaker that looks like a "natural" for any do-it-yourself bookshelf system. The "Trihelix" actually consists of three mechanically independent speakers with crossover points at 1500 and 5000 cps. Frequency range is within $\pm$ 3.0 db from

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Also in November POPULAR ELECTRONICS:

- PRINTED CIRCUITS—the new development in electronics that has finally come of age. You'll find out what they are... types used in different equipment... how they are made.
- LOAD LINES—how to draw and use them to design your own vacuum tube circuits. They're used with vacuum tube characteristic curves found in every tube manual.
- MODIFYING YOUR TRANSCEIVER—is easy with this November POPULAR ELECTRONICS feature. Tells you how to add a tuning vernier dial, plate current meter and other modifications to your CB or amateur transceiver to increase operating ease.

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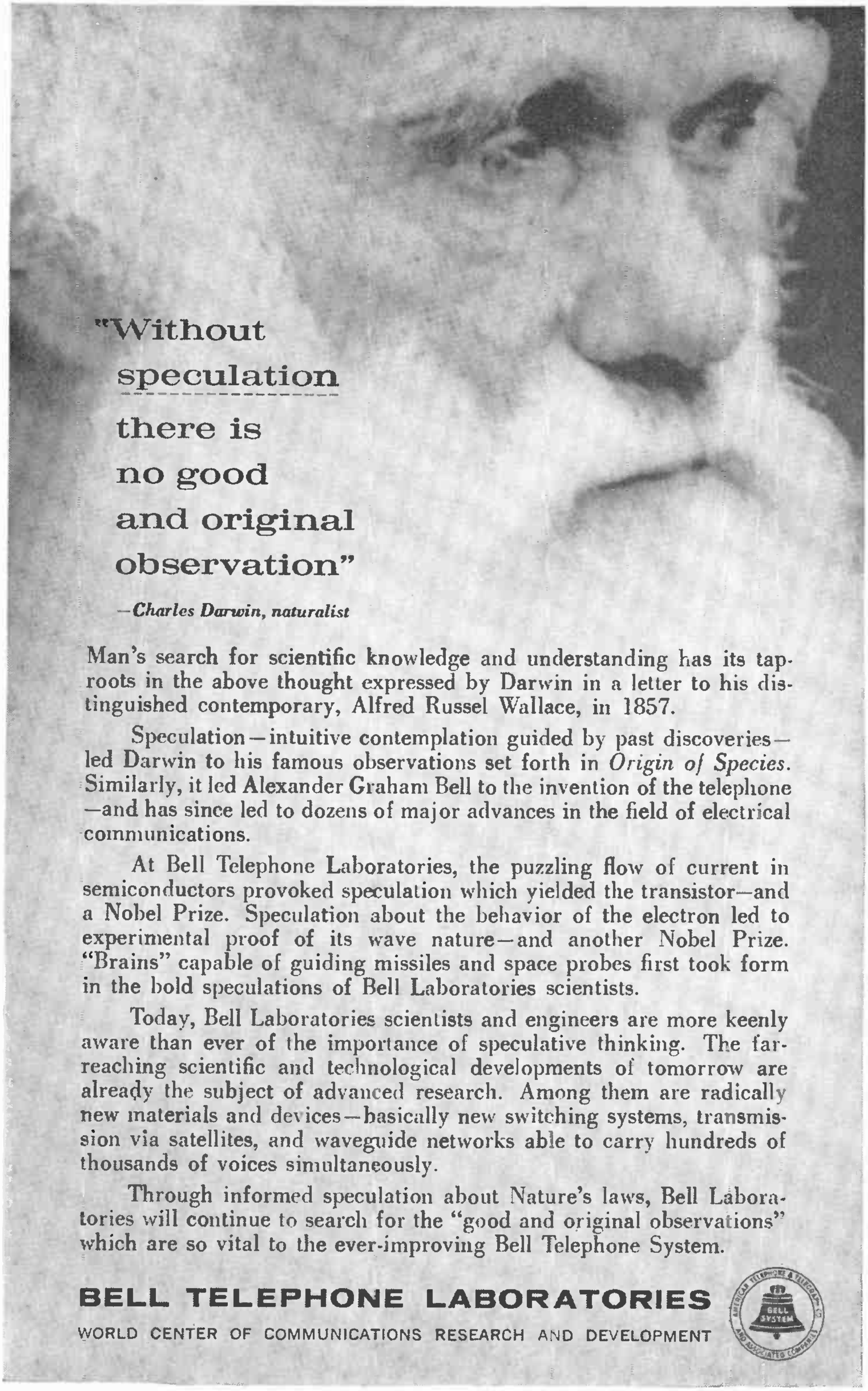
Showcase

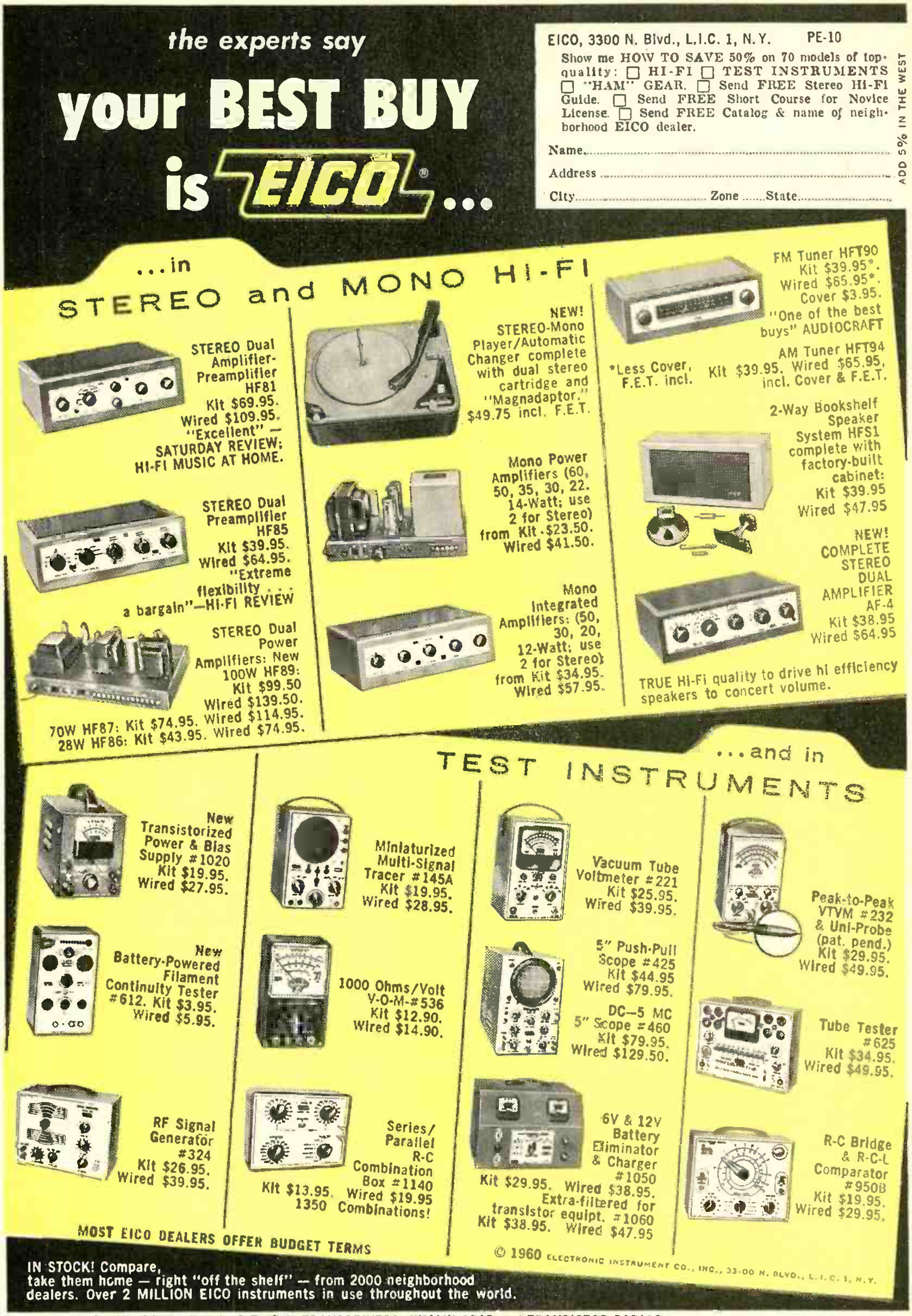
(Continued from page 36)

30 to 12,000 cps; overall response is 20 to 20,000 cps. Priced at $32.50, this unit represents an unusual buy . . . Another mail-order house with its own brand is *Radio Shack*. Its popular "Realistic" 4-speed turntable (with hysteresis motor) has been redesigned and an all-new stereo tone arm added; the combination is being labeled the "Mark VIIIa." A special mounting board is furnished with it which measures 13" deep, 15" wide, and requires 3½" clearance above and 4" below the mounting plate. Price, $59.95.

Rek-O-Kut has come to the obvious conclusion that some audiophiles just don't like to be bothered with the soldering and shielding of tone arm leads. The result is the Rek-O-Kut "Micropoise" tone arm which incorporates two color-coded plug-in leads; a ground wire is permanently anchored to the base of the arm. The "Micropoise" is also dynamically-balanced (calibrated from 0 to 6 grams), a departure from the statically-balanced arms produced heretofore. Prices are $29.95 (12") and $34.95 (16") . . . Have you noticed that cartridge manufacturers are not forgetting the 78-rpm libraries? *H. H. Scott* now sells a special cartridge for its British-made Model 1000 stereo integrated arm and cartridge. The 78-rpm head has a 3-mil stylus and just the right weight to play at 3.5 grams. By the way, H. H. Scott will replace—apparently free of charge—any of the original London-Scott 1000 cartridges with a ruggedized version not susceptible to stylus damage . . . *Audio-Empire* has a new turntable—the Empire 208—featuring all three record speeds and a belt drive! One other manufacturer has a hybrid turntable (part idler-drive and part belt-drive), but we're pretty sure that Herb Horowitz's crew has come up with something extra special. In fact, they measure rumble vibration amplitude in millionths of an inch. Price, $87.50. —30—

Audio-Empire (Dyna-Empire, Inc.), 1075 Stewart Ave., Garden City, N. Y.
BSR (USA) Ltd., College Point, Long Island, N. Y.
Eric Engineering Co., 1823 Colorado Ave., Santa Monica, Calif.
Gray High Fidelity Div., 16 Arbor Street, Hartford 1, Conn.
Lafayette Radio, 165-08 Liberty Ave., Jamaica 33, N. Y.
Radio Shack Corp., 730 Commonwealth Ave., Boston 17, Mass.
Rek-O-Kut Co., Inc., Corona, N. Y.
H. H. Scott, Inc., 111 Powdermill Road, Maynard, Mass.


"Without speculation there is no good and original observation"
—Charles Darwin, naturalist
Man's search for scientific knowledge and understanding has its tap-roots in the above thought expressed by Darwin in a letter to his distinguished contemporary, Alfred Russel Wallace, in 1857.
Speculation—intuitive contemplation guided by past discoveries—led Darwin to his famous observations set forth in Origin of Species. Similarly, it led Alexander Graham Bell to the invention of the telephone—and has since led to dozens of major advances in the field of electrical communications.
At Bell Telephone Laboratories, the puzzling flow of current in semiconductors provoked speculation which yielded the transistor—and a Nobel Prize. Speculation about the behavior of the electron led to experimental proof of its wave nature—and another Nobel Prize. "Brains" capable of guiding missiles and space probes first took form in the bold speculations of Bell Laboratories scientists.
Today, Bell Laboratories scientists and engineers are more keenly aware than ever of the importance of speculative thinking. The far-reaching scientific and technological developments of tomorrow are already the subject of advanced research. Among them are radically new materials and devices—basically new switching systems, transmission via satellites, and waveguide networks able to carry hundreds of thousands of voices simultaneously.
Through informed speculation about Nature's laws, Bell Laboratories will continue to search for the "good and original observations" which are so vital to the ever-improving Bell Telephone System.
BELL TELEPHONE LABORATORIES
WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT
BELL SYSTEM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STEREO Dual Preamplifier HF85 Kit $39.95. Wired $64.95. "Extreme flexibility . . . a bargain"—HI-FI REVIEW
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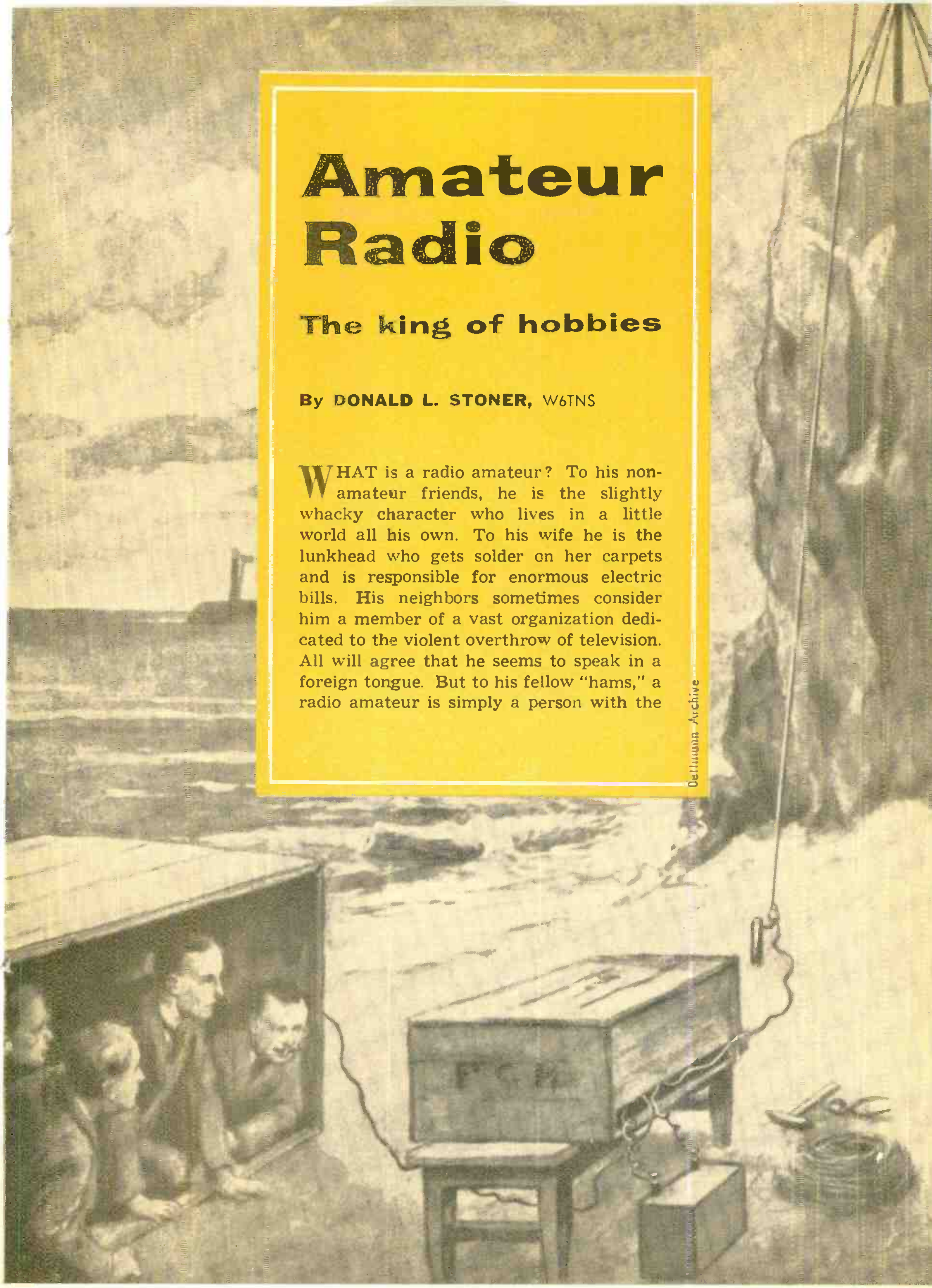
Amateur Radio

The king of hobbies

By **DONALD L. STONER,** W6TNS

WHAT is a radio amateur? To his non-amateur friends, he is the slightly whacky character who lives in a little world all his own. To his wife he is the lunkhead who gets solder on her carpets and is responsible for enormous electric bills. His neighbors sometimes consider him a member of a vast organization dedicated to the violent overthrow of television. All will agree that he seems to speak in a foreign tongue. But to his fellow "hams," a radio amateur is simply a person with the



Bettmann Archive

most interesting, unusual, and rewarding hobby in the world.

Birth of the Hobby. Although amateur radio is strictly a twentieth-century hobby, the birth of an infant called "wireless" occurred long before the turn of the century. In 1887, when the chief interest of most of the population was attending a band concert, a brilliant young German scientist named Heinrich Hertz was experimenting with electricity. Hertz discovered that a spark could be made to jump a gap some distance from the source of power—with no connecting wires! He correctly deduced that electromagnetic waves traveled between the source and the spark gap at the speed of light. The units could be separated by only a few feet, however, or no spark could be detected. Nevertheless, Heinrich Hertz might well be called the world's first radio amateur.

The Italian genius Marconi carried Hertz's simple experiment further by connecting one side of the "sending" spark gap to wires buried in the ground; the other side of the gap was connected to a "skywire" or antenna. Equally important, Marconi applied the telegraph code, devised by Samuel Morse for telegraph lines, to his new invention. With this setup, electromagnetic waves generated by the crackling spark traveled more than a mile to a receiving station (see page 41). Practical wireless telegraphy had arrived on the scene; the year was 1895.

Marconi worked ceaselessly to increase the range of his equipment, and more sensitive devices were invented to reproduce the sound of the code. By the time practical distances had reached 200 miles, many government and commercial companies were beating on Marconi's door in their search for wireless equipment. By late 1901, Marconi had thrust his signals 1800 miles from Wales to Newfoundland, in one great leap.

Mushrooming events in the wireless field created more public interest than had ever been known. Experimenters found that they could listen in on this new marvel by building their own receiving stations; amateur transmitting stations followed in short order. The English end of the transatlantic circuit stimulated a similar interest in that country—the amateur experimenters, or "am's" as they were called, built receiving gear with a frenzy.

Keep in mind that there were no tubes, capacitors, resistors, megacycles, or meters. And there were no government regulations, frequency allocations, or organizations for amateurs. Anyone who wanted to experiment built the necessary parts and plunged into the construction of his station.

Heinrich Hertz, a brilliant German scientist, discovered the principle of electromagnetic radiation in 1887. Although Hertz died before he succeeded in transmitting waves more than a few feet, he was the world's first "radio amateur." *(Culver Pictures photo)*

Important Milestone. Then the rotary spark gap was invented. Rather than use a fixed gap for the spark, this device used many gaps which rotated at high speed. It produced pleasant-sounding oscillations at the then fantastic rate of 50,000 cps. Even more important, the oscillations could be modified by the human voice.

Many experimenters feared insanity when voices, rather than the whine of the sparkset, leapt out of their headsets. But once again amateurs scrambled, this time to hurl their voices across space. The art of radiotelephone transmission had been created; the year was 1906.

Publications describing all kinds of devices for the experimenter were numerous. The papers described feats of distance and

Guglielmo Marconi, an Italian, was first to transmit signals across the 1800-mile span of the Atlantic Ocean. *(Culver Pictures photo)*

Hiram Percy Maxim (right), co-founder of the American Radio Relay League, was instrumental in the repeal of the war-time ban on radio amateurs. *(QST photo)*

"heroism" by wireless stations almost daily. The tiny stream of fire created by Hertz and Marconi had become a tremendous blaze in the eyes of experimenters everywhere.

With the increased activity came an ever-rising tide of interference between stations. With no regulations, all stations —amateur, commercial, and government— were intermingled. The interference culminated in the Wireless Act of 1912, with the adoption of the rules which provide the framework under which amateurs operate today. Most important, the government was to control all wireless transmissions, all operators had to be licensed, and amateurs were relegated to a no-man's land of wavelengths shorter than 200 meters (near the high end of the present broadcast band). Commercial and government stations were the only wireless stations allowed below this frequency, except by special permit.

Amateurs protested violently, for they felt that this regulation effectively slashed the wrists of their sending hands. The new wavelengths were uninhabited and incapable of propagating energy across a small village, or so they thought. The more progressive experimenters soon discovered that their range had been increased, rather than decreased, and with no additional transmitting power! The better stations could communicate over distances in excess of 30 miles.

Formation of ARRL. In 1914 another great event occurred. The Radio Club of Hartford, Conn., formed a league of amateur stations. This group, as the American Radio Relay League, still represents U. S. amateurs in all official matters. The purpose of the League was to band amateurs together so that they could relay messages from one point to another as commercial stations did.

An early network of amateurs was attempted between Boston and Denver, with the eventual hope of spanning the continent. Soon, with the leadership of League co-founder Hiram Percy Maxim, messages were flying back and forth. By 1921, with improved equipment and techniques, a message and answer could make the round trip between coasts in six minutes! Although the League suffered severe financial troubles in the beginning, it was able to publish the first issue of its official organ in December, 1915—a magazine still known as "QST."

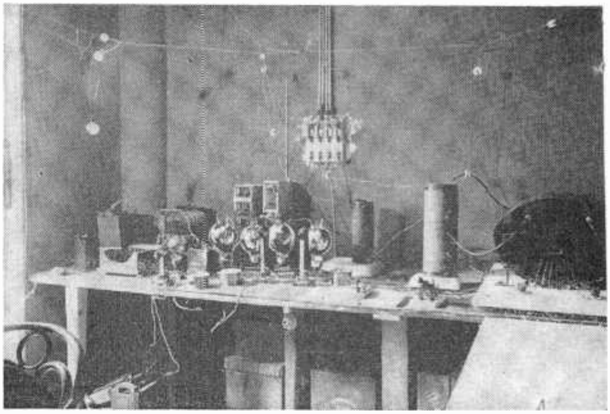
During the First World War, two-thirds of the 6000 amateurs trooped off to the battlefield, and all amateur transmissions ceased. During the war, and with the help of amateurs, the government discovered how valuable the wavelengths shorter than 200 meters were. These frequencies became the exclusive property of the Navy; and after the shooting had died down, the Navy was hesitant to return them. Under the pressure of League president Maxim and secretary Warner, however, the government relented. In October of 1919, amateur radio was restored. Call letters, consisting of a number and two letters, were again assigned by area to amateurs. (It was much later before the W and K prefixes were added.)

The war also made a commercial item out of a device that was once a laboratory curiosity. It was called a valve (vacuum tube) and could be used to make receivers more sensitive. Even more important, this magic bottle could be used to generate radio signals electronically, with no moving parts whatever. The glow of the vacuum-tube filament cast a shadow over the spark gap and helix coil which signaled the end of a great era. With a mighty whoosh of ozone, King Spark shuddered and died!

New Vistas. Armed with this electronic invention, the ARRL sent Paul F. Godly, 2ZE, to Europe for transatlantic tests. During the experiments, thirty American amateurs were heard on the continent. Finally, after many months of preparation, the first two-way amateur contact flashed across the Atlantic.

In the course of these tests, it was discovered that the shorter wavelength provided superior propagation of electromagnetic energy. Later it was found that the wavelengths between 40 and 10 meters were optimum for long-distance contacts. A mass exodus to the "short wavelength" bands began which made the California Gold Rush seem like a school fire drill.

From then on improvements in equipment and techniques appeared in rapid succession. Today, with modern advances, we think nothing of speaking with amateurs on the other side of the globe—it happens daily! In fact, the amateur radio hobby has literally soared through the ionosphere and far out into space. For ex-

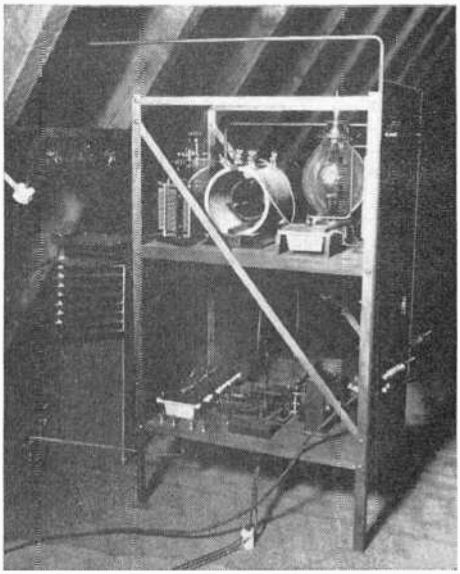


First transatlantic two-way communication between amateurs took place 37 years ago. In November, 1923, stations 1MO and 1XAM (now W4CF and K6BJ) in the United States worked station F8AB in France. Photo shows F8AB as it looked then.

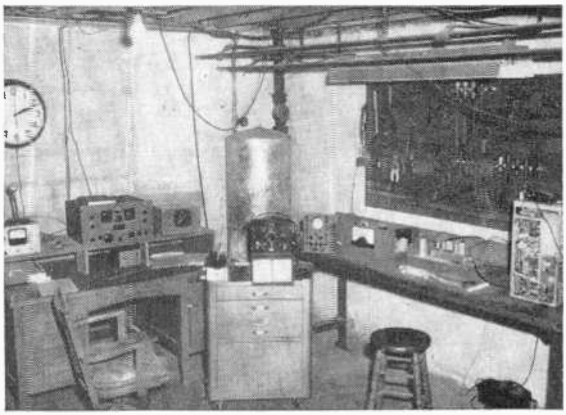
ample, early in 1953, two outstanding radio amateurs, Ross Bateman (W4AO) and Bill Smith (W3GKP), succeeded in bouncing amateur signals from the surface of the moon back to earth. Although they used the legal maximum power for amateurs—1000 watts—theirs was truly a marvelous technical accomplishment.

Of equal merit was the transmission between John Chambers, W6NLZ, and Ralph Thomas, KH6UK, in 1957. In that year they communicated between California and Hawaii on the 144-mc. band. Frequencies this high, like TV signals, are usually confined to short distances, and covering the 2540-mile path was thought impossible. Later, these same two pioneers repeated the feat on the 220-mc. band—again confounding the experts.

Facets of the Hobby. Amateur radio is actually a large group of hobbies within a hobby, for amateurs have many methods of communication. Some prefer to use the telegraph code system, claiming it is more



Amateur station 3OT (left) in the year 1925. Object in center is a tapped coil; a large transmitting tube is on the right. *(QST photo)*



Homemade station W4AO (below, left) in the basement of Ross Bateman's home was used to bounce signals off the moon. *(QST photo)*

Ham of the Year (1959) Walter Ermer, Sr., W8AEU (below, right), helped provide Cleveland, Ohio, with a 300-man emergency corps.

reliable and less expensive. Others insist that talking over the air is more personal. Still other hams do their "talking" with rattling teletype machines. And a few hardy souls even have their own TV stations. In all, there are more facets to the hobby than to the Hope diamond! Let's look at a few of the activities that occupy the time of almost 200,000 people.

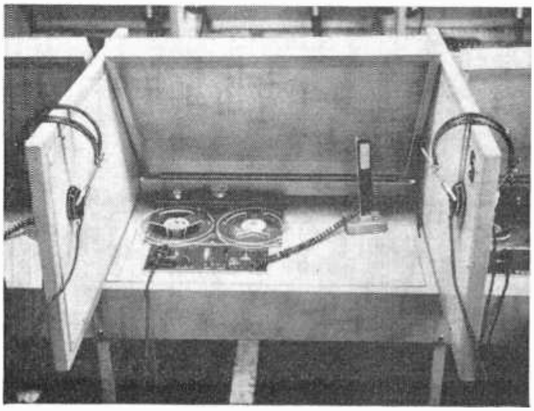
Chatting, or *"rag-chewing,"* is by far the most popular diversion, for hams love to talk! As soon as the first cigarette of the morning is lit, Sam Ham will flick on his receiver and transmitter, even before putting the coffee pot on the stove. Other hams are doing the same thing. More often than not, a group of these early birds collect in a "round-table," and the microphone is passed around via the air waves until it is time for the various members to dash off to work. The scene is repeated after supper by some of the more rabid members of the clan.

"What do you find to talk about?" hams are often asked. The simplest answer is that sex, religion, and politics are frowned upon, but virtually everything else goes. Generally, the conversation drifts around to technical subjects, new equipment, the latest circuits, and so on.

Sam Ham might also be interested in an-

(*Continued on page* 134)

Instructors at New York University's language lab, left, walk around the classroom, keeping tabs on each student's progress and straightening out any problems that may arise.



Student's booth contains a tape recorder, a microphone, and a set of headphones. The student listens to a prerecorded lesson and repeats it phrase by phrase into his tape recorder. In playback, he hears the two tracks one after the other and is able to compare his pronunciation with that of the instructor.

Language Laboratories

The electronic answer to the language-teaching problem

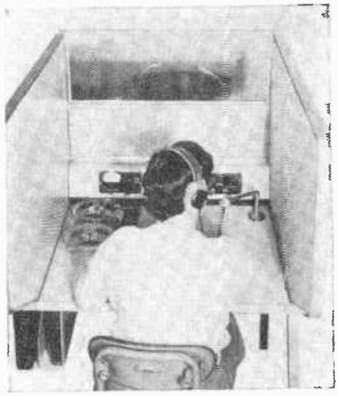
By GEORGE LESKO

WHEN it comes to foreign languages, Americans have traditionally been among the most poorly educated people in the world. This is unfortunate and perhaps even dangerous. With modern technology making the world smaller every month, it is becoming increasingly apparent that a knowledge of foreign tongues is important in the pursuit of world peace.

To facilitate the teaching of languages in our schools, educators are turning to electronics—more specifically, to the magnetic tape recorder. "Language laboratories" which center around the use of tape recorders are springing up in high schools and colleges all over the country.

How does a "language laboratory" work? As an example, let's consider the one recently installed at New York University.

Dual Recording. In a classroom measuring 100′ x 100′, there are 177 semi-enclosed booths. Each booth is lined with sound-absorbing material and contains a microphone, headphones, and a tape recorder. A bank of 11 "master" tape recorders located in the front of the classroom permits



The success of the language-lab concept has led to production of commercial equipment specifically designed for this application. At left above is the control console for the "Medallion" 50-student, 4-language system, produced by the DuKane Corp., St. Charles, Ill. Directly above is one of the "Medallion's" listening booths. At left, a high-school class in Russian is finding out that the language-lab method of learning is quick and easy.

11 languages to be taught simultaneously.

As a student sits at his booth, he listens to a prerecorded lesson. After the instructor's voice speaks a word or phrase, the student repeats it into his microphone, and both voices are recorded on tape. In playback, the new recording allows the student to compare his pronunciation with that of the instructor.

The progress of the students is noted in two ways. First, the instructor can walk from booth to booth, plugging in his headphones to listen to a single student; this gives the student a feeling of personal attention and provides a means of solving individual problems. In addition, the instructor can plug his headphones into the master control at the head of the classroom and listen to students without their knowledge.

"Electronic" Education. How does the electronic language laboratory advance education? It frees the instructors from the drudgery of routine teaching, practice drill, and pronunciation problems. One instructor becomes 30 teachers at the same time, and is capable of giving individual attention to any single student without holding up the others.

Also, the students get much more practice in the language lab. In a conventional language class, a student averages perhaps one minute of active participation during a session. The language lab enables him to have forty minutes of speaking time per session.

The future for language laboratories looks exceedingly bright. In the New York City school system alone, about twenty language labs are expected to be in operation by the end of the 1961 school year. Other educational centers throughout the country are also planning to make full use of this revolutionary new electronic teaching tool. —30—

Living with Loudspeakers

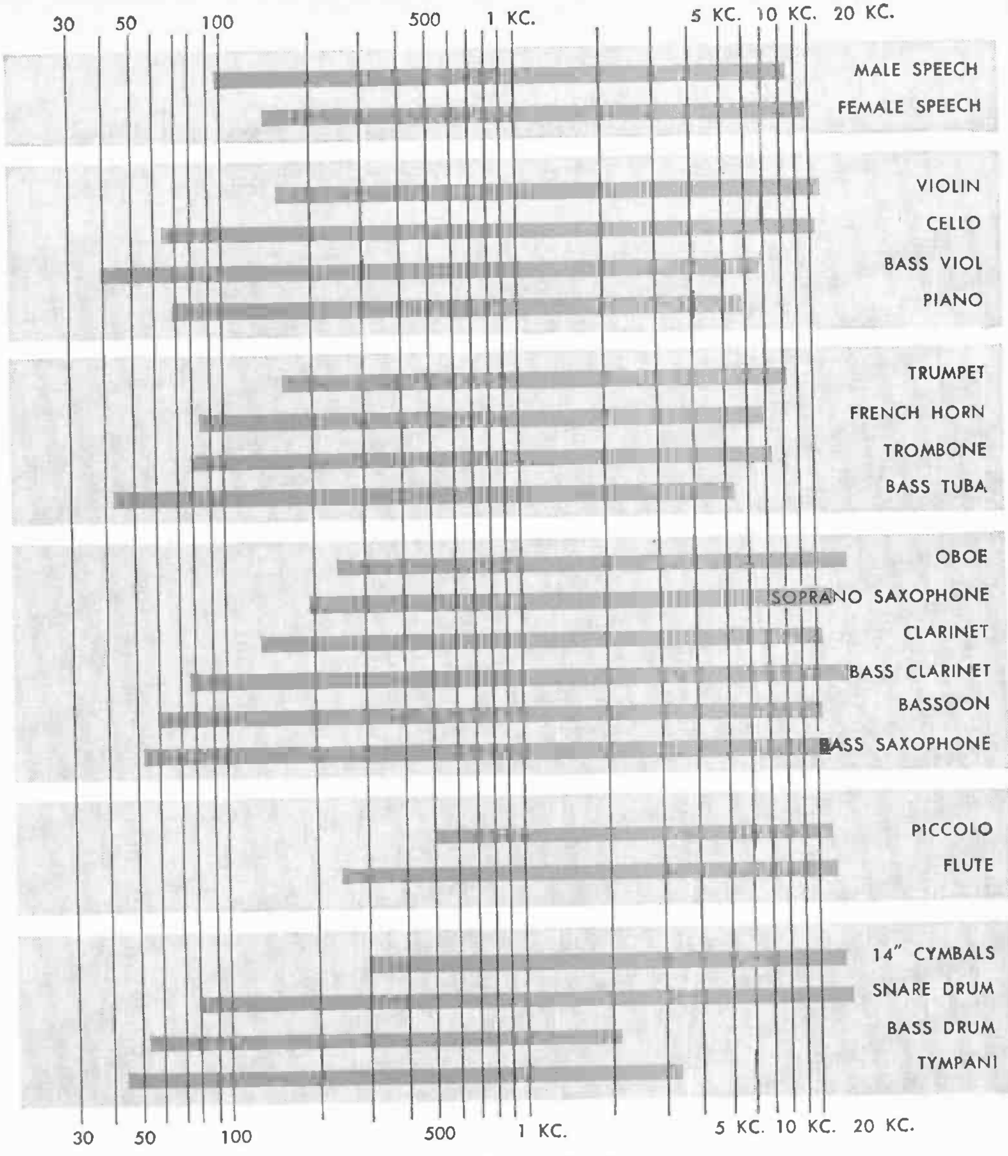
By JOHN MILDER

There are good reasons for the differences you hear between speaker systems. Understanding the differences is the key to finding the right speaker for you

EVER since the beginning of the hi-fi era, loudspeakers—like every other component in the sound-reproducing chain—have been fuel for heated arguments between audiophiles. But unlike amplifiers and preamps, speakers have managed to hold on to their very audible personalities. The bumpy response curves of even the most expensive speaker systems are somehow unimpressive in comparison with those straight-as-an-arrow graphs drawn for quality amplifiers. Fortunately, most speaker systems sound a lot better than their response charts look.

Thanks to the individuality of speakers and the people who listen to them, listening tests and reports on speaker systems have never been easy to make. All things considered, there are good reasons for relying on *your* ears as the ultimate judges of speaker quality. But to make your ears reliable test instruments, it's important to understand the reasons for those hard-to-describe differences between speakers and your reactions to them.

Speaker Coloration. Despite traditional yardsticks like frequency response and distortion measurements, most audiophiles rely on the term "coloration" to describe the differences between a pair of speaker systems. Classifying the kind of sound from any speaker usually calls for words like "mellow," "brilliant," "crisp," and so on. But the ultimate praise for the speaker an audiophile picks to take home to his living room is the word "uncolored."

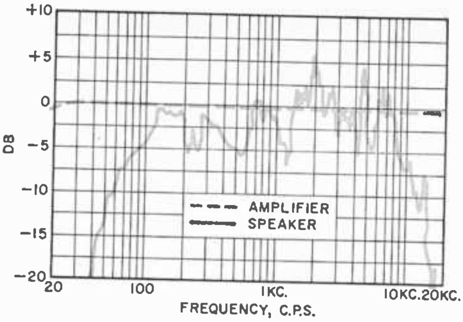


Frequency ranges of human speech and typical musical instruments. Organ (not shown) extends to 30 cps.

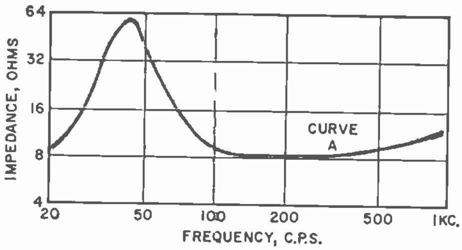
Since "coloration" gets a real workout in the lingo of hi-fi showrooms, let's take a closer look at it and see what it really means.

Although you may not know enough about the world of hi-fi music to tell a score from a schematic, you're buying a musical instrument when you select a speaker system. Like a violin or a bass drum, a speaker vibrates to set air in motion and produce sound. A violin gets its orders from the man behind the bow, while a speaker obeys electronic directions from an amplifier.

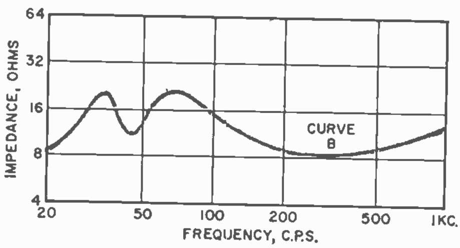
Each instrument in a symphony orchestra sounds different because of the varying harmonics they produce along with their fundamental frequencies. Without their distinctive harmonics, all instruments would act like sine-wave generators and sound exactly like each other. The harmonics themselves get their start in life from the construction of the instruments,



On-axis response of a high-quality speaker compared to response curve for a typical hi-fi amplifier. Note pronounced dropping off of speaker response at upper and lower limits.



Impedance increases at speaker's resonant frequency (curve A, above). However, a properly designed bass-reflex enclosure will substantially reduce this rise (curve B, below).



the materials used, and the way the instruments are played. Everything about a violin, for instance, down to the glue used to put it together, helps to decide its "coloration" and musical personality.

Speaker coloration follows the same rules. Speakers are made from many materials—from paper pulp to plastics—and any material that's part of a speaker's vibrating mass will add harmonics which color the speaker's sound. Since only one of today's speakers—Electro-Voice's "Ionovac" tweeter—creates sound with an ionized air "diaphragm," virtually any speaker you buy will have some degree of coloration.

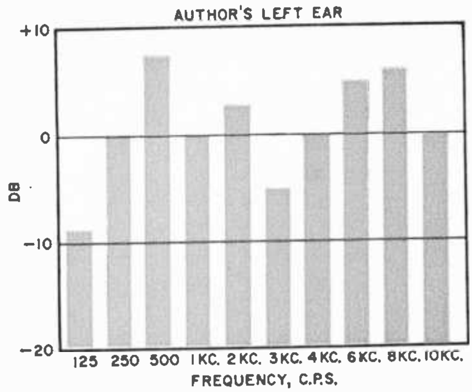
Coloration and Distortion. When we call a speaker harsh or muddy, the speaker itself is overshadowing the sound it's trying to reproduce. On test instruments, excessive coloration will show up both as distortion and as very uneven frequency response.

When a speaker won't let you forget for a minute that it's only a speaker, it's having a field day with its harmonics and paying little attention to an amplifier's directions. Often the reason is the use of too "live" a material for a speaker cone; the closest musical equivalent would be banging on an oil drum instead of a tympani. But even a cone of good inert material can go off on its own. If the cone isn't properly designed or isn't adequately controlled by the magnetic field which surrounds its voice coil, it can vibrate independently or flex at the wrong points along its surface. A speaker with all these faults sounds as musical as Jack Benny's violin.

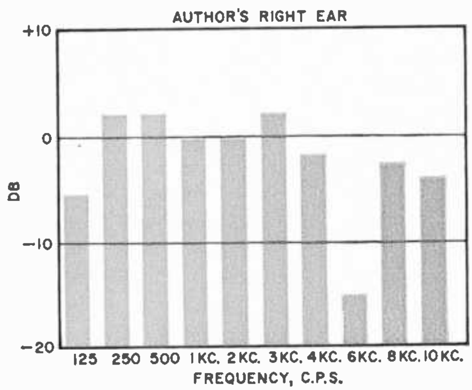
Most speaker manufacturers go to great lengths to avoid excessive coloration. They test cone materials and experiment with suspensions and magnetic structures. And they do their best to make sure that speakers don't assert their own character at the expense of the music they are called upon to reproduce.

The acid test of the manufacturer's success is your ability to "hear through" a speaker system without being distracted by its over-all sound quality. It's worth remembering, though, that the subtle differences you can hear between quality speakers are unavoidable. Whether it's a moving-coil or an electrostatic unit, every speaker has its trademark in sound, yours to like or dislike.

Speaker Enclosures. While speakers provide enough problems to keep any engineer from getting bored, the enclosures in

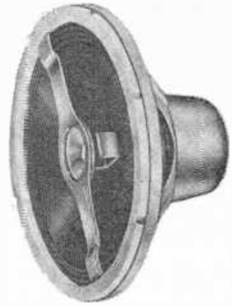


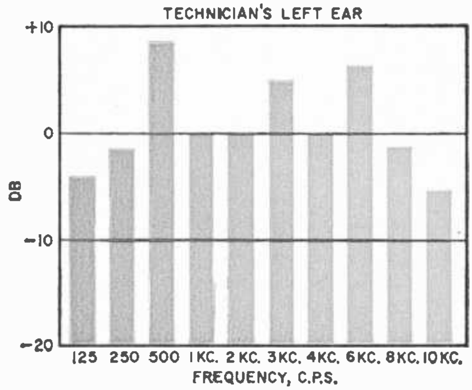
The author, male and under 30, found that his right ear was more uniform in sensitivity than his left ear, as shown in the charts above and below. Sensitivity varies with age and sex.



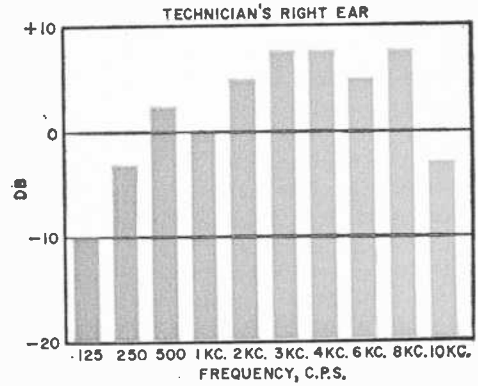
which they are mounted also have their say as musical instruments. The role of an enclosure can be as important as the sound chamber of a Stradivarius violin. The part played by an enclosure in the overall sound of a speaker system depends to a large extent on what we ask it to do. Its general sound quality will also depend in part on how well it's made.

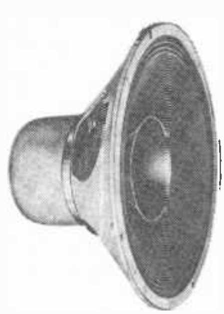
A bass reflex cabinet, usually designed to cancel out a speaker's resonant frequency and extend its bass response, adds its own distinct flavor to a speaker's sound. Depending on its design, it can make for a juicy resonance in the base response by adding harmonics at intervals above the speaker's resonant frequency. Other resonant enclosures—those designed along the lines of an organ pipe, for example—also color a speaker's sound. There's nothing particularly unmusical about this type of colora-





A lab technician, female and also under 30, was generally more sensitive to middle and higher frequencies. Most tests indicate that women have better "ears" than men do.

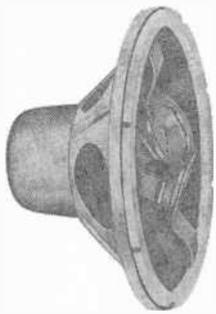




tion, but a badly tuned or poorly built enclosure adds boominess or rattling which makes for uneasy listening.

An infinite baffle, intended primarily to keep a speaker's back-wave from cancelling out its front-wave at low frequencies, also adds its own kind of coloration. Overall sound from an infinite baffle can be distinctly unpleasing as a result of panel resonance from poor construction.

Horn enclosures, too, have the job of boosting a speaker's ability to move air at low frequencies. But a badly designed or constructed horn can add a very annoying coloration, and using a horn enclosure with a speaker intended for infinite baffling can produce a muddy, bass-heavy sound.



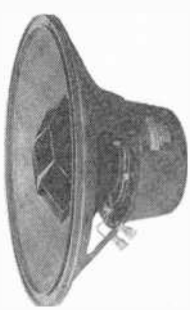
Since any enclosure is meant to be a partner—ideally a silent one—for its speaker, it's always smart to follow the instructions of a speaker's manufacturer to a "T" when you build your own cabinet. But whether or not you're a do-it-yourself'er, make sure that you judge a speaker only in an enclosure specifically designed for it.

Listener Response. In any listening test, our own listening habits affect our judgments as much as anything that a manufacturer builds into his speaker systems. By hi-fi standards, though, the quality control with which we're turned out as listeners is pretty poor, and the "frequency response chart" of an average pair of ears is much more uneven than the graph for a mediocre full-range speaker (see charts on p. 51). Medical standards for "normal" hearing ability permit almost a 25-db variation in our response from 125 to 10,000 cps; audio equipment with that kind of tolerance would put a manufacturer out of business.

Although your own frequency response chart would make any speaker's chart look good in comparison, the up's and down's in your "response curve" are important for judging a speaker system. If one person has trouble hearing a frequency at which a speaker is peaking or distorting badly, he may be able to listen comfortably to a speaker which would drive another person —with better hearing at that frequency— out of the room.

In addition to our individual hearing abilities, there's also the matter of listening habits. After some experimentation, one listener discovered that speaker systems which sound right to a violinist friend of his sound very harsh and unnatural to him. His friend is used to the piercing, gutty quality of a violin at close range, while he is used to the string tone heard from the back rows of a balcony. Many similar listening habits help to shape our preference in recorded sound.

Our imperfections as hi-fi listeners ought to keep us from being arbitrary in our judgments of speaker systems. They are also our best defense against critical friends who find our speaker systems too tinny or too dull for their tastes. If a speaker passes the objective tests we can give it, there's no reason to cringe under criticism from a neighbor with "golden ears."



Use Your Ears. There are several reliable tests for judging a speaker, and today's range of speaker systems makes it easy to find one for your particular tastes. The job will be even easier, though, if you trust your common sense and avoid arbitrary standards which don't take *you* into account.

If you have any fixed ideas on how wide a speaker's frequency response must be for hi-fi listening, don't insist on them. Trust your ears to tell you which speaker in your price range comes closest to live sound as you know it; and make sure that a speaker's response at one end of the frequency range is balanced by its performance at the other end. A speaker with very good highs but weak lows will wind up sounding thin and unsatisfying in your living room, and a system with solid lows and missing highs will leave you thinking that an orchestra has too many bass fiddles and drums.

Many authorities feel that the product of the lowest and highest notes your system will handle should equal 400,000; others have picked totals as high as 600,000. This

(*Continued on page* 137)

PULSE MODULATION

This exciting method of communication is reaching out beyond the frontiers of space

By HERBERT KONDO

FROM SATELLITE 1959-*delta* the message came loud and clear: a huge belt of electrons circles the planet earth thousands of miles out in space. Our 1959-*delta* had further jolting news: the outer Van Allen radiation belt, once thought to expand after a solar eruption, actually shrinks. Even more striking was the news that there is a huge interplanetary "atom smasher" centered about the sun.

Satellite 1959-*delta,* commonly known as "Explorer VI," had a lot more to say. But how it said it is just as interesting as what it said. A great deal of Explorer VI's information was sent by a five-watt transmitter that used pulse modulation, the most sophisticated modulation system known today. So important is this new communications system that it is already used for telegraphy, radar, multi-channel microwave transmission, and telemetry, as well as space communications.

Basic Theory. The idea of pulse modulation has been around a long time. In telegraphy, the familiar "dots and dashes" of the Morse code are pulses produced with a switch or key. Ham operators have long been using a form of pulse modulation when they key their high-frequency transmitters to send out pulses of electromagnetic energy in code. Television servicemen come across a form of pulse modulation in the gated-beam tube.

The principle behind the pulse modulation system is actually ridiculously simple: information is impressed on a train of pulses instead of directly on a continuous-wave carrier. But if it's as simple as that, why all the excitement about it? What does pulse modulation have that more familiar forms of modulation—AM and FM—don't have?

For one thing, pulse modulation offers practically noise-free transmission and reception—even more so than FM. To visualize this concept, let's consider a train of ideal pulses—pulses with vertical sides, as shown in (A) of Fig. 1. Noise is picked up during transmission, resulting in the waveshape shown in (B). With suitable clipping and limiting circuits, we can reproduce only that part of the pulse signal between the dotted lines, as shown in (C). Having done this, we can then re-transmit this new signal free of noise.

Pulse modulation has another outstanding advantage. It uses transmitter energy more efficiently than either AM or FM because of the simple "on-off" nature of the pulses. This means that a pulse transmitter will have a longer range than an AM transmitter of the same power.

All pulse modulation systems boil down to two basic principles:

(1) A message signal modulates a train of pulses which are applied to a subcarrier.

(2) The subcarrier then modulates a high-frequency carrier.

The relation of a subcarrier to a carrier can be made clear by an analogy. Let's suppose that there are five messenger boys on the same subway train in New York City. Each boy is carrying a message to a different destination (receiver). If we think of the subway as the carrier, then each messenger boy is a subcarrier. The message each boy carries is the modulated signal.

Sampling. The most important idea in pulse modulation is sampling, a concept which we come across almost every day. For example, if you've never heard a stereophonic recording, you can listen to a "stereo sample" record and get a good idea of what stereo is like. Another widely known use of sampling is the public-opinion poll which bases its findings on selective sampling techniques.

If we want to transmit a conversation by pulse modulation, we take samples of the conversation—thousands of samples each second—and then transmit them in the same order in which they were spoken. Each pulse is actually a single sample; its height, width, or position indicates the instantaneous value of the sound sent.

For good reproduction, it has been shown that the number of samples per second must be greater than twice the highest frequency of the signal we wish to send. Thus, if the highest frequency in a telephone conversation is 4000 cps, we must take at least 8000 samples each second.

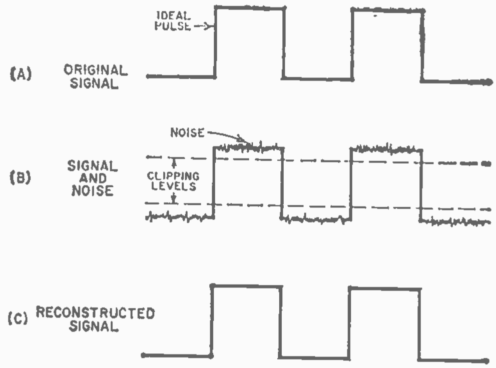


Fig. 1. Original signal amplitude of pulses (A) is affected by noise in transmission (B). Electronic clipping restores original signal (C).

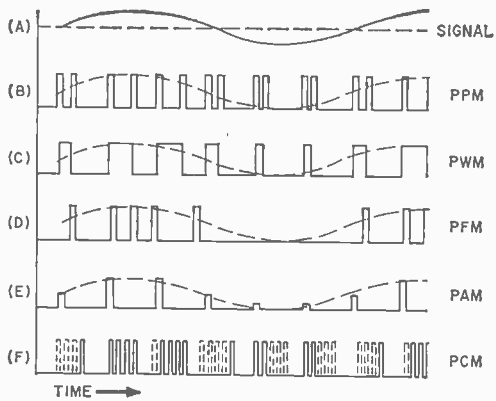


Fig. 2. Information contained in the modulating signal in (A) is shown as it would appear using the various pulse transmission methods (B through F). Binary numbers corresponding to signal amplitudes can be transmitted in the PCM system.

Types of Modulation. Another basic concept in pulse modulation is the modulation itself. When we modulate a carrier wave, we ordinarily alter its amplitude (AM), its frequency (FM), or its phase (PM). The nice thing about a pulse is that there's another characteristic we can use for modulation, namely, *time*.

If we alter the timing of the pulses, we are effectively changing their position relative to one another—this is actually done in pulse position modulation (PPM). In pulse width modulation (PWM), we alter the width of the pulses; in pulse frequency modulation (PFM), the frequency of the pulse changes. We can also alter the amplitude of the pulses to produce pulse amplitude modulation (PAM). And we can even code the pulses, as is done in pulse code modulation (PCM).

Let's take a closer look at all of these pulse modulation techniques and find out how a sine wave—see Fig. 2(A)—is transmitted in each system. Later, we'll see how pulse width modulation and pulse code modulation are used in transmissions from satellites and in multi-channel telephone communications.

PPM. Pulse position modulation, widely used in radar and in microwave relays, depends on a modulating signal varying the position of the pulses. A separate generator produces a series of marker pulses which act as reference points. With PPM, the relative position of the signal pulse and the marker pulse are important, as shown in Fig. 2(B).

PWM. In pulse width modulation, the width or duration of the pulses varies directly in accordance with the modulating signal, as shown in Fig. 2(C). Also known as pulse duration modulation (PDM), PWM varies either the leading or the trailing edges, or perhaps even both edges, of the pulses. For example, if the leading edges of the pulses were spaced at equal time intervals, the trailing edges could then be varied (displaced in time) in accordance with the amplitude of the modulating signal. Since pulse width modulation requires relatively simple circuitry, it is the ideal type of pulse modulation for use in outer space vehicles.

PFM. Pulse frequency modulation is somewhat similar to ordinary FM, except that the basic carrier consists of equally spaced pulses rather than a sine wave. The occurrence of the pulses varies with the amplitude of the modulating signal, as in Fig. 2(D).

PAM. In pulse amplitude modulation, the height of the pulses varies directly in accordance with the modulating signal, much like the amplitude modulation of a continuous-wave (c.w.) carrier. In Fig. 2(E), the *positive*-going portion of a sine wave increases the height of the pulse train, while the *negative*-going portion of the signal decreases the height.

PCM. Pulse code modulation uses the presence or absence of a pulse to convey information. In the sample shown in Fig. 2(F), the code makes use of a group of four positions, which may be "filled" with either a pulse or a space (absence of a pulse).

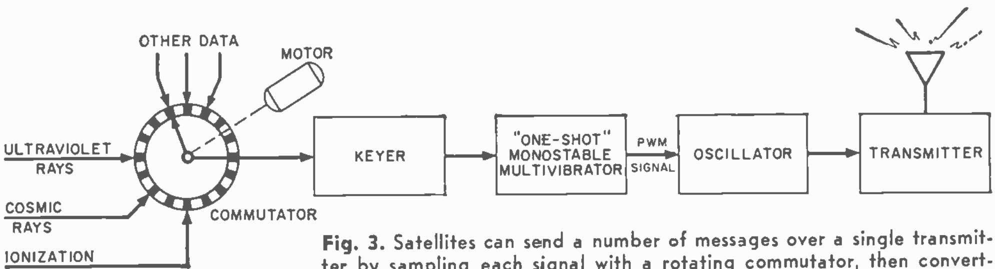


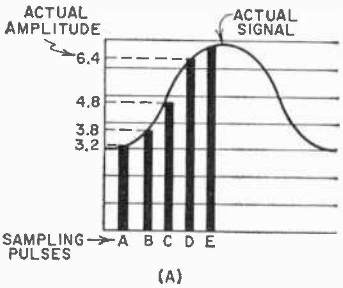
Fig. 3. Satellites can send a number of messages over a single transmitter by sampling each signal with a rotating commutator, then converting the sampled information to PWM signals for transmission to earth.

PWM in Outer Space. If we were to make a block diagram of the telemetry system used in the Vanguard rocket, it would break down into the five simple blocks shown in Fig. 3. (See "Telemetering—Vital Link to the Stars," in the November 1959 issue of POPULAR ELECTRONICS for a complete discussion of telemetry.)

In Fig. 3, a rotating sampling switch—called a commutator—samples a number of contacts which are connected to devices that measure outer space data (cosmic and ultraviolet rays, X-rays, etc.). Information from the contacts is then sent to the keyer which triggers a one-shot multivibrator (itself a special type of PWM generator). With this arrangement, the multivibrator produces pulse signals whose width varies in accordance with the information (voltage) supplied to it by the commutator and keyer. The PWM signals are fed to the oscillator, which modulates the

transmitter that sends satellite performance **information** to earthbound receiving **stations**.

"Explorer I," which discovered the Van Allen radiation belt, also used pulse width modulation. The initial output of the cosmic ray channel, which carried the Van Allen radiation information, was a pulse width signal which then frequency-modulated a subcarrier oscillator. The subcarrier, in turn, phase-modulated the carrier of the satellite's transmitter. This rather complex sequence of modulation techniques also occurred on the cosmic dust transmissions from Explorer I.



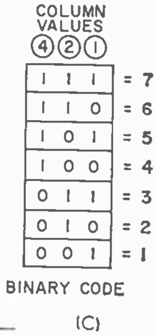
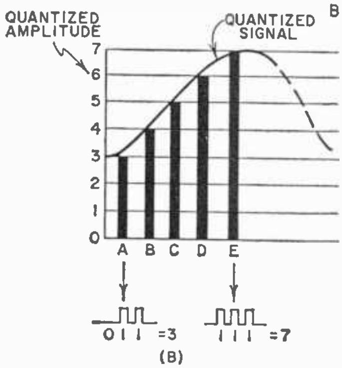


Fig. 4. In the PCM system, amplitude of actual signal (A) is sampled at regular intervals. The samples are rounded off into whole-number pulse amplitudes —a quantized signal (B)—and then converted to binary numbers. Binary code chart (C) gives decimal value of binary numbers.



PCM in Communications. Of all forms of pulse modulation, the most exciting is pulse code modulation. Says a one-time Bell Telephone Laboratories scientist: "It's the most sophisticated communication technique around. It has the advantage of an extremely high signal-to-noise ratio, plus the added element of secrecy. PCM is statistical in nature, and it's hard to jam any statistical communication system—the less predictable the system, the harder it is to design electronic countermeasures against it."

Suppose you bought a VTVM kit for $29.17, tax included. If a friend asked you how much you paid for it, you might tell him that it cost $30.00. Would you be lying? Not at all—you are perfectly justified in rounding off the numbers to the nearest easily remembered figure. People are doing this sort of thing all the time. The same technique is used in pulse code modulation.

For example, if the amplitude of the signal we wish to send is 4.7 volts, PCM would send it through as 5 volts; if the signal amplitude is 2.37 volts, PCM would transmit it as 2 volts. This simplification is necessary because the signal has to be coded, and the code uses only whole numbers.

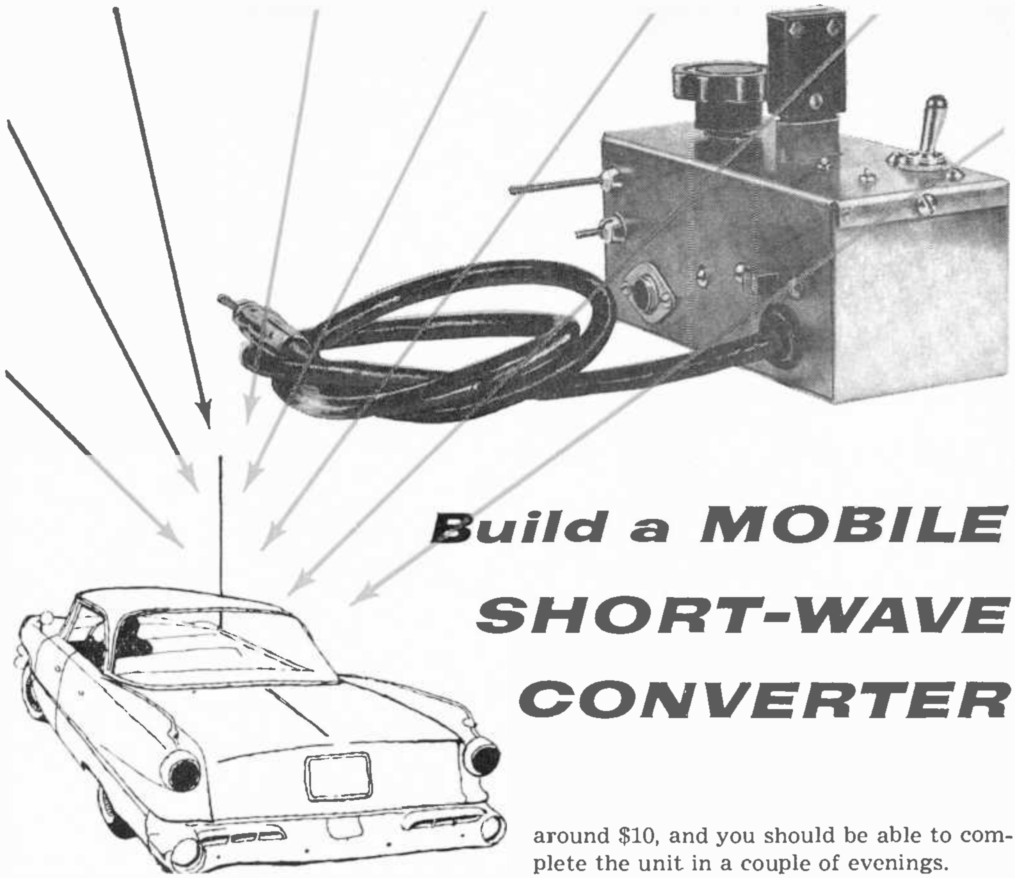
Let's suppose we want to send the signal shown in Fig. 4(A). Sampling pulses sense the amplitude of the signal to be transmitted. Pulse A, which has a value of 3.2 volts, is changed to an amplitude of 3 volts as shown in Fig. 4(B). Pulse B, which has a value of 3.8 volts, is changed to an amplitude of 4 volts. This process of simplifying the original signal in terms of whole numbers is called *quantizing* the signal; the result is known as a *quantized signal*—see Fig. 4(B).

Once the signal is quantized, it must be coded for transmission (hence the name, pulse code modulation). For this, the binary code is used (see "The Language of Digital Computers," Popular Electronics, January 1958, p. 68).

Each quantized pulse representing the amplitude of the signal at a given point must be changed into a group of pulses in the PCM binary code. Always keep in mind this distinction between the quantized pulse and the pulse group: the quantized pulse is a sampling pulse, whose value will be determined by its *amplitude;* the pulse group represents the original signal in binary language.

In a binary pulse group, only the presence or absence of a pulse has meaning. If the code is a three-pulse group, as shown in Fig. 4(C), then the far-right position has a value of 1 if a pulse is present, or 0 if the pulse is absent. The middle position would have double the first position's value, or 2, if a pulse were present, but would

(*Continued on page* 124)



Build a MOBILE SHORT-WAVE CONVERTER

By J. A. STANLEY

Self-powered unit pulls in short-wave and ham broadcasts while you drive

TUNING IN short-wave or ham stations on your auto radio is easy with this crystal-controlled converter. A small, self-powered unit, it can be quickly connected to any auto radio by simply inserting it between the radio and the antenna. Although the converter uses only one transistor, it will pull in foreign short-wave broadcasts easily. You'll be able to tune all frequencies between 30 and 49 meters (about 5 to 10 mc.), using only five different crystals.

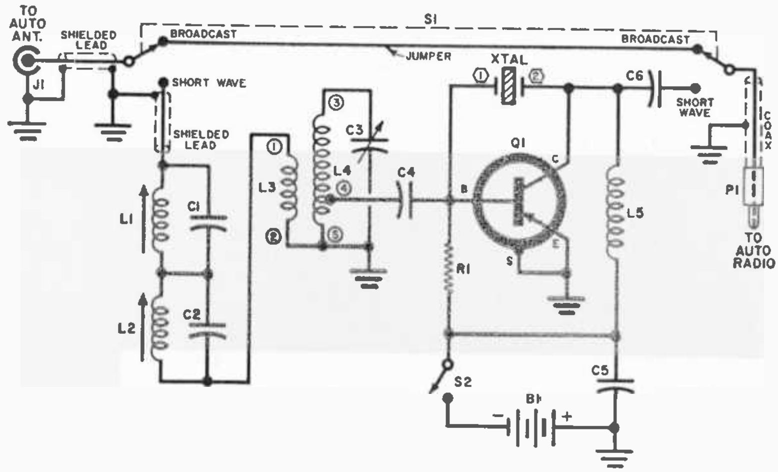
Since the converter runs on its own battery, you won't have to break into your car's electrical system. Parts will cost around $10, and you should be able to complete the unit in a couple of evenings.

Construction. The complete converter is built into a 5" x 2¼" x 2¼" aluminum box as shown. Using a slightly larger box will make assembly easier, but take care to keep tuned-circuit leads short.

Of the five coils (*L1* through *L5*) in the converter, only two (*L3* and *L4*) are hand-wound. Coil *L4* consists of 22 turns cut from a section of Barker and Williamson 3016 coil stock. Any similar coil stock can be used as long as it has a spacing ratio of 32 turns to the inch and a 1" diameter. Note that *L4* is tapped 2½ turns from the ground end, as shown in the pictorial detail.

Antenna coil *L3* consists of nine turns of No. 22 solid insulated hookup wire wound directly over *L4*. A turn or two of plastic tape around *L4* separates the two coils.

Coils *L1* and *L2* are the "garden" variety of broadcast-band antenna loopsticks. If you have a couple of these in your junk box, so much the better, but keep in mind that they have to be short enough to fit into the box you select for the converter. The r.f. choke (*L5*) should have a value of about 2.5 mh., as shown in the parts list;



Schematic diagram of converter shows a p-n-p transistor for Q1. Battery polarity should be reversed if an n-p-n transistor is used.

PARTS LIST

B1—3-volt battery (two penlight cells in series, Burgess Type Z or equivalent)
C1—500-μμf. ceramic capacitor
C2, C4—100-μμf. mica or ceramic capacitor
C3—100-μμf. midget variable capacitor (Hammarlund APC-100B or equivalent)
C5, C6—.001-μf. ceramic capacitor
J1—Auto antenna jack (Motorola 1207 or equivalent)
L1, L2—Ferrite broadcast-band loopstick (Lafayette MS-11 or equivalent)
L3—Antenna coil (see text)
L4—Tuning coil (see text)
L5—2.5-mh. r.f. choke (National R-100 or equivalent)
P1—Auto antenna plug (Motorola 1200 or equivalent)
Q1—2N247 transistor (see text)
R1—390,000-ohm, ½-watt resistor
S1—D.p.d.t. slide switch (Lafayette SW-17 or equivalent)
S2—S.p.s.t. slide switch (Lafayette SW-14 or equivalent)
Xtal—5- to 8-mc. crystal (James Knight H-73 or equivalent—see text)
1—5" x 2¼" x 2¼" aluminum box (Bud CU3004A or equivalent)
Misc.—Hardware, battery holder, sockets

current rating isn't important, but the d.c. resistance should be as low as possible.

Any number of transistors will work in the converter; a 2N247 (RCA) was used in the model, but the AO-1 and 2N344/SB101 (Philco) will serve as well. The converter will even work with the low-cost 2N170 (G.E.), if you reverse the battery polarity shown on the schematic. With the 2N170, though, the converter's tuning range may be limited from 5.5 to 6 or 7 mc., depending on how well your 2N170 oscillates.

Frequency Coverage. Select a crystal with a fundamental frequency between 5 and 8 mc. Any 40-meter ham-band crystal will do, as will the surplus FT-243 units.

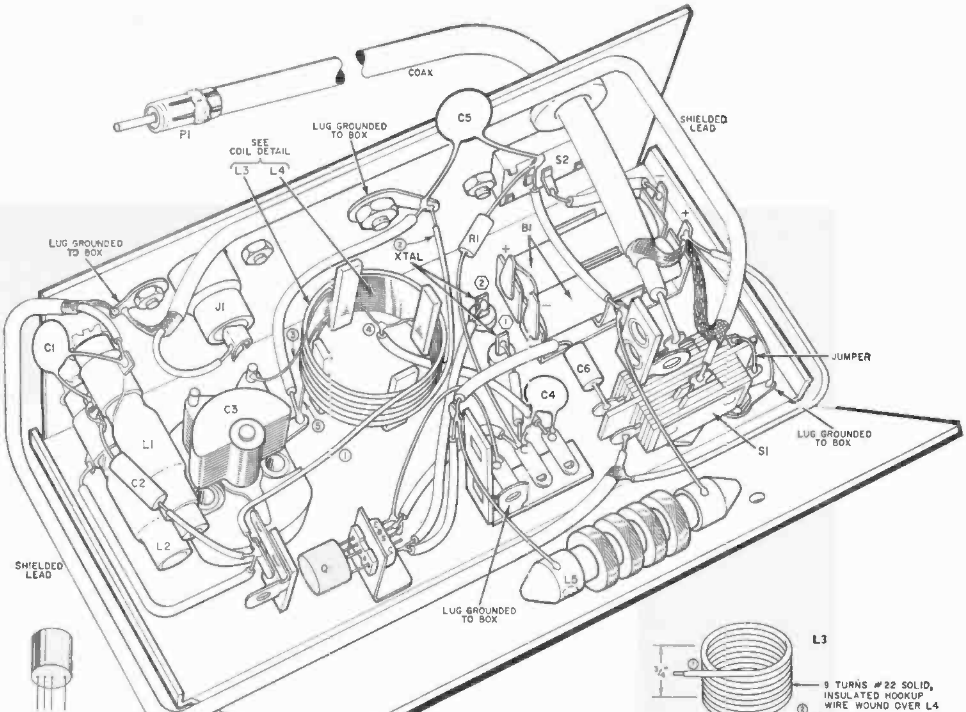
The converter will tune from 550 to 1600 kc. *higher* than the frequency of the crystal you select. For example, if you select a 6450-kc. crystal, you will be able to tune from 7000 to 8050 kc. on your auto radio dial. This range takes in the 40-meter ham band and the 39-meter international short-wave band.

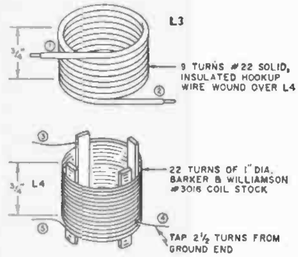
If you want to pick up other frequencies in the converter's 5- to 10-mc. range, simply select a crystal *near* the frequencies shown in the following table.

Crystal Frequency (kc.)	*Frequency Covered by Auto Radio (kc.)*
5000	5550 to 6600
6000	6550 to 7600
7000	7550 to 8600
8000	8550 to 9600

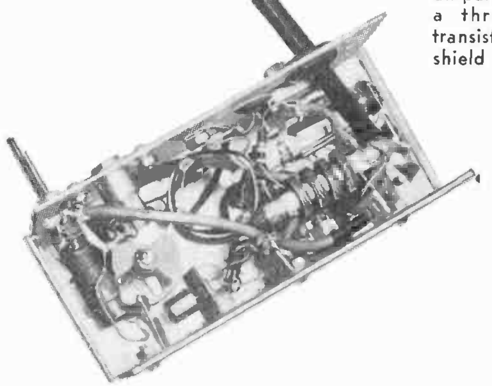
Operation. Once the crystal has been selected, it's an easy matter to fire up the converter. Simply unplug the antenna lead from the auto radio and plug it into jack *J1* on the converter. Then insert plug *P1* from the converter into the auto radio's antenna jack.

Now switch on the converter and the auto radio. Set bandswitch *S1* on the converter to "short wave." and tune the car radio. Instead of the usual broadcast sta-





Pictorial diagram shows placement of all parts. If you use a three-terminal transistor, disregard shield connection.



HOW IT WORKS

The converter is basically a self-oscillating mixer. With switch *S1* in the short-wave position, signals picked up by the auto antenna are fed into jack *J1* and pass through the switch contacts. Short-wave signals pass through both broadcast-band traps consisting of tuned circuits *L1-C1* and *L2-C2*, while unwanted broadcast-band signals are eliminated. The short-wave signals are then induced into tuning coil *L4* from antenna coil *L3*; capacitor *C3* tunes *L4* to the frequency of the short-wave signal.

Transistor *Q1* operates as an untuned crystal oscillator and an r.f. mixer. The desired signal is applied to the base of *Q1* through capacitor *C4* and is mixed with the frequency of the crystal. The difference frequency (signal frequency minus crystal frequency), which falls on the standard broadcast band, appears at the collector of *Q1*. This signal is applied to the auto radio via capacitor *C6*, switch *S1*, and plug *P1*. Resistor *R1* supplies base bias to *Q1*, choke *L5* serves as a collector load, and *C5* serves as an r.f. bypass capacitor. Transistor *Q1* is powered by battery *B1* through on-off switch *S2*.

When the converter is not in use, bandswitch *S1* is placed in the broadcast position. With this setting of *S1*, broadcast-band signals are fed through jack *J1* and plug *P1* directly to the auto radio.

tions, you should hear short-wave stations. You can now adjust tuning capacitor *C3* on the converter for best results.

If there are one or two broadcast stations that still "ride through," adjust the slugs on coils *L1* and *L2* to eliminate them. Otherwise, just set one slug "in" and one "out" to trap broadcast stations equally well across the band.

For normal broadcast-band reception on your car radio, switch off *S2* on the converter and set bandswitch *S1* to "broadcast band." —30—

Kill Those Harmonics

Inexpensive, easy-to-make tuned stubs will eliminate harmonics from your CB or ham rig

By KENT A. MITCHELL, W3WTO

WHETHER you're a Citizens Bander or a ham operator, harmonics from your transmitter can ruin your neighbor's TV pleasures and bring him pounding on your door. Likewise, the FCC takes a dim view of anyone who clutters up the bands with spurious radiations.

One sure way to help clean up your signal is to connect a stub filter to your antenna transmission line. Although relatively simple and inexpensive, quarter-wave stub filters are very effective in eliminating even-order harmonics (2nd, 4th, 6th, etc.) from the output of a transmitter feeding a single-band antenna.

There are two types of quarter-wave stub filters. In one case, a quarter-wave stub with a shorted end is connected in parallel with the transmission line; in the other, a quarter-wave stub with an open end is hooked up in series with either leg of the transmission line. Let's see how these two types of stubs work and how they are used.

Figure 1(A) shows a shorted quarter-wave stub connected in parallel with the transmission line from transmitter to antenna. Since the stub is a quarter wavelength of the signal frequency, it presents a very high impedance to the transmitted signal, and the signal passes on to the antenna with little or no loss in power. Even-order harmonics, however, are confronted with a virtual short circuit, since the stub offers a very low impedance at these frequencies. The parallel shorted stub is easily connected to coaxial transmission lines as well as twin-lead and open-wire lines.

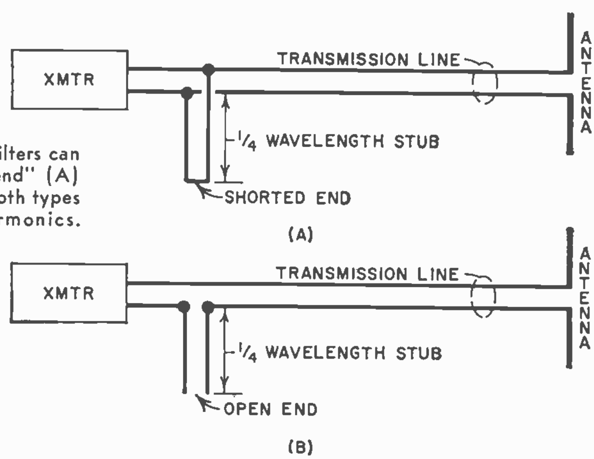


Fig. 1. Quarter-wave stub filters can be of either the "shorted end" (A) or "open end" (B) types. Both types eliminate even-order harmonics.

Figure 1(B) shows an open-end quarter-wave stub hooked up in series with the transmission line. The stub offers little or no resistance to the fundamental frequency, allowing it to pass to the antenna. Even harmonics, on the other hand, "see" some multiple of one-half wavelength—a near-infinite impedance for these frequencies—which prevents them from reaching the antenna. Open-end series stubs are not suitable for coaxial transmission lines since

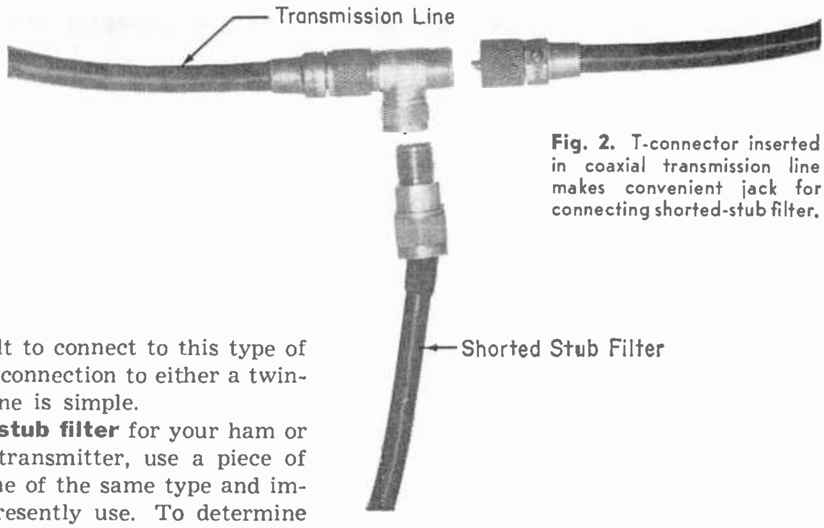


Fig. 2. T-connector inserted in coaxial transmission line makes convenient jack for connecting shorted-stub filter.

they are difficult to connect to this type of line. However, connection to either a twin-lead or open line is simple.

To make a stub filter for your ham or Citizens Band transmitter, use a piece of transmission line of the same type and impedance you presently use. To determine the length of the stub, substitute the fundamental frequency of your transmitter in the following formula:

$$\text{Length of stub (feet)} = \frac{246}{\text{Freq. of xmtr. (mc.)}} \times \text{Velocity factor of stub}$$

Incidentally, coaxial cables such as RG-8/U, RG-58/U, RG-11/U, and RG-59/U have a velocity factor of 0.66; flat 300-ohm TV twin-lead has a velocity factor of 0.82; tubular 300-ohm line is rated at 0.84; and the popular 450-ohm open-wire transmission line at 0.90.

As an example, let's say we are going to cut a shorted stub filter for the 6-meter amateur band on 50.1 mc., using coaxial cable. Applying the formula, we find:

$$\text{Length of stub (feet)} = \frac{246}{50.1} \times 0.66$$
$$= 3.24' \text{ or } 39''$$

A quarter-wave shorted stub for the popular CB channel 11 (27.085 mc.) would be determined as follows:

$$\text{Length of stub (feet)} = \frac{246}{27.085} \times 0.66$$
$$= 6' \text{ or } 72''$$

Hook up the stub to your coax transmission line using a T-connector (Amphenol 82-36 or equivalent) as in Fig. 2. Then just attach a male coax connector (Amphenol 83-851 or equivalent) to the stub so that it can be easily connected to the T-connector. For twin-lead or open-wire stubs, solder the stub directly to the line as shown in Fig. 3.

Keep in mind that a stub filter is not intended to replace a low-pass filter but rather to supplement one. A stub filter is more efficient in attenuating troublesome even harmonics which can be a cause of TVI, while a low-pass filter attenuates all harmonics very effectively. —30—

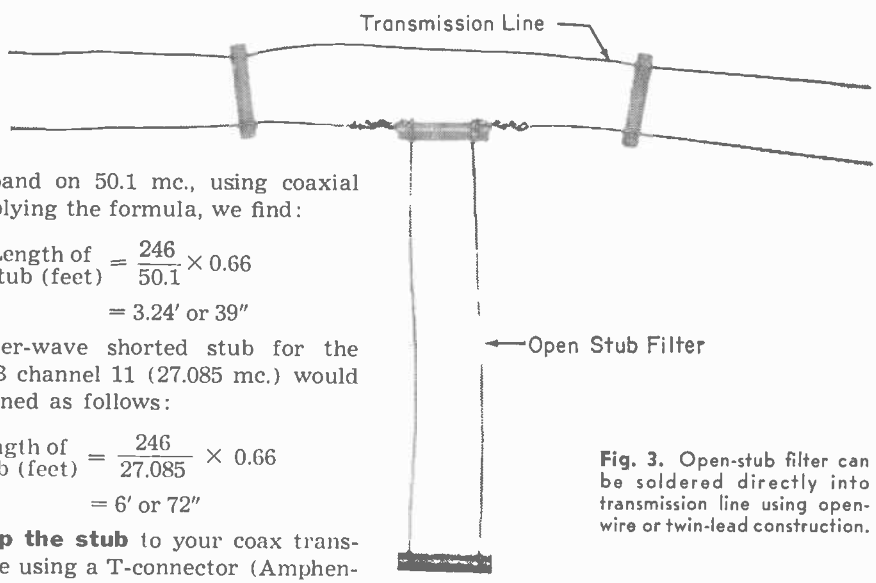
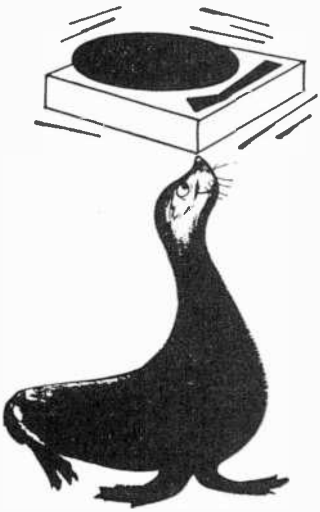
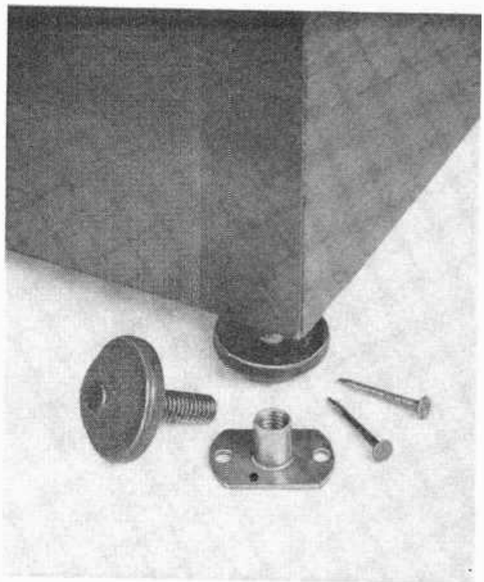


Fig. 3. Open-stub filter can be soldered directly into transmission line using open-wire or twin-lead construction.





Various manufacturers sell adjustable leveling feet for turntable or record-changer bases. Unit shown above replaces the customary felt corner pad.

Keeping your Hi-Fi on the Level

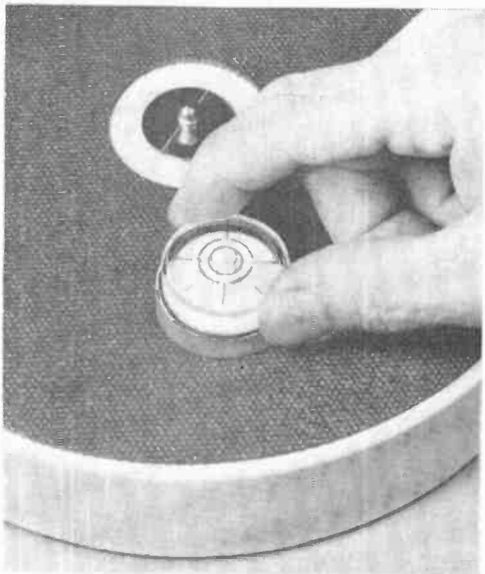
Simple adjustments can prolong life of stereo records

By ART TRAUFFER

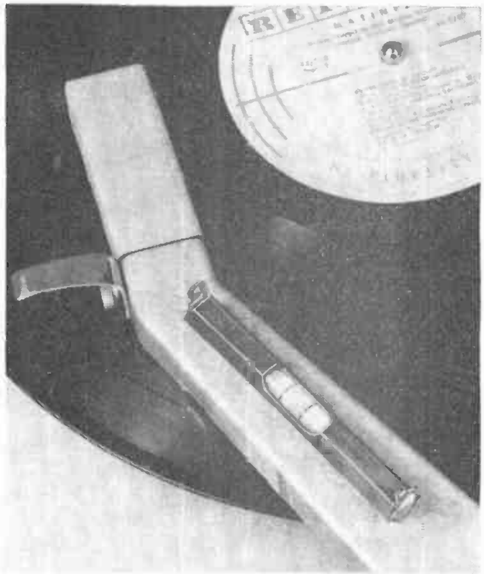
TOP stereo disc performance is possible only when your turntable, tone arm, and cartridge are perfectly level. If the turntable and/or tone arm are not exactly level, the cartridge may jump grooves and slide across the face of the record. Even if this doesn't happen, the stylus and record grooves will wear more rapidly on one side than on the other. In addition, tilting causes unbalanced response and distortion. Accurate leveling of turntable and cartridge is the only way to insure correct tracking.

If your turntable and tone arm are mounted on a wood platform, the best way to level the turntable is to install adjustable leveling feet on the bottom corners of the base. Lay either a tubular level or round level on the turntable and adjust the leveling feet screws until the turntable is exactly level. The round level is preferable since it indicates unbalance in any direction without the necessity for repositioning it on the turntable.

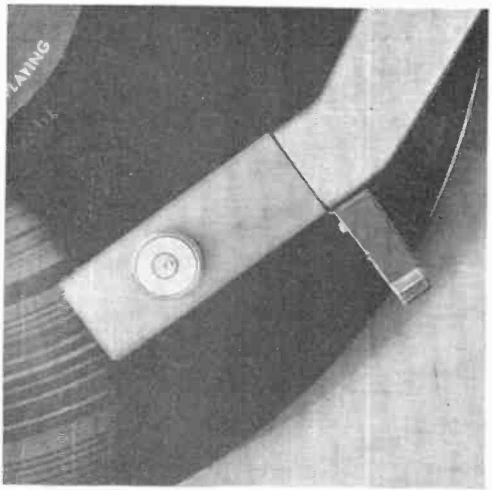
If your turntable and tone arm are mounted in a console cabinet, you can tilt the turntable by making adjustments in the mounting board, or by placing thin metal shims under the feet of the console legs. If your console cabinet is not too heavy, you may be able to install adjustable leveling feet on the bottoms of the legs.



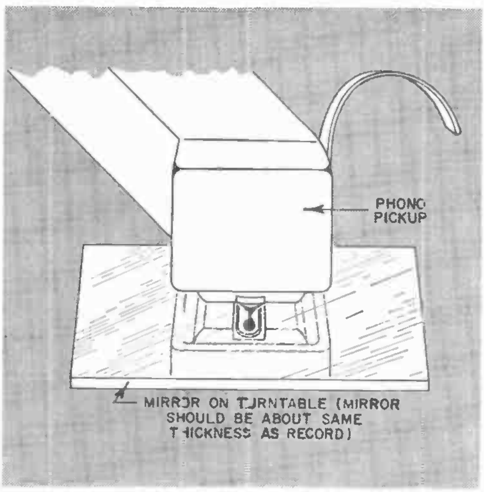
Circular bubble level costs about 90 cents, can be placed anywhere on turntable, and will reveal even small amounts of slope without repositioning.



Top surface of most professional tone arms should be parallel to the record surface. Check this with a level and adjust height of the arm accordingly.



Adjusting cartridge shell to make it parallel with record surface is easy with a circular level. Some pickups can also be adjusted from side to side.



Pocket mirror provides simple method of checking vertical alignment of the cartridge stylus. Equal force should be exerted on both sides of groove.

After the turntable has been leveled, the next step is to level the tone arm from front to back. First place a record on the turntable and set the stylus on the record. Then set a tubular level on top of the pick-up arm. If your particular tone arm calls for it, adjust the height of the arm until it is exactly horizontal from front to back.

A novel way to align the stylus from side to side is to use a small mirror of about the same thickness as your records and adjust the tone arm from side to side until the stylus and its reflection in the mirror are in a vertical line. —30—

Build a Vibrator Substitute

Transistorized unit features long life and noise-free operation

By PATRICK A. GAINER

CAR OWNERS bothered with car-radio vibrator replacement from time to time can try this transistorized plug-in substitute. Although it costs about $8 to build—somewhat more than a replacement vibrator—the unit will probably outlive the car and give years of service free from annoying vibrator buzz. It will work with any 6- or 12-volt automobile electrical system that has a *negative* ground.

Less than ten standard parts are needed to build the vibrator substitute. One of the parts, the transformer, needs a bit of unwinding, but this is easily done.

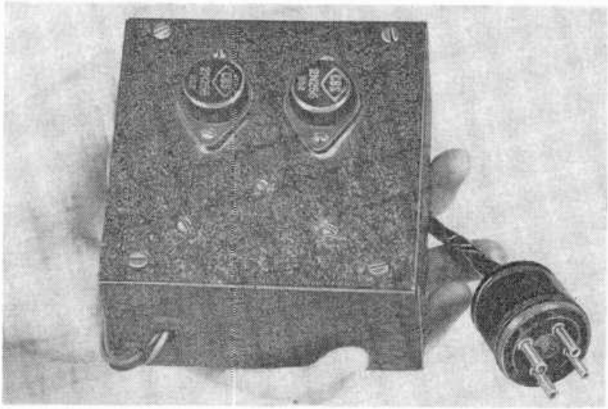
Construction. Since the parts used in the vibrator substitute, mainly transistors *Q1* and *Q2* and transformer *T1*, take up a little more room than the vibrator they replace, the unit is housed separately in a 4" x 4" x 2" aluminum chassis box. Mount *Q1* and *Q2* on one of the box's cover plates after carefully scraping the surface of the plate in that area; the scraped surface will make a good heat sink for the transistors and provide electrical contact for their collectors.

Transformer *T1* has two windings—a primary and a center-tapped secondary; only the secondary—the outermost winding—need be unwound. Note that the primary is color-coded with a red and a blue lead; the secondary is color-coded with a yellow and a green lead, and the black lead is the secondary's center-tap. The secondary actually comprises two separate coils, one using a light-color enameled wire and the other a darker enamel, wound side-by-side.

Remove *T1*'s metal frame, and push the coil off the laminated core, being careful not to damage the coil. Now slowly take off the outer layers of insulation until the outermost winding is reached. Disconnect only the light enameled wire from the black lead, and start unwinding it together with the dark enameled wire which is connected to the yellow lead. Remove 60 turns of each for 6-volt cars, or 90 turns for 12-volt cars. Be careful not to break any of the other leads or transformer windings.

After unwinding the proper number of turns, leave about four inches of each color enameled wire for leads. Fasten down the leads with plastic tape and reassemble the transformer. Hook up the new light and dark enameled leads and the rest of the color-coded leads as shown.

Wire up the four-prong vibrator adapter plug (*P1*) to the circuit using a couple of

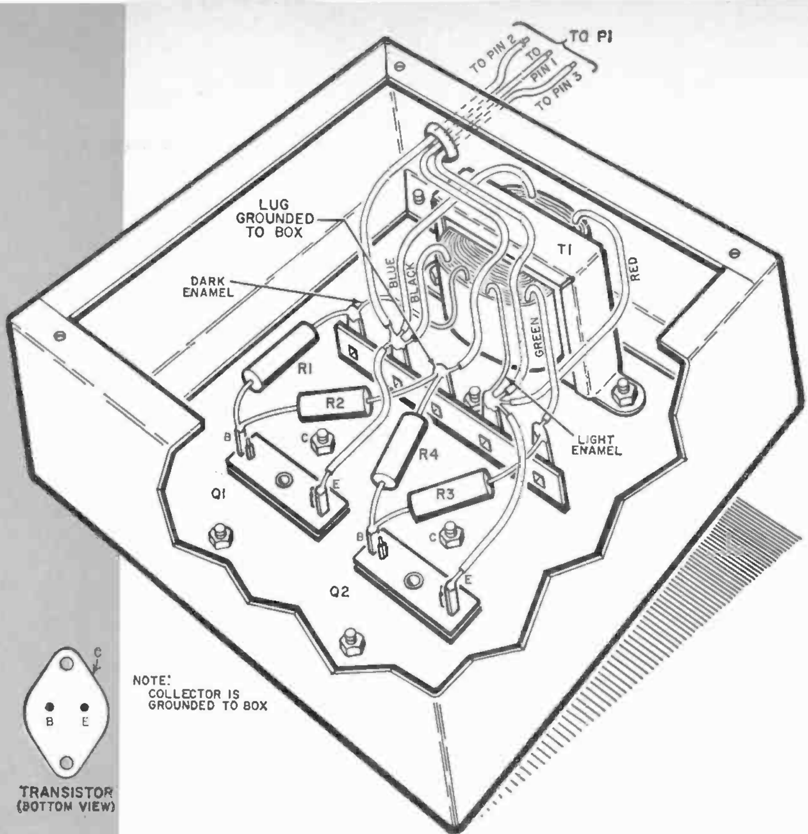


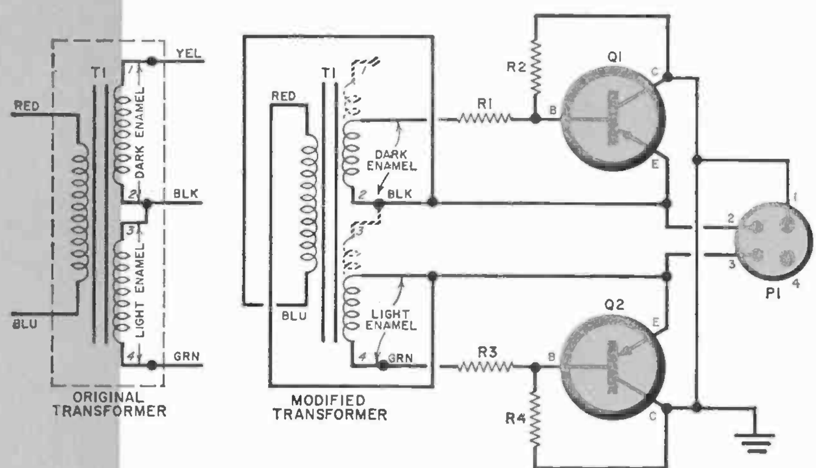
PARTS LIST

P1—Four-prong plug (Amphenol 86-PM4 or equivalent)
Q1, Q2—2N256 transistor (for 12-volt cars) or 2N677 transistor (for 6-volt cars)
R1, R3—220-ohm, 1-watt resistor
R2, R4—10-ohm, 1-watt resistor
T1—Feedback transformer (Stancor TA-16—see text)
1—4" x 4" x 2" aluminum chassis box (Bud AU-1083 or equivalent)
Misc.—Hardware, transistor sockets, terminal lug, etc.

HOW IT WORKS

The vibrator substitute accomplishes electrically what the vibrator does mechanically by generating an output similar to the output of the vibrator. Transistors *Q1* and *Q2* are connected in a push-pull oscillator circuit with transformer *T1* providing feedback at the proper voltage and phasing to sustain oscillation; resistors *R1*, *R2*, *R3*, and *R4* maintain the correct base bias for *Q1* and *Q2*.





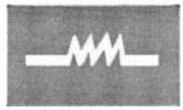
feet of wire for each lead. Now tape the leads together to form a cable.

Operation. Mount the vibrator substitute near the radio in a cool place under the dash, then plug the unit into the vibrator socket and switch on the radio. If you don't hear a faint buzz from transformer *T1*, check all wiring and the radio's fuse. If the buzz is too loud, *T1's* laminations are probably loose.

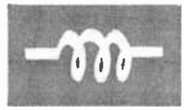
If the radio is turned off for a few seconds and then on again, the starting load may be great enough to prevent oscillation. In this case, just leave the radio off for about 15 seconds until the tube filaments have had a chance to cool.

—30—

POPULAR ELECTRONICS Quiz



Resistive?



Inductive?

or Capacitive?

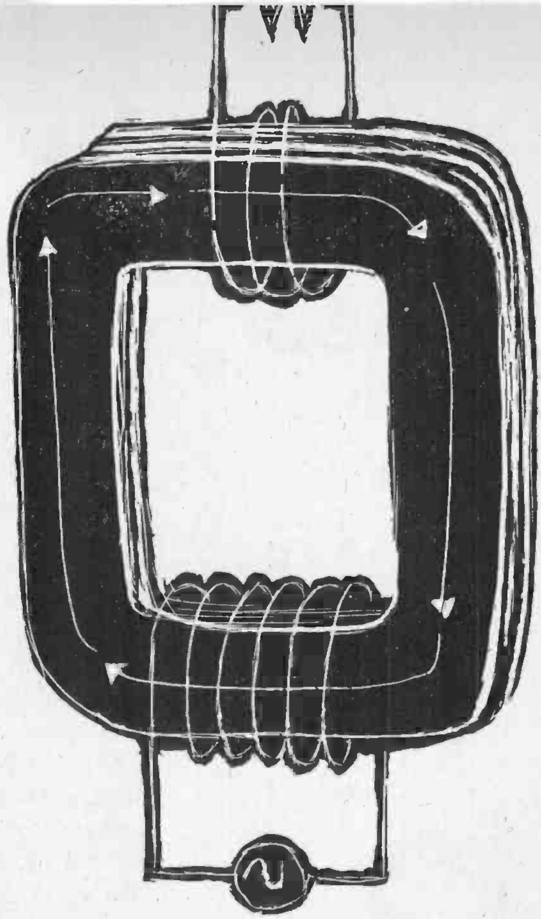
By
ROBERT P. BALIN

In all of electricity and electronics, there are only three basic properties: resistance, inductance, and capacitance. These properties, or combinations of them, can give us complete control over current, voltage, phase, and power in any electric circuit.

Since resistive, inductive, and capacitive circuits operate on entirely different principles, each type of circuit has a distinctive character of its own. But regardless of where or how these three basic properties are used, they retain their individual characteristics. From the descriptions of their behavior given below, can you identify the type of circuit referred to?

Circle R if you think the circuit is resistive; L, if inductive; and C, if capacitive. Answers will be found on page 127.

1	Electrical energy can remain stored in this type of circuit even after the source of energy is removed	*R*	*L*	C
2	The current in this type of circuit is always in phase with the source of voltage	*R*	*L*	C
3	Arcing is likely to occur between the contacts when this circuit is opened	*R*	*L*	C
4	Electrical energy is stored in the magnetic fields found in this type of circuit	*R*	*L*	C
5	This circuit tries to keep its voltages constant	*R*	*L*	C
6	The flywheel effect is characteristic of this type of circuit	*R*	*L*	C
7	Electrostatic fields are used in this circuit	*R*	*L*	C
8	This type of circuit always has unity power factor	*R*	*L*	C
9	This circuit acts almost like a short circuit to a.c. voltages	*R*	*L*	C
10	Voltage across this circuit builds up to a high potential instantaneously when the circuit is opened	*R*	*L*	C
11	If the frequency of the source voltage for this circuit is increased, the current goes down	*R*	*L*	C
12	The current in this circuit leads the source voltage	*R*	*L*	C
13	This type of circuit can act almost like an open circuit at the instant that power is applied	*R*	*L*	C
14	No electrical energy is stored in this type of circuit at any time	*R*	*L*	C
15	Because of the surge currents in this circuit, its fuse may blow when power is applied	*R*	*L*	C
16	Conductor or component insulation may be damaged when power is removed from this circuit	*R*	*L*	C
17	This type of circuit tries to keep its current constant	*R*	*L*	C
18	Current never actually flows through this type of circuit	*R*	*L*	C
19	In this circuit the current remains the same regardless of changes in the frequency of the source voltage	*R*	*L*	C
20	This type of circuit has a lagging power factor	*R*	*L*	C



the transformer

a fundamental coupling device, the transformer is one of electronics' most capable magicians—here's what's behind its electrical sleight-of-hand and how it performs its multitude of valuable tricks

by ken gilmore

what the transformer does

The electrical power that makes your light bulbs glow, runs your refrigerator, and operates your hi-fi set comes into your home at a potential of about 115 volts. Yet if you were to climb the utility pole outside and measure the voltage there, it could turn out to be as high as 6000 volts. If you kept on climbing poles at other places around town, you might find voltages as high as 120,000 volts!

Even in your home, some appliances—air conditioners, clothes dryers, electric ranges, and other heavy-duty equipment—may operate at 230 volts instead of the usual 115 volts. And if you probe into your television set, you'll find an even wider voltage range. For although your TV draws its power from the wall plug—and power there is at 115 volts—your set has the ability to change this voltage into a number of different values, so that each tube and circuit can operate under the exact conditions it likes best. Consequently, in some places, you will find values as low as one or two volts; in others, values as high as 15 or 20 *thousand* volts.

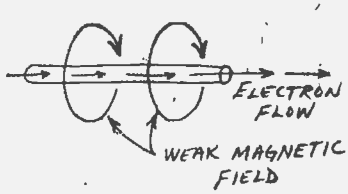
Electric power, one of our most useful servants, becomes tremendously *more* useful when we can change it at will to dozens, or even hundreds, of different voltages. Fortunately, we can make these changes easily and economically with a device known as the transformer.

Transformers are all around us. One—the gadget about the size of a large garbage can hanging near the top of utility poles—changes the 6000-volt transmission-line power into the 115 and 230 volts you need. Another—this one about as big as a flashlight—takes 6 or 12 volts from your car's battery, and changes it into the 10,000 or more volts needed to fire your spark plugs. Still another—a square can a little bigger than your fist—channels high-fidelity electrical signals into the speakers of your hi-fi set.

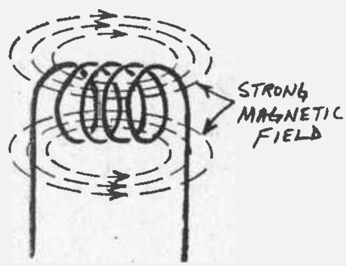
We'll talk more about these special applications —and others like them—a little later. Right now, let's get down to the business of seeing just how a transformer goes about performing this valuable electrical sleight-of-hand—changing one voltage into another.

how the transformer works

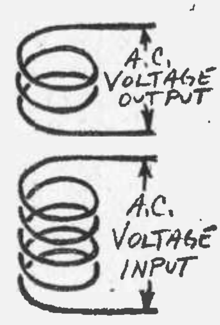
When an electric current flows in a wire, a weak magnetic field is set up around it. If we twist the wire into a coil, the weak field around each turn of the wire is reinforced by the fields around the other turns; the result is a much stronger field.

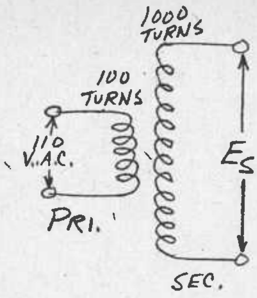


If an a.c. current flows in the coil, the magnetic field builds as the current flows in one direction; dies down, or decays, as the current returns to zero; then builds in the opposite polarity as the current flows in the other direction. You can think of the building and decaying magnetic field as a pulsing, invisible force, expanding and contracting as the current reverses its direction of flow. As the field builds and decays, the magnetic flux lines (the circular lines in the diagram) cut back and forth through the coil.



Now suppose we put another coil of wire next to and in line with the first, although not actually touching it. As the magnetic field expands and contracts, the flux lines will cut back and forth through the second coil as well as through the first one, and a voltage will be *induced* in the second coil. This is called "mutual induction," and is the basis of all transformer action. Because of this property, a simple transformer can be made—and many are—simply by placing two coils of wire



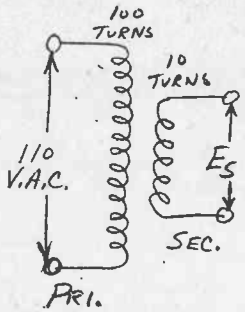


$E_S = \frac{1000}{100} \times 110 = 1100\text{ V.}$

close together and applying an alternating current to one of them.

The main value of a transformer lies in the fact that the ratio of the voltages in the two coils can be controlled by the number of turns of wire in each. To put it another way, if the secondary (the coil into which voltage is induced) has ten times as many turns of wire as the primary (the coil across which the original voltage is applied), then the secondary voltage will be ten times the primary voltage. In such a case we have a *step-up* transformer.

On the other hand, if the secondary has only one-tenth as many turns as the primary, the secondary voltage will be one-tenth the primary voltage, and we have a *step-down* transformer.



$E_S = \frac{10}{100} \times 110 = 11\text{ V.}$

efficiency

In the above calculations, we have assumed that *all* magnetic lines of flux, as they expand and contract, cut *all* turns of the transformer. The magnetic coupling in such a case would be 100%. Of course, in practical transformers a few lines of force manage to stray outside the useful area. But by careful design, engineers are able to produce transformers with efficiencies of 80%, 90%, and even more. In fact, for the purposes of most calculations, transformer efficiency can be considered to be virtually 100%.

voltage vs. current

Even though we can get a higher voltage from a transformer than we put into it, the transformer is not capable of creating power. What we gain in voltage, we lose in current. On the other hand, if we step down the voltage, we get more current.

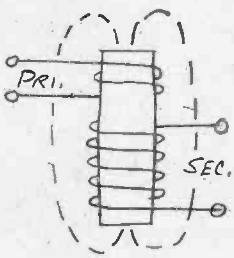
If the current flowing in the primary of the step-up transformer in the diagram above is 5 amperes and the voltage 110 volts, the power consumed in the primary is 550 watts. Since the output voltage is 1100 volts, or ten times as much, we would have available only one-tenth the current, or 0.5 ampere. Thus, even though we can juggle voltages and currents at will, the output *power* is 550 watts—the same as the primary input. (Actually, the output power would be slightly less than 550 watts, due to the small losses in efficiency mentioned earlier.)

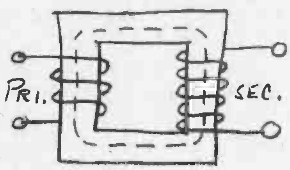
iron cores

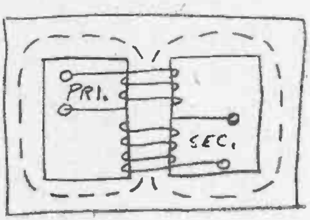
So far, we have described a transformer as two coils of wire, placed close together along a common axis. Although some transformers are actually built this way, most use other types of construction. Instead of being placed side by side, the two coils are usually arranged with one coil inside the other; this gives much closer and more efficient magnetic coupling.

For use at low frequencies, designers wind the two coils around a common iron core. Since iron is a much more efficient conductor than air, the magnetic field built up is much stronger. That is, almost all the magnetic lines of force developed by the primary winding are gathered up by the iron core and shaped so that almost all cut through the secondary winding. Therefore the efficiency of the transformer is greatly increased.

The diagrams at left show the three principal types of iron-core transformers. First is the open-core transformer which, while possible, is never used because of its relative inefficiency—a large part of the magnetic field would still have to be in air, rather than in iron. The closed-core transformer is considerably more efficient; and the shell core transformer is most efficient of all. The shell-core type has another advantage: since the flux path is almost entirely contained in the iron core, it is less subject to disturbances by external magnetic fields than other types, and it doesn't disturb other nearby circuits as much.

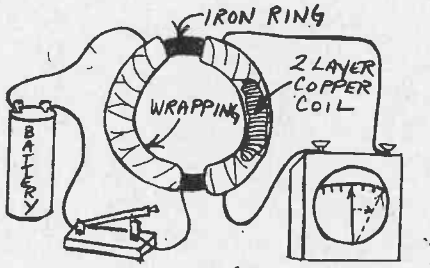






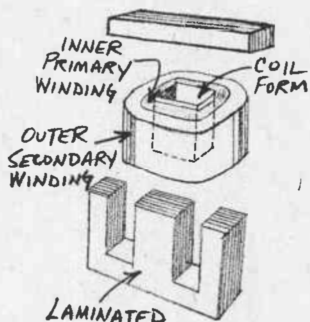
transformer losses

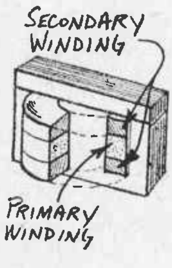
The first transformer ever made was simply an iron ring with two 2-layer coils of wire wrapped around it. Its inventor was Michael Faraday, the great English electrical pioneer. He discovered electromagnetic or mutual induction—the principle upon which the transformer works—in 1831. When he connected his primitive iron-ring transformer as shown, the galvanometer needle jumped as the switch was closed.

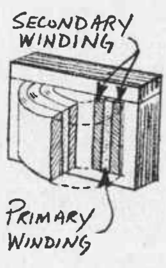


Although Faraday's device was a true transformer, its losses were high. Today's modern, refined transformers have assumed a wide variety of sizes, shapes, and characteristics as engineers have attempted to minimize the losses that are a part of every transformer's operation.

Transformer losses come from many different sources. First, not every magnetic flux line cuts the secondary—some simply travel out into space, consuming energy from the primary, but doing no useful work. This loss is called *flux leakage*. Designers minimize it by careful physical arrangement of the coils and core. Sometimes the primary is wound on the core first, then the secondary applied on top. At other times the secondary is split into two layers with the primary in between.





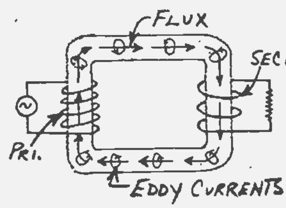


copper losses

The so-called copper losses are caused by the electrical resistance of the transformer windings. Although copper is a good conductor, it has a measurable resistance, as does any conductor. When current flows through this resistance, heating takes place and power is wasted. As a result, almost any transformer will feel warm to the touch when operating normally, and some are actually hot.

core losses

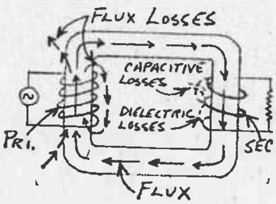
Since the iron core itself, as well as the coils, is cut by the expanding and contracting magnetic field, a current is induced here, too. As this *eddy current* flows in the core, it steals energy from the primary circuit and dissipates it as useless heat. The eddy current flows at right angles to the magnetic flux. It can be reduced by substituting several thin layers of iron for the solid core. These thin layers—laminations—are separated by layers of glue which electrically insulate the laminations from each other. In practice, a small eddy current is set up separately in each lamination, but the total loss is much less than for a solid-core transformer.



Still another core loss is caused by the alternating current itself. Since this current reverses its direction 120 times a second, the iron core—in effect, an electromagnet—must continually reverse its polarity. And since the minute magnetic elements in the core tend to resist this change, power must be expended to realign them. This is called *hysteresis loss.* Engineers reduce it by building transformer cores of steels which change magnetic polarity with comparative ease, so that less power is consumed in making the switch.

miscellaneous losses

Since the turns of wire in a transformer are close together, there is some distributed capacitance between the turns, between different layers of windings and between separate windings. This capacitance, though small, is cumulative. Like a small capacitor connected across the transformer, it shorts out some of the voltage developed across the windings. At low frequencies (the usual 60 cps of house current, for example) this loss is unimportant, but at higher frequencies engineers must go to great lengths to minimize it.



Another small loss is caused by the imperfection of transformer insulation. A small leakage current will flow through almost any insulator, and thus absorb some of the transformer's power. This is known as *dielectric loss.*

Then, too, particularly at high frequencies, a transformer can begin to act as a small but efficient radio transmitter, and actually radiate power like a broadcast antenna. This is called *transmission loss.*

Most of these losses, under normal conditions, are minor, but at times they become serious. For example, eddy current losses are small at power-line frequencies, but at the high end of the audio spectrum—say around 20,000 cps—they become significant. This means that a poorly designed transformer in the output stage of a hi-fi amplifier will operate much less efficiently at 20,000 cps than at 1000 cps; the result is poor frequency response.

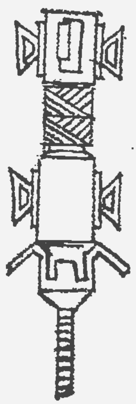
To minimize eddy currents designers specify thinner laminations. Where laminations 20 to 25 thousandths of an inch thick are used in power transformers designed to work at 60 cps, audio transformers rarely have laminations thicker than 10 or 15 thousandths of an inch. For really good hi-fi reproduction, lamination thicknesses may range from ten thousandths of an inch all the way down to only one thousandth of an inch.

higher and higher frequencies

As frequencies go still higher, even one thousandth of an inch is too much, and eddy current losses become excessive. Consequently, r.f. transformers frequently have cores made of minute grains of iron suspended in an insulating material and compressed under high pressure into a solid mass. Since the grains are insulated from each other, they break up the eddy current path and help reduce eddy current losses.

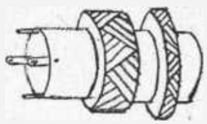
As might be expected, the size of the iron granules becomes important as the frequency increases, since at high frequencies eddy currents are even set up within the individual granules. Granules several thousandths of an inch thick are satisfactory below 100,000 cps, but as the frequency goes higher the particles cannot be larger than several millionths of an inch thick.

A new type of magnetic core made of iron ferrite has recently allowed designers to build iron-core transformers to operate at frequencies higher than ever before. These ferrites—varieties of iron oxide, or rust—are valuable because they have magnetic properties, and yet are insulators and do not conduct current. Because of the unusual construction of these transformers, no eddy currents form.



If you have bought an ultra-portable radio recently, you are benefiting from ferrite-improved transformers. Miniature radios of even a few years ago had loop antennas at least 8 to 10 inches long and almost as high to collect enough signal to operate. Now ferrite-core antennas, far more efficient because of their magnetic core but not susceptible to eddy current ills, can be built as small as a short pencil. As a result, portable radios can now be produced smaller than they have ever been produced before.

In many applications, particularly for very high frequencies, air-core transformers are used. The coils are wound on a non-magnetic form such as Bakelite or polystyrene. The coils may be concentric, or end to end. Frequently one is movable, so that the degree of coupling between them is adjustable.



One of the biggest problems in high-frequency transformer design, particularly where multiple layers of winding are involved, is stray capacitance. If a regular winding were used, with adjacent layers lying parallel to each other, this capacitance could become intolerable. Consequently, layers are frequently spiraled back and forth as in the transformer shown in the drawing at right. This makes adjacent layers cross each other almost at right angles instead of being parallel, and stray capacitance is materially lowered as a result.

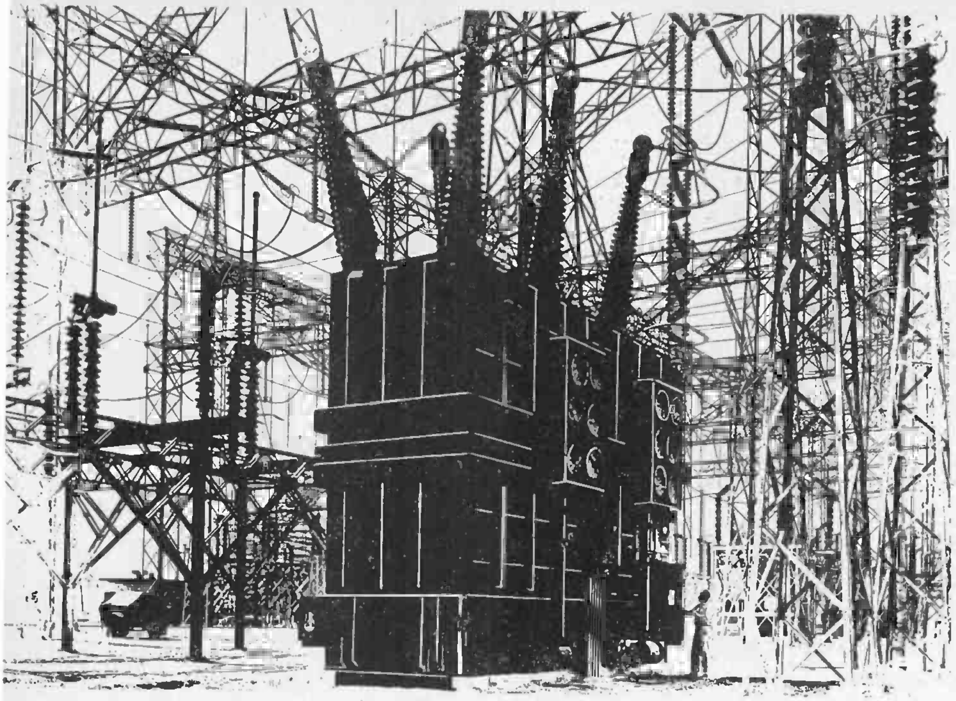
how the transformer is used

The transformer invented in the 1830's wasn't put to work outside the laboratory until 1885 when William Stanley, an engineer who worked for George Westinghouse, designed and tested a transformer power-distribution system. He used a 500-volt generator and fed the power directly into a 4000-foot transmission line. A transformer to step down the voltage to 100 volts was used at the other end of the line.

Westinghouse wasted no time in putting Stanley's superior transmission system into operation. That same year he built the first plant especially designed for transformer power distribution in Buffalo, N. Y. It went into use on November 30, 1886. His generator produced a 1000-volt, 133-cps output which was fed directly into the transmission line, and stepped down at the customer's home.

In spite of its obvious superiority, however, high-voltage transmission with transformers did not gain immediate acceptance. Thomas Edison, for one, was violently opposed to a.c. power, and he used his tremendous prestige to gain support for his own d.c. system. Consequently, it was not until many years later—after the turn of the century—that high-voltage a.c. power distribution became common. Even today there are a few places—some areas of New York City, for example—still receiving Edison's legacy of d.c. power.

But giant power transformers and their complex distribution stations now dot the landscape all over the country. The one shown on the next page, one of the largest ever built, can handle enough electric power for a city of 500,000 inhabitants.



power distribution

Why use transformers for power distribution? The efficiency of transmission is tremendously increased by stepping up the voltage to as much as several hundred thousand volts. Also, a given size of wire can carry far more power at high voltage than low, saving money in transmission costs. Let's see why.

As an example, let's take a transmission line of No, 1 wire 10 miles long—that's a conductor about the size of your little finger. The resistance of one such wire 10 miles long is about 7 ohms. (Actually, the resistance of each wire in the transmission pair is 7 ohms but for the sake of illustration let's consider just one.) Now let's say that we transmit a current of 120 amperes at 120,000 volts (a common transmission-line voltage) over the 10 miles. The total power fed into the line at the generating station is 14,400,000 volt-amperes.

With 120 amperes flowing in the 7-ohm line, the voltage drop over the ten miles will be 840 volts. Thus, the output voltage will be 119,160 volts; 120 amperes at 119,160 volts gives a 14,299,200 volt-ampere output. Along the line we have lost 100,800 volt-amperes, dissipated by the resistance of the transmission line. This seems like a lot of power, but if we figure it in terms of percentage, the loss amounts to a negligible 0.7% of the total fed into the line.

Now let's see what happens if the supply voltage is reduced to only 12,000 volts. The power input is now 1,440,000 volt-amperes. We will assume that the transmission line is still carrying 120 amps—its maximum load under any conditions. Since the current and resistance are the same, the voltage drop over the 10 miles will also be the same—840 volts. The loss in the transmission line will still be 100,800 volt-amperes, but now this represents a whopping 7% of the total fed into the transmission line.

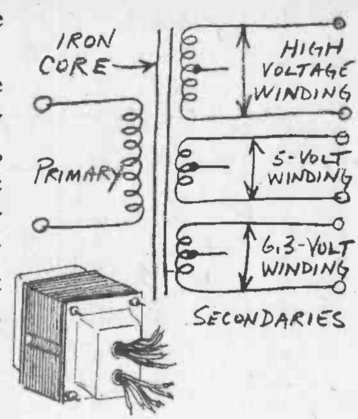
Obviously, the high-voltage transmission is far more efficient. As also demonstrated in this example, the transmission line can carry far more power under high-voltage conditions. For these reasons, all transmission lines operate at higher voltages than those delivered to your electric meter by the power companies.

At Niagara Falls, N. Y., for example, hydroelectric generators produce power at 6000 volts. It is immediately stepped up by transformers to 120,000 volts and fed to long-distance transmission lines. At various points it is stepped back down to 6000 volts for distribution over local areas, then stepped down once again to 230 and 115 volts for home use.

power transformers

Although a power-distribution transformer is more spectacular, you're much more likely to be familiar with the ordinary power transformer used in radios, amplifiers, and TV sets. Such devices have a primary winding and usually several secondary windings to meet the various voltage and current requirements of a receiver or amplifier; a drawing of a typical power transformer is shown at right, above. The primary is usually designed for 115 volts; the high-voltage secondary may produce anywhere from 250 to as high as 600 or 700 volts (higher for some purposes). The other secondaries, usually rated at 5.0 and 6.3 volts, are for tube filaments.

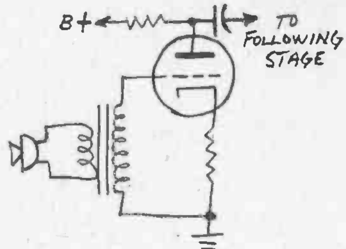
Power transformers are available with a wide variety of windings and current capabilities. They may have four, five, six, or even more windings, each rated at a different voltage for some specific purpose. The high-voltage winding of a light-duty power transformer may be capable of producing perhaps only 30 or 40 ma., while a heavy-duty unit may turn out 300, 400, or even 500 ma. Transformers for high-power transmitters produce voltages and currents far in excess of these values, but for such applications separate transformers are generally used for high-voltage and filament supplies.



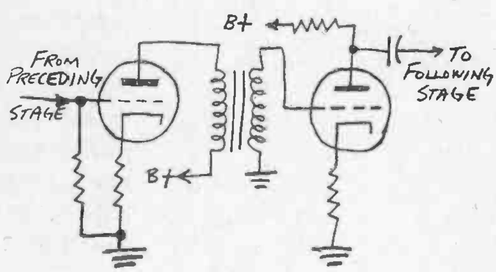
audio transformers

So far, all the transformers we have talked about in detail are designed for use in power circuits which operate at 60 cps. But transformers can operate on a wide variety of frequencies—every audio amplifier uses at least one transformer of this sort, and many include several such transformers.

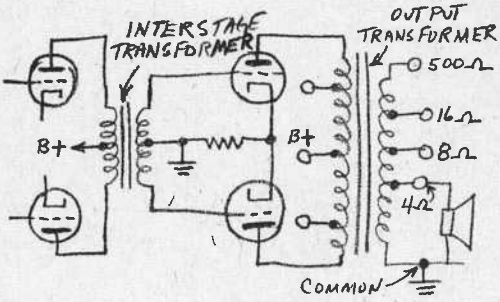
Although the same basic principles of step-up and step-down are used in audio transformers, this is usually of secondary importance to the transformer's ability to serve as an impedance-matching device. Take, for example, an input transformer. Here it may be necessary to match a phonograph pickup, a microphone, or other input source of as little as 200 or 300 ohms (even less, in some cases) to a grid circuit of as much as several hundred thousand ohms. If the pickup or microphone were connected directly to the grid, a serious *mismatch* would occur, which would not only reduce the efficiency of the circuit but upset frequency response as well. The input transformer matches the components so that each operates properly.



The interstage transformer is another variety of the audio transformer and performs much the same kind of job: matching the output tube—sev-



eral thousand ohms—to a grid circuit of a much higher impedance.



A third variety is the output transformer, whose main task is again impedance-matching. The plate circuit of the output tubes may have an impedance of many thousands of ohms, while most loudspeakers are 4, 8, or 16 ohms. To accommodate various tube-speaker combinations, most output transformers have a series of "taps" on the secondary winding, and perhaps on the primary as well, so that windings of the proper impedance can be selected. Only the part of the transformer windings actually used (in the diagram, the portion between the first and second terminals) affects the circuit's impedance values. One form of output transformer—known as a "universal" type—is so designed that it is capable of matching virtually any possible tube and speaker combination.

better and better design

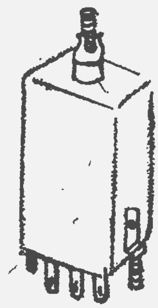
Great progress has been made recently in audio-transformer design. Just a few years ago it was difficult to get a transformer with any appreciable output above, say, 10,000 to 15,000 cps. Today, transformers with flat outputs up to 20,000 cps are common, while units flat to 50,000 or even 100,000 cps are available.

Tremendous problems had to be overcome to produce today's outstanding transformers. In addition to the losses mentioned earlier, a transformer has inductive reactance which varies according to frequency (remember that a transformer is also a coil). At frequencies of 100 and 1000 cps, the inductive reactance of the primary will be 10 and 100 times, respectively, its value at 10 cps. The inductive reactance appears to the output tube's plate as a load resistance, and thus various amounts of amplification take place at various frequencies. As a result, the gain of the amplifier is about two-and-a-half times higher at 200 cps than at 10 cps. At 3000 cps it would be three times higher. At still higher frequencies, distributed capacitance becomes an important factor, and gains fall off rapidly.

Engineers go to great lengths to compensate for these effects; by means of special core materials, unique coil designs, special wrapping patterns, interlaced layers, and other techniques, they have produced a variety of audio transformers with unbelievably even response over an extremely wide range of frequencies.

r.f. circuits

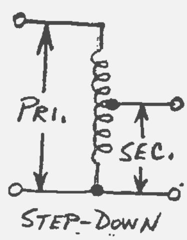
As mentioned earlier, transformers are also widely used in r.f. circuits. Even the simplest five-tube a.c.-d.c. radio will usually have as many as four transformers, in addition to its audio output transformer. A typical radio, for example, might have an antenna coil (actually a small transformer which couples the antenna's output into the grid of the first amplifying tube), an oscillator coil (a transformer which supplies feedback for the oscillator), and two i.f. transformers which couple the various stages.



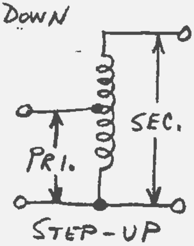
These transformers are likely to be air, powdered-iron, or ferrite-core transformers, since a regular iron core would cause intolerable eddy-current losses. The windings will also probably be of a special spiral design calculated to minimize capacitance effect.

special-purpose transformers

Although the transformers we have been discussing make up the bulk of those used, there are many other types, all of which perform their useful, specialized jobs.

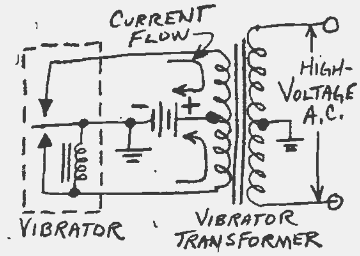


The *autotransformer*, for example, uses only one winding instead of two, but accomplishes an effect similar to that of a regular transformer. If the whole coil is used as the primary and only a portion as the secondary, then it is a step-down unit. Hooked in reverse, it is a step-up device. This transformer, of course, cannot be used in circuits



which must be electrically isolated from each other. But it serves very well in your automobile where it draws current from the 6- or 12-volt battery or generator and puts out the 10,000 or more volts needed to fire your spark plugs.

While we're on the subject of your automobile, let's take a look at the car radio which uses another kind of specialized device, the *vibrator transformer*. This device effectively "transforms" d.c. As the vibrator element moves back and forth touching each contact in turn, current flows through each half of the primary alternately, with each pulse going in a different direction. With the proper turns ratio, the output from the original 6- or 12-volt d.c. source can be as much as several hundred volts a.c.

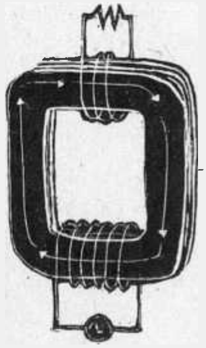


Photoflash transformers, used to operate photographer's electronic flash or "strobe" units, are also vibrator-operated. They can take the vibrator-interrupted output from a 1½-volt battery and turn it into several thousand volts a.c.

Pulse transformers are used primarily in radar. They range from tiny units (several of which can fit in a thimble) that put out a few millionths of a watt to huge, multi-ton giants that transmit powerful million-watt pulses. These transformers are designed to step up odd-shaped waveforms without changing the waveshape.

One of the newest types—*transistor transformers*—are similar to those used in regular r.f. and a.f. circuits except that their impedances and voltage ratings are calculated to match the operating requirements of transistors. Some of these units, by the way, can fit in a cube three-eighths of an inch square, and they weigh only a fraction of an ounce.

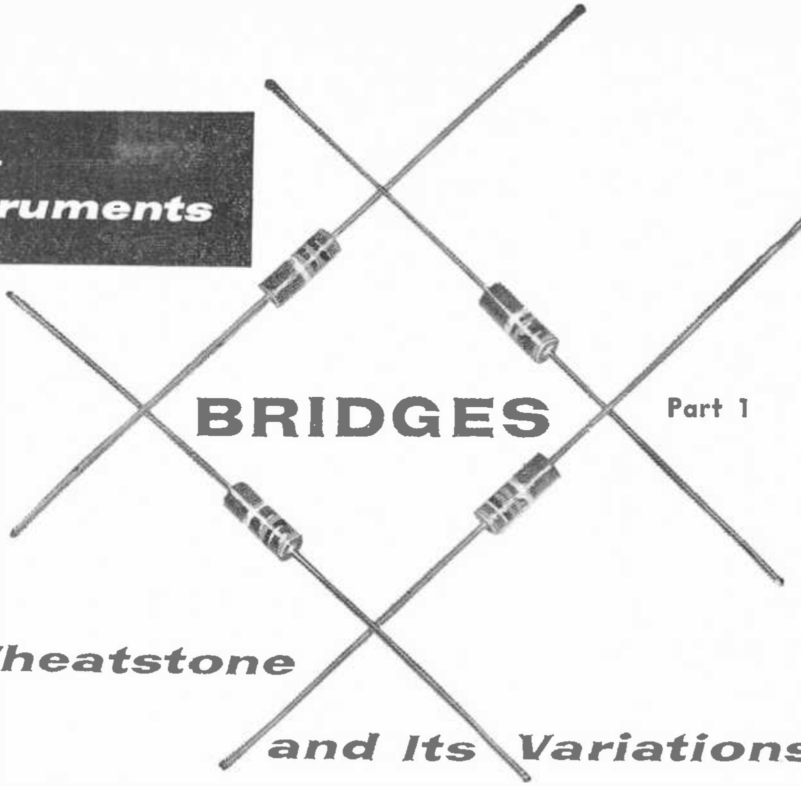
Thus, through the ingenuity of the design engineer, the transformer—though always operating on the same simple principle discovered by Faraday—can be adapted to perform hundreds of useful and important services.



Test Instruments

BRIDGES

Part 1



The Wheatstone and Its Variations

By G. H. HARRISON

WHEN a chemist or pharmacist wants to measure chemicals to the highest possible degree of accuracy, he uses his delicate balance scale to weigh each ingredient. For rough work, the ordinary spring scale will do. But for precision, there is no substitute for the balance.

In electronics, an ordinary volt-ohm-milliammeter is good enough for most work. Like the spring scale, it is reasonably accurate. But when the scientist or engineer must measure resistance, capacitance, or inductance with the utmost accuracy, he—like the chemist—turns to the balance. The electronic balance he uses is known as "the bridge."

How the Bridge Works. As might be expected, the bridge does its job by carefully balancing an unknown resistor against a known one, an unknown capacitor against a known one, and so on. Its accuracy is limited only by the component which it uses as a standard; and thus extremely precise measurements are possible.

The bridge is even relatively independent of the inaccuracies of the meter used to indicate when the bridge is "in balance." The meter acts only as a null detector, indicating when *no current* is flowing. Its inaccuracies, therefore, whatever they may be, do not appreciably affect the actual measurement.

Although there are dozens or perhaps scores of variations on the basic bridge circuit, they all spring from the original *Wheatstone* bridge, devised by S. H. Christie in 1833 and first used by Sir Charles Wheatstone in 1847. The basic Wheatstone circuit, still the most accurate means of measuring resistance known to modern science, is shown in Fig. 1.

Let's assume that the battery supplying current to the bridge is 12 volts, $R1$ is 40 ohms, $R2$ is 80 ohms, and that Rs is a variable resistor. Indicator $G1$ is a center-reading galvanometer; with no current flowing, its needle will come to rest in the center of the scale. Current of one polarity causes

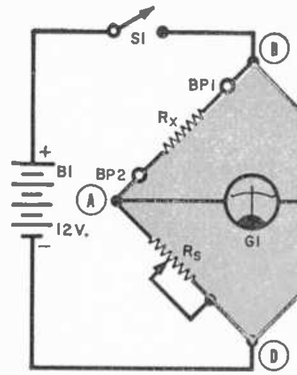


Fig. 1.

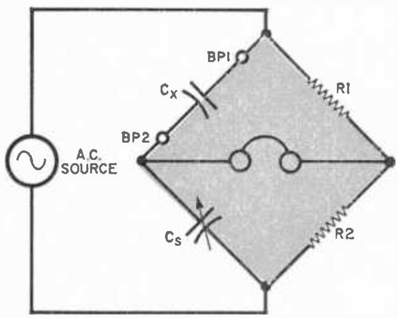


Fig. 2.

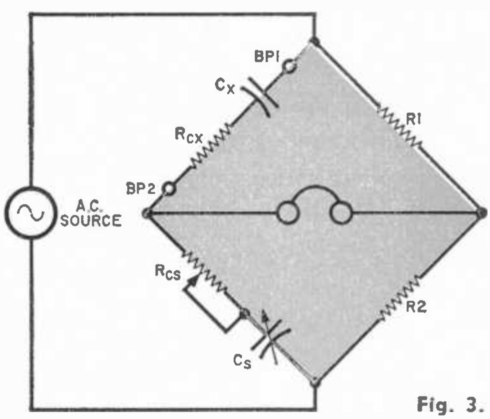


Fig. 3.

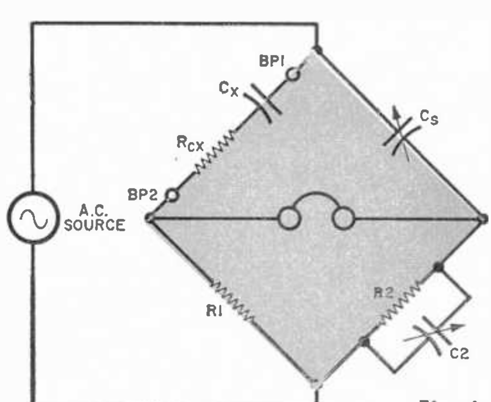


Fig. 4.

it to move to the right; the opposite polarity, to the left.

Measuring Resistance. Now, with the constants as given above, let's connect an unknown resistor (*Rx*) across the test terminals *BP1* and *BP2* and find its resistance. When switch *S1* is closed, the galvanometer needle swings off center. We adjust *Rs* until it again reads zero. This means that no current is flowing through the galvanometer in either direction. Since no current is flowing through *G1*, the voltage at point A must equal the voltage at point C. Resistor *Rs*—which is calibrated—reads 100 ohms. With the information we now have about the circuit, let's calculate the value of *Rx*. As you might guess, we'll call on Ohm's law.

The voltage from point B to point D is 12 volts, and the sum of *R1* and *R2* is 120 ohms. Since $I = E/R$, the current through this leg of the circuit ($R1 + R2$) is 100 ma. Going one step further, the voltage drop across *R1* can now be calculated: $E = IR = 0.1 \times 40 = 4$ volts. The drop across *R2* is: $E = 0.1 \times 80 = 8$ volts.

Since point C is 8 volts positive with respect to point D, and since the bridge is balanced, point A must also be 8 volts positive with respect to point D. Thus, the current through *Rs* must be: $I = E/R = 8/100 = 80$ ma.

Since *Rs* and *Rx* are in series, the current through *Rx* is also 80 ma., and its voltage drop is 4 volts. Its resistance, then, is: $R = E/I = 4/0.08 = 50$ ohms.

As Ohm's law shows in this example, the *ratio* of the voltage drops across *Rx* and *Rs* must equal the *ratio* of the drops across *R1* and *R2*. We can express this relationship as: $Ex/Es = E1/E2$; or $IRx/IRs = IR1/IR2$; or, cancelling, $Rx/Rs = R1/R2$.

Transposing algebraically gives the formula most widely used for calculating the value of the unknown resistor: $Rx = (Rs \times R1)/R2$.

In most practical bridges, calculations are frequently simplified even further by the careful selection of *R1* and *R2*. For example, if *R1* and *R2* are equal—say, each is 100 ohms—then *Rs* and *Rx* will be equal when the bridge is balanced. The value of *Rx* will equal the dial reading of *Rs*. If *R1* is 100 ohms and *R2* is 50 ohms, then *Rx* will be twice the *Rs* dial reading, and so on.

Measuring Capacitance. We have considered only d.c. bridges so far, but in practice many bridges use alternating current.

Capacitance, for example, is measured with an a.c. bridge; the basic circuit, shown in Fig. 2, uses the same principle as the basic Wheatstone bridge. The ratio of the reactance of Cx to Cs must equal the ratio of the resistance of $R1$ to $R2$. To put it mathematically: Reactance Cx / Reactance $Cs = R1/R2$. Since Reactance Cx/Reactance $Cs = Cx/Cs$, then $Cx/Cs = R1/R2$, or $Cx = (Cs \times R1)/R2$.

Incidentally, the headphones shown in this circuit are frequently used in a.c. bridge circuits as null detectors. If the frequency of the a.c. supply voltage is between 500 and 5000 cps, where the human ear is most sensitive, then the bridge can be very accurately balanced by simply tuning until the tone has completely disappeared.

When working with very low voltages, an amplifier is sometimes used in conjunction with the headphones or loudspeaker as a null indicator. At higher frequencies, an oscilloscope, vacuum-tube voltmeter, a wave analyzer, or an ordinary radio receiver can be used. Actually, any circuit or instrument which will accurately detect a null meets the requirements.

Some a.c. bridges are constructed with $R2$, rather than Cs, as the variable component, but the principle is the same. Once the bridge is balanced, the ratio $R1:R2$ is noted, and the ratio $Cx:Cs$ will be the same. To put it another way, with the formula $Cx = (Cs \times R1)/R2$, the unknown can always be calculated, no matter which element is varied to balance the bridge.

In practice, the unknown capacitor will not be purely capacitive, but will contain some resistance as well. Even though the value of resistance will be low, it can affect the accuracy of the reading. Consequently, this resistive component (Rcx) is usually balanced out with a small variable resistor (Rcs) in series with Cs (Fig. 3).

In most conventional capacitor bridges, this circuit usually appears as the Schering bridge (Fig. 4). Here, the resistance of Cx (Rcx) is cancelled out by adjusting $C2$. The adjustable capacitor, Cs, is calibrated directly in microfarads or micromicrofarads, depending on circuit constants.

Measuring Inductance. Inductance can be measured on another a.c. variation of the Wheatstone bridge (Fig. 5). This circuit, however, is seldom used because of the difficulty and expense of manufacturing high-quality accurately-calibrated variable inductors.

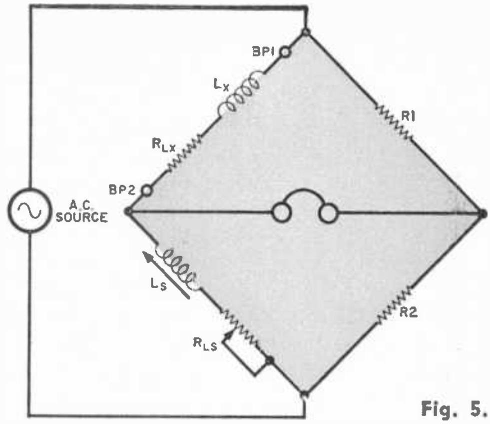


Fig. 5.

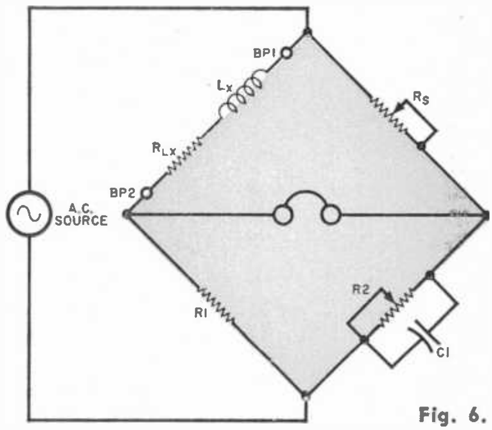


Fig. 6.

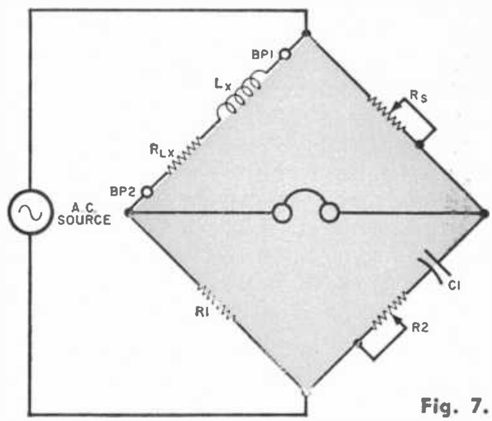


Fig. 7.

Instead, most commercial induction bridges use either the Maxwell bridge (Fig. 6), or the Hay bridge (Fig. 7). In both circuits the inductive reactance of the unknown inductance Lx is balanced against

(*Continued on page* 126)

On the Citizens Band

By **TOM KNEITEL**, 2W1965

AMONG the new equipment making news in CB circles, perhaps the most talked about is the Philmore "station" consisting of the CT-1 transmitter kit, CC-1 converter kit, and CPA-1/CPM-1 power supply.

The CT-1 transmitter is a six-channel job which, although tiny (3" high, 9" wide, 8" deep), weighs seven pounds and has a lot of hair on its chest. It features a 6CX8 in the final, a 12AX7 mike preamp and driver, and a 6AQ5A modulator. It has a pi output network to match any antenna, and it's fully neutralized to squelch parasitics. The CT-1 also boasts a push-to-talk switch and a panel meter which instantly indicates

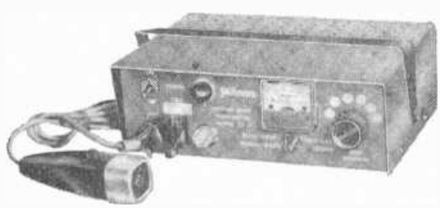


plate input power in watts or relative output and modulation.

The CC-1 converter will hook into any receiver, mobile or base. If you want to use it with a receiver that already tunes the 11-meter band, you can change the CC-1 to a preamplifier and add two more r.f. stages to your receiver by merely removing the crystal from the converter.

The transistorized mobile and base power supplies deliver 300 volts d.c. at 100 ma., choke-filtered.

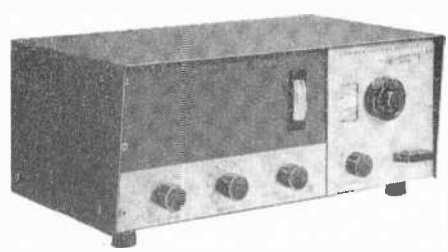
Abuses of the CB Service seem to be growing as the Service itself grows. A number of areas are suffering from "VFO artists," poor sports with variable frequency oscillators. They seem to get a kick out of jamming CB communications by running their carrier back and forth across the band.

There is also a varied assortment of wisecrackers without call letters who like to add their own insipid comments to everyone else's conversations. And then there are the guys with the itchy mike fingers—they seem so anxious to get on the air that—before they get their license—they either swipe someone else's call or make up their own.

Needless to say, such operations are against federal laws, and the violators are subject to appropriate governmental action when they are caught.

Another new entry in the CB equipment field, going along with the component, or "modular," theory of putting together a station made up of separate units, is Browning Laboratories' R-2700 receiver.

This rig has a dual-conversion circuit with 0.2-microvolt sensitivity. In addition to being tunable, the R-2700 has five crystal positions and gives adjacent-channel selectivity better than −40 db. Other features

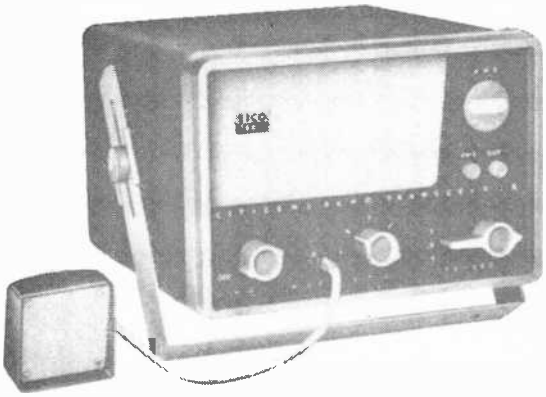


include a noise limiter, an "S" meter, squelch, a.v.c., and 55 db image rejection.

We're waiting for news of the T-2700, companion transmitter to the R-2700.

Wrist-watch CB is on the way—the Longines-Wittnauer Watch Company recently received U. S. Patent No. 2,937,271 for a wrist-watch-housed, CB-activated alarm device. When the owner's code signal is transmitted, a bell inside the watch rings, letting him know that someone is trying to reach him. Although the device is not being manufactured as a separate item, it will be part of a complete two-way unit of the future. It measures about 1" square and ⅜" thick. —30—

builds a Citizens Band Transceiver Kit



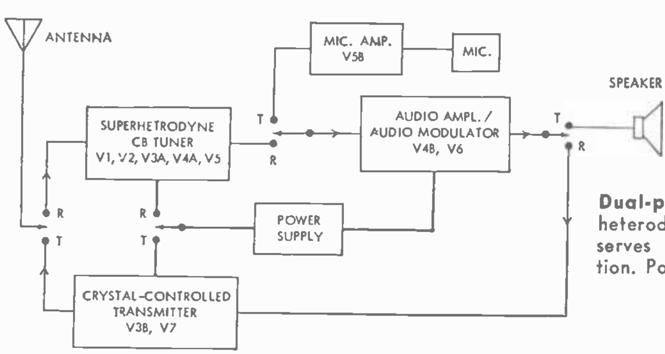
Rugged construction and quick-disconnect features make EICO Models 761 and 762 ideal for shared mobile fixed-station operation

As MORE AND MORE mobile Citizens Band transceivers hit the air, the need for ruggedized equipment becomes increasingly apparent. With mobile operation in mind, EICO (33-00 Northern Blvd., Long Island City 1, N. Y.) has released a new Citizens Band transceiver which meets this requirement. There are three versions, each of which comes in both kit and factory-wired form.

Two mobile versions, Model 761 and 762, work on 6 and 12 volts respectively, and each also works on 117 volts a.c. The kits are priced at $69.95, the factory-wired models at $99.95. A third version, Model 760, operates only on 117 volts a.c. ($59.95 for the kit, $89.95 for the factory-wired model). Otherwise, all three versions are identical.

Encased in a steel cabinet and using only solid steel chassis and brackets, the transceiver is literally built like a battleship. You can mount either of the mobile versions under the dash of your car quickly and easily with the universal mounting bracket supplied, and—if desired—it can be quickly removed for use in the house.

Circuitry. The transceiver is divided into four basic circuits as shown in the block diagram below. In the superheterodyne tuner section, you'll



Dual-purpose audio amplifier in superheterodyne tuner section of transceiver serves as modulator for transmitter section. Power supply is common to all sections.

find an r.f. amplifier, a mixer, two 1750-kc. i.f. amplifiers, a detector and a noise limiter. A single knob provides for continuous tuning over the entire Citizens Band (26.965 to 27.255 mc.). Sensitivity is 1 microvolt for a 10-db signal-to-noise ratio. The audio amplifier section for the receiver also doubles as a modulator for the transmitter section.

When transmitting, an audio preamplifier stage is added to the modulator circuit to boost the signal from the crystal microphone. Crystal control is used in the transmitter which consists of an oscillator stage and a final r.f. amplifier operating at the 5-watt maximum permitted by the FCC. A variable "pi" network matches the transmitter's final to 50- and 75-ohm antennas. The power supply uses a pair of silicon diodes for rectifiers; this keeps cabinet temperature down.

Special Features. The outstanding feature of the transceiver kit models is the factory-wired and sealed transmitter circuit. With this much of the work done for you by the manufacturer, you can legally tune up your antenna system while on the air without an FCC commercial license. However, if you tamper with the seal in any way, this antenna tuning privilege is voided.

Mobile operation in crowded urban areas with their multitude of man-made noise generators usually makes for unfavorable reception. The EICO people have licked this problem by incorporating a diode noise limiter in the transceiver which takes the bite out of the noise. You won't have dead silence between transmissions but rather a gentle murmur to tell you that the set is alive.

Another small, but thoughtful, design feature is the provision of two antenna jacks. One is a standard auto antenna jack and the other is a coax jack which makes for quick connect-disconnect when you change from mobile to fixed-station operation. Incidentally, no changes are necessary when you switch from battery operation to house current—you just unplug the battery and plug in the a.c. power. —30—

The Radar Man

If ever you saw upon the street
A man who walked with dipole feet
With a lagging train of pips behind—
He was a radar man with a micromind.

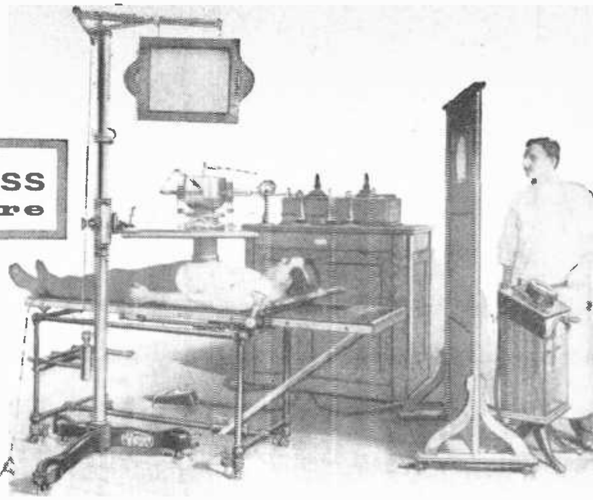
With microseconds and microwaves
And microvolts, he filled his days;
And thus in the course of passing time
His brain had shrunk to a micromind.

His eyes gave out with a neon gleam,
His nose lit up like a radar screen,
His ears worked like an electronic gate,
And his heart pumped blood at a video rate.

This man obtained, in passing years,
Infinite impedance between his ears.
At last he succumbed to a heavy jolt
When he probed what he thought was a microvolt.

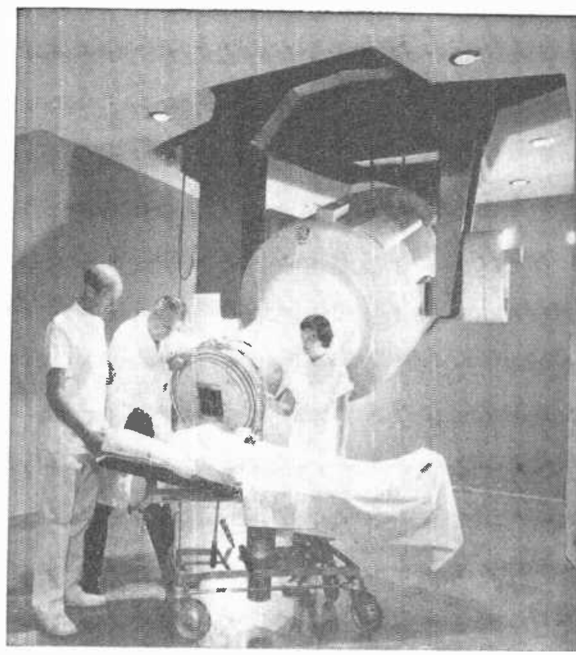
The Doc looked up from his microscope
And said to the nurse, "Behold this dope!
Since of his brain not a trace can I find,
He was a radar man with a micromind."

Educated G.I.



X RAYS

By FRED E. EBEL, W9PXA



Is it light?
No.
Is it electricity?
Not in any known form.
What is it?
I don't know.

Discovered by chance only 65 years ago, X rays are one of our most valuable research tools

With such scientific frankness did physics professor Wilhelm Konrad Roentgen relate his discovery of a mysterious new ray to a newspaper reporter. Stumbled upon by accident during a routine laboratory experiment on the night of November 8, 1895, the new ray was dubbed an "X ray" by Roentgen. "X," then as now, was the mathematical symbol for the unknown.

Much of the "X" has been taken out of X rays since the modest German physics professor demonstrated this startling radiation and its power to penetrate tin, paper, wood, and even the human body. When X-rays were first put into use, you ordinarily had to visit a hospital to see them in action. Today, unlimited industrial applications make X rays far more than just a diagnostic and therapeutic tool of medical science.

Chance—or Fate? Just what did happen on the night of November 8, 1895? Call it fate, fortune, or chance, but there were a number of conditions that conspired to make this night one to remember. First, Roentgen had completely covered the Crookes tube he was using with a black cardboard, making it light-tight. Secondly, his laboratory itself was plunged in darkness. Finally, the *piece de resistance*—a sheet of paper painted with crystals of barium platinocyanide—lay on a bench some distance from the tube.

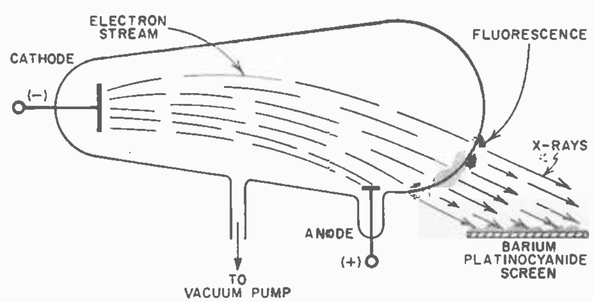
The barium platinocyanide screen was the "chance" that nature gave Roentgen to unlock one of her secrets. For when the crystals glowed with a shimmering yellow-green fluorescence, Roentgen's keen scientific mind became curious. True, cathode rays could make the crystals glow —but at this distance? He placed the crystal screen at an even greater distance from the tube than the range cathode rays were known to penetrate. Still the strange fluorescence!

Heart pounding, he grabbed a book and placed it between the Crookes tube and the screen. The crystals continued to glow. Whatever it was, it was coming through the book! Next, he tried metals—and found that the rays penetrated in varying degrees, although lead and platinum stopped them completely.

Now came the most dramatic test of all. Roentgen exposed his hand, and—his heart must have almost stopped—saw the shadows of his bones. As Roentgen made photographs of his findings, it was obvious that he had found something far more exciting than cathode rays—X rays!

How X Rays Are Formed. How was Roentgen able to produce these powerful rays with his crude apparatus—a modified Crookes tube, mercury interrupter, and a Ruhmkorff induction coil that furnished a bare 20,000 volts? The simple fact is this: X rays are relatively easy to generate. You simply speed up electrons and let them collide with a target. The electrons cause disturbances within the atoms of the target, releasing X rays. Any material, even a gas or liquid, will release X rays when bombarded by high-velocity electrons.

Obviously, then, glass can be a target, as is was in the Crookes tube Roentgen used—see Fig. 1. Here a gas-type tube, consisting



of an anode and cold cathode, was connected to a high-tension induction coil. Heavy positive ions in the residual gas were drawn to the negative cathode (unlike charges attract), striking with such force that they knocked electrons from the cathode metal. It was this positive-ion bombardment that created and maintained a source of electrons, the "work horses" for X-ray generation.

The negatively charged electrons, in turn, were drawn toward the high-voltage positive anode. The resultant stream of electrons, actually cathode rays, traveled so fast—about 30,000 miles per second—that most of them could not "turn the corner" to reach the anode. Instead, they smashed into the glass wall of the tube. The glass, therefore, was the target, providing the barrier for the sudden stoppage of electrons. The result: radiation of X rays, and, of course, the glow of fluorescence of the glass that Roentgen observed.

Nature of X Rays. X rays are electromagnetic rays similar to visible light rays,

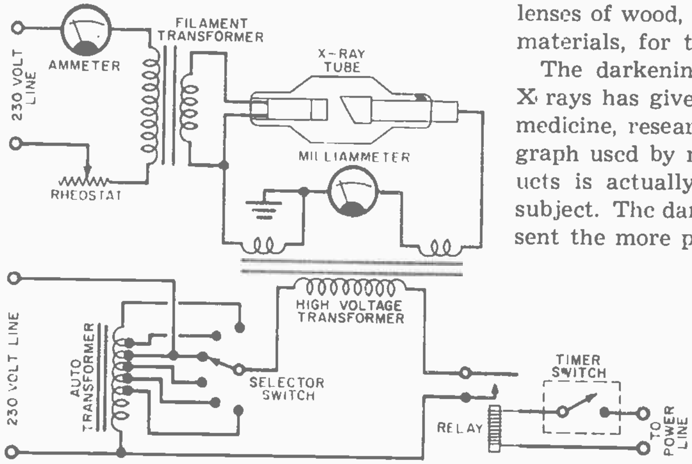


Fig. 2. Basic X-ray unit includes X-ray tube and high-voltage supply.

◀ **Fig. 1.** Crookes tube used by Roentgen produced X rays when electrons flowing from its cathode to its anode bombarded the glass tube.

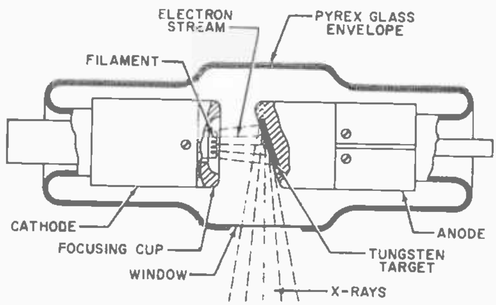


Fig. 3. X-ray tube detail. The focusing cup concentrates electron stream from cathode and directs it toward tungsten target material.

with this important exception—their wavelength is very small, about 1/10,000th that of light. These tiny wavelengths are measured in angstroms, units so small that you can line up 254,000,000 of them between the one-inch marks on a ruler. The X-ray region in the electromagnetic spectrum ranges from about 0.006 to 1000 angstrom units. Interestingly enough, it is this exceedingly short wavelength of X rays that makes possible their penetration of matter, and which enables the researcher to delve into the vast voids of molecular inner space.

Unlike the cathode ray generated in your TV picture tube, X rays are non-electrical. Thus, they are unaffected by electrostatic and magnetic fields. This can be proved by placing a magnet or charged plate near X rays; they will be neither attracted nor repelled as in the case of cathode rays.

Traveling at the same speed as light and radio waves—186,000 miles per second, X rays can be reflected and refracted only at very small angles. (Roentgen failed to focus X rays, despite many experiments with lenses of wood, glass, aluminum, and other materials, for this reason.)

The darkening of photographic film by X rays has given them wide application in medicine, research, and industry. A radiograph used by makers of cast-metal products is actually a shadow picture of the subject. The dark regions of the film represent the more penetrable parts—gas pockets in a weld, for example; the lighter regions identify the more opaque areas.

How X Rays Work. A basic X-ray unit is comprised of filament, high-voltage transformer and timing circuits—see Fig. 2. The heart of the unit is the X-ray tube. Like Roentgen's original tube, the modern tube also has a cathode and an anode, but with tremendous improvements. Now the tube is evacuated to an extremely high vacuum. The cathode structure contains a coil of tungsten wire—the filament—which "boils off" electrons when heated to incandescence. A metal reflector or focusing cup on the cathode directs the electron beam toward the target—as shown in Fig. 3.

Tungsten is ordinarily used for the target material, since it can withstand high temperatures without melting. This is important because less than 1% of the energy in the electrons is converted to X rays upon bombardment with the target; most of the energy is converted to heat. To help dissipate the heat, the tungsten is imbedded in a large mass of copper which conducts the heat into air or into oil, as in the case of the oil-immersed tube.

It is desirable to have the focal spot—the area of the target that receives the electron bombardment—as small as possible. The smaller the focal spot, the better the detail of the radiograph. But a small focal spot means an intense blast of electrons in a tiny area; even tungsten melts under such grueling treatment. This problem can be solved by simply rotating the anode target. The target constantly turns another "face" to the electron stream, area—see Fig. 4.

An induction motor provides the rotating power in an ingenious way. The stator surrounds the outside of the evacuated glass bulb tube and provides the rotating magnetic field that turns the rotor in the tube at approximately 3000 rpm. The rotor in the "neck" of the tube is, of course, connected to the target. The entire moving assembly is located inside the evacuated tube.

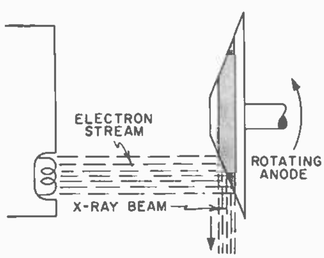


Fig. 4. Rotating anode in target constantly turns new face to electron stream in order to distribute heat over a wide area.

The high-voltage circuit consists of a step-up transformer and its controls; an autotransformer supplies voltage to the primary winding of the high-voltage transformer. Any change of the autotransformer voltage produces a corresponding change in the high-voltage output which is applied to the X-ray tube. Changes in voltage are made with a selector switch; increasing the tube voltage results in a decrease in wavelengths of X rays, accompanied by an increase in penetrability.

If "soft" X rays of low penetrability and longer wavelengths are desired, the selector switch is set at about 20,000 volts. But if "hard" X rays of high penetrability and shorter wavelengths are desired, the switch is set for several hundred thousand volts.

Rectification of the high-tension alternating current to the tube can be very simple—in fact, the circuit can be made self-rectifying. Current will flow through the tube only on the half cycle when the anode is on its negative half cycle, since the anode now repels the negative electrons. Some X-ray systems use a high-voltage full-wave rectifier circuit, permitting conduction of current through the tube on each half cycle of alternating current—see Fig. 5.

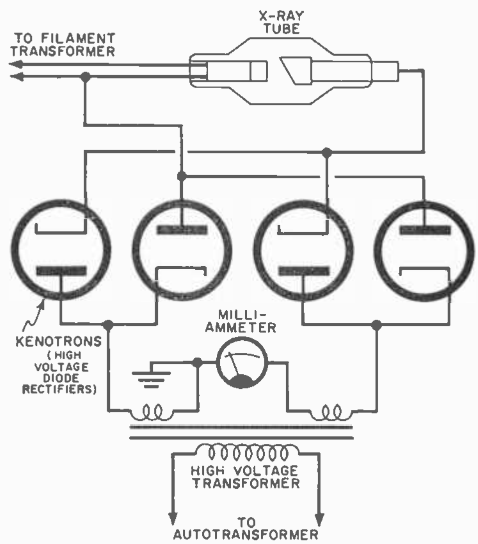


Fig. 5. High-voltage rectifier circuit used in some X-ray systems.

Present-Day Uses. Quality control in manufacturing makes extensive use of the non-destructive quality of X rays in the inspection of casting and weldments for such defects as cracks and gas pockets. X-ray devices in beverage plants "look into" opaque cans moving rapidly on a conveyor line and give the signal for automatic rejection of under-filled cans.

Similar devices reveal foreign bodies in food stuffs; detect the hollow heart of potatoes; separate pithy from juicy oranges; and reveal the improper assembly of electronic tubes, switches, and small electrical assemblies. X rays also gauge the thick-

(*Continued on page* 128)

Across the Ham Bands

By
HERB S. BRIER
W9EGQ

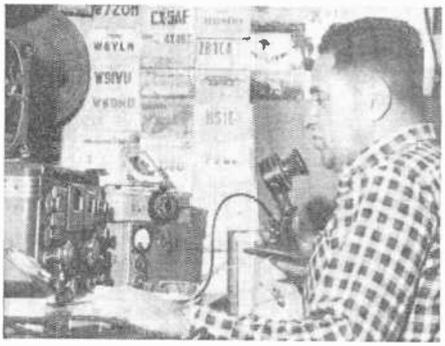
SUBSTITUTING PARTS IN CONSTRUCTION PROJECTS

YOU'VE probably noticed that construction articles often suggest digging into your "junk box" for parts. Most hams go for this idea to help preserve well-rounded pocketbooks. Unfortunately, the parts in their junk boxes are seldom the exact parts specified in the parts list for the gear they want to build. This brings up the question of how far you can deviate from specified values without degrading the performance of the finished product.

Obviously, this is not an easy question to answer without having all the facts. But with a little knowledge of what's involved, you should be able to experiment with other values intelligently.

Overall Considerations. First, read the construction article carefully, and take a close look at the diagrams, pictures, and parts list. The writer of the article has probably pointed out the critical components—don't change them. On the other

Ham of the Month



Yair Ben-Nissim, 4X4GB, of Kfar Ganim, Petah Tikva, Israel, says that he much prefers a long rag-chew with a strong station to digging out and working a weak one in a new country. But we wonder if he means it—in a worldwide DX contest last fall, Yair racked up the world's highest phone score. Not only has he rag-chewed with fellow hams in over 185 countries on phone, but he has confirmations from 160 of them.

Now 28 years old, Yair Ben-Nissim earned his call letters back in 1952. The present equipment at 4X4GB's station is a 250-watt transmitter (a pair of 813's modulated by 805's) and a Hallicrafters SX-28 receiver. For antennas, Yair has a 50′ high "Christmas tree," consisting of separate three-element wide-spaced rotary beams for 10, 15, and 20 meters, spaced four feet apart. He uses simple dipoles for 80 and 40 meters.

Until last year, 10 meters was 4X4GB's favorite band. But the influx of so many Russian hams with frequency-modulated signals on this band has spoiled it for DX work in much of the Middle East. So Yair currently spends most of his time hamming on 15 meters.

Even when he isn't hamming, Mr. Ben-Nissim's not far from ham radio. He's a radio technician for the Israeli government, working in the engineering service, radio section, of the Israeli Post Office. In this position, he handles amateur license examinations and issues the licenses.

For an interesting DX rag-chew, look for Yair Ben-Nissim, 4X4GB, on the air.

hand, feel reasonably free to call on your junk box for the less critical ones.

The parts list will probably name the manufacturers of the major parts used in the original model followed by "or equivalent." When using equivalent parts, it's a good idea to gather them together before beginning construction. Otherwise, you may discover that your parts differ physically from the specified ones, and you may have to change the parts arrangement to make the equivalent parts fit. Such rearranging is easier to do if you plan it ahead of time than after you have most of the parts mounted.

It's also a good idea to weed out defective junk box parts with your VOM. Check resistors for changes in resistance; capacitors for shorts and leakage; and chokes, transformers, and coils for open windings.

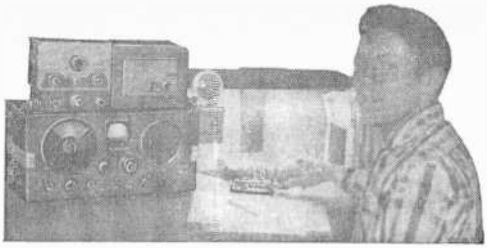
Resistors. Because fixed resistors and fixed capacitors are the most numerous components in the average piece of electronic gear, they offer the greatest opportunity for using spare parts. Unless otherwise specified, fixed resistors commonly have a tolerance of 10% or 20%. Consequently, you can substitute any resistor whose measured resistance is within the tolerance rating of the resistor specified.

You can also connect resistors in series or in parallel to produce a specified resistance. For example, two 22,000-ohm resistors in *series* or two 100,000-ohm resistors in *parallel* can be substituted for a 10% or 20% tolerance, 47,000-ohm resistor. Use the following formulas to calculate the effective resistance (Rt): for resistors in series, $Rt = R1 + R2 + \ldots$; for two resistors in parallel, $Rt = R1 \times R2/R1 + R2$.

You can always substitute a higher-wattage resistor if you have room for it. For economy, composition resistors are normally specified in sizes up to 2 watts; higher-wattage units are usually wire-wound. The two types are generally interchangeable, but never substitute a wire-wound resistor for a composition type in r.f. circuits.

Capacitors. Fixed capacitors come in a wide variety of types—mica, silver-mica, paper, ceramic, oil-filled, electrolytic, and so on. In spite of the great number of types available, however, it's not really hard to remember how each is used.

Mica capacitors (especially silver-mica capacitors) and zero-temperature-coefficient ceramic capacitors are specified where low losses and high stability are required.



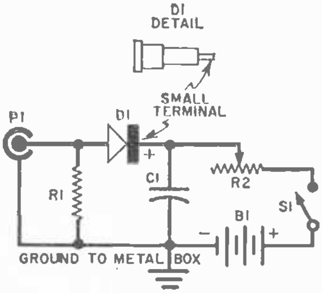
Here's proof of what low power can do. Keith B. MacAdam, K2RXI, (above), worked 23 states on 40 meters with a nine-watter. And Matthew Blanding, K4FNX, (below), racked up 300 contacts using 15 watts output as a Novice; now a General, his record includes 41 states and 14 countries.

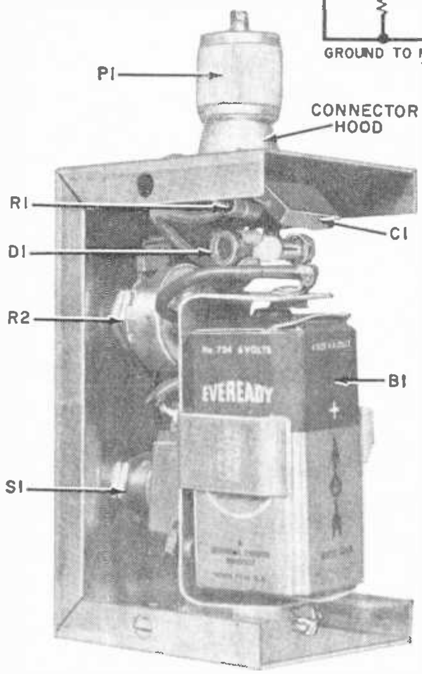
Normally, you shouldn't substitute other types for them. On the other hand, you can ordinarily substitute mica capacitors for other types.

The standard tolerance rating for paper and ceramic capacitors is 20%, although the tolerance rating for some general-purpose ceramic capacitors is as wide as −30% to +100%. Obviously, the exact capacitance is relatively unimportant in many bypassing and coupling applications, and you can usually deviate up to 50% from the specified value without trouble.

Where lots of capacitance in a small, low-cost package is required, the electrolytic capacitor is king. However, if you have some oil-filled capacitors on hand—war surplus units, for example—you can substitute them for electrolytic capacitors of the same ratings. Usually, the exact capacitance of electrolytics is not too important; in a pinch, you can use the nearest available capacitance—preferably on the high-capacitance side.

Don't assume from the above that the





PARTS LIST

B1—6-volt battery (Eveready 724 or equivalent)
C1—0.005-µf. mica or ceramic capacitor
D1—1N21B or 1N23B silicon diode (Sylvania)
P1—Coaxial connector plug or jack (see text)
R1—51- or 300-ohm, 5%, ½-watt composition resistor (see text)
R2—25,000-ohm audio taper potentiometer (Mallory U-28A or equivalent)
S1—S.p.s.t. toggle switch
1—2¼" x 2¼" x 4" aluminum box (Bud CU-3003A or equivalent)
1—Battery holder (Keystone 175 or equivalent)
Misc.—Hardware, terminal strip, wire, solder, etc.

Test your receiver's sensitivity with this easy-to-build noise generator. Although a coaxial plug (with hood) is used here for P1, a coaxial jack may be substituted if you wish.

parts list accompanying a construction article isn't important—the designer undoubtedly had good reasons for specifying the values he did. Nevertheless, it is helpful to know that you can do a little changing in experimental circuits and still get satisfactory results. But when in doubt, always follow the book.

DIODE NOISE GENERATOR

Just how sensitive is your receiver on the higher-frequency ham bands? Does your buddy hear weak signals that you miss on 21 and 28 mc. because he has a more sensitive receiver or because he's in a better location? This simple diode noise generator will quickly answer these and similar questions.

The one critical component in the generator is the silicon diode, *D1*. Either a 1N21B or a 1N23B silicon diode works well, but a general-purpose germanium diode, such as the 1N34A, is *not* suitable. Fortunately, both the 1N21B and 1N23B are available at reasonable cost both in new and "surplus" stocks.

Construction. The noise generator is housed in a 2¼" x 2¼" x 4" aluminum box. Output connector *P1* can be either a coaxial plug (Amphenol 83-1SP or equivalent) or a coaxial jack (Amphenol 83-1R or equivalent). If you choose the plug, as shown in the photo, you must also use a coaxial hood (Amphenol 83-1H or equivalent) to insure proper shielding. In either case, mount the connector at one of the 2¼" x 2¼" ends of the box's cover.

If the hood-and-plug combination is used, insert the round end of the hood in back of the plug and solder them together. Then, mount the hood-and-plug combination to the box by means of the four mounting holes in the hood. No soldering is required if you use the coaxial connector jack—the jack is simply attached to the box by its four mounting holes.

Silicon diode *D1* has a different diameter terminal on each end. Use a ¼" cartridge-

(*Continued on page* 131)

Keep Those Contacts Clean

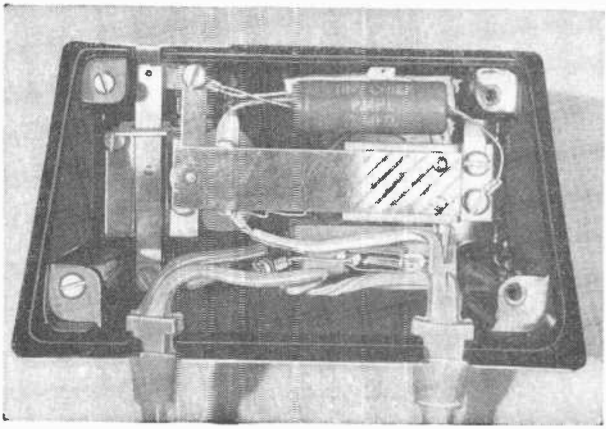
Dirty contacts in switches and other types of controls are a perennial source of trouble—here are ways to keep them clean

By KEN MURRAY

HIGH-RESISTANCE CONTACTS, one of the hidden causes of poor performance on the part of electrical appliances, can be found almost everywhere. Dirt and dust, as well as various forms of corrosion, can reduce or even stop the flow of electricity through the contacts of switches, relays, thermostats, and other types of control devices.

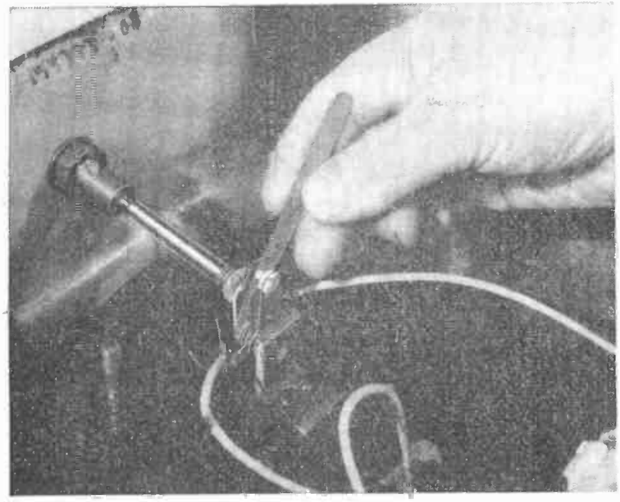
Cleaning and polishing low-voltage contacts is easy if you follow the recommendations of furnace-control manufacturers. Most of them suggest passing a strip of clean white paper between the closed contact points. If such contacts give trouble frequently, look inside the housing for dust accumulations. Trouble can often be prevented by blowing the unit out periodically.

A piece of sandpaper or a file both make good cleaning agents. Or you can use a flat typewriter eraser for a light cleaning. Even a pencil eraser will help remove corrosion, but remember to brush or wipe off any rubber particles which might be left be-



Wiring a capacitor across switch contacts will reduce sparking. Installation above, right, employs a 0.1-μf. unit.

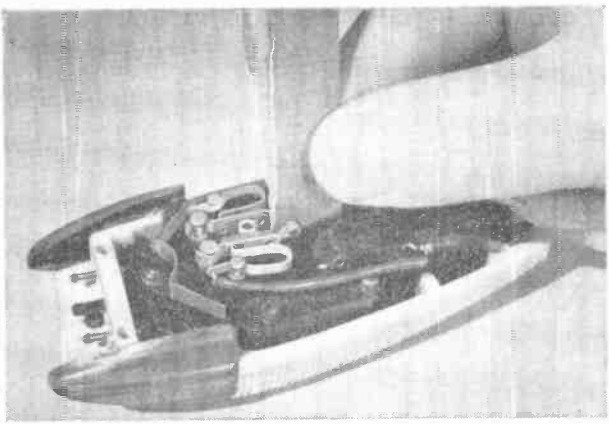
Prepared contact cleaner dissolves corrosion (right) as well as lubricating and preserving all types of contacts.

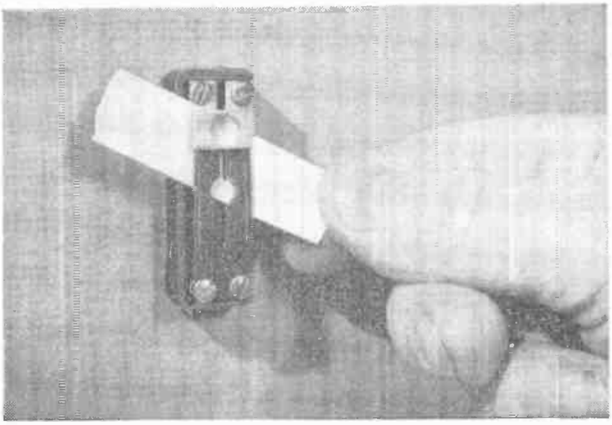


Light filing will clean up contacts that are pitted from heavy service, as in the 1300-watt electric plate shown at left.

Badly worn contacts can be cleaned with a piece of sandpaper (center). Be sure to blow out all abrasive particles.

Plain white paper can be used to clean low-voltage contacts (bottom) by simply drawing the paper between the points.





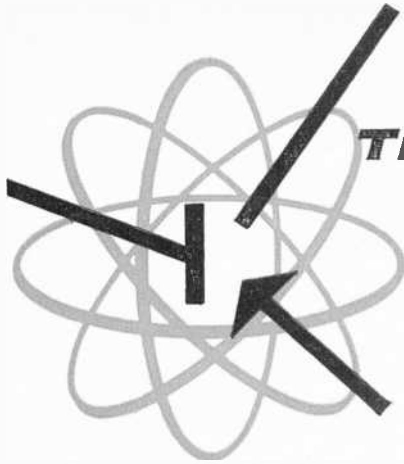
hind. Neither an ordinary cloth nor an emery cloth should be used because of the possible residue of lint or emery particles.

When there are many contacts to keep clean, you may want to use one of the radio repairman's aids—a commercial "contact cleaner." It's sold in small bottles. Apply it with a toothpick (or medicine dropper), and—like magic—blackened contacts will be brightened in a second or two while you watch.

Excessive pit-causing sparking at contacts can be reduced by wiring a small capacitor across the points. Its capacitance should not be large enough to eliminate sparking altogether: a weak spark will help burn off dust and grease as they accumulate.

When switches, plugs, relays, etc., are located where damp air or moisture can get at them, they need frequent attention. Knife switches in such locations can be kept clean with a thin coating of petroleum jelly (Vaseline).

In a car, corrosion of electrical contacts can be the cause of dim and fluctuating lights. The thing to do here is check the condition of fuse contacts, switches, sockets, and ground connections. Auto repairmen know that almost all trouble encountered with generator regulators is due to burned contact points—they use a special fine-cut file for cleaning. —30—



Transistor Topics

By LOU GARNER

WITH Election Day not far off, we can look forward to an increasing deluge of political news, including a barrage of public opinion polls and "predictions" of the election results by electronic computers. If past performances are any criteria, all the major radio-TV networks will have batteries of computers warmed up and waiting to give minute-by-minute predictions as early returns come in.

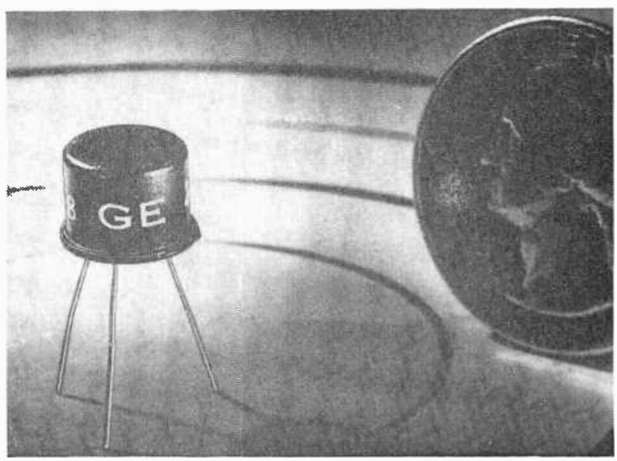
Our favorite semiconductor components—transistors and diodes—will play an important role in all of this activity, for most modern computers use transistorized circuits. Compared with vacuum tubes, transistors offer the advantages of smaller physical size, lower power consumption, less heat dissipation, and improved reliability, particularly when thousands of units are in use simultaneously.

To many, the giant electronic computers—some of which employ tens of thousands of transistors—are complex almost beyond understanding. In actual fact, however, their complexity lies in the multiplication of rather simple circuits. In this respect, they are much like a tremendous building erected with millions of concrete blocks or bricks—taken by itself, each individual block is a relatively simple object.

In one sense, an ordinary superheterodyne short-wave receiver is more complex than a basic computer, for it is apt to employ a larger *variety* of basic circuits: r.f. amplifier, mixer, local oscillator, i.f. amplifiers, crystal filters, beat frequency oscillator, demodulator, audio and power amplifiers. By contrast, a computer may consist of only three or four basic switching circuits—each multiplied a thousand times.

Typical basic transistor circuits used in computers are shown in simplified form in Fig. 1: a "logic" circuit in Fig. 1(A), a "flip-flop" or switching circuit in Fig. 1(B).

A logic circuit is one that performs simple reasoning operations—if either of several conditions are true, then an output signal is developed. Or the circuit may be arranged so that a signal is developed only



if several conditions are true at the same time. Let's see how this can be done.

Figure 1(A) shows a simple one-stage amplifier using a *p-n-p* transistor *(Q1)* in the common-emitter arrangement. Resistor *R3* serves as a collector load, *C1* as an output coupling capacitor, and *R2* as a base resistor. Collector bias is furnished by battery *B2*. Under normal conditions, no signal is developed by the stage, since there is no base bias applied to *Q1*.

Suppose, now, that s.p.s.t. switch *S1a* is

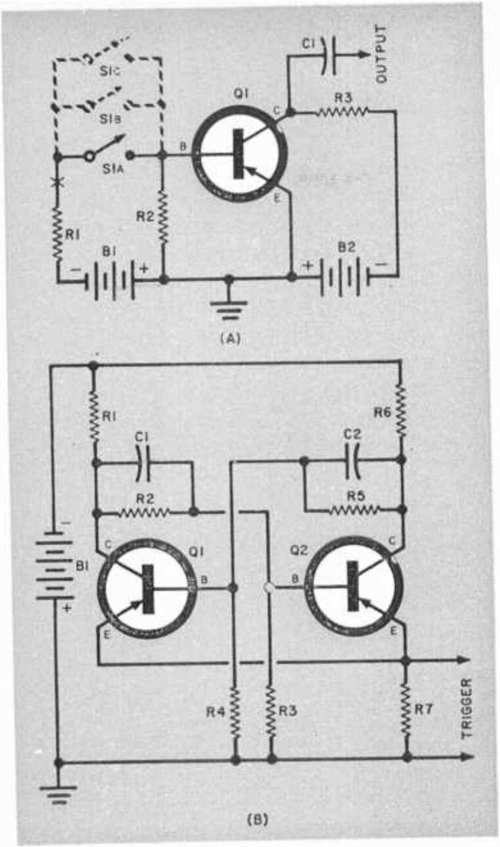


Fig. 1. Simplified versions of two basic transistor circuits employed in electronic computers: a "logic" circuit (A), and a "flip-flop" circuit (B).

Typical high-speed germanium switching transistor of the type used in modern computer circuits is shown at left. This is a General Electric unit.

closed. A bias current can be delivered by battery *B1* through limiting resistor *R1*. This, in turn, permits a flow of collector current, developing an output pulse across *R3*. Thus, we have obtained a basic logic function, i.e., a signal is developed *if* a switch is closed.

We can extend this basic operation to cover other situations by connecting other switches in parallel with *S1a*, as shown by the dotted lines. With this arrangement, the basic circuit can perform logic calculations involving several situations.

A signal is developed if *S1a or S1b or S1c* is closed; such an arrangement, for obvious reasons, is called an "or" circuit. By breaking the lead at point "X" and inserting another s.p.s.t. switch, we can change the circuit function to perform another basic operation; with this connection, the stage becomes an "and" circuit, for it will deliver an output signal only if *S1a and* our new series switch are closed simultaneously. If we use signal polarity as an indication of function, the same basic circuit can be used to perform the negative logic functions "nor" and "and not." These four functions are basic to all reasoning.

In practice, the simple switches are generally replaced by electronic circuits which perform the same function, but much faster. A typical circuit is shown in Fig. 1(B). Here, two *p-n-p* common-emitter stages are cross-coupled as a basic electronic switch. Resistors *R1* and *R6* serve as collector loads, *R3* and *R4* as base resistors, and *R2* and *R5* (bypassed by *C1* and *C2*) as coupling resistors. Common emitter resistor *R7* permits the application of a control signal or "trigger" to initiate circuit operation, and d.c. bias is supplied by *B1*.

In operation, either *Q1* or *Q2* conducts, with the other acting as essentially an "open" circuit. Their roles can be interchanged by applying a trigger signal across *R7*. Let us assume that *Q1* is conducting. The d.c. drop across its load resistor, *R1*, is such that little or no bias voltage is available to be applied through *R2* and across *R3* to *Q2*'s base. Since *Q2* is operating with little or no base bias, it acts as a high resistance or open circuit. There is virtually no d.c. drop across its collector load, *R6*, and adequate base bias is applied through *R5* to keep *Q1* conducting.

Now suppose that a negative pulse is applied across *R7*. It has no effect on *Q2*, since this stage is operating as an "open" circuit. As far as *Q1* is concerned, however, a negative pulse applied to its emitter effectively reduces the base-emitter bias, thereby reducing the collector current flow, and reducing the d.c. drop across *R1*. This drop, in turn, is reflected as an increase in *Q2*'s base bias, causing the second stage to start conducting. The action is cumulative and rapid, with *Q1* transferred to a non-conducting state, and *Q2* conducting heavily. A second input pulse applied to *R7* will "flip" the circuit back to its original condition—and so on.

While these two circuits are not the only ones found in electronic computers, most computers employ variations of basic logic and switching circuits. If you understand how these simple typical circuits operate, you'll be in a good position to study—and to understand—more advanced computer circuits.

Reader's Circuit. Not long ago we received an interesting letter from reader T. L. Clayton aboard the U.S.S. "Hornet" in Pearl Harbor. With the letter was the circuit of a two-transistor receiver he had designed in his spare time *and* a tape recording as "proof" of the receiver's performance. His circuit has a number of offbeat features which should prove worthy of further experimentation.

Referring to Fig. 2, r.f. signals are picked up by loop antenna *L1* and selected by a

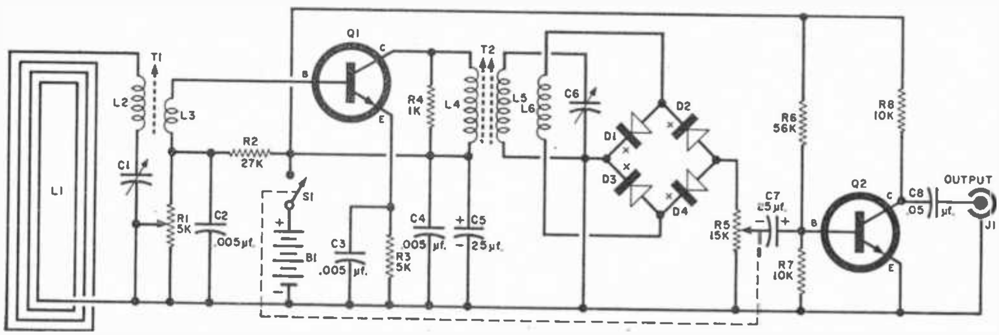


Fig. 2. Reader T. L. Clayton's two-transistor receiver circuit has a number of unusual features. See text for details.

tuned circuit which includes the loop, *L2*, and variable capacitor *C1*. Step-down winding *L3* matches the high impedance of the tuned circuit to the moderate impedance of the common-emitter r.f. amplifier, *Q1*. From *Q1*, the amplified r.f. signal appearing across collector load *R4* and *T2*'s primary winding *L4* is coupled to the tuned secondary *L5-C6* and to impedance-matching secondary *L6*. The signal is detected by a full-wave bridge rectifier (*D1*, *D2*, *D3*, *D4*), with an audio signal appearing across *Gain* control *R5*. From here, the audio signal is coupled through *C7* to a common-emitter audio amplifier, *Q2*, with the amplified output signal developed across collector load *R8* coupled through d.c. blocking capacitor *C8* to the set's output terminals.

Both stages use *n-p-n* transistors, with *Q1*'s base bias furnished by voltage-divider *R1-R2*, bypassed by *C2*, in conjunction with emitter resistor *R3*, bypassed by *C3*. Transistor *Q2*'s base bias is supplied by voltage-divider *R6-R7*.

Except for the coils used, all components are standard. Transistor *Q1* is a type 2N94A r.f. unit, *Q2* a type 2N35. Capacitor *C1* is a dual 365-μμf. tuning capacitor with *both* sections connected in parallel; *C6* is a single 365-μμf. variable capacitor; *C2*, *C3*, and *C4* are 0.005-μf. ceramic, mica, or paper capacitors; *C5* and *C7* are 25-μf. electrolytics; and *C8* is a 0.05-μf. ceramic or paper unit. Except for the electrolytics, which should be rated at 25 volts, capacitor working voltages are non-critical.

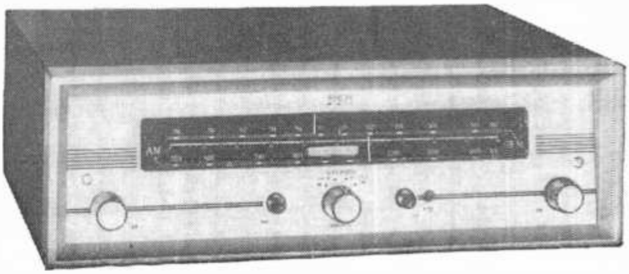
All resistors are half-watt units except the 5000-ohm bias control, *R1*, and 15,000-ohm *Gain* control, *R5*, which are standard potentiometers. The bridge-type detector is made up of four type IN34A diodes, but other general-purpose diodes will serve as well. Power switch *S1* is ganged to *R5*, while battery *B1* may be a single 15-volt assembly or ten flashlight or penlight cells connected in series.

Coil *L1* consists of three turns of standard hookup wire around the outer edge of a 2' x 3' piece of cardboard. Transformer *T1* is made up by winding a single layer of litz wire over the paper sleeve covering a Grayburne ferrite loopstick; this extra winding serves as *L3*. Transformer *T2* consists of two loopsticks (*L4* and *L5*) placed on a common axis with the coils end-to-end, and with a single layer of litz wire over *L5*'s paper sleeve. This last winding serves as coil *L6*.

Layout is not especially critical, but Clayton points out that *Q1*'s input and output circuits should be kept well separated to prevent feedback, and that *T1* and *T2* should be mounted at right angles to each other to prevent r.f. oscillation.

(*Continued on page* 129)

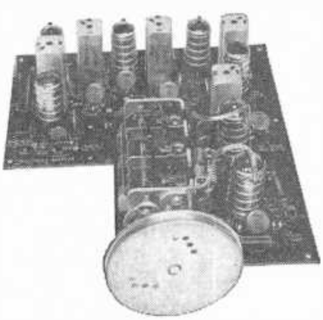
NEW AM/FM STEREO TUNER



PACO's Model ST-45 comes as a kit, semi-kit, or factory-wired

A good-looking and good-sounding unit, the Model ST-45 AM/FM stereo tuner is available in three forms: as a kit ($84.95), as a semi-kit ($99.95), or factory-wired ($134.95). It's made by PACO Electronics Company, Inc., 70-31 84th St., Glendale 27, N. Y.

If you decide to get the complete kit, you'll find that the assembly instructions are practically "built in." Two printed-circuit boards are used, one for the seven-tube FM section (shown at right) and another for the three-tube AM section. The detailed instruction manual covers the special techniques of soldering to a printed-circuit board. With the pre-aligned transformers, no alignment for either section is necessary—the set will play the moment it is plugged in.



Two tubes use conventional wiring: the power rectifier and the dual AM-FM cathode-follower triodes. Both are in a non-critical part of the circuit and will not affect the alignment of the set. The tube line-up is rounded off with an electronic tuning eye which provides accurate tuning on AM and FM.

The semi-kit is identical to the kit except that both FM and AM circuit boards are completely wired. All tuned circuits are aligned and tested at the factory. You just wire the audio and power sections, and you're in business. Even if you've never assembled a kit before, you should have no trouble with the semi-kit.

Now let's take a look at the circuits of the Model ST-45 and see what you get for your money. In the r.f. stage of the FM section is a 6AQ8, one half operating as a grounded grid amplifier and the other half as a mixer. A separate dual triode is used for the local oscillator and for a.f.c. operation. In the 10.7-mc. i.f., two full stages of amplification are followed by two limiter stages. A standard Foster-Seeley discriminator is used to detect the FM signal and the resultant audio is fed into a cathode-follower triode. There are separate audio level controls for both FM and AM on the front panel. Overall sensitivity of the FM section is 2 microvolts for 30 db of quieting; the i.f. bandwidth is over 200 kc.

You probably won't need an outdoor antenna for FM reception, since the set is quite sensitive. However, if you live in a FM fringe area, a good directional antenna will be helpful on weak signals.

Featured in the AM section is a tuned r.f. stage, followed by a heptode converter and a single stage of i.f. A crystal diode is used as a detector which feeds the cathode follower audio output. There is also a rotatable ferrite antenna in the AM section, and a 10-kc. whistle filter eliminates the interference which unfortunately is inherent to AM broadcasts on a very crowded band that exists today.

The power supply uses a standard full-wave rectifier with an electrostatically shielded transformer. You'll find that the shielding will help eliminate noise pickup from the power line—especially important for good AM reception. —30—

Super

Six-channel high-fidelity sound accurately follows action of wide-screen movie with no "hole-in-the-middle" effect

Huge VU meters connected to each of six stereo channels enable Todd-AO technicians to "track" screen action with dialogue, music, sound effects.

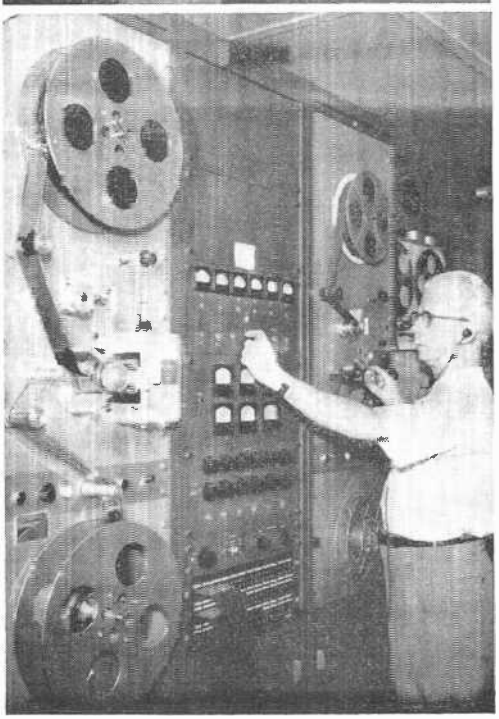
Minnesota Mining and Manufacturing Co. photos

EVER wonder why big movie productions —such as "South Pacific" and "Porgy and Bess"—don't end up with a stereophonic "hole in the middle?" The answer, according to the sound department of Todd-AO, is the use of *six*-channel stereo.

Getting the cumulative mixture of sound effects, solo singing voices, speech, choruses and background music properly oriented on six stereo tracks is no easy matter. In fact, the actual filming time of "Porgy and Bess" took only 93 days, while the time spent in perfecting the multi-channel sound came to five months—60 days of pre-recording vocals, choruses and music, plus another 90 days to cut, edit and re-record for final finished prints ready to be shown at your local theater.

Of greatest interest to the stereophile is the technique of "panning" or "swinging" the sound back and forth across the movie screen to follow the action. After the film has been satisfactorily edited (for showing time, flow of story action, etc.), the music

Stereo



score is recorded and edited to fit. Then all of the individual sound tracks are blended and mixed in the first re-recording phase; this step involves making the dialogue tracks coincide with the action—especially important due to the immense size of the screen. Next, the sound effects are "swung" in the same manner, and, occasionally, even the choruses must be made to follow screen action.

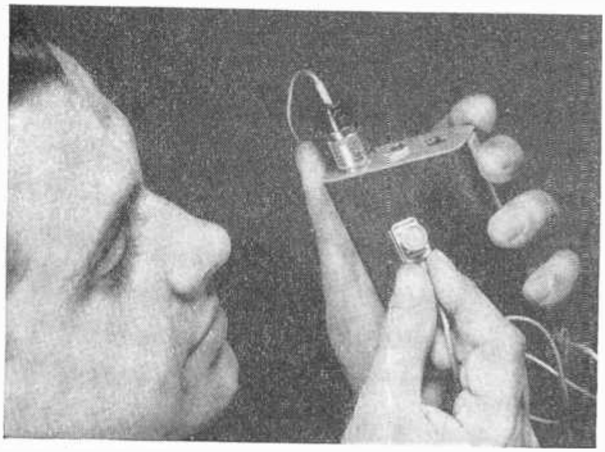
Todd-AO technicians have devised an unusual way of accomplishing the "swinging" process. Sitting at four consoles, the sound engineers mix music, dialogue and sound effects by watching the edited version of the film and simultaneously observing six VU meter readings. Each VU meter is fed from one of the six channels and pertains to a certain area of the movie screen. As the action moves about, the engineers "track" the dialogue from channel to channel.

Over three million feet of magnetic film —"Scotch" No. 125—was used in the production of "Porgy and Bess." The frequency response of the six magnetic tracks exceeds that of an optically recorded sound track in an ordinary motion picture by a wide margin: 40 to 12,000 cps for the magnetic film strip compared to only 100 to 8000 cps for the optical recording. —30—

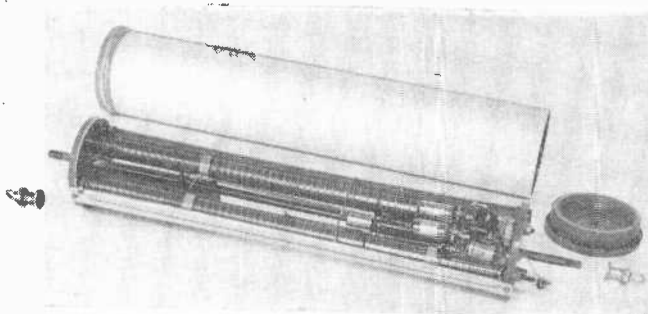
Sound tracks from bank of 35-mm. tape playback machines (above left) are fed through a console to a pair of six-track recorders. Final version of "Porgy and Bess" consisted of 14 reels.

Magnetic oxide strip on ultra-wide 70-mm. motion picture film (left) has synchronized audio dubbed in from 35-mm. six-channel audio tape. Operator shown here is monitoring the VU meters.

Transmitters on the Move

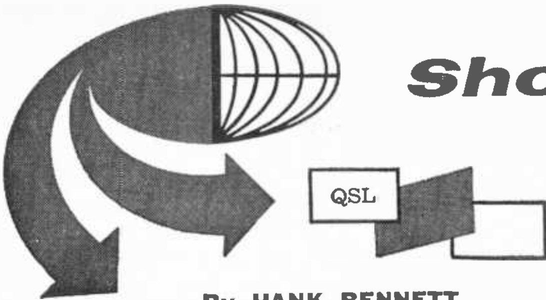


"WALK AND TALK" operation is possible with this miniature transmitter and ultra-miniature dynamic microphone. Developed by Telefunken, and tabbed the "Mikroport," the unit puts out low-power FM signals on 37 mc. Intended for voice transmissions only, the microphone has a frequency range of from 100 to 1500 cps. The shielded wire on the 30" microphone cable eliminates audio hum pickup and serves as the antenna as well.



SHIPWRECKED SAILORS or passengers on planes forced down in uninhabited areas or in the ocean will benefit from the emergency self-powered transmitter shown above. When this new Telefunken unit is assembled in its cylindrical housing, it is completely waterproof and insensitive to shock. Even when the transmitter is floating in water, its special ferrite antenna radiates enough of a signal on the 2.182-mc. distress frequency for an accurate radio fix miles away.

A LITTLE RED WAGON provides the action in this mobile radio setup, used for surveying operations at Monterey, Calif. With it, surveyor Don Kjelstrup gives directions for the precise placement of piles for a small craft dock to the barge in the background. Another surveyor, out on the wharf, has his own red wagon unit. *(UPI photo)*



Short-Wave Report

By **HANK BENNETT**
W2PNA/WPE2FT

HOW many DX'ers can lay claim to the ability to do housework while listening to the British Broadcasting Corporation? Or to wash the dishes and mop up the kitchen floor while tuned to the morning broadcast from *Radio Australia?* Our Featured DX'er this month, Mrs. Ira Kalish, of 2537 Dock Rd., Bellmore, N. Y., is one of those who can.

While DX'ers of the feminine sex are few and far between, Ruth Kalish can proudly boast of being one of the really active "Lady DX'ers" at the present time. In 18 months, Ruth has logged stations in 47 countries, 33 of which have been verified. Her veries from *All India Radio* and *Radio Omdurman* (Sudan) are the most highly prized; her favorite stations are the BBC for newscasts, *Deutsche Welle* (Germany) and Lisbon for their excellent musical programing.

A former code operator on analog computers, Ruth has found that a combination of housework and DX'ing can and does work. Her Hallicrafters S-85 receiver is located in the kitchen, and her present antenna can be found somewhere between the kitchen cabinets and the window screen.

Ruth began DX'ing in May, 1959, when she was presented with her receiver as a Mother's Day gift (her son Conrad is almost three years old—she's 27). An inveterate radio fan but bored with the ever-present commercial advertising, she went into the shorter waves. She soon found that many highly enjoyable hours could be spent in just listening, if not tuning for DX.

With daytime DX'ing the rule, Ruth usually monitors the 16- and 19-meter bands. During the evening, husband Ira often takes over the listening post for a session of code practice from W1AW, the American Radio Relay League's headquarters station in West Hartford, Conn.; and from latest

Daytime DX'er Ruth Kalish combines short-wave listening and housework. In 18 months, she has logged 47 countries (33 verified) with her Hallicrafters S-85.

reports, he is doing nicely at around 13 words per minute. Baby Conrad is the only member of the Kalish household not yet engaged in SWL'ing.

The Kalishes just recently moved to their home in Bellmore. Future plans call for expansion of the antenna system into a long-wire or doublet type; previously they had little space for an antenna. However, Ruth has asked us to point out that a fancy antenna is not a necessity for DX'ing. She and Ira were slow in starting their hobby because someone had told them a beam antenna was almost a must for foreign station reception. A random length of wire and a good ground is all that is necessary to hear the larger stations; for those real rough catches, of course, you have to get down to the finer points, antennawise.

Our housewife-DX'er also wants to pass along a tip that she noticed in the March, 1960, "Across the Ham Bands" on using a 6AC7 tube in place of the 6SG7 as r.f. amplifier in the S-85 receiver. Ruth made the substitution and is highly satisfied with the increase in sensitivity. She suggests that others might find it worth trying.

Engraved Desk Plate. If you want to show off your WPE call letters, here's an item that will enhance any listening post. It's an engraved desk plate made of five-ply plastic laminate with a mahogany finish. There is no paint filling, the finish will never fade, and an occasional waxing will keep it sparkling. Priced at $3.20, the desk plate comes with a rubberized bottom section so that it won't slide. Orders may

be sent directly to your Short-Wave Editor (P.O. Box 254, Haddonfield, N. J.); checks or money orders should be included rather than the actual cash to avoid any possible loss.

If you haven't yet registered for your Monitor Certificate and call letters, fill out the form below and mail it to: Monitor Registration, POPULAR ELECTRONICS, One Park Ave., New York 16, N. Y. Please include a dime to help cover handling costs, and a stamped, self-addressed business envelope.

If you live outside of the United States, send either two International Reply Coupons (IRC) or postage stamps of equivalent IRC value. Canadians may send either two IRC's, stamps, or 10 cents in coin. To help us speed up the processing of overseas applications, let us know the amateur prefix used in your area.

(*Continued on page* 138)

Short-Wave Monitor Registration

(Please Print)

Name ....

Address .... City .... State ....

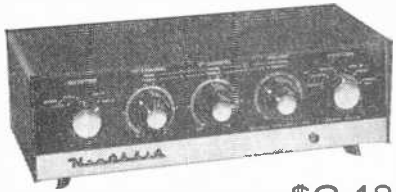
Receiver | Make .... Model ....

Make .... Model ....

Principal SW Bands Monitored .... Number of QSL Cards Received ....

Type of Antenna Used ....

Signature .... Date ....



AA-20 $34^95

ECONOMY STEREO PREAMPLIFIER KIT

Although these two new Heathkit models are designed as companion pieces, either one can be used with your present stereo system. The preamplifier (AA-20) features 4 inputs in each stereo channel and gives you a choice of 6 functions. It will accommodate a magnetic phonograph (RIAA equalized), a crystal or ceramic phonograph, and two auxiliary sources (AM-FM tuners, TV, tape recorders, etc.) and is completely self-powered. The six-position function selector switch gives you instant selection of "Amplifier A" or "Amplifier B" for single channel monophonic; "Monophonic A" or "Monophonic B" for dual channel monophonic using both amplifiers and either preamplifier; "Stereo' and "Stereo Reverse". 8 lbs.

AA-30 $45^95

HI-FI RATED 14/14 WATT BASIC STEREO AMPLIFIER KIT

Two 14-watt high fidelity amplifiers, one for each stereo channel, are packaged in the single, compact, handsomely styled amplifier (AA-30). Suitable for use with any stereo preamplifier or with a pair of monophonic preamplifiers, it features individual amplifier gain controls and speaker phase reversal switch. Output terminals accommodate 4, 8 and 16 ohm speakers. 21 lbs.

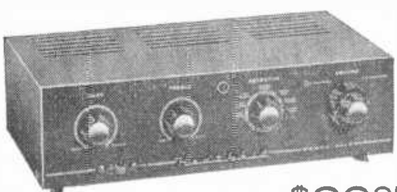
HI-FI RATED 14/14 WATT STEREO AMPLIFIER KIT

A tremendous dollar value in the medium power class, this top-quality stereo amplifier-preamplifier combination delivers full 14 watts per stereo channel (28 watts monophonic) to drive your stereo system with ease, while versatile controls give you fingertip command of its every function. In addition to "stereo" and "stereo reverse" functions, the SA-2 provides for complete monophonic operation. Inputs on each stereo channel accommodate "magnetic phono" (RIAA equalized), "crystal phono", "tuner" and high level auxiliary input for tape recorder, TV, etc. Other features include a speaker phase-reversal switch, clutched volume controls, ganged tone controls, filament balance controls, and two AC outlets to accommodate accessory equipment. Handsomely styled in black with inlaid gold design. 23 lbs.

SA-2 $54^95

UTILITY RATED 3/3 WATT STEREO AMPLIFIER KIT

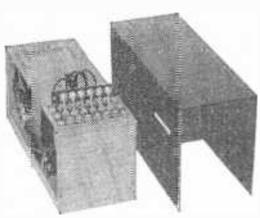
Your least expensive route to stereo, the SA-3 delivers 3 watts per stereo channel (6 watts monophonic), adequate for average living-room listening. The high level preamplifier has two separate inputs for each channel and is designed for use with ceramic or crystal cartridge record players, tuners, tape recorders etc. Featured are ganged bass and treble tone controls, clutched volume controls, channel reversing switch, speaker phase reversal switch and mono-stereo function selector switch. Attractively styled with satin-black cabinet. 13 lbs.



SA-3 $29^95

MIXED LOWS STEREO CROSSOVER NETWORK KIT

The AN-10 makes it possible for you to convert to stereo or improve your present stereo system by using just one bass "woofer"; saves buying a second bass speaker, permits using more economical "wing" speakers, improves the bass response of any stereo system. Delivers the non-direction bass frequencies of both channels below 250 cps to a single woofer and passes the higher frequency stereo channels to a pair of wing speakers. Rated at 25 watts per channel. Matches 8 or 16 ohm woofers, 8 ohm high frequency speakers, or Heathkit SS-1-2-3 speaker systems. 10 lbs.



AN-10 $19^95

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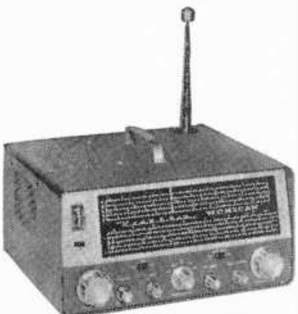

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An excellent portable or fixed station receiver. Many firsts in receiver design, ten transistor circuit, flashlight battery power supply and new ceramic IF transfilters. The amazing miniature transfilters used in the GC-1 replace transformer, inductive and capacitive elements used in conventional circuits for shaping bandpass; offer superior time and temperature stability, never need alignment, provide excellent selectivity. Telescoping 54" whip antenna, tuning meter, flywheel tuning and large slide-rule dial also featured. Covers 550 kc to 30 mc in five bands. Electrical bandspread on five additional bands cover amateur frequencies from 80 through 10 meters. Operates up to 400 hours on 8 standard size "C" batteries. Sensitivity: 10 uv, broadcast band; 2 uv, amateur bands, for 10 db signal-to-noise ratio. Selectivity: 3 kc wide at 6 db down. Measures 6½" x 12" x 10". 20 lbs.

HEATHKIT XP-2. Plug-in power supply for 110 VAC operation of GC-1. 2 lbs. **$9.95**

HD-19
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HD-20
$14.95

XR-2P
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(6 lbs.)

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Unsurpassed quality and styling are combined in these handsome sets to provide you with superb and dependable portable entertainment wherever you are—wherever you go! Choose the gleaming, two-tone molded plastic model or the handsome simulated leather-and-plastic combination—both feature a gracefully curved grille in smart beige plastic. The XR-2P complements the handsome grille with a mocha colored case of high-impact plastic, while the XR-2L encases the beige grille in suntan color Sur-U-Lon simulated leather. Vernier tuning control gives you smooth, precise station selection. Six Texas Instrument transistors are used for quality performance and long life; a large 4" x 6" PM speaker with heavy magnet provides "big set" richness of tone. Ready to play after simple assembly—transformers prealigned. Six flashlight batteries used for power (500—1,000 hrs.) (Batteries not included).

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HW-29 (6 meter)

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NEW 100 KC CRYSTAL CALIBRATOR KIT (HD-20)

This versatile ham aid provides marker frequencies every 100 kc between 100 kc and 54 mc. Use to align all types of communications equipment. Features transistor circuit dependability, battery power portability, and crystal control accuracy. .005% crystal supplied. 1 lb.

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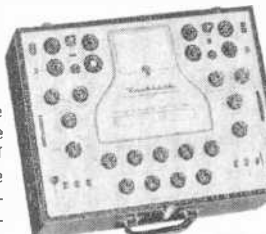

TT-1

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EK-1

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The impressive list of its features make this tube tester a fine value. Tests Gm (amplifiers) from 0-24,000 micromhos, Emission, Leakage, Grid current (¼ microampere sensitivity), Voltage regulators (built-in variable DC power supply), Low power Thyratron and Eye tubes. Features 300, 450, and 600 ma constant current heater supplies, life test, Hybrid tube test, built-in switch operated calibration circuit. Large easy-to-read meter, and constant tension free-rolling roll chart mechanism. Individual selector switches allow testing any tube type, regardless of basepin connections, protecting against obsolescence. Assembly simplified by 7 wiring harnesses and transformer terminal board. Assembly skill of technician or higher recommended, time 40 hours average. Black leatherette case with white trim, nylon feet, removable top. 27 lbs.

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By
JOHN T. FRYE
W9EGV

Carl and Jerry

The Crazy Clock Caper

IT WAS almost the end of an exasperatingly beautiful, warm, sunny school day. Carl and Jerry were sitting in class listening impatiently to the voice of the Latin teacher droning on and on about the second conjugation. Their eyes were on the clock over the door.

Suddenly the voice of the principal issued from the intercom speaker: "Miss Manders, will you please have Jerry Bishop and Carl Anderson come to my office at once?"

The boys rose from their seats at a nod from Miss Manders and started for the door. They could feel the backs of their necks growing hot under the concentrated questioning stares of their classmates.

"Now what've we done?" Carl muttered as they walked along the hall.

"Rather: what have they caught us at?" Jerry whispered.

Jerry knocked at the office door, and the sight of the principal's smiling face banished their worries.

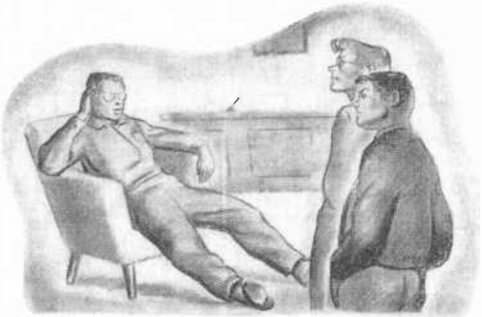
"Boys, this is Mr. Stoner from Center City," he said. "Mr. Stoner is here to straighten out a little trouble we're having with our new automatic clock and bell system."

Tall, thin, bespectacled Mr. Stoner stopped his nervous pacing about the office long enough to shake hands.

"He needs a couple of boys to help him with his testing," the principal explained. "I suggested you two because of your interest in electricity and electronics. I have to leave for a board meeting, but I'm sure you three can get along without my help—especially since my wife says I can't even plug in the electric toaster and do it right!"

As the principal closed the door behind him, Mr. Stoner slumped into a chair. Nervously tugging at his ear, he stared searchingly into the faces of the two boys. Finally he spoke:

"Boys, I'm going to level with you. I'm in a spot. Actually, I'm an electric typewriter serviceman. The man who is supposed to take care of these clocks is on vacation, and I'm pinch-hitting for him. I know just a little about the system, but that little doesn't seem to be enough to find the trouble. I've spent three days on it, and my boss is beginning to ride me. He thinks a man who can fix electric typewriters should be able to fix anything. On top of



that, my wife called last night and said that my little boy is sick—I should be home with them.

"The principal tells me you two are sharp on electronics. I hope he's right, for I certainly could use some help."

"What's wrong?" Jerry asked.

"All the clocks in the building are supposed to keep in step with the master clock here in the office," Mr. Stoner replied, as he sprang up and renewed his pacing. "Every fifty-ninth minute this master clock causes an audio tone of a certain frequency to be fed into a power amplifier located there in the closet. The signal is built up to about forty watts and fed into the 117-volt a.c. line. It goes out over the power lines to the electric clocks plugged in in the various rooms.

"Inside each clock is a transformer with tuned windings. The primary in series with a capacitor is connected directly across the a.c. line. The coil and capacitor are series-resonant at the audio frequency, so maximum current flows in the primary. Audio voltage developed across the parallel-tuned secondary fires a cold-cathode thyratron tube. Current through this thyratron actuates an electric clutch that causes the sweeping second hand to pick up the minute hand and carry it to the vertical position before dropping it. Every twelve hours a similar arrangement corrects the hour hand.

"In some installations the correction takes place at 6 a.m. and 6 p.m., but the hour hand is corrected at noon and midnight in this setup. Different audio frequencies are fed into the line by the clock at preset times. These signals are picked up by other tuned transformers with thyratrons that close relays and ring bells in the classrooms. By using different frequencies, the bells of different rooms can be rung at different times so a complex time schedule can be accommodated.

"Every morning several of the room clocks indicate the wrong hour. Others are on time. Different clocks are incorrect on different mornings. At noon they are all automatically corrected, and they stay on time until school is out. But the next morning it's the same old story."

"WHAT have you done so far?" Carl wanted to know.

"I've checked the tone generator and the power amplifier thoroughly. All the tones are on frequency, and there's no parasitic oscillation or noise in the amplifier. I've checked the tuning of the transformers in the clocks to make sure they're right on frequency. I've gone over the wiring. And I've measured the clock-setting signal at all the clocks—it's supposed to be in excess of 0.8 volt, and it is.

"Incidentally, the coupling between the primary and secondary of each tuned transformer is variable so that the voltage delivered to the thyratrons can be kept uniform in spite of different audio voltage levels present across the wall sockets into

(*Continued on page* 120)

"It looks to me like you need a new vibrator."

Pity The Poor Customer

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C	Radio & TV Servicing (V-3)	2 yrs. High School	Day 9 mos. Eve. 2¼ yrs.
D	Transistors*	V-3 or equivalent	Eve. 3 mos.
E	Electronic Drafting (V-9)*	2 yrs. High School, with Algebra, Physics or Science	Eve. 3 yrs.
F	Color TV	V-3 or equivalent	Day 3 mos. Eve. 3 mos.
G	Audio-Hi Fidelity*	V-3 or equivalent	Eve. 3 mos.
H	Video Tape*	V-3 or equivalent	Eve. 3 mos.
I	Technical Writing (V-10)	V-3 or equivalent	Eve. 3-18 mos.
J	Radio Telegraph Operating (V-5)*	2 yrs. High School, with Algebra, Physics or Science	Day 9 mos. Eve. 2¼ yrs.
K	Radio Code (V-4)*	8th Grade	Eve. as desired
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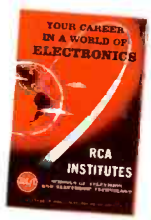

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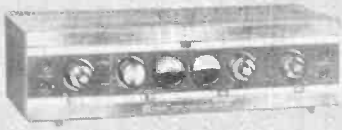

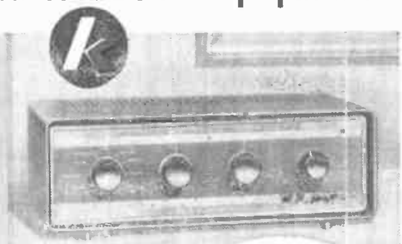

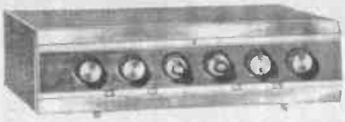

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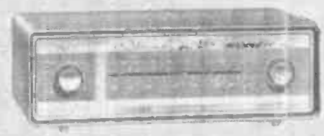

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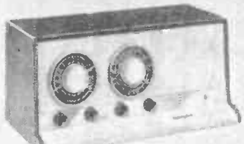

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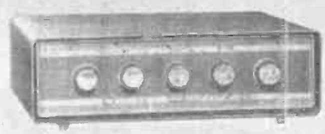

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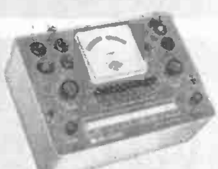

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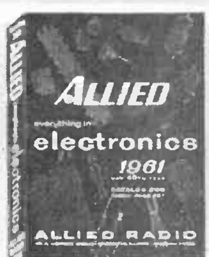

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Carl and Jerry

(*Continued from page* 113)

which the clocks are plugged. Since the audio signal must thread its way through the maze of a.c. wiring and be subjected to various bypassing actions of different loads on different parts of the wiring, it is understandable that these levels would be different."

"It's kind of funny that nothing happens during the day," Jerry mused. "Maybe something the janitors do at night upsets the clocks."

"I thought of that. The only electrical apparatus they use regularly is a power vacuum sweeper. When the vacuum is running, it produces some noise on the line, but this noise only measures .2 volt—far too low to trip the clock-setting mechanism. Oh, yes, there's one odd thing the principal noticed: more clocks seem to go crazy when it rains. That would point toward humidity as the cause of our trouble, but I can't imagine how."

"Do you have any other ideas?" Carl wanted to know.

"Just one. Today I figured that line voltage variation occurring at night might somehow upset things, so I borrowed this variable-voltage transformer from a TV shop. I'll crank the voltage applied to the signal generator and the power amplifier up and down while you two check the clocks in various rooms to see if anything happens."

Carl and Jerry went from room to room inspecting the clocks while Mr. Stoner raised and then lowered the line voltage applied to the clock-regulating equipment by ten percent. The clocks never budged.

"Well, there goes my last idea," Mr. Stoner said dispiritedly as the boys came back into the office. "I just don't know—"

He was interrupted by the ringing of the telephone on the desk. He answered it, and the boys could see him becoming more and more agitated as he talked.

"My little boy has just been taken to the hospital for an emergency appendectomy," he reported as he hung up the telephone. He began gathering up his tools and throwing them into his tool box. I must go home at once. Have the janitor lock the office. I don't know when I'll get back." This last sentence was shouted back over his shoulder as he dashed out the office door.

Carl and Jerry hunted up the janitor and delivered the message, then started for home.

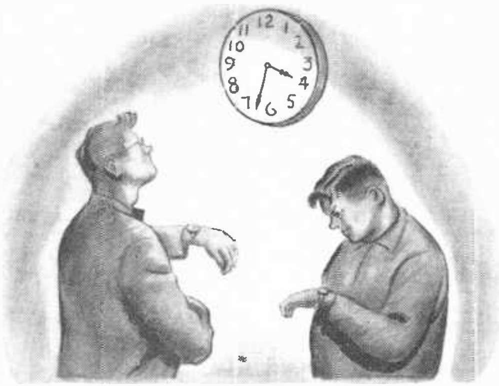
"You know," Carl remarked, "I feel sorry for Mr. Stoner. He really has trouble. I wish we could help him."

"Maybe we can," Jerry answered. "Let's go to school a half hour early tomorrow and check those clocks ourselves. We just might get lucky and stumble onto something."

THE NEXT MORNING the boys found only seven of the forty-one clocks with the incorrect time. Two were in the basement, three on the first floor, and two on the top floor.

Shortly before noon it began to rain, so Carl and Jerry ate lunch in the school cafeteria. As they ate, they puzzled over their problem. "It simply has to be something that happens between midnight and morning," Jerry finally decided. "Suppose we ask the principal to let us snoop around here tonight and see what goes on."

The principal readily agreed to the plan and gave the boys a pass key that would let them into any of the classrooms. The sensible thing would have been for the boys to go to bed right after supper and get some sleep before midnight, but what did our heroes do? They stayed up and watched the late show until a quarter of twelve! Then they set out for the school, Jerry



carrying an a.c. voltmeter, and Carl a pair of binoculars.

Quietly, they let themselves into the dimly-lit building. There was something spooky and a little sinister about the empty halls and the closed doors of the classrooms. From somewhere in the building came a faint humming sound, and they moved softly about in their sneakers until they located it. The hum was coming from the large tank of an industrial vacuum sweeper which was sitting on a low cart in front of an open door.

As the boys peered around a corner, the janitor came out of the room and piled the

long flexible hose of the vacuum cleaner on the cart, recovered the line cord that had been plugged into a socket in the room, and pushed the cart to the next door.

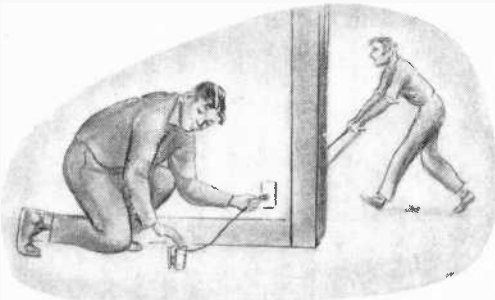
It took the janitor only a few minutes to vacuum this room, but he apparently decided that the floor of the next one was too dirty to be dry-cleaned. First he sloshed sudsy water over the floor and gave it a quick going-over with a rotary wet mop. Then he used the vacuum to suck up the excess water. As he did this, the boys could hear the motor of the cleaner slowing down in protest. Finally, he went over the floor with a clean mop and clear water.

Jerry silently beckoned Carl into a classroom across the hall. The floor was still damp, and the clock was four hours fast!

"I've got an idea," Jerry whispered. "You take the key and get into that wing across the way where you can see the clocks in the rooms the janitor is cleaning. Don't let *him* see *you*. I'll be doing some checking here. We'll meet in this room in half an hour."

Carl waited until the janitor had started on another room and then slipped away.

Jerry tiptoed across the hall to a baseboard outlet socket just outside the room in which the janitor was working. There he plugged in his own version of a tuned transformer he had made from an old TV flyback transformer. Placing his voltmeter across the secondary of this transformer enabled him to read the voltage of any



clock-setting signal on the line without interference from the 60-cycle a.c. current.

When the janitor switched on the vacuum cleaner, Jerry got a reading that represented 0.2 volt; but when the sweeper began to suck up water, this reading quadrupled! With a smile of satisfaction, Jerry unplugged his apparatus and returned to the rendezvous room to await Carl.

The latter soon appeared, his eyes wide with excitement, and his uncased binoculars dangling about his neck. "When that vacuum sweeper begins to suck up water, the clock in the room goes crazy," Carl reported.

They did not discuss the matter further. It was two o'clock, and both boys were growing very sleepy. They slipped out of the building and went straight home to bed.

WHEN Carl and Jerry arrived at school the next morning, Mr. Stoner was standing on the steps, smiling and relaxed.

"The little boy is getting alone fine," he said, "and I feel like a new man. I guess I needed a shock to show me what was really important. Now that my son is going to be all right, nothing else bothers me. We'll lick this clock thing in time, and I refuse to get worked up about it again."

Excitedly, both boys talking at once, Carl and Jerry told him what they had observed the previous night.

"That's it!" Mr. Stoner exclaimed. "The vacuum cleaner was only sucking air when I checked it. When it sucks water, the motor works harder and produces a noise of the right amplitude and frequency to trip the clock-setting mechanism in the room where the vacuum sweeper is being used. It's too weak to bother more distant clocks, and even the clock in the room isn't disturbed during the dry-cleaning process. Well, installing a noise filter inside the motor housing will stop the noise in a jiffy."

"Only one thing bothers me," Carl said slowly. "Why did more clocks get out of synch when it rained?"

"That's easy," Jerry broke in. "When it rained, the kids tracked in more mud, making it necessary to scrub more rooms that night. So more clocks were off the next morning."

"I don't know how to thank you fellows," Mr. Stoner said sincerely.

"Well," Carl suggested slyly, "you *could* say you needed us to help you install that noise filter during the Latin period. We're due to have a quiz, and—"

"Say no more!" Mr. Stoner interrupted with a chuckle. "I'm sure I need you more than Caesar does today." —30—

Pulse Modulation

(*Continued from page* 56)

again have a value of 0 if there were no pulse. The far left position would have double the value of the middle position, or 4, if a pulse were present, but a value of 0 if no pulse were there.

Suppose our quantized pulse has a value of 3. Then, in a three-pulse binary code, there would be a pulse in the far right (1) and middle (2) positions only $(1+2=3)$. If the quantized pulse has a value of 7, then all three pulses in the group would be needed $(1+2+4=7)$.

With a three-pulse binary group, we can send out the waveshape shown in Fig. 4(B) using any of seven values. For greater "fidelity" in reproducing the waveshape, we would need a large number of samples, and larger binary pulse groups would be required. A five-pulse group, for example, gives 32 different amplitudes; a seven-pulse group gives 128 different amplitudes.

The binary-coded signal is ultimately fed to an r.f. transmitter, which is turned alternately on and off by the binary pulses.

Multiplexing and PCM. Bell Telephone Laboratories has many plans for pulse code modulation. For example, they envision a 24-voice-channel PCM telephone system which would allow 24 people to talk at the same time over a single line.

If you've had any experience with present-day "party lines," you know it's impossible for two people to talk over the same line at the same time. How, then, can 24 people do it? The answer is multiplexing, a kind of sampling technique. The type used in telephony is time-division multiplexing.

Let's consider a case where six people are sharing a single telephone line. Three of them are talking in city A and three are listening in city B. By means of a rotating commutator in city A, each speaker is rapidly hooked up to the line in succession. At the same time a second commutator in city B, synchronized with the commutator in city A, samples the line and distributes each speaker's voice to the intended listener in city B. It's possible to have as many as 176 simultaneous conversations over a single line using PCM.

Multiplexing, incidentally, is the method used by earth satellites to transmit different types of information back to earth. Instead of hooking up 24 talkers in sequence, we can hook up 24 transducers which give information about temperature, cosmic ray density, magnetic field strength, etc. Each transducer modulates a subcarrier oscillator, which in turn modulates the regular high-frequency carrier. Both time-multiplexing and PCM were used in the Explorer VI.

PCM offers great possibilities as a television transmission system, and Bell Labs is actively at work on this idea also. In microwave radio, PCM promises practically interference-free transmission. And since a PCM signal is easily applied to magnetic tape, it is ideal for missile and satellite telemetering as well.

Compared to other forms of pulse modulation, PCM has the sole disadvantage of a wider bandwidth requirement. But as telemetry systems move from the lower megacycle bands to the 2200-mc. region, this disadvantage becomes less and less important.

An Exciting Future. Pulse modulation is no longer just theory—it is a reality. Young as it is, pulse modulation is the giant behind the front-page news of space exploration.

As we explore the frontiers of outer space, and as we search for ways to improve and increase the information-handling capacity of our existing communications systems, it becomes increasingly evident that pulse modulation is one of the most exciting developments of modern electronics. —30—

Test Instruments

(*Continued from page* 85)

the capacitive reactance of *C1*. Resistor *R2* in each case is used to cancel out the resistance of the inductor (R_{Lx}), and then *Rs* is used to balance the bridge.

Figure 8 shows a commercial multi-range Maxwell bridge. Although at first glance it may seem to bear little resemblance to the bridge circuits shown so far, a closer investigation will reveal that it is simply the Maxwell bridge circuit arranged so that different components can be switched in to allow measuring a wider range of values. The unknown inductance and *R1*, *R2*, or *R3*, depending on which one is in the

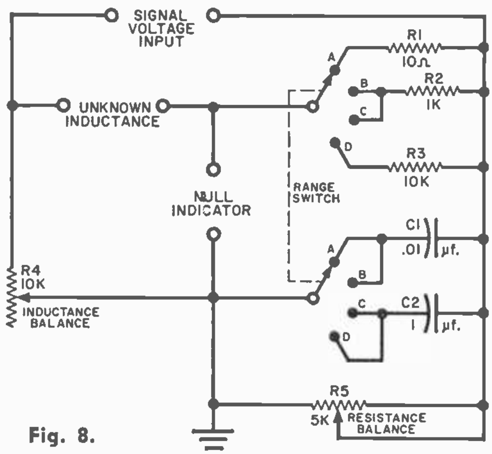


Fig. 8.

circuit at any given time, form the leg comparable to *Lx* and *R1* in Fig. 6. Resistor *R4* and the parallel network, *R5* and *C1* or *C2*, correspond to *Rs* and the network *R2-C1* in Fig. 6.

In such a circuit, *C1*, *C2*, *R1*, *R2*, *R3*, and *R4* serve as the standards against which the unknown values are measured, and must, therefore, be of the highest precision; *R4* is a decade resistor for this reason. Actually, all precision bridges use decade resistors rather than the variable potentiometer type shown for the sake of clarity in all of the diagrams so far.

The decade resistor (*R4*), as illustrated in Fig. 8, is simply a series of precision resistors combined with a switching arrangement so that any value of resistance can be easily and quickly set from the front panel by turning the knobs of the rotary switches.

Incidentally, with the circuit constants shown, the inductance ranges are: Position A, 10 to 1000 μh.; Position B, 1 to 100 mh.; Position C, 0.1 to 10 henrys; Position D, 1 to 100 henrys. Usually, a low-distortion audio signal generator set for 400 or 1000 cps is used as the voltage source. The lowest voltage which will produce a clearly audible signal should be used, since too much current flowing in the bridge components can heat them and cause them to change values.

Some inductance bridges are arranged so that the *C1-C2, R5* network can be switched into either a series or parallel arrangement, changing the bridge from Maxwell (parallel) to Hay (series). This is a highly desirable feature because the Maxwell bridge is more efficient at measuring the inductance of low-*Q* coils, while the Hay bridge does a better job on high-*Q* inductances. Some commercial testers are even arranged so that Hay, Maxwell, Schering, and Wheatstone bridges can all be set up by manipulating the panel controls.

Bridge Accuracy. Just how accurate are the measurements made with bridge circuits? Most laboratory-type bridges are accurate to within 1 or 2% of the resistance measured, and some extremely fine instruments measure to within a fraction of 1%. These figures compare with normal ohmmeter accuracy of 5 to 10% for typical service instruments.

Regular laboratory capacitance and inductance bridges do even better, usually achieving an accuracy of 0.2 to 1%, as compared with 5 to 10% for other types of capacitance- and inductance-measuring instruments and circuits.

Next month we will examine some other types of versatile bridge circuits and see how they are used in harmonic-distortion meters, oscillators, and other specialized instruments. —30—

ANSWERS TO CIRCUIT QUIZ

appearing on page 66

1	C	11	L
2	R	12	C
3	L	13	L
4	L	14	R
5	C	15	C
6	L	16	L
7	C	17	L
8	R	18	C
9	C	19	R
10	L	20	L

X Rays

(*Continued from page* 92)

ness of electroplating, as well as that of hot steel strip racing along at 4000 feet per minute in a rolling mill.

Dramatic applications abound in X-ray diffraction. Here, X rays are made to bounce off mirror-like atomic planes of crystalline substances to reveal secrets of inner structure. Nylon, magnetic TV tape, synthetic rubber, high-temperature alloys, high-test gasolines, and penicillin are just a few of the products X-ray diffraction has helped to develop or improve.

Art museums use X rays to examine the authenticity of old paintings. In other applications, X rays distinguish real diamonds and pearls from their imitations.

Biologically Speaking. It is now well known that X rays as well as gamma rays can mutate or change the genes (hereditary units) of our bodies. Excessive X-radiation can also affect flesh, bone, and blood destructively. For these reasons, it is of utmost importance that exposure to radiation be kept at a minimum.

What can be done in this respect? So far as background radiation is concerned, even Adam and Eve had to contend with the small amount of gamma radiation from radioactive material which occurs naturally in soil, rocks, and even plants. In fact, there are radioelements in our bodies that give each of us a daily unavoidable radiation dose of 0.0001 roentgen. (The roentgen is the unit of X- and gamma-ray dose.) In addition, cosmic rays from interstellar space add to our daily dose of background radiation.

In essence, X rays are simply a form of man-made radiation, but new techniques and advancements greatly reduce the effects of their exposure to patients. Diagnostic voltages now up to 150 kv. permit much shorter exposure times, as do faster films. Significant, too, are collimators that confine the X-ray beam to the exact area desired.

All in all, few would deny that the tremendous diagnostic and therapeutic benefits of X rays far outweigh any possible deleterious effects. In fact, many a man, woman, and child is alive today because of Roentgen's startling discovery. Since that eventful night in 1895, these once strange and unknown rays have done much to alter the nature of the world we live in. —30—

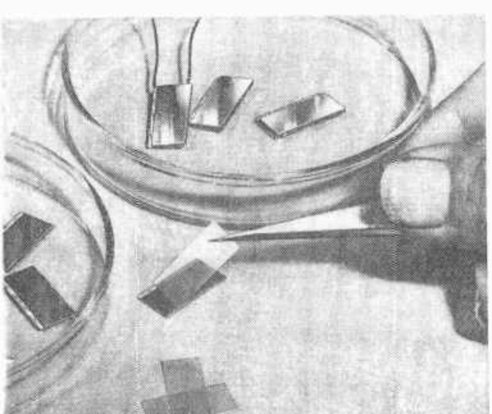
Transistor Topics

(*Continued from page* 100)

When the wiring is completed, *L1* should be connected to the receiver proper with a short length of twisted hookup wire. A local station is tuned in by adjusting both *C1* and *C6*; the trimmers on these units should be adjusted for best alignment and tracking. Potentiometer *R1* is adjusted for maximum gain and left fixed in position unless *Q1* is replaced. Good results should be obtained with moderate-impedance (4000 to 10,000 ohms) magnetic or high-impedance crystal earphones, although Clayton indicates that he uses his receiver as a tuner for an audio installation.

The Sun At Work. Sun-powered devices continue to make news. The International Rectifier Corporation (1521 E. Grand Ave., El Segundo, Calif.) has developed a series of silicon solar cells for use in space vehicles, satellites, and related applications. The cells are covered with a thin, optically-coated glass which provides: (a) reduced cell temperature and higher efficiency; (b) protection of the cell's surface from micrometeorite bombardment and abrasion; (c) reflection of that portion of the solar spectrum not effective in electrical conversion; and (d) an anti-reflection surface to improve the transmission of desired radiation. Many of these silicon solar cells are already in use.

Switching from outer space back to earth, the Hoffman Electronics Corporation, another California firm, has developed a highway-emergency call system powered by solar energy. The transmitter consists



Glass-topped silicon solar cells developed by International Rectifier Corp. for space applications.

of a push-button operated call box, designed for mounting on a pole or lamp post. Pushing a button will summon the fire department, police, an ambulance, or service truck. Operating power is furnished by a rechargeable nickel-cadmium power pack kept charged by five silicon solar cells. According to the manufacturer, five minutes of full sunlight supplies enough current for one message.

Product News. A new series of high-voltage silicon cartridge rectifiers has been announced by the General Instrument Semiconductor Division (65 Gouverneur St., Newark 4, N. J.). Available with axial lead or fuse clip mounting arrangements, these units can supply currents up to 250 ma. and can handle voltages from 600 to 16,000 PIV. Typical applications are in high-voltage supplies for cathode-ray and Geiger counter tubes.

Of the more than 4,000,000 portable radio receivers sold in 1959, over 90% were transistorized. This year, an even higher percentage will be tubeless.

Sylvania (Woburn, Mass.) has introduced a new "pancake" type of packaging for subminiature transistors. Types SYL-1986 and SYL-1987, *p-n-p* and *n-p-n* units, respectively, with cutoff frequencies of several megacycles and maximum dissipation ratings of 100 mw. are the first to be so housed; overall dimensions are only 0.070" high by 0.270" wide, exclusive of leads.

From the Stoddart Aircraft Radio Co. (6644 Santa Monica Blvd., Hollywood 38, Calif.) comes news of a pocket-sized transistorized v.l.f. receiver. Designed as a standard receiver for aircraft, shore stations, and mobile units, as well as for personal use, it is crystal-controlled and tunes to five stations between 14 and 20 kc. The set's bandwidth is 500 cps, sensitivity is 0.005 microvolt, and power output is 10 milliwatts. Measuring 1" x 3¾" x 4" overall, it weighs only 10 oz. and will operate up to 100 hours on its self-contained 4-volt mercury battery.

Two bidirectional transistors have been announced by RCA (Somerville, N. J.). Designed primarily for medium-speed switching applications, Types 2N1169 and 2N1170 have cutoff frequencies of 7 mc. Their emitter and collector electrodes may be used interchangeably.

That does it for now. I'll be back next month with more circuits and news.

—*Lou*

Across the Ham Bands

(*Continued from page* 95)

type fuse clip for the larger diode terminal, and a pin from a wafer-type octal socket for the smaller terminal. Using a two-lug insulated terminal strip, solder the fuse clip to one lug and the socket pin to the other lug; do not insert the diode until you've completed the soldering.

Together, the clip, pin, and terminal strip make the diode holder which is mounted behind *P1*. Connect the large clip of the diode holder to the center terminal of *P1*.

Terminating resistor *R1* should have a resistance equal to the input impedance of the receiver under test. This impedance is usually 50 or 300 ohms; check the manufacturer's specifications to be sure. Use a 51- or 300-ohm, 5%, ½-watt composition resistor for *R1*, depending on the resistance you need. Now mount *R1* and capacitor *C1* close to *P1*, keeping all leads short.

Location and lead length of all other components is not critical. Mount potentiometer *R2* and toggle switch *S1* on the 2¼" x 4" side of the box; the battery holder can be mounted wherever convenient.

Operation. First, connect the noise generator to your receiver antenna terminals using a length of coaxial cable. If you selected the coaxial plug for *P1*, you can plug the generator right into the receiver's antenna jack.

Next, connect a low-range a.c. voltmeter

"It's the bank—they say that when you endorse a check you should stop adding your call letters to your name."

or multimeter across the voice coil of the receiver's speaker. Turn the receiver's a.v.c. and BFO off and the r.f. gain control full on. Now, adjust the audio volume control for a convenient reference reading on the meter. Turn on *S1* on the noise generator, and advance *R2* for a 3-db increase on the meter. If your meter is not calibrated in db, 1.4 times the *reference* meter reading will equal a 3-db increase.

The less you have to advance *R2* for a 3-db increase in receiver output, the *better* your receiver sensitivity. On frequencies below 14 mc., only a slight advance of *R2* should be necessary. But on the 14-mc. and higher-frequency bands, even advancing *R2* full on may not do the job. In the latter case, check your tubes and receiver alignment. Try a "hotter" tube in the first r.f. amplifier tube socket, or build a "signal booster" (see "Across the Ham Bands," March, 1960). —30—

News and Views

Ron Slattery, K9TOF, 5029 West 157th St., Oak Forest, Ill., shares his ham station with his dad, KN9UFN. The rig is a Heathkit DX-20 feeding either a 245′ long-wire or a 137′ Windom antenna. Their receiver is a Hallicrafters S-53A helped along by a Heathkit QF-1 Q-Multiplier and the 14- to 29-mc. signal booster described in our March, 1960, column. For local phone contacts, Ron modulates the DX-20 with the cathode modulator described in the April, 1959, column; although he admits making many substitutions in building it, he gets excellent quality reports. . . . . **Alan Garfinkle, KN4WMW,** 54 Chadwick Dr., Charlestown, S. C., has worked only nine states in two months on the air. But he expects to do better now that he has repaired the break in the coaxial feedline to his beam antenna (see the May, 1959, issue of POPULAR ELECTRONICS). Someone drove a nail through the coax—accidentally, of course. Alan pushes with a Heathkit DX-40 and pulls with a Hallicrafters S-85. He's currently constructing a 2-meter rig.

W5AYV is owned by the Grace Methodist Church, 400 N. Carolina Dr., El Paso, Texas, with Ross A. Sheldon, K5UCH, as trustee. The pastor, Rev. D. L. Hinckley, believes that the station gives the young people of the church an introduction to the importance of communications and electronics in the space age. Also, he says, "it is an indirect effort in Christian evangelism." W5AYV uses a Heathkit AT-1 transmitter, an end-fed antenna, and a war-surplus RAL-7 receiver. Bigger and better things are hoped for in the future, but being on a "scrounge budget," it will be a slow process. This station operates in the Novice bands only, because most of its operators are Novices. They are more anxious to send you their card than to receive yours; make a sked on any Novice band between

2:00 and 4:00 p.m., MST, on Sundays. . . . . **Gary Yantis, KNØBHM,** 10809 Johnson Dr., Shawnee, Kansas, has been on the air for two weeks and already has made 90 contacts in ten states. His transmitter is a Globe Chief 90A at 75 watts, which feeds a long-wire antenna; he receives with a Hallicrafters SX-99. His favorite band is 80 meters, although he has been known to make a few contacts on 40 and 15 meters.

By the time you read this, **Bill Watts, K4JQV,** ETN-3, USN, Lorac Support Team #3, C/O Fleet Post Office, N. Y., should be operating portable from Newfoundland. Then, for the next two years, he expects to operate from Bermuda, The Bahamas, Grand Turks, and other islands—if he can get licenses to operate from them. If you have any information about how he should go about getting the permission, drop him a line. Bill calls himself a "General-Class-type Novice," and spends most of his ham time in the Novice bands. . . . . **WV2???** is 15 and lives at 117 Center St., Hamburg, N. Y., but he forgot to tell us his name or call letters. He uses a Heathkit DX-40 transmitter, a Gonset G-43 receiver, and has worked 21 states, including Alaska, plus Puerto Rico, with a 12′ high antenna. WV2??? expects to have knocked the "V" out of his call by the time he writes again—let's hope he tells us who he is at the same time.

Bill Clements, K4GMR, 1712 Temple Ave., Nashville 12, Tenn., was a Novice for just about a month and has been a General for a bit over a year. Bill uses a DX-40 driven by a VF-1 VFO. It feeds 40-, 20-, 10-meter dipoles through a single coaxial feedline, permitting him to work 40 through 10 meters. On 80 meters, he loads the antenna as a random-length wire with an antenna coupler. Bill's favorite activity is plain old-fashioned rag-chewing, mostly on c.w., and he spends half his time in the Novice bands. Nevertheless, his station record is 47 states worked, all QSL'ed, and 51 countries worked, 37 confirmed. A Hammarlund HQ-145 separates the wanted signals from the interference.

Ray Mote, Jr., 1110 E. Caeser, Kingsville, Texas, who expects to get his Novice license soon, says you can tune in sideband signals on the Knight-Kit "Ocean Hopper" and similar regenerative receivers by advancing the regeneration control to beyond the oscillation point—the same setting used for code reception—and very carefully tuning in the signal. At one critical setting, the received voice will quit sounding like "Donald Duck" and become perfectly readable. . . . . **Darrel Booth, K5THS,** Route 3, Box 151, Emerson, Ark., really has an antenna farm—it consists of an 800′ long-wire; an 80-meter doublet; a home-built 10- and 15-meter beam; a 10-, 15-, and 20-meter vertical; and a 75′ long-wire. Darrel modulates a Globe Chief 90A with an EICO 730 modulator and drives it with a Meissner VFO; he receives on a Hallicrafters S-38E. He works all the phone and c.w. bands from 3.5 to 29.7 mc., but 75-meter phone is his favorite.

How about sending us *your* ham shack pictures, news, and construction projects? 73,

Herb, W9EGQ

Amateur Radio

(*Continued from page* 45)

other phase of the hobby—*mobile operation.* If he is, he probably has a miniature duplicate of his home station built into the family car. As Sam threads his way to the office, he can once again participate in the "round-table" by transmitting the words "break-break" over his rolling radio station. Or, should Sam elect to, he can switch the frequency of his equipment and join in the conversation with a similar group of hams clear across the country.

Before you get the idea that radio amateurs are a bunch of chattering magpies, remember that the original intent was public service and the *handling of messages.* The majority of amateurs today carry on in the same tradition.

A device to assist amateurs in handling messages is known as a "phone patch." It connects the receiving and transmitting equipment to the phone lines so that telephone conversations can be transmitted over the air. As a result of this device, American servicemen stationed overseas can talk directly to their loved ones via ham radio.

"Ham of the Year." Each year one amateur is selected, from all the others, to receive an award for meritorious service to the community or country. The award is granted by the Edison Radio Amateur Award Committee of General Electric Company; the group screens hundreds of nominations and selects the amateur with the most outstanding service accomplishment.

The 1957 award was presented to James E. Harrington, K5BQT, of Lake Charles, La. In June of that year, Harrington provided emergency communications from hurricane-stricken Cameron, La. With the help of two other amateurs, he gathered emergency equipment and supplies and traveled 40 miles by boat through the swollen Calcasien River. At Cameron, Harrington and his helpers waded through waist-deep water to reach the court house. Once there, he operated continuously for three days and handled some 1500 messages.

The 1958 Edison Award was presented to an 18-year-old high school student, Julius Madey, K2KGJ, of Clark, N. J. Julius was chosen from a large field of worthy candidates because of his outstanding public service in handling more than 12,000 messages and phone patches for isolated South Pole personnel.

And Walter Ermer, Sr., W8AEU, won the 1959 award for his outstanding organizational and administrative ability in providing Cleveland, Ohio, with a 300-man voluntary amateur radio emergency corps. During the year this corps handled vital communications on 23 occasions, including storm and tornado emergencies, and floods.

Thrills of DX'ing. The DX-minded ham is an unusual variation of the typical amateur. Like Sam Ham, our inveterate DX'er rises before dawn. He turns on the station and starts the coffee brewing almost at the same time. However, DX Dan does not head pell-mell into a round-table. Instead, he squashes a pair of headphones on his ears and intently tunes the receiver dial to and fro. Several days may come and go without so much as a peep out of Dan's powerful transmitter.

Then one morning Dan flushes his quarry and a look of grim determination settles across his face. He is listening to the faint rolling dots and dashes of HS1A in Thailand! Suddenly, as HS1A stands by, Dan's powerful "rig" springs to life and his measuring instruments swing to and fro. Less than one minute later, Dan pushes the telegraph key away and writes down this new contact in his log book.

Most amazing, perhaps, is that DX Dan probably heard many other rare and exotic stations while searching the band for HS1A. On a typical morning he may have heard 15 out of the 19 districts of the Soviet Union, Sarawak, Brunei, Mauritius, Orkney Island, Qatar, Trucial Oman, and of course the more common countries such as Burma, Malaya, Australia, or New Zealand. But Dan ignored their CQ calls in favor of the more elusive Thai amateur, for he had talked to these other stations long ago. As our DX'er prepared to dash off to work, he checked off number 261 on his list of the almost 300 countries in the world.

In addition to the thrill of having "hooked" a new one, Dan will get a material reward also. Hams exchange postcard-sized QSL cards which confirm their contacts; each card carries details such as date and time heard, mode of transmission (voice or code), and a signal strength report. Thus, a few months after his contact, Dan will receive a card that he can proudly display.

An interesting variation of the DX-minded ham is Ambassador Al. Al "gets his kicks" by conversing with overseas amateurs, but only to gain friends and exchange ideas. Although he may never meet one of these hams, he is truly a man of the world. He can tell you what the temperature was yesterday in Kuala Lumpur, Malaya, or who is winning the tennis matches in Melbourne, Australia. Al has two or three favorites overseas and maintains weekly schedules with them. Often they exchange inexpensive gifts, and once in a while they have the opportunity of meeting each other. Needless to say, our "ambassadors of the air waves" have created more good will for this country than John Q. Public realizes.

The YL's. Although we have used the *male* gender in describing the various types of amateurs, men are far from having a monopoly on the hobby. There is no accurate tabulation, but approximately one out of every thirty hams is a woman!

Probably the first woman ham was Miss Cecil Powell, secretary to the ARRL co-founder, Hiram Percy Maxim. In 1915, she constructed her own station, learned the code, and became an active amateur.

What do they talk about? Well, what *do* women talk about when they get together? There are DX'ers, public-service spark plugs, and ambassadresses among the skirt and sweater brigade also. A YL can even do her ironing, or other household chores, while exchanging recipes with an XYL (married young lady) 2000 miles away.

How About You? Think you'd like to be a ham? Amateur licenses are issued by the Federal Communications Commission to any citizen of the United States who can pass the radiotelegraph code and written examination.

If you already hold a license and toss your call letters across the ether, you're probably as sold on the hobby as any of your 200,000 fellow hams. But if you have yet to experience the thrill of world-wide communication or the satisfaction of an around-the-state round-table, your fun has not yet begun. Why not join the crowd of enthusiastic hams—come on in, the ether's fine! —30—

Living with Loudspeakers

(*Continued from page* 52)

means that if 40 cps is the lowest note your system can deliver, any response much over 10,000 or 15,000 cps will result in an unbalanced overall sound (40 x 10,000 equals 400,000; 40 x 15,000 equals 600,000). Keep in mind, too, that the real extremes in bass and treble response cost plenty of money, and that smooth and balanced response in a moderately priced unit will beat wide-range distortion every time.

Watch out for speakers which seem to project one part of an orchestra—trumpets, for instance—into your lap. No matter how sensational they sound in a showroom, speakers with this kind of coloration will set your nerves on edge in your living room, and leave you with an advanced case of listening fatigue. Any system which draws your attention to one part of the frequency range is suspect.

Perhaps the most important thing you can listen for in a speaker's performance is good transient response—the ability of a speaker to follow the amplifier's directions without sluggishness. Good transient performance will show up in the sharp impact of musical instruments, in the crisp definition of a drum roll, or the slow dying out of a piano chord. It will also give you a good idea of the kind of hall in which a recording was made—from a small, acoustically dead studio to a large, reverberant concert hall. A speaker with good transient response provides a more genuine kind of "presence" than a speaker which puts one section of an orchestra in your lap.

Don't be too quick to condemn a speaker that seems to have poor transient response, however. The speaker is only part of the reproducing chain and can't be expected to do any better with transients than the other elements that make up the chain do.

Pick up all the advance information you can, from specification sheets to magazine test reports, before you settle down for your own listening tests. But keep an open mind when the writer of a test report sounds off with his opinion of a speaker's coloration. And remember that a speaker with a modest-looking response curve may turn out to be more than realistic enough for your ears. If a friend tells you that the speaker you've chosen sounds "tinny," give him a smile and take him down for an audiometer test. —30—

Short-Wave Report

(*Continued from page* 106)

The following is a résume of the current station reports. All times shown are Eastern Standard, and the 24-hour system is used. At time of compilation all reports are as accurate as possible, but stations may change frequency and/or schedule with little advance notice.

Albania—*R. Tirana* currently has its Eng. program at 1730-1800 on 7157 kc. (*WPE8MS*)

Argentina—LRA, Buenos Aires, has moved to 11,725 kc. and was noted around 1800 opening the Eng. feature. The 15,345-kc. outlet has not been heard and presumably 11,725 kc. has replaced it. (*WPE9KM*)

Begium—"Belgian Magazine" in Eng. is scheduled from Brussels on Sundays, Tuesdays, and Thursdays at 1730-1800 on ORU3, 11,850 kc., and ORU4, 15.335 kc. (to N.A. and S.A.) and on ORU5, 6000 kc. (to Southern Europe); on Sundays, Mondays, Tuesdays, Thursdays, and Fridays at 1930-2000 on ORU3, 11,855 kc. (to N.A.) and on OTC (Leopoldville) on 9655 kc. (to N.A. and S.A.); on Saturdays at 1815-2000 on ORU3 (to N.A.) and OTC (to N.A. and S.A.). All reports go to P. O. Box 26, Brussels-1, Belgium. (*WPE3ALZ, WPE3AYB*)

Brazil—Listed as inactive, PRG9, *R. Nacional de Sao Paulo,* has been noted on 6125 kc. at 1928-1930 with news and a talk. PRN9, Rio de Janeiro, 9295 kc., was heard with a special Eng. xmsn at 1920, cut up by QRM. (*WPE3DS*)

ZYÇ7, *R. Tupi*, Rio de Janeiro, 6015 kc., can be heard at 2000 with a regular show in Portuguese. *R. Difusora do Maranhao*. Maranhao, 2370 kc., is noted at times around 1930-2000 with ads, talks, and music, all-Portuguese. (*WPE1HC*)

On 2420 kc., try for Anapolis around 2145 with Latin-American vocals and instrumentals. You'll have to dig deep for this one. If you tune in prior to 2145 you may pick up Martinique. (*WPE3NF*)

Ceylon—*R. Ceylon,* in a letter, asks that reports be sent to them at either G.P.O. 1510, Colombo (preferably) or Torrington Square, Colombo. Do not combine the addresses. Clifford Dodd is the man to whom your reports should be sent. (*WPE2YS*)

Congo—Former *R. Congo Belge* outlets are now identifying as *Ici Leopoldville, Radiodiffusion de la Republique du Congo.* (*WPE1BM*)

Cuba—The largest Cuban network, *Radio Progreso*, has been taken over by the government. This network has an s.w. outlet on 9362 kc. (*WPE1AGM*)

Curacao—*R. Curom* has moved to 9750 kc.; a good signal was noted from 2215 to 2232 s/off, with programs of varied music and all-Dutch anmts. (*WPE9KM*)

Dahomey—With careful tuning, *Radiodiffusion du Dahomey*, Cotonou, can be heard on

4870 kc. at 0045; native chants are followed by talks in a native language. News in French is given at 0100. (*WPEØVB*)

Dominican Republic—HIX, Ciudad Trujillo, 9505 kc., has been noted at 0635, 0930, and at 2300/closing. Programs consist of music and frequent talks in Spanish; ID's are prefaced by "Dios, Patria, and Libertad." The ID is given as *HIX, Radio Nacional Dominican.* (*WPE4BC*)

El Salvador—According to word received from the station, they have a new outlet on 4800 kc. with a slogan of *R. Tropical.* Reports should be sent to Apartado Postal 1006, San Salvador, E. S. (*WPE6CJ*)

Fiji Islands—A colorful veri from *R. Suva* lists these outlets: VRH4, 3980 kc., VRH5, 5980 kc., and VRH6, 6005 kc., each 250 watts, plus three medium-wave outlets. The 6005-kc. outlet is believed to be inoperative at present. VRH5 is noted at 0150-0300, all Eng., with news at 0200. (*WPE1ANK, WPEØAE*)

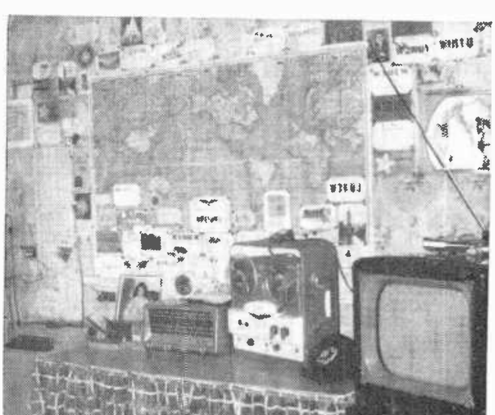
Gilbert Islands—VSZ10, Tarawa, 6050 kc., is noted at 0300-0320 with native language talks and native music but with an Eng. ID at 0305. (*WPEØAE*)

Honduras—A new station is *La Voz de Suyapa,* 9705 kc., Tegucigalpa, noted with religious program at 0647-0705, news in Spanish to 0718, religious program to 0731, concert music to 0800; again from 2025 to 2200 s/off with pop records. The call letters are not certain; various reports claim them to be HRBA (or HRVA) or HRCF (or HRCS). Do not confuse with *R. Suyapa* on 4940 or 6125 kc. (*WPE3DS, WPE9KM*)

Hungary—*R. Budapest* operates twice daily in Eng. to N.A. at 1900-2000 and 2230-2330 on 11,910, 9833, and 7220 kc. Reports go to: North American Service, *R. Budapest,* Budapest, Hungary. (*WPE1ARV*)

India—*All India Radio,* Delhi, is heard at 1445-1515 in Eng. beamed to the United Kingdom and Western Europe on 11,710 kc. News is given at 1445-1455. Delhi also has Eng. news at 1930-1950 on 17,820 kc., and at 2130-2145 on 17,765 and 17,825 kc. (*WPE8HF, WPEØAE*)

Iran—*R. Teheran* operates its External



Listening post of John Rushton, WPE1ARV, Providence, R. I. His equipment includes a Hallicrafters S-38E receiver, a Webcor "Regent" tape recorder, a Firestone 17" TV set, and a 101' long-wire antenna.

Service as follows: at 1230 in Kurdish and at 1330 in Arabic on EPB7, 7288 kc.; at 0700 in Urdu on 9680 and 3750 kc. (EQO); at 1500 in Russian, at 1515 in Turkish, at 1530 in French, and at 1545 in Eng. on EQC, 9680 kc. All broadcasts are non-directional and xmtr power is 100 kw. (*WPE8MS*)

Italy—Rome is noted on 3995 kc. from 1730 to 1800 closing. A veri letter states that it belongs to the Home Service. There is also the "Programma Nazionale" daily on 6060 kc. (dual to 9515 kc.) and the "Second Programma" on 7175 kc. The "Notturno d'Italia" is broadcast daily at 1705-0030 on 9515 kc. (*GP*)

Japan—The Japan B/C Corp., NHK, to mark its 25th year of international broadcasting service, is sending letters of appreciation and small souvenirs to listeners who have regularly submitted reception reports covering the various transmissions. The letter, 8½"x11" in size and suitable for framing, is nicely printed on fine Japanese paper (certificate style) and signed by Ichiro Matsui, Director of the Int'l. Broadcasting Dept. (*WPE6EZ*)

Liberia—ELWA, Monrovia, was noted on 15,082 kc. at 1125 with native language; French later. The programs had the usual religious content. S/off is at 1301 with the Liberian National Anthem. (*WPE3NF*)

SHORT-WAVE ABBREVIATIONS

anmt—announcement	kc.—Kilocycles
BBC—British Broadcasting Corp.	kw.—Kilowatts
Eng.—English	N.A.—North America
FM—Frequency modulation	QRM—Interference
ID—Identification	R.—Radio
IRC—International Reply Coupon	S.A.—South America
IS—Interval signal	s/off—Sign-off
	s/on—Sign-on
	xmsn—Transmission
	xmtr—Transmitter

Mali Federation—Brazzaville's current Eng. schedule reads: 0015-0100 on 15,445, 11,970, 9730, 7105, 5970, and 21,500 kc.; 0330-0400 on 21,500 and 15,445 kc.; 0600-0630 on 21,500, 15,445, and 11,970 kc.; 0700-0745 on 15,445 and 11,970 kc.; 0930-1000 on 17,720 and 21,500 kc.; 1200-1230 on 21,500, 11,970, 9770, and 5970 kc.; 1330-1400 and 1430-???? on 15,190 kc.; and 2015-2100 and 2115-2130 on 11,970 and 9625 kc. (*WPE6AA*)

Mauretanie—*Radiodiffusion de la Republique Islanique de Mauretanie,* Saint Louis, operates at 0200-0300 and 1455-1845 on 4855 kc. and at 0715-0830 on 9610 kc. Power is 4 kw. They appreciate reports and will verify all correct ones; an IRC must be included (*WPE8MS*)

Mexico—XERR, *Radiodifusoras Comerciales,* is a new outlet for XERH and XEHH (1500 and 11,880 kc.) according to their verification. (*WPE2AXS*)

XEDF, Mexico City, 9535 kc., is heard from 0650 to 0700 fade-out with music, commercials and anmts. (*WPE3DS*)

Morocco—The previously thought-to-be Amman, Jordan, station is definitely located at Sebaa-Aioun (announcing as Rabat) on 11,735 kc. News in Eng. is given at 1315-1330, Arabic to past 1645. (*WPE3DS, WPE3NF, WPE9KM*)

Sebaa-Aioun is down to 9502 kc. around 1313 in Arabic. Another new outlet is on 5985 kc. at 2335 with Arabic chanting. (*WPE1BM, WPE3NF*)

Mozambique—*R. Clube de Mozambique,* Lourenco Marques, gives the following schedule. Portuguese—3250 kc. at 1200-1530; 4924 kc. at 1030-1530; 9656 kc. at 2345-0100 and 0430-0700 (0045-0700, 0800-1030 Sundays); 15,152 kc. at 1030-1300, 2345-0100, and 0430-0700 (0045-0700 Sundays). English and Afrikaans—3221 kc. at 2230-2300 and 1230-1600 (to 1700 Saturdays); 4840 kc. at 2230-0100 and 1000-1600; 7254 kc. at 2230-1200; 9620 kc. at 0000-1000; 11,760 kc. at 2230-1400 (2355 Saturday to 1400 Sunday); and 15,097 kc. at 0400-0800. Try for them in the East African xmsn on 4840 kc. around 2330-0000 with Eng. and pop records. (*WPE8FV, WPEØVB*)

Nicaragua—A letter from Miguel Angel Solis, Jr., manager of *R. Philips,* YNRS, 7660 kc., 150 watts, stated that they do not have printed schedules or veri cards, and indicated that a formal log of the station showing minute details of the xmsns is not kept. He gave the schedule as 0700-2300. (*WPEØAKR*)

Niger—*R. Niger,* Niamey, has moved to 4785 kc.; s/on 0028 with a flute IS, ID in French, then native chanting. A good signal and dual to 5050 kc. (*WPE3NF*)

North Borneo—*R. Sabah,* Jesselton, operates on 5980 kc. in Eng. at 2330-0000 (Saturdays at 2200-2300), at 0600-0615 with BBC and local news, and at 0730-0900. "Radio Sabah Calling" is issued every two weeks in Eng., Chinese, Malay, and Kadazan; the price is 30 cents per issue, $8.00 yearly. (*WPE8MS*)

Pakistan—Karachi is noted weakly at 1030-1045 with dictation news on 15,275 kc. (*WPE4AIX*)

Peru—Definite channel changes include: OAX8C, *R. Nacional del Peru,* Iquitos, on 9335 kc. (from 9610 kc.) at 1830-2045; OAX6L, *R. Nacional del Peru,* Tacna, on 9350 kc. (from 9374 kc.) at 1830-2045; and OAX4W, *R. America,* Lima, on 9455 kc. (from 9510 kc.) also at 1830-2045; all with Spanish music, talks, commercials, and variety shows. The "International Service" from Lima on 15,150 kc. is carried on Monday, Wednesday, and Friday, with Eng. at 1600-1700. (*WPE8NE, WPE9KM, WPEØAE*)

Philippines—The Far East B/C Co., Manila, carries Eng. at 1600-1830 on 17,805 and 21,515 kc., at 1830-1930 on 15,385 and 21,515 kc., at 0230-0400 on 9730, 11,920, 15,300, 17,805, and 21,515 kc., at 0400-0500 on 6030, 11,855, and 21,515 kc., and at 0500-0730 on 11,920 and 21,515 kc. News is given at 1645, 1830, 0430, and 0700. (*WPE6OU, WPE8MS*)

Puerto Rico—WKYN, Rio Piedras, can often be noted on 26,310 kc. This is an FM link between studios and xmtrs; the basic station being on 630 kc. Reports may be sent to P. O. Box 816, San Juan, care of Quality B/C Co. (*WPE9MV*)

Saudi Arabia—Djeddah was logged at new s/on time of 2313 with IS and march on 11,950 kc., and then into Arabic at a weak level. (*WPE9KM*)

Sudan—Omdurman gives this schedule: Arabic at 2315-0030 (Fridays to 0600) and 0930-1600; Southern Sudan program at 0900-0930; English at 0730-0800. Channels listed: 5039 kc. (20 kw.); 9600 kc. (7.5 kw.); and 11,750 and/or 7200 kc. Reports go to Box 572, Omdurman, Sudan. (*WPE1BM*)

Swan Island—While *R. Swan* is not a short-wave station, DX'ers will now have a chance to log this rarely-heard island in the Caribbean. The Gibralter Steamship Co. of New York is operating the station on 1160 kc., 50-kw. power, beamed to Cuba. Look for *R. Swan* evenings but beware of QRM from WJJD, Chicago, on the same frequency. (*Ed.*)

Sweden—Stockholm has an Eng. mailbag every other Wednesday at 0900-0930 on 17,840 kc. (*WPE1ZR, WPE8HF, WPE9BGC, WPE9IP*)

Thailand—*R. Thailand* s/on at 0525 on 11,910 kc., Eng. news at 0530. English to N.A. is heard at 2215-2315, with news at 2225. The Home Service (Arabic) is heard on 6240 and 7140 kc. at 0700-1020. Return postage is *not* required with your report. (*WPE1BM, WPE1BY, WPE3-AGZ, WPE9KL, VE1PE2C*)

USSR—*R. Ulan Bator*, Outer Mongolia, has been noted on 10,380 kc. at 1830-1930 with many talks and chanting with instrumental music; no English. (*WPEØAE*)

R. Baku, Azerbaijan, has verified for 9840 kc. Their schedule runs: 2300-2315 in Azerbaijani; 2330-2345 in Persian. (*WPEØEH*)

Venezuela—*R. Rumbos*, Caracas, has apparently moved into the 25-meter band. A definite ID was noted at 2200 on 11,970 kc. Much checking indicates that this is a fundamental frequency rather than a harmonic. (*WPE9KM*) —30—

SHORT-WAVE CONTRIBUTORS

Jim Silk (*WPE1AGM*), Madison, Conn.
Dave Swedock (*WPE1ANK*), Meriden, Conn.
John Rushton (*WPE1ARV*), Providence, R. I.
Jerry Berg (*WPE1BM*), W. Hartford, Conn.
Alan Roth (*WPE1BY*), Bridgeport, Conn.
Bud Barto (*WPE1HC*), Naugatuck, Conn.
Dave Quintin (*WPE1ZR*), New Britain, Conn.
Robert Newhart (*WPE2AXS*), Merchantville, N. J.
Michael Mattes (*WPE2YS*), E. Williston, N. Y.
C. Vernon Hyson (*WPE3AGZ*), Kensington, Md.
Bill Plack (*WPE3ALZ*), Pittsburgh, Pa.
Walter J. Schulz (*WPE3AYB*), Philadelphia, Pa.
Dan Metro (*WPE3DS*), McKeesport, Pa.
George Cox (*WPE3NF*), New Castle, Del.
Gene Pearson (*WPE4AIX*), Birmingham, Ala.
Grady Ferguson (*WPE4BC*), Charlotte, N. C.
Stewart Mac Kenzie, Jr. (*WPE6AA*), Long Beach, Calif.
Bill Lund (*WPE6CJ*), Santa Monica, Calif.
J. Art Russell (*WPE6EZ*), San Diego, Calif.
Laurence Hansford (*WPE6OU*), Modesto, Calif.
Richard England (*WPE8FV*), Columbus, Ohio
Dan Wilt (*WPE8HF*), Akron, Ohio
Mike Kander (*WPE8MS*), Dayton, Ohio
Ronald Beitman (*WPE8NE*), Amelia, Ohio
Dan Brintlinger (*WPE9BGC*), Decatur, Ill.
Robert Frey (*WPE9IP*), Niles, Ill.
Ron Rende (*WPE9KL*), Stickney, Ill.
A. R. Niblack (*WPE9KM*), Vincennes, Ind.
Ron Kozor (*WPE9MV*), Fort Wayne, Ind.
John Beaver, Sr. (*WPEØAE*), Pueblo, Colo.
Richard E. Davis (*WPEØAKR*), Englewood, Colo.
Dick Schreiber (*WPEØEH*), Wheat Ridge, Colo.
George Buchanan (*WPEØVB*), Webster Groves, Mo.
Fred Baines (*VE1PE2C*), New Glasgow, N. S.
Giacomo Perolo (*GP*), Bauru, Brazil

POPULAR ELECTRONICS

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rms/piv 560/800 $1.05	rms/piv 630/900 $1.25	rms/piv 700/1000 $1.70	rms/piv 770/1100 $2.00

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POPULAR ELECTRONICS

Advertiser's Index

OCTOBER 1960

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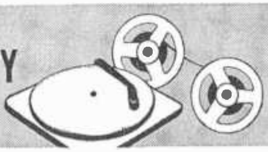

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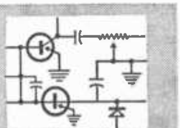

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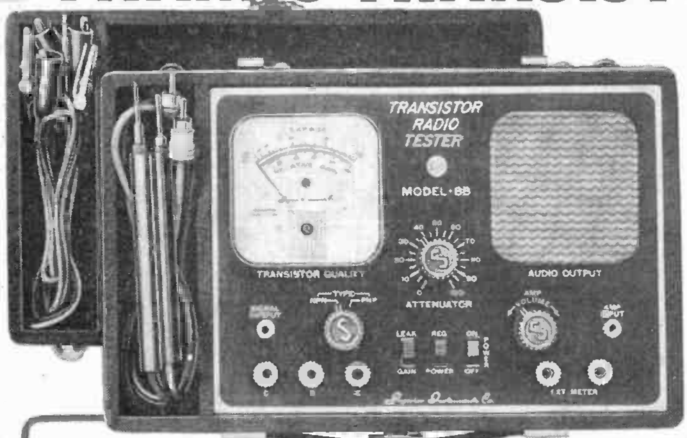
The Model 88.... A New Combination

TRANSISTOR RADIO TESTER and DYNAMIC TRANSISTOR TESTER



The Model 88 is perhaps as important a development as was the invention of the transistor itself, for during the past 5 years, millions of transistor radios and other transistor operated devices have been imported and produced in this country with no *adequate* provision for servicing this ever increasing output.

The Model 88 was designed specifically to test all transistors, transistor radios, transistor recorders, and other transistor devices *under dynamic conditions.*

Model 88 TRANSISTOR RADIO TESTER & TRANSISTOR TESTER . . . Total Price . . . $38.50
Terms: $8.50 after 10 day trial, then $6.00 monthly for 5 months if satisfactory. Otherwise return, no explanation necessary.

AS A TRANSISTOR TESTER

The Model 88 will test all transistors including NPN and PNP, silicon, germanium and the new gallium arsinide types, *without referring to characteristic data sheets.* The time-saving advantage of this technique is self evident. A further benefit of this service is that it will enable you to test new transistors as they are released!

The Model 88 will measure the two most important transistor characteristics needed for transistor servicing; leakage and gain (beta).

The leakage test measures the collector-emitter current with the base connection open circuited. A range from 50 ohms to 100,000 ohms covers all the leakage values usually found in both high and low power transistor types.

The gain test (beta) translates the change in collector current divided by the base current. Inasmuch as the base current is held to a fixed value of 50 microamperes, the collector current calibrated in relative gain (beta), is read directly on the meter scale.

AS A TRANSISTOR RADIO TESTER

We feel sure all servicemen will agree that the instruments and methods previously employed for servicing conventional tube radios and TV have proven to be impractical and time consuming when used for transistor radio servicing. The Model 88 provides a new simplified rapid procedure — a technique developed specifically for radios and other transistor devices.

An R.F. Signal source, modulated by an audio tone is injected into the transistor receiver from the antenna through the R.F. stage, past the mixer into the I.F. Amplifier and detector stages and on to the audio amplifier. This injected signal is then followed and traced through the receiver by means of a built-in High Gain Transistorized Signal Tracer until the cause of trouble whether it be a transistor, some other component or even a break in the printed circuit is located and pin-pointed. The injected signal is heard on the front panel speaker as it is followed through the various stages. Provision has also been made on the front panel for plugging in a V.O.M. for quantitative measurement of signal strength.

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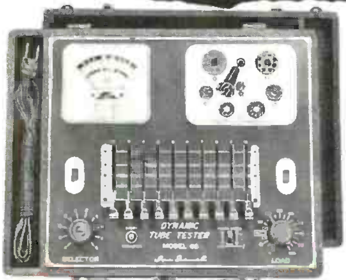

Model 85—Trans-Conductance Tube Tester. Total Price—$52.50.
Terms: $12.50 after 10 day trial, then $8.00 monthly for 5 months if satisfactory. Otherwise return, no explanation necessary.

Superior's New Model 85—a DYNAMIC type TRANS-CONDUCTANCE

TUBE TESTER

● Employs latest improved TRANS-CONDUCTANCE circuit. Tests tubes under "dynamic" (simulated) operating conditions. An in-phase signal is impressed on the input section of a tube and the resultant plate current change is measured as a function of tube quality. This provides the most suitable method of simulating the manner in which tubes actually operate in radio, TV receivers, amplifiers and other circuits. Amplification factor, plate resistance and cathode emission are all correlated in one meter reading.

● **SYMBOL REFERENCES:** For the first time ever in a trans-conductance tube tester, Model 85 employs time-saving symbols (★, +, ●, ▲, ■) in place of difficult-to-remember letters previously used. Repeated time studies proved to us that use of these scientifically selected symbols speeded up the element switching step. As the tube manufacturers increase the release of new tube types, this time-saving feature becomes more necessary and advantageous.

● **THE "FREE-POINT" LEVER TYPE ELEMENT SWITCH ASSEMBLY** marked according to RETMA basing, permits application of test voltages to any of the elements of a tube. The addition of an extra switch position permits the application of the necessary grid voltage needed for dynamic testing and insures against possible obsolescence due to changes in basing design.

● **NEW IMPROVED TYPE METER** with *sealed air-damping chamber* provides accurate, *vibrationless* readings.

● **FREE FIVE (5) YEAR CHART DATA SERVICE.** The chart provided with Model 85 includes easy-to-read listings for *over 1,000 modern tube types*. Revised up-to-date subsequent charts will be mailed to all Model 85 purchasers *at no charge* for a period of five years after date of purchase.

● **SPRING RETURN SAFETY SWITCH** guards Model 85 against burn-out if tube under test is "shorted."

● **7 AND 9 PIN TUBE STRAIGHTENERS** have been included on the front panel to eliminate possibility of damaging tubes with bent or out-of-line pins.

● **AN ULTRA-SENSITIVE CIRCUIT** is used to test for shorts and leakages up to 5 megohms between *all* tube elements.

Model 85 comes complete, housed in a handsome portable cabinet with slip-on cover. Only........ **$52.50**

Model TW-11—Tube Tester
Total Price $47.50
Terms: $11.50 after 10 day trial, then $6.00 monthly for 6 months if satisfactory. Otherwise return, no explanation necessary.

Superior's New Model TW-11 STANDARD PROFESSIONAL

TUBE TESTER

• Tests all tubes, including 4, 5, 6, 7, Octal, Lockin, Hearing Aid, Thyratron, Miniatures, Sub-miniatures, Novals, Subminars, Proximity Fuse Types, etc.

• Uses the new self-cleaning Lever Action Switches for individual element testing. All elements are numbered according to pin-number in the RMA base numbering system. Model TW-11 does not use combination type sockets. Instead individual sockets are used for each type of tube. Thus it is impossible to damage a tube by inserting it in the wrong socket.

• Free-moving built-in roll chart provides complete data for all tubes. Printed in large easy-to-read type.

NOISE TEST: Phono-jack on front panel for plugging in either phones or external amplifier detects microphonic tubes or noise due to faulty elements and loose internal connections.

EXTRAORDINARY FEATURE

SEPARATE SCALE FOR LOW-CURRENT TUBES Previously, on emission-type tube testers, it has been standard practice to use one scale for all tubes. As a result, the calibration for low-current types has been restricted to a small portion of the scale. The extra scale used here greatly simplifies testing of low-current types.

Housed in handsome, portable Saddle-Stitched Texon case. Only .... **$47.50 Net**

We invite you to try before you buy any of the models described on this page, the preceding page and the following pages. If after a 10 day trial you are completely satisfied and decide to keep the Tester, you need send us only the down payment and agree to pay the balance due at the monthly indicated rate.

NO INTEREST OR FINANCE CHARGES ADDED!

If not completely satisfied, you are privileged to return the Tester to us, cancelling any further obligation.

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MOSS ELECTRONIC, INC.
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Please send me the units checked on approval. If completely satisfied I will pay on the terms specified with no interest or finance charges added. Otherwise, I will return after a 10 day trial positively cancelling all further obligation.

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☐ Model TV-50A ... Total Price $47.50
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Model TV50-A—Genometer
Total Price $47.50
Terms: $11.50 after 10 day trial, then $6.00 monthly for 6 months if satisfactory. Otherwise return, no explanation necessary.

Superior's New Model TV-50A **GENOMETER**

7 Signal Generators in One!

- R.F. Signal Generator for A.M.
- R.F. Signal Generator for F.M.
- Audio Frequency Generator
- Marker Generator
- Bar Generator
- Color Dot Pattern Generator
- Cross Hatch Generator

This Versatile All-Inclusive GENERATOR Provides ALL the Outputs for Servicing:

• A.M. RADIO • F.M. RADIO • AMPLIFIERS • BLACK AND WHITE TV • COLOR TV

R. F. SIGNAL GENERATOR: 100 Kilocycles to 60 Megacycles on fundamentals and from 60 Megacycles to 180 Megacycles on powerful harmonics.

VARIABLE AUDIO FREQUENCY GENERATOR: Provides a variable 300 cycle to 20,000 cycle peaked wave audio signal.

MARKER GENERATOR: The following markers are provided: 189 Kc., 262.5 Kc., 456 Kc., 600 Kc., 1000 Kc., 1400 Kc., 1600 Kc., 2000 Kc., 2500 Kc., 3579 Kc., 4.5 Mc., 5 Mc., 10.7 Mc., (3579 Kc. is the color burst frequency)

BAR GENERATOR: Pattern consists of 4 to 16 horizontal bars or 7 to 20 vertical bars.

DOT PATTERN GENERATOR (FOR COLOR TV): The Dot Pattern projected on any color TV Receiver tube by the Model TV-50A will enable you to adjust for proper color convergence.

CROSS HATCH GENERATOR: The pattern consists of non-shifting horizontal and vertical lines interlaced to provide a stable cross-hatch effect.

Complete with shielded leads

$47.50 Net

Model 77—VACUUM TUBE VOLTMETER. . Total Price $42.50
Terms: $12.50 after 10 day trial, then $6.00 monthly for 5 months if satisfactory. Otherwise return, no explanation necessary.

Superior's New Model 77

VACUUM TUBE VOLTMETER

WITH NEW 6" FULL-VIEW METER

Compare it to any peak-to-peak V. T. V. M. made by any other manufacturer at any price!

• Extra large meter scale enables us to print all calibrations in large easy-to-read type.

• Employs a 12AU7 as D. C. amplifier and two 9006's as peak-to-peak voltage rectifiers to assure maximum stability. • Meter is virtually burn-out proof. The sensitive 400 micro-ampere meter is isolated from the measuring circuit by a balanced push-pull amplifier. • Uses selected 1% zero temperature coefficient resistors as multipliers. This assures unchanging accurate readings on all ranges.

AS A DC VOLTMETER: The Model 77 is indispensable in Hi-Fi Amplifier servicing and a must for Black and White and color TV Receiver servicing where circuit loading cannot be tolerated.

AS AN ELECTRONIC OHMMETER: Because of its wide range of measurement leaky capacitors show up glaringly. Because of its sensitivity and low loading, Intermittents are easily found, isolated and repaired.

AS AN AC VOLTMETER: Measures RMS values if sine wave, and peak-to-peak value if complex wave. Pedestal voltages that determine the "black" level in TV receivers are easily read.

SPECIFICATIONS

• DC VOLTS—0 to 3/15/75/150/300/750/1,500 volts at 11 megohms input resistance. • AC VOLTS (RMS)—0 to 3/15/75/150/300/750/1,500 volts. • AC VOLTS (Peak to Peak)—0 to 8/40/200/400/800/2,000 volts. • ELECTRONIC OHMMETER—0 to 1,000 ohms/10,000 ohms/100,000 ohms/1 megohm/10 megohms/100 megohms/1,000 megohms. • DECIBELS: −10 db to + 18 db, + 10 db to + 38 db, + 30 db to + 58 db. All based on 0 db = .006 watts (6 mw) into a 500 ohm line (1.73v). • ZERO CENTER METER—For discriminator alignment with full scale range of 0 to 1.5/7.5/37.5/75/150/375/750 volts at 11 megohms input resistance.

Comes complete with operating instructions, probe leads, and streamlined carrying case. Operates on 110-120 volt 60 cycle. Only....... $42.50

TRY FOR 10 DAYS

BEFORE you buy! THEN if satisfactory pay in easy, interest free, monthly payments. See coupon inside.

We invite you to try before you buy any of the models described on this and the preceding pages. If after a 10 day trial you are completely satisfied and decide to keep the Tester, you need send us only the down payment and agree to pay the balance due at the monthly indicated rate. (See other side for time payment schedule details.)

NO INTEREST OR FINANCE CHARGES ADDED!

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