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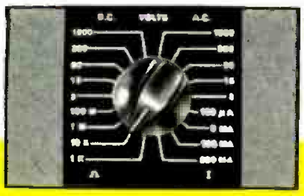

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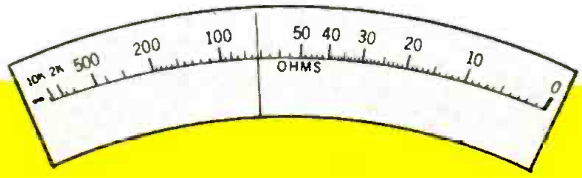

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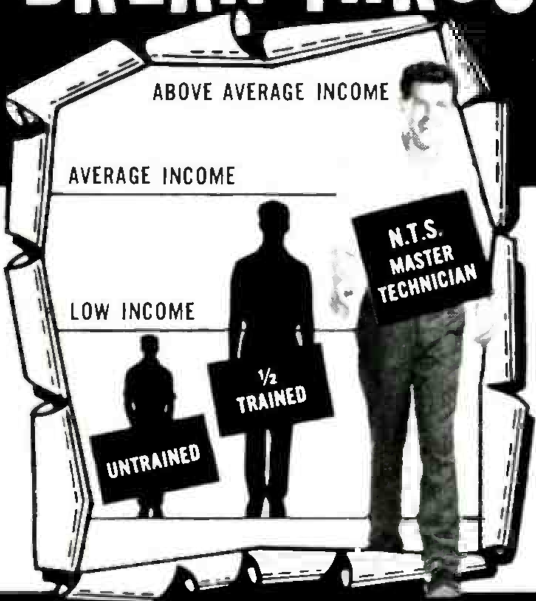

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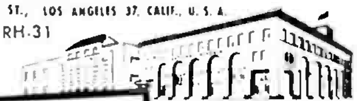

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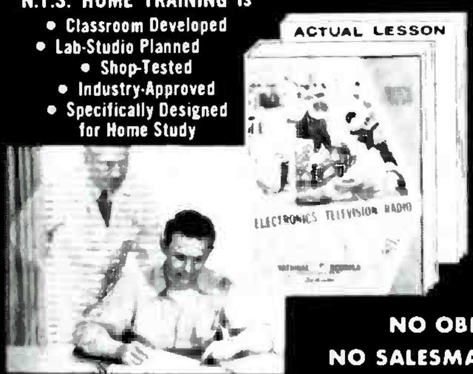

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...for the Record

By **W. A. STOCKLIN**
Editor

The Challenge of Color

THE RECENT ANNOUNCEMENT by Brig. General David Sarnoff, Chairman of *Radio Corporation of America*, that color television is now more than a $100-million a year industry, marks a milestone in the history of color TV. Looking backwards we recall the many problems and headaches that beset the industry in the early days of color TV. Most of us will recall September 1, 1950 when the FCC made its startling announcement giving the nod to the *CBS* semi-mechanical system of color transmission. This was one of the biggest surprises of our times and caught the entire industry, as well as ourselves, off guard. Our staff had spent many days preparing an editorial coverage program, and all our work and effort went by the wayside when the FCC exploded its bomb. Everyone felt that an all-electronic system was the only practical answer, but to do the FCC justice, the *RCA* system that was demonstrated at the time of the hearings did have a few drawbacks.

The years that followed were dormant ones with regard to sales efforts, but the laboratories continued their feverish work. It was not until 1954 that the FCC reversed its decision and gave the green light to an all-industry, all-electronic system. Still, color set sales continued small in comparison to black-and-white set sales, but they increased gradually year by year.

1960 was dramatically different. While the general sale of consumer goods eased and fell off, while black-and-white TV sales dropped by 7%, color TV sales increased by a whopping 30%.

There are several solid reasons for the increase in color set sales: the price of the receivers has become more realistic, color programming has increased, and the servicing and maintenance of receivers is no longer a major problem.

The industry predicts that '61 sales will better '60 by more than 50%. This would mean the selling of some 226,000 units to bring the total number of color sets in use to more than ¾ million by the year's end. Thinking along these lines, it is not too implausible to forecast that the sale of color sets will equal the sale of black-and-white sets in 5 to 8 years and that eventually color sets will be in greater demand.

Thinking along these lines also brings to mind a future problem. Who is going to service the coming flood of color sets? We seriously wonder who these people will be. Will they be the captive-service technicians or will they be the independent service groups?

In a way, we are reminded of the situation that existed at the resumption of TV set production after World War II. Many of the technicians of that period refused to face the imminent advent of television. Can you recall their plaints, "Who is going to buy those expensive television sets? Who is going to squint into a tiny seven-inch picture tube? Besides TV is too hard to service, and requires too much expensive test equipment." The men who could not or did not want to keep up with the industry have long since folded their test leads and disappeared into other fields of endeavor. The men who made it their business to know TV are still in the field and are earning more than they did before television.

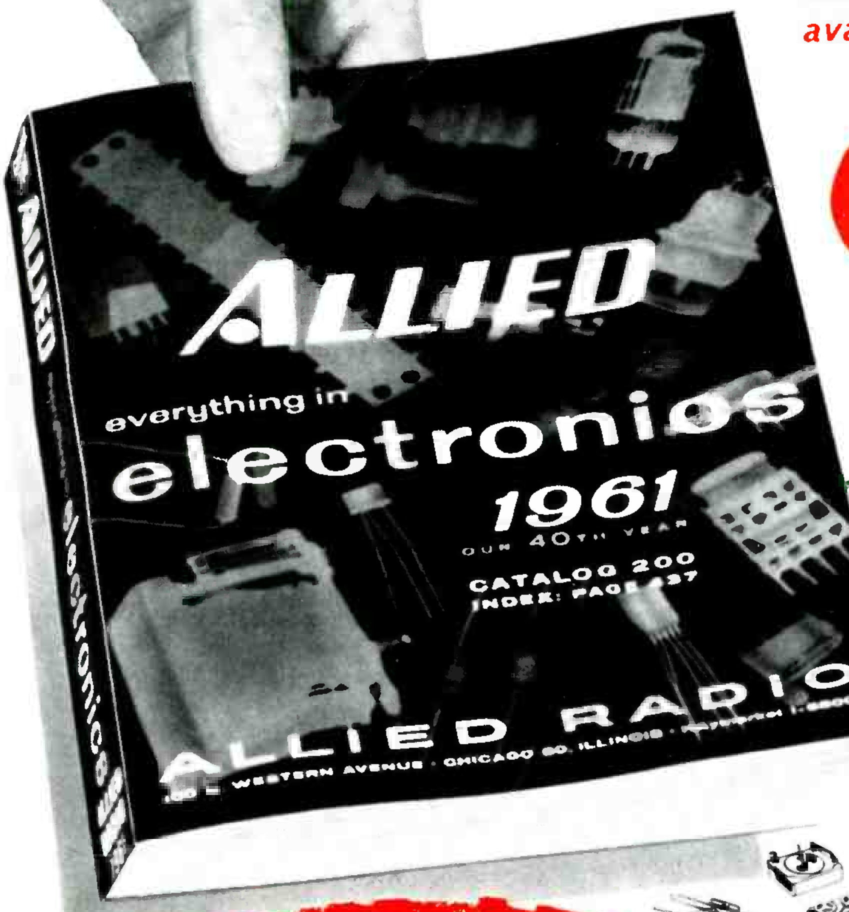
The situation today is much the same. At first inspection color TV appears to be an insurmountable obstacle. There is so much new theory to learn; so much new equipment to buy.

And yet, is there really that much additional to learn; is there that much additional equipment to purchase? Granted, color TV cannot be mastered by anyone in an afternoon, nor a month of afternoons. The fact remains that the man who has a working knowledge of black-and-white TV has the basis upon which to build his knowledge of color TV. It is also true that the practicing black-and-white TV technician has most of the equipment necessary to service color. The additional equipment needed, while running into a few hundred dollars, represents but a small fraction of his present total investment.

Many technicians have made the effort to master color TV, and many have invested in the equipment needed. But judging from the sale of color test equipment, many more, by far the largest percentage, have not. The men who do not learn to service color TV will, in a number of years, be largely forced to drop out.

If these men leave the industry in the immediate years that follow, it will be both a pity and a loss. A pity that they have come so far only to be frightened off by a minor obstacle; only to drop out before the service industry receives a generous pay boost equal, if not greater, than the pay boost that followed the introduction of black-and-white TV. The loss, of course, will be to the general public which needs the independent service technician.

In keeping with the times ELECTRONICS WORLD will put greater emphasis on color in the years ahead and, to be specific, next month we will publish a special article on servicing and maintenance of color TV sets. Along with this, our cover will highlight the coming of age of this, not new, but fast-growing field. —30—



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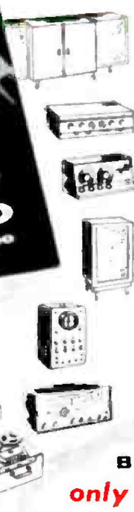

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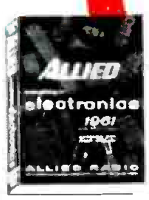

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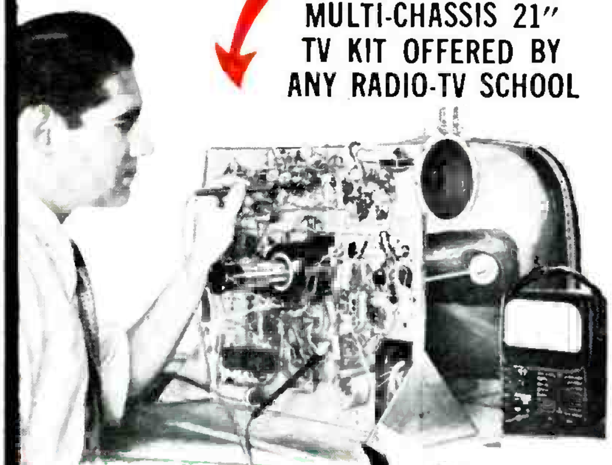

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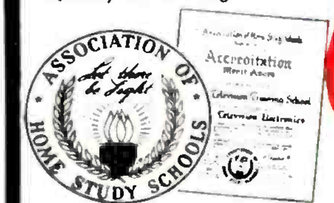

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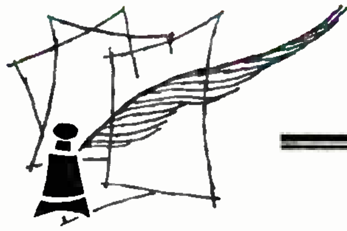


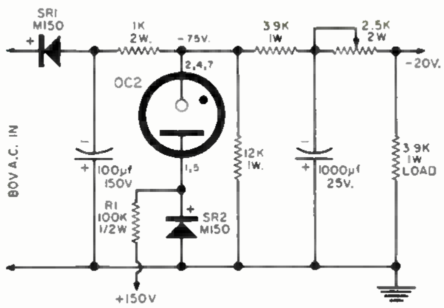
from our Readers

SERIES VR TUBES

To the Editors:

A very interesting article by Mr. Dave Stone appeared in the September 1960 issue of ELECTRONICS WORLD. The accompanying circuit illustrated that two series VR tubes may be ignited with a minimum supply voltage only slightly greater than the combined operating voltage of the two tubes.

A similar problem recently arose in the Maintenance Department at CBWT. It became necessary to build a number of regulated power supplies to provide -20 v. of bias and control voltages to our stabilizing amplifiers. Only 80 volts of a.c. was available. This would provide sufficient d.c. to operate an 0C2 or VR-75 but just short of that required to initially ignite it. After much head-



scratching and several unsuccessful attempts the circuit shown here was evolved.

When power is first applied, SR_2 is cut off by virtue of 150 v. positive from the external source appearing at the cathode, therefore the combined voltages of the positive and negative supplies appear across the VR tube in series with R_1. When the VR tube conducts, SR_2 also conducts, placing the junction essentially at ground. The VR tube now remains ignited and R_1 appears as a light load across the 150 v. positive supply.

Nine of these power supplies have been built and put into continuous operation. In a period of almost a year they have exhibited absolutely no problems whatsoever.

E. A. JOHNSON,
TV Maintenance Supervisor
Canadian Broadcasting Corp.
Winnipeg, Canada

We are sure our readers will be interested in how the above problem was solved.—Editors.

ELECTRONIC pH MEASUREMENT

To the Editors:

I was pleased to find the article "Electronic pH Measurement" by Mr. Tom Jaski in your September issue. Let me tell you how much I enjoyed the article and that I plan to make it assigned reading for my students in Advanced Quantitative and Instrumental Analysis.

There were, however, some imperfections in the discussion which could lead to much confusion on the part of the readers. Mr. Jaski states that the molecular weight of a substance is the number of times its molecule is heavier than a molecule of hydrogen, whose *molecular* weight is 1. First of all, the *atomic* weight of hydrogen (H) is 1.0080 and the *molecular* weight of hydrogen (H_2) is 2.0160 or twice the atomic weight. But the system of atomic weights is not based on hydrogen in the first place. Rather it is based on oxygen with an arbitrarily assigned atomic weight of exactly 16.0000. All other atomic and molecular weights are relative to this value so far as chemists are involved.

Next there is confusion between molarity and molality, the latter not belonging in the discussion at all. Molarity refers to the number of moles of solute per *liter* of *solution*. Molality means the number of moles of solute per *1000 grams* of *solvent*. These two can be close as, for example, in a dilute aqueous solution, but they are not to be thought of as the same nor used interchangeably by any means.

Finally, a small point, the value of 6.06×10^{23} has not been used for years. Modern chemistry books use 6.024×10^{23} for the number of molecules per mole.

H. L. COVER
Mary Washington College of the University of Virginia
Fredericksburg, Virginia

Thanks to Reader Cover and to many other readers, particularly in the chemistry departments of many of the universities, who called the above inaccuracies to our attention. We also appreciate Reader Cover's offer of the facilities of his college in working on future articles that depart somewhat from the field of electronics and get into the field of chemistry.—Editors.

STABLE TRANSISTOR V.F.O.

To the Editors:

My article "Stable Transistor V.F.O." (October ELECTRONICS WORLD) mentions that it is not necessary to use the toroid form mentioned in the parts list. However, I should have mentioned that slug-tuned coils will have less "Q" and several circuit modifications may be required. A typical unit, using 18 turns of #22 enameled closewound on a ¾" ceramic form required the following changes for stable oscillations. The tap was placed at 7 turns, capacitor C_4 was changed to 75 μμf. and C_8 was changed

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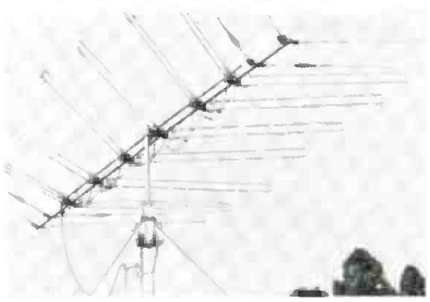

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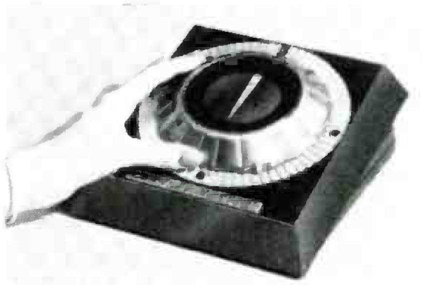

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to 100 μμf. It has also been pointed out that FM of the oscillator, due to r.f. pickup, can occur unless the oscillator box is well grounded to the transmitter chassis.

DONALD STONER
Alta Loma, California

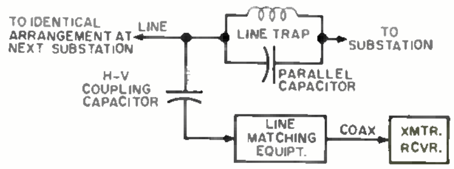
These suggestions will improve the stability of the circuit whenever a toroidal coil is not used.—Editors.

POWER-LINE CARRIER

To the Editors:

I believe the terminology used in your article "Power-Line Carrier Communications" (January 1961 issue) may be a little confusing to the non-industrial technician.

The entire trap shown is in series with the 60-cycle line, however the trap itself is a parallel one tuned to the operating r.f. and used as the author states.



The parallel capacitor for this trap may be seen in Fig. 4 just protruding from the right-hand end of the coil. The trap shown is just as weighty as the coupling capacitor shown in Fig. 2, being on the order of 500 pounds or so.

I have subscribed to your magazine for many years and fully enjoy each issue; the latest copy is no exception.

ROBERT J. HUNTER
Tucson, Arizona

Thanks to Reader Hunter for this additional information. The circuit shown above should clarify the arrangement used.—Editors

* * *

SYNCHRONOUS PHONO MOTORS

To the Editors:

What's the difference between the hysteresis synchronous (HS) and just plain synchronous (S) motors indicated in your directory of hi-fi turntables (February issue)?

JOHN MURPHY
Roanoke, Va.

Actually both types of phono motors referred to above use rotors made of magnetic steel and operate on the same basic principle. The motors referred to in our directory as synchronous (S) are very similar to the type used in many electric clocks. The rotors here are one or more hardened steel discs running in a sealed metal cylinder. These small motors, although very accurate in speed, have low torques; hence, they must be used with lightweight turntables. The rotor in the usual hysteresis synchronous (HS) motor is constructed like the more conventional squirrel-cage rotor and has considerably more torque. Some HS motors are "inside-out" types, in which the rotor rotates around the outside of an inner fixed stator assembly.—Editors.

—30—

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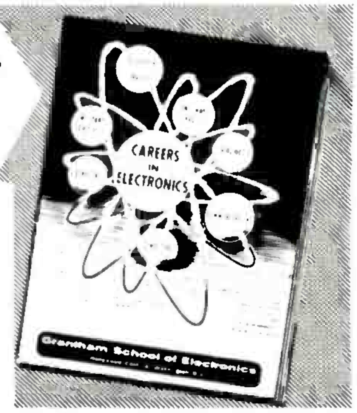

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16C

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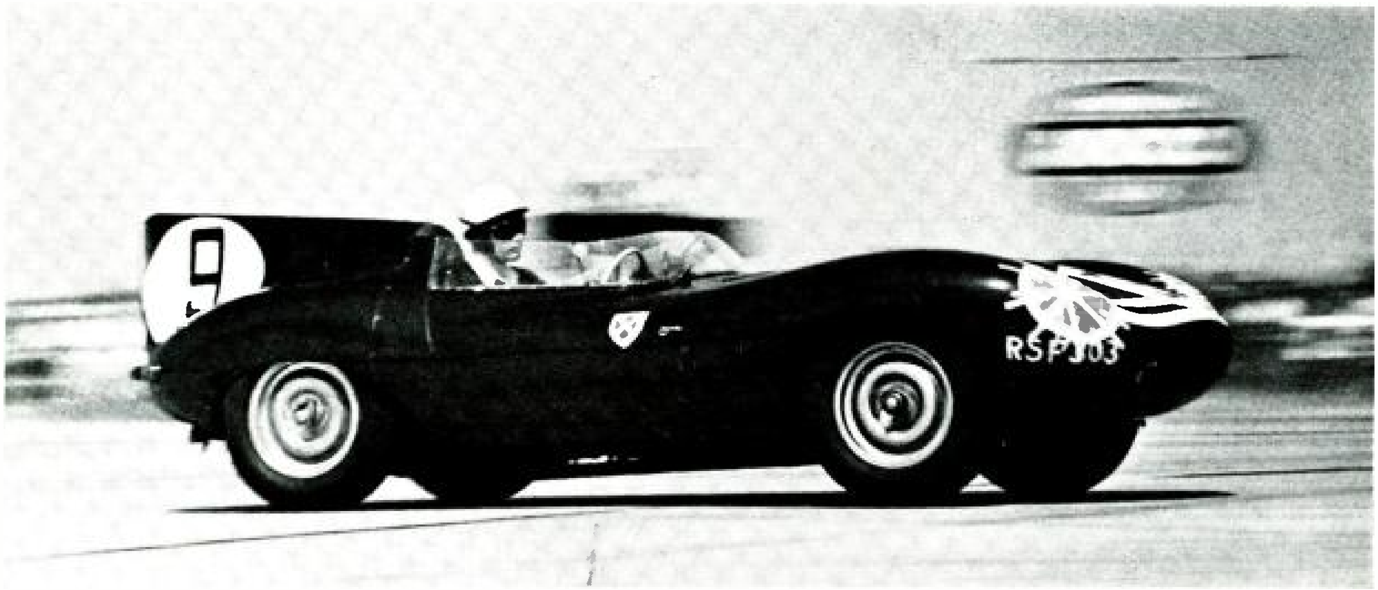

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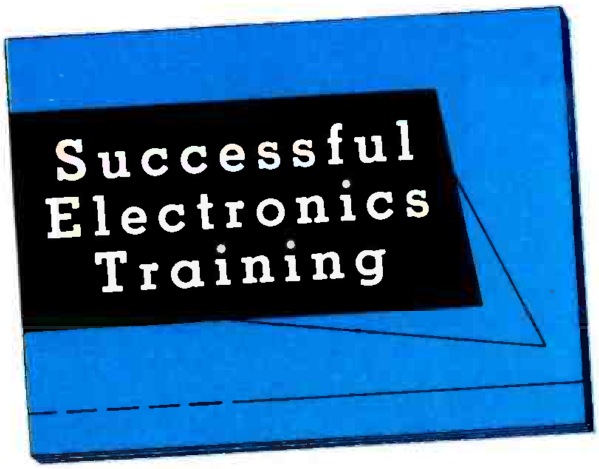

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The quality and advanced standing of the CREI educational program is readily seen in the appreciation expressed for it by both industry and government. At present there are 5,240 U. S. Navy electronics personnel enrolled in CREI extension programs. More than fifty leading electronics organizations in this country and in foreign nations actually pay all or part of the tuition for employees taking CREI courses. The list below comprises a few of these organizations:

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Latest Information on the Electronic Industry

Spot News

By ELECTRONICS WORLD'S WASHINGTON CORRESPONDENT

ELECTRONIC COMPONENT OUTPUT NEARLY TRIPLES IN DECADE—Electronic component manufacturing is now a $3-billion annual business—almost three times the output of a decade ago—Washington revealed in a year-end report. In its first major study of this industry, the Department of Commerce Electronics Division noted that about 60 per-cent of the component production is for the civilian market, the remainder for the manufacture of military electronic equipment or for maintenance purposes. In textual and tabular form, the study, entitled "Electronic Components, Production and Related Data, 1952-1959," is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. for 20 cents a copy.

WORLD'S LARGEST AUTOMATIC RELAY STATION OPENED AT FORT DETRICK—A $25-million control station for the Strategic Army Communications System (STARCOM), designed to give almost split-second control over the far-flung Army commands, is now in operation at Fort Detrick, Frederick, Maryland. The control center, key station of the network, which includes communications stations and long-distance radio, wire, and cable circuits, can handle 275,000 messages a day and can store 5000 messages at a time. For high-speed automatic handling, messages are recorded on perforated tape and converted back to printed messages at their destination. A feature of the center is the use of troposcatter to reduce atmospheric interference. A 65-mile troposcatter system links the station to the Army's overseas radio receiving station at La Plata, Maryland, with an extension via a microwave contact to the transmitting site at Woodbridge, Maryland.

IMPLICATIONS OF SATELLITE-BASED COMMUNICATIONS SYSTEM CITED IN SPACE REPORT—Scientists and engineers believe that in a relatively few years the world will be wrapped in a communications net based on satellites. So viewed the Brookings Institution in a 190-page report prepared for the National Aeronautics and Space Administration. Since such a system will be international in its scope, it was emphasized, planning must take into account potential users abroad and the problems that will surely arise. It will be necessary, for instance, to devise a frequency allocation plan that will resolve or minimize not only economic, social, and legal difficulties, but technical problems such as the relative non-directionality of satellite signals and the different frequency-control requirements of active and passive systems; also receiver and possibly transmitter antenna control and sharing. Privileges and priorities of satellite use will also have to be considered. Cost-sharing arrangements may be more difficult to enforce with passive systems and scheduling of messages via active systems will require special agreements. A particularly important technicality that will require study will be compatibility of components produced and used by various nations. In addition, our role will be bound up with questions involving national interests and private profit motives. Thus, we will have to decide under what circumstances the government should provide launching facilities and research and development centers. If taxpayers are to finance portions of technological developments, agencies will have to firm up not only patent ownership policies, but rules and regulations regarding systems that might be owned and operated by government or private interests.

"MISSILE-MASTER" COMMUNICATION NETWORK SET UP BY ARMY—Electronic centers, called "Missile Masters," designed to coordinate air defenses of key industrial and population areas, have been announced by the Army. Located in the Washington-Baltimore, Seattle, Boston, New York, Buffalo, Detroit, Pittsburgh, Philadelphia, Chicago, and Los Angeles zones, the network provides a communications and fire coordination link to "Nike" missile batteries.

40-HOUR TAPE PLAYBACK DEVELOPED IN ENGLAND—A long-playing magnetic tape recorder that will provide up to 40 hours of unattended service has been developed in England for use in civil aircraft, entertainment, and general industries. A two-track head on a cam assembly enables 40 tracks of recording to be made on one 1200-foot, one-inch-wide tape that is wound on a 5½-inch reel. The play speed is 3.75 inches-per-second.

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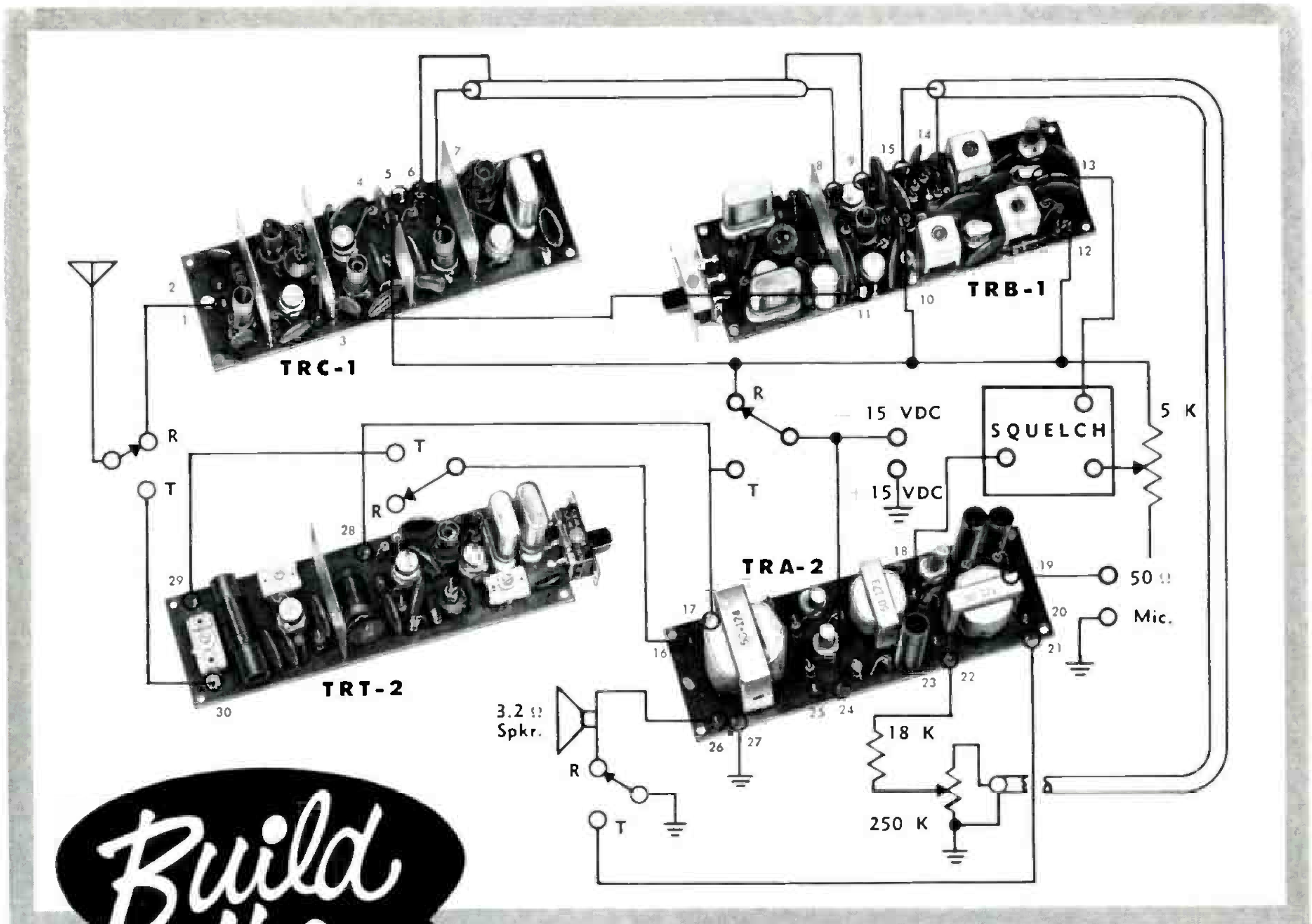

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Crystal controlled, 3 transistors for 10 meters or Citizens band. RF amplifier, mixer/oscillator. Double tuned front end. IF output 6 mc. Others on special order. Power: 15 volts dc @ 5 ma. Wired, tested with Crystal.
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TRB-1 MIXER IF UNIT
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TRA-2 AUDIO UNIT
Three transistors. Input 100,000 ohms and 50 ohms. Speech amplifier for dynamic microphone. Push-pull power amplifier class B. Output 300 mw. Wired and tested. Cat. No. 400-104 .... $21.50

TRT-2 TRANSMITTER
Crystal controlled. Three transistors. Output 100 milliwatts minimum with #1 transistors. Power stage uses special HF transistors. Wired and tested less crystals and transistors. Cat. No. 200-118 .... $10.00
#1 Transistor Kit (100 mw output). Cat. No. 150-128 .... $17.50
#2 Transistor Kit (50 mw output). Cat. No. 150-129 .... $ 9.00
Crystals FCB for Citizens band (.0025%) .... $ 4.75
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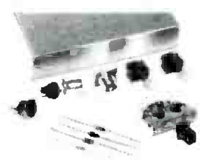

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Within the Industry

HAROLD L. RUSSELL has been named general sales manager of the *Weston Instruments Division* of *Daystrom, Inc.* He was promoted from his former position as process instrument sales manager. By this appointment and associated reorganization of the sales division, the company hopes to increase the effectiveness of its home office marketing organization and to provide stronger support for its field sales force.

Before joining *Weston* in 1960, Mr. Russell was general sales manager for *Fischer and Porter Company,* Hatboro, Pa. and prior to that was associated with the industrial division of *Minneapolis-Honeywell Regulator Company.*

Mr. Russell graduated from the University of Pennsylvania with a B.S. in electrical engineering. He is a member of the Instrument Society of America and the AIEE.

* * *

GENERAL ELECTRIC has announced its entry into the $20-million annual capacitor replacement market with the series of unique merchandising and packaging ideas to help move these components.

Fried grasshoppers and other exotic foods will be included in the "surprise packages" which will contain ten of the most frequently used capacitors. The packages will be sold by distributors for the cost of the capacitors alone.

Featuring an "Application Rating" system for the electrolytic types, the company offers a total of 275 "Twist-Prong" and tubular capacitors to replace as many as 1217 different capacitors used in a wide variety of equipment.

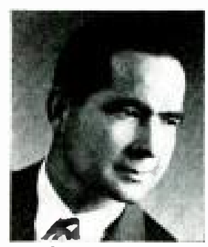
The "Rating" approach is expected to reduce by 65 per-cent the number of types presently stocked by a distributor. This should make possible a 50 per-cent annual saving in space and inventory investment. Company studies of capacitor movement by types have indicated that twenty *G-E* capacitors will meet 70 per-cent of all conventional replacement needs.

* * *

HARMON-KARDON stockholders have agreed to accept one share of **JERROLD ELECTRONICS CORPORATION** stock for each 1.8 shares they now hold, thereby approving the proposed acquisition by the Philadelphia firm. There will be no change in personnel or management of the new subsidiary . . . **MALLORY** has established a new department to develop and produce microminiature electronic components . . . M. R. Friedberg, president of **ANTENNA SPECIALISTS COMPANY,** Cleveland, has announced the purchase of **TELE-BEAM INDUSTRIES INC.,** Napa, California manufacturer of base station and mobile antennas . . . Arthur Feldon announces the formation of **MICROSEMICONDUCTOR CORPORATION,** of which he is president. The company is now conducting research and development in its 15,000-square-foot facility in Culver City, Calif. . . . **AMERICAN ELECTRONICS, INC.** and **ELECTRONIC SPECIALTY CO.** announce that negotiations are proceeding on a plan of consolidation. The combined companies will operate under a new name which will be revealed at a later date. The merger will be effected by means of stock exchange. The combined sales of the two firms are currently at an annual rate of $40,000,000 . . . **SPRAGUE ELECTRIC COMPANY** has acquired **VEC TROL ENGINEERING, INC.** of Stamford, Conn., which will operate as a wholly owned subsidiary with Walter J. Brown, its founder, continuing as president and chief engineer.

* * *

GLEN E. DAVIDSON has been chosen to fill the newly created position of vice-president and director of marketing for *Heath Company.* Mr. Davidson will be in charge of sales, advertising, and other marketing functions involved in the distribution of *Heathkit's* complete line of products on a world-wide basis.



Mr. Davidson leaves the *Fruzola Candy Company,* where he headed the re-organization of that company's marketing department. Prior to that, he was director of marketing for the *W. A. Sheaffer Pen Company.*

He is a veteran of World War II; served as a pilot in the U. S. Navy from 1942 to 1945. In 1948, Mr. Davidson received a degree in Economics and Business Administration from Cornell College, Mt. Vernon, Iowa.

* * *

WOODROW SMITH has been named engineering manager for *Babcock Electronics Corporation.* He replaces **DONALD A. GEHLKE** who was recently made vice-president, corporate director of advanced development . . . **JESSE MARSTEN,** senior vice-president of *International Resistance Co.,* retires after 30 years. He will be succeeded by **JOHN H. DUMMER** who will assume the duties of director of foreign operations and affiliates . . . **TED CUTLER** has been appointed distributor sales manager of *Radio Receptor Company,* which is a wholly owned subsidiary of *General Instrument Corporation* . . . **W. C. JANSEN** is

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now sales manager of the newly created Commercial Sound Department of *North American Philips Co.*'s High Fidelity Products Division ... **ROBERT B. CALLAHAN** takes over as sales manager for *G-E's* industrial electronic components while **CHARLES A. RICHARDSON** moves on to manage the company's industrial electronics sales group in the East-Central region ... *CBS Electronics* announces that **DONALD CHRISTIANSEN** will be manager of publications, a new post; **ROBERT TOMER** will manage information services; **HERBERT L. REICHERT** will head dealer products sales; and **JOHN HOUSER** is to be general manager of distributor sales.

* * *

SIDNEY WHITE, JR. has been named manager, operations services for *RCA Industrial Tube Products*, at the Lancaster plant. Mr. White will be responsible for planning, personnel, purchasing, manufacturing, and engineering services. He succeeds Earl M. Wood, who has retired from this post.

He holds a B.S. in mechanical engineering from Stevens Institute of Technology. In 1933 he joined *RCA* as a manufacturing engineer. In 1940 he became group supervisor and, two years later, general foreman of production at Lancaster. He was appointed superintendent of the power tube group in 1945; manager of the section in 1952, Lancaster plant manager in 1956, and has been manager of super-power tube manufacturing since 1959.

* * *

CORNELL-DUBILIER ELECTRONICS is transferring its corporate headquarters to Newark, N.J. Some of the manufacturing operations will remain in South Plainfield, N.J. ... **CONCORD ELECTRONICS CORPORATION's** offices and warehouse are now located at 809 North Cahuenga Boulevard in Los Angeles ... **VIKING** has just completed an 11,000-square-foot addition to its Minneapolis facilities and has broken ground for a 23,000-square-foot building near Savage, south of the Twin Cities ... **ALCO ELECTRONIC PRODUCTS INC.** has opened a new 10,000-square-foot sales facility in Lawrence, Mass. ... **DIGITRONICS CORPORATION** of Albertson, Long Island has moved into a new, enlarged manufacturing plant that triples its previous facilities. The one-floor plant has 30,000 square feet of operating space and is fully air conditioned ... **SYLVANIA** will begin a 17,000-square-foot addition to its Hillsboro, N.H. plant in April. The addition will bring the total plant area to 53,000 square feet. At present, the division occupies leased space at North Branch, which is located some five miles away.

* * *

INSTITUTE OF RADIO ENGINEERS has announced the recipients of its eight 1961 Awards.

Ralph Bown, former *Bell Telephone*

(*Continued on page 86*)


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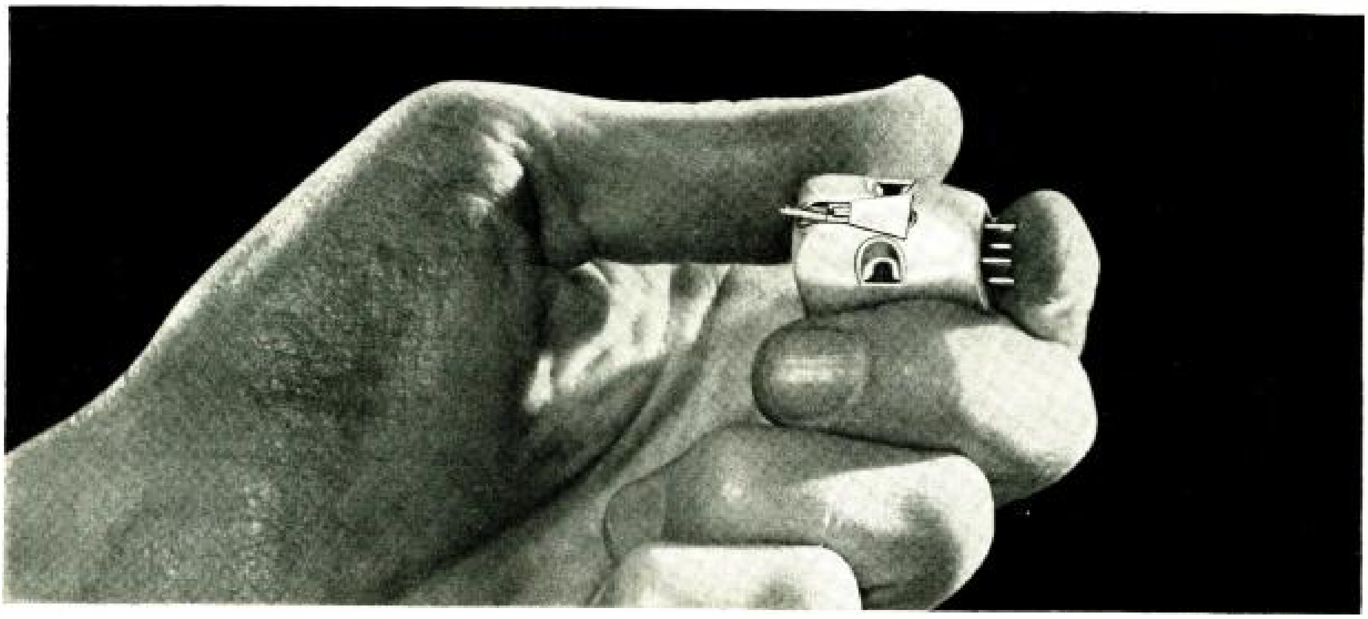


NEW ACHIEVEMENT IN SOUND REPRODUCTION

Audio Dynamics reveals the six performance features of the amazing, new ADC-1 stereo cartridge.

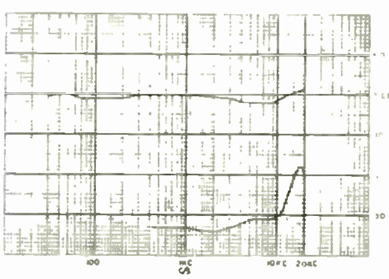
Ability to track at less than 1 gram is only *one* of the impressive advantages of the new ADC-1. Read how this and other features reduce distortion, increase record life and help you enjoy an unusual degree of high fidelity sound reproduction.

With the ADC-1 your dealer gives you a guarantee that this stereo cartridge meets or exceeds your requirements for trouble-free performance and high fidelity sound reproduction. Audio Dynamics' President, Peter Pritchard, wants you to know the six performance features of the ADC-1 stereo cartridge that make this startling promise possible.

Feature 1—Low tracking force reduces distortion and record wear, prolongs the life of your records

The ADC-1 can track at less than 1 gram, touching your record with the lightness of a feather passed across your hand, never bouncing against or leaving record groove walls.

Surface noise and distortion are greatly reduced. Record wear is almost non-existent; record life is prolonged.



Typical response and separation curve, ADC-1 Stereo Cartridge.

Feature 2—Optimum sensitivity results in low amplifier noise

A sensitivity reading of the ADC-1 reveals 7 millivolts at 5.5 cms a second. This means the cartridge develops enough voltage to prevent amplifier strain—a major cause of amplifier noise. (Too high pickup sensitivity can overload an amplifier and cause distortion).

When you use the ADC-1 stereo cartridge, sound fidelity is achieved without strain on your amplifier—or your nerves.

Feature 3—Excellent channel separation in critical audio range assured

As the sounds of recorded instruments run up and down the scale, some have a way of wandering from speaker to speaker. The sound of a violin on the left, for instance, may drift towards the room center.

The ADC-1 overcomes this by achieving 30 decibels of separation in the critical 50-7,000 cps range.

You enjoy excellent channel separation, virtually no wandering.

Feature 4—High compliance moves tone arm fundamental resonance well below the range of audibility

Much as you lower resonance by slackening the tension of a violin string, resonance at low frequencies has been lowered in the new ADC-1. This produces well-rounded bass tones and greatly reduces the possibility of rumble and feedback.

In this case, the violin string is the ADC-1 stylus tip. By reducing tip tension to a compliance of 20 x 10^{-6} cms/dyne, resonance drops below the audible range. Bass tones are clean and well-rounded.

Feature 5—Low dynamic mass recreates brilliant highs free from peaks and distortions

The moving mass of the new ADC-1 comes to just one-half milligram—the lowest ever and the result of a major design breakthrough by Audio Dynamics' engineers. No other cartridge is so minute a magnetic power plant!

This remarkable development enables the stylus tip to resonate with the vinyl disc at a frequency above that registered by the human ear. Highs are brilliant and free from peaks and distortions.

Feature 6—Visible stylus tip protects your records

The ADC-1's stylus tip sits forward, is always visible, aids proper placement of the tip on the record.

This feature protects both your stylus tip and your record, helps safeguard your listening pleasure.

SPECIAL NOTE: Replacing the ADC-1 stylus is particularly easy. The job's done without tools in 10 seconds.

These six performance features of the new ADC-1 enable you to enjoy an unusual degree of high fidelity sound reproduction. Please write for our descriptive brochure. Then *hear* the ADC-1; ask your dealer for a demonstration. Act *today!*

ADC-I Net Price $49.50
ADC-R-I Stylus Replacement . . . $25.00

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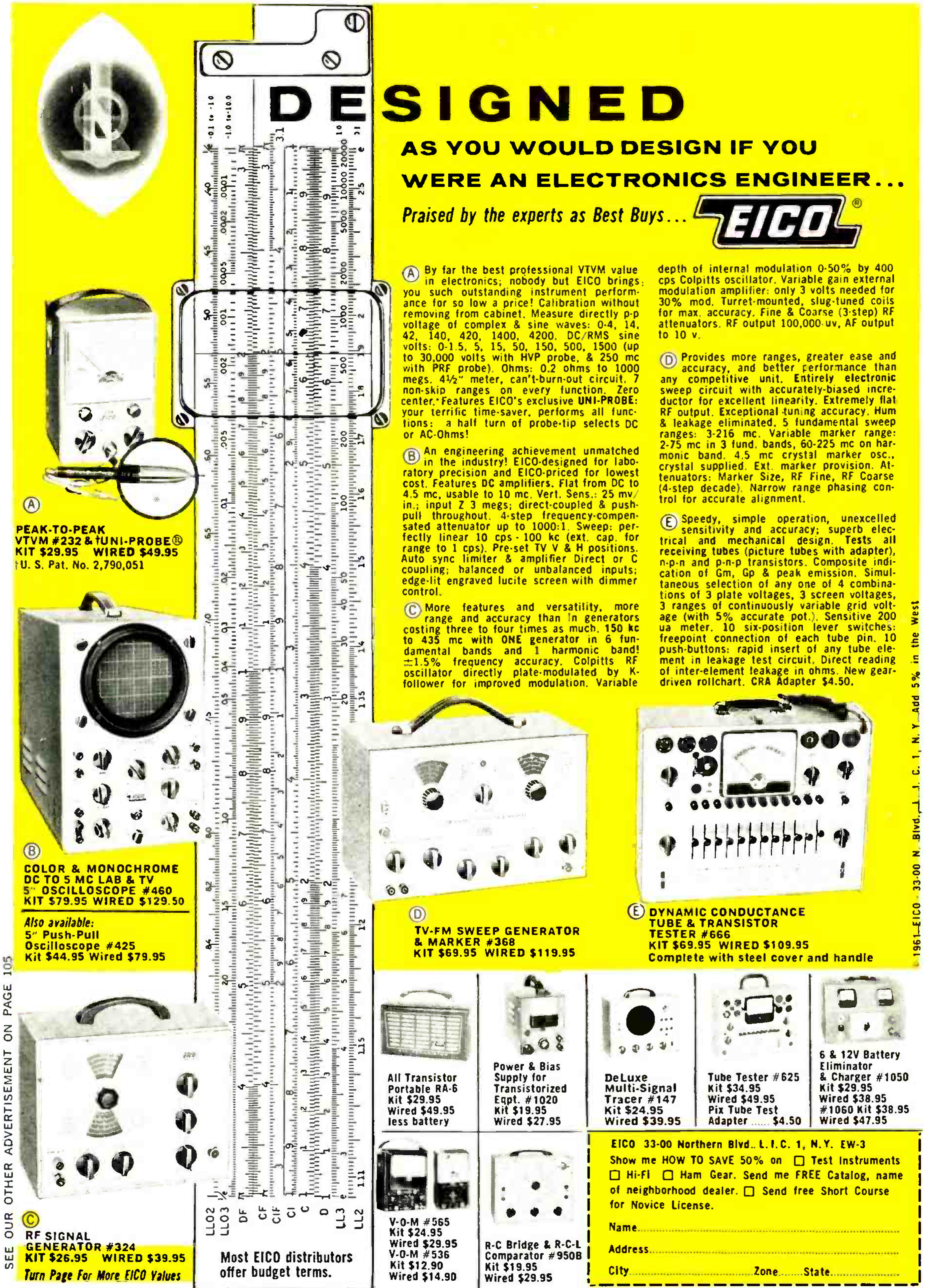

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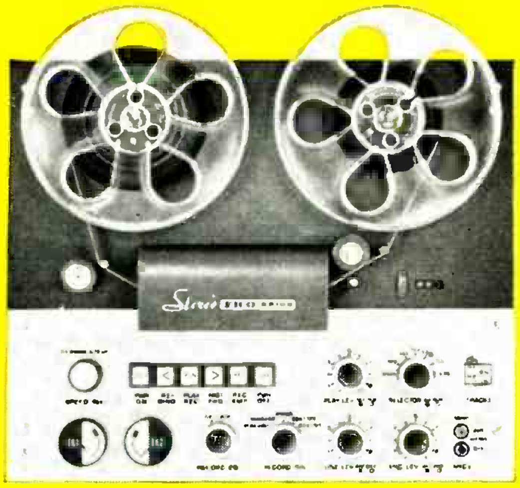

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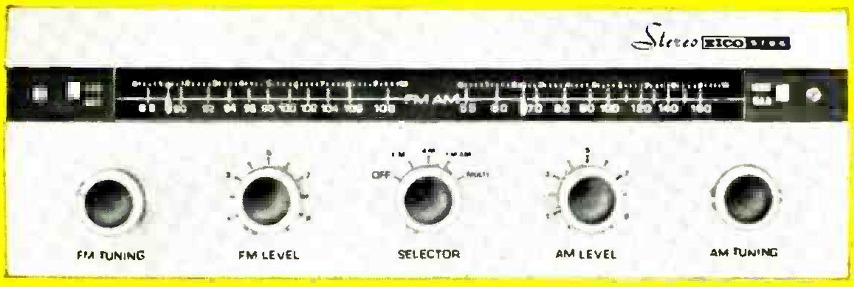

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Switched "wide" and "narrow" bandpass. High Q filter eliminates 10 kc whistle. Sensitivity: 3uv for 1.0V output at 20db S/N ratio. Frequency Response: 20-9,000 cps ("wide"); 20-4,500 cps ("narrow").

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ST70: Cathode-coupled phase inverter circuitry preceded by a direct-coupled voltage amplifier. Harmonic Distortion: less than 1% from 25-20,000 cps within 1db of 70 watts. Frequency Response: ±½db 10-50,000 cps.

ST40: Highly stable Williamson-type power amplifiers. Harmonic Distortion: less than 1% from 40-20,000 cps within 1 db of 40 watts. Frequency Response: ±½db 12-25,000 cps.

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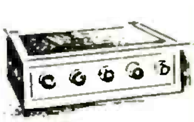
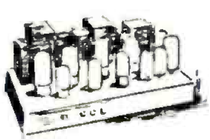
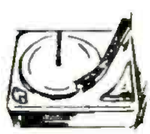
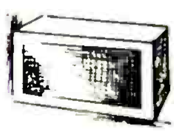

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DUAL 35-WATT STEREO AMPLIFIER

By **PAUL JACOBS** and **PRAVEEN JARIWALA**

Electronic Tube Div.
Westinghouse Electric Corp.

Construction information on a quality medium powered hi-fi amplifier that utilizes the new 7591 beam-power output tubes.

THE 7591 BEAM-POWER pentode recently introduced by *Westinghouse Electric Corporation* for use in audio power amplifiers makes it possible to build this high-quality, low-cost stereo amplifier which combines high power output with low total harmonic distortion. The circuit to be described uses readily available parts, making it an ideal project for the home builder.

Operation Data on the 7591

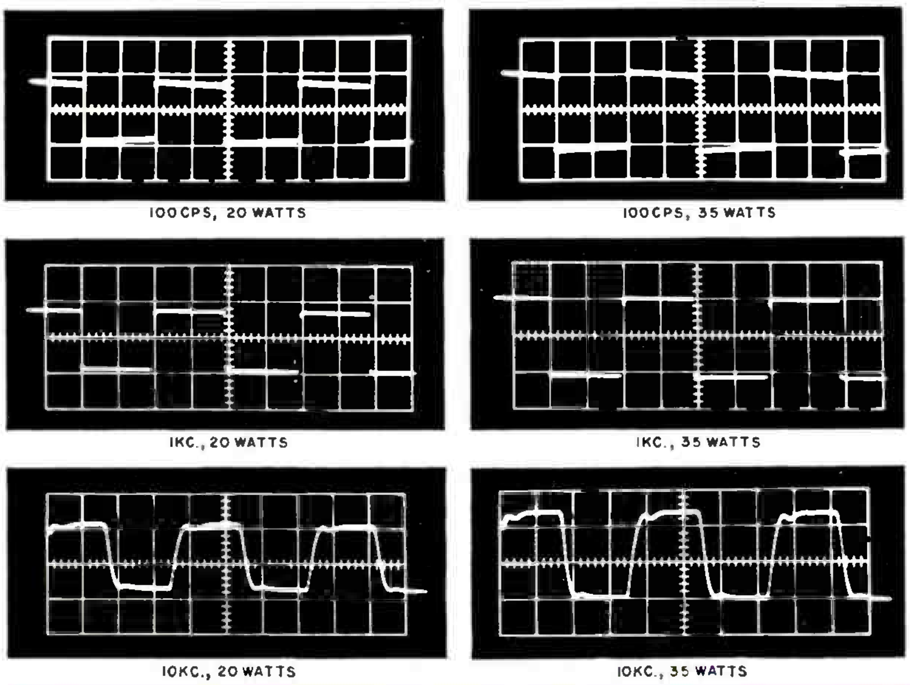
Table 1 shows typical operating data for a pair of 7591's in class AB_1 push-pull. The output tubes used in the amplifier to be described operate class AB_1 under conditions that come close to those shown in the third column of Table 1. As indicated, the 7591 in push-pull application will deliver up to 45 watts power output with total harmonic distortion not exceeding 1.5 per-cent.

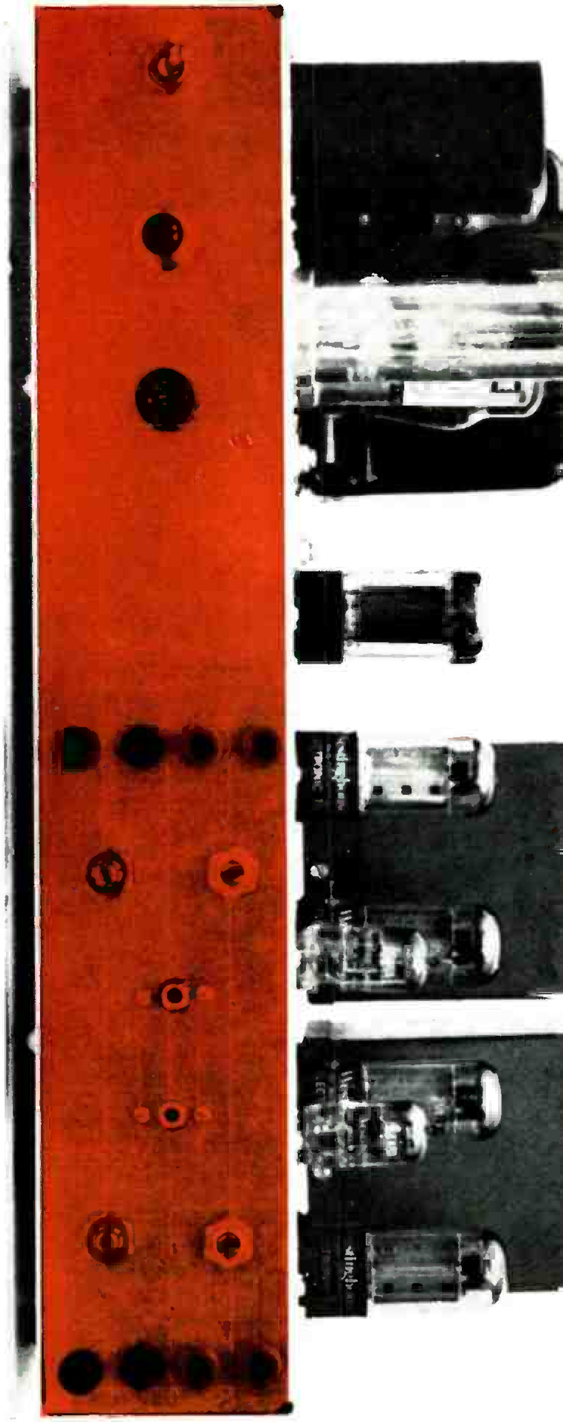
The amplifier to be described is rated at 35 watts per channel with a total harmonic distortion of .3 per-cent. The amplifier was purposely designed so the average home builder could construct the entire unit. With this in mind, no attempt was made to push the amplifier power output to the maximum obtainable as this would have resulted in more elaborate design for the amplifier stages and for the power supply. Instead, more emphasis was placed on keeping the total harmonic distortion low as this will provide more listening satisfaction. In addition, it was felt that a rating of 35 watts would more than cover the peak power which would occur in any hi-fi system used in the average home.

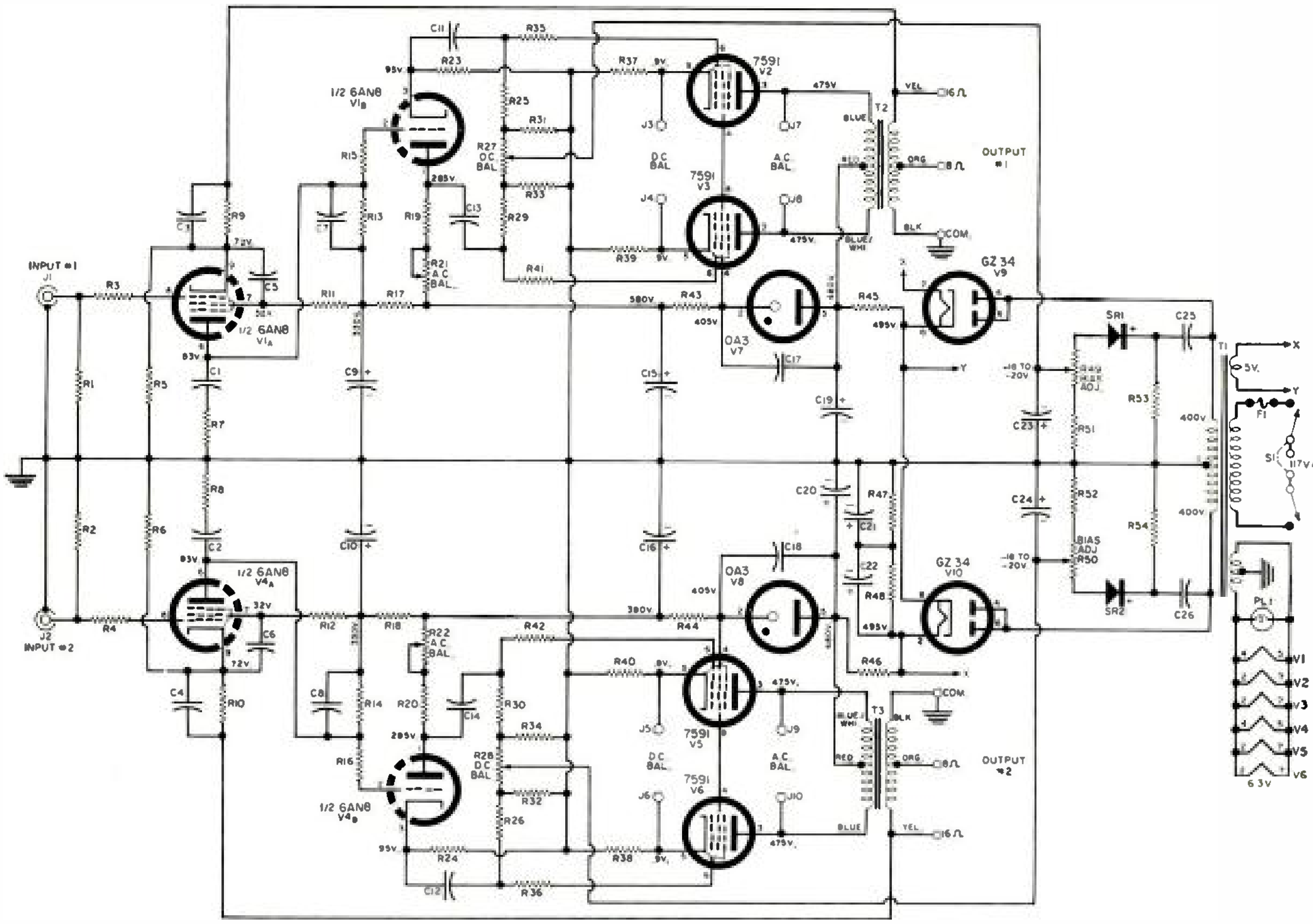
Table 2 summarizes the published ratings of the 7591.

The rated maximum screen dissipation is 3.3 watts. The screen dissipation is permitted to reach 6 watts during periods of maximum speech and music input. Operation of the 7591 at this rate

Square-wave performance of the dual 35-watt amplifier taken at three widely spaced frequencies and at two output power levels.







R_1, R_2—470,000 ohm, ½ w. res.
R_3, R_4—15,000 ohm, ½ w. res.
R_5, R_6—750 ohm, ½ w. res.
R_7, R_8, R, R, R, R—27,000 ohm, 1 w. res.
R_9, R_{10}—39,000 ohm, ½ w. res.
R, R—1.5 megohm, ½ w. res.
R, R—270,000 ohm, ½ w. res.
R, R, R, R, R, R—1000 ohm, ½ w. res.
R, R, R, R—47,000 ohm, 1 w. res.
R_{19}, R_{20}—22,000 ohm, 1 w. res.
R, R, R, R—50,000 ohm linear taper pot
R, R, R, R—100,000 ohm, ½ w. res.
R, R—5000 ohm linear taper pot
R, R, R, R—56,000 ohm, ½ w. res.
R, R, R, R—27 ohm, 1 w. res.
R, R—10,000 ohm, 1 w. res.
R, R—200 ohm 10 w. wirewound res.
R, R—180,000 ohm, 2 w. res.
C, C—50 μμf. ceramic capacitor
C, C—82 μμf. ceramic capacitor
C, C, C, C, C, C—.25 μf., 600 v. paper capacitor
C, C—5 μμf. ceramic capacitor
C, C, C, C—20/20/20/20 μf., 450 v. elec. capacitor (Sprague TVL-4763 or equiv.)
C, C—.01 μf., 400 v. paper capacitor
C, C—40/40 μf., 500 v. elec. capacitor (Sprague TVL-2940 or equiv.)
C, C—150 μf., 300 v. elec. capacitor (C-D XA0355)
C, C—40 μf., 150 v. elec. capacitor (Sprague TVA-1413 or equiv.)
C, C—.05 μf., 600 v. paper capacitor
F_1—3 amp fuse
S_1—D.p.s.t. toggle switch ("On-off")
J_1, J_2—Phono jack
J, J, J, J, J, J, J, J_{10}—Insulated tip jack (GC-7816)
PL_1—6.3 v. pilot light
SR_1, SR_2—25 ma. selenium rectifier
T_1—Power trans. 400-0-400 v. @ 340 ma.; 5 v. @ 4 amps; 6.3 v. c.t. @ 5 amps (Thordarson 22R35 or equiv.)
T_2, T_3—Output trans. 30-40 watts, push-pull 6600-ohm primary (Dynaco A-420 or Acro TO-300)
V_1, V_4—6AN8 tube
V, V, V, V—7591 tube (Westinghouse)
V, V—0A3 tube
V_9, V_{10}—GZ34/5AR4 tube

Fig. 1. Schematic shows that two identical channels are employed with screen-grid regulation for the beam-power output tubes.

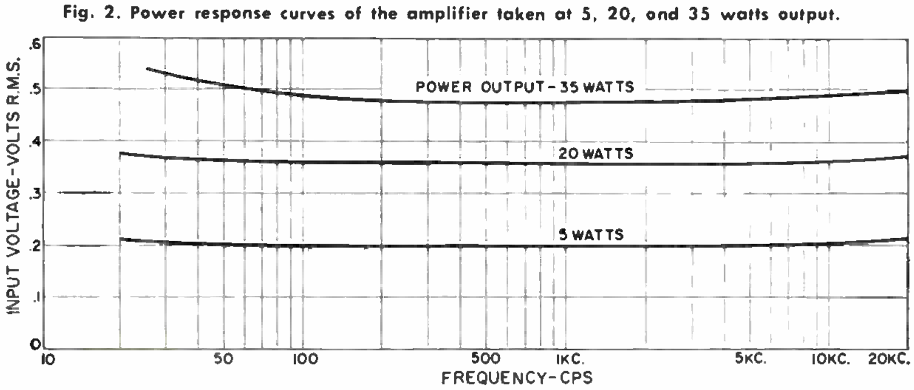
of screen dissipation is made possible by the use of large screen side rods of high conductivity material and of a thermal radiator with external connections to both side rods. The high plate power dissipation of the tube results from special plate construction in which a highly conductive, copper-core material eliminates hot spots from the plate. The 7591 has a T-9 glass bulb, an octal base, and may be mounted in any position.

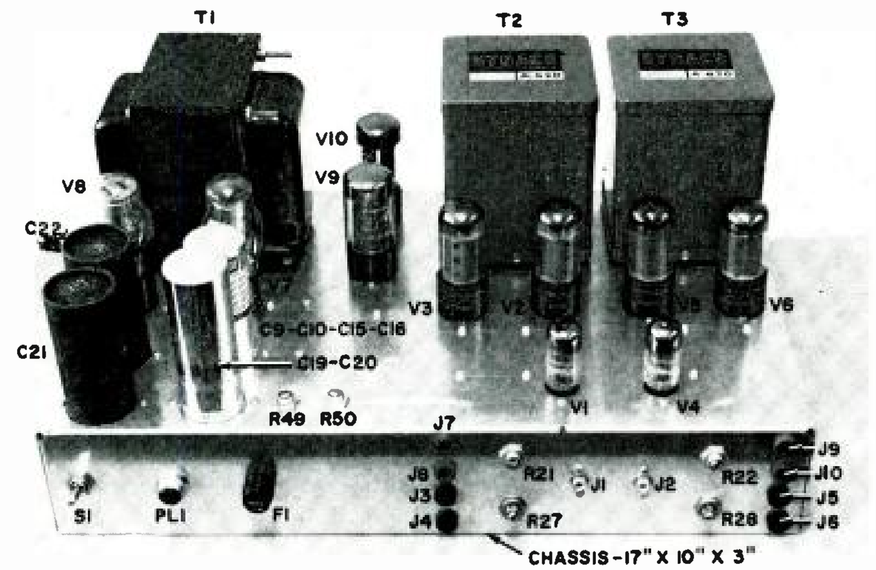
Amplifier Circuit

The circuit, Fig. 1, is a three-stage feedback amplifier employing a common 6AN8 triode-pentode as the voltage amplifier and phase inverter and the 7591 pentodes as output tubes. The number of stages is kept to a minimum in order to reduce phase shifts. The result is extremely stable when feedback is applied over the entire amplifier. The input signal is applied to the 6AN8 pentode grid, after being coupled through the 15,000-ohm isolating resistor. The pentode acts as a voltage amplifier and d.c.-couples the signal to the grid of the triode phase inverter. The 47,000-ohm and the 22,000-ohm resistors in series with the 50,000-ohm potentiometer, couple the signals to the grids of the output tubes through .25-μf. capacitors. The 50,000-ohm variable resistor serves as the "a.c. balance" control.

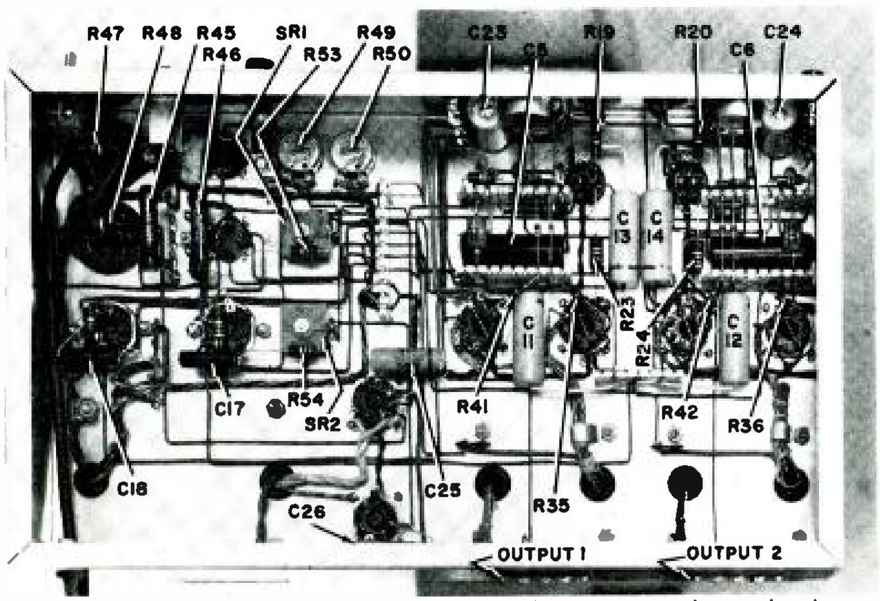
The 50-μμf. capacitor and 27,000-ohm resistor network in the plate circuit of the 6AN8's pentode section controls the

Fig. 2. Power response curves of the amplifier taken at 5, 20, and 35 watts output.





Over-all view of amplifier. Power-supply parts are grouped at left side of chassis.



Chassis underside. Note the very symmetrical and clean-cut construction employed.

upper frequency cut-off point of the amplifier and thus controls the amplifier's transient stability. Its effects, along with the effects of the 5-$\mu\mu$f. and the 82-$\mu\mu$f. capacitors in the feedback loop, can be most easily observed on an oscilloscope when a 10-kc. square wave is connected to the amplifier input. The values of these capacitors were chosen so that the square-wave response of the amplifier showed optimum flatness at the top and bottom of the square wave, thus making the amplifier very stable to fast-rising waveforms.

The plate-to-plate loading of the output stage is 6600 ohms. With a feed voltage of 480 at the center tap of the output transformer primary, the combined zero signal anode and screen-grid dissipation of the output tubes is 14 watts per tube. The output tubes are used in pentode connection with fixed bias.

The output transformers, T_2 and T_3, are *Dynaco* A-420 units. The A-420 is ideally suited to the 7591 tubes, providing the correct impedance match for maximum output and lowest distortion. The frequency response of the A-420 is flat ± 1 db from 6 to 60,000 cps, thereby providing the necessary low phase shift over the audio range for best feedback stability and faithful transient response. The halves of the primary are tightly coupled to make available a full 35 watts of power output over the entire audio range. No difficulty was experienced in obtaining full undistorted output at the low frequency extreme.

Positive voltage is supplied to the amplifier by a conventional full-wave power supply, using GZ34 indirectly heated, full-wave rectifiers with capacitor-input filter.

An old TV power transformer may be used in the power supply. Such a transformer is easily obtained and provides high current with good regulation. A voltage regulator (0A3) is used in the screen voltage supply for each channel. It is generally known that the characteristics of the 0A3 are such that quite large variations of current through the 0A3 do not greatly alter the potential drop across the tube. Consequently, the difference between plate and screen voltage is constant, resulting in the extremely stable grid-#2 voltage required for low distortion at full power output.

Plate Voltage	**550 Volts**
Screen Voltage	**440 Volts**
Plate Dissipation	**19.0 Watts**
Screen Dissipation	**3.3 Watts**
Cathode Current	**85 Ma.**
Grid #1 Circuit Resistance, Self Bias	**1.0 Megohm**

Table 2. Maximum ratings of 7591 tube.

A.C. Balancing

The 50,000-ohm potentiometer, called "a.c. balance," is set to give equal a.c. in the output tubes. This is the condition for cancellation of even harmonics generated by the output tubes, and results in minimum distortion. This a.c.-balance control eliminates the need for matched output tubes and for d.c. balancing of the output tubes (although the latter adjustment is also provided). The "a.c.-balance" control may be adjusted by using one of the following methods:

1. Connect an oscilloscope across a

Table 1. Typical operating data for pair of 7591's operating in class AB_1 push-pull.

Plate Voltage	300	400	450	Volts
Screen Voltage	300	350	400	Volts
Grid #1 Voltage	−12.5	−16.0	−21	Volts
Peak A.F. Grid-to-Grid Voltage	25	32	42	Volts
Zero Signal Plate Current	86	85	66	Ma.*
Maximum Signal Plate Current	116	143	144	Ma.*
Zero Signal Screen Current	12.6	11.0	9.4	Ma.*
Maximum Signal Screen Current	26.0	27.0	30.0	Ma.*
Effective Load, Plate-to-Plate	6600	6600	6600	Ohms
Total Harmonic Distortion	2.5	1.5	1.5	Per-cent
Maximum Signal Power Output	23	37	45	Watts

*Values for Two Tubes

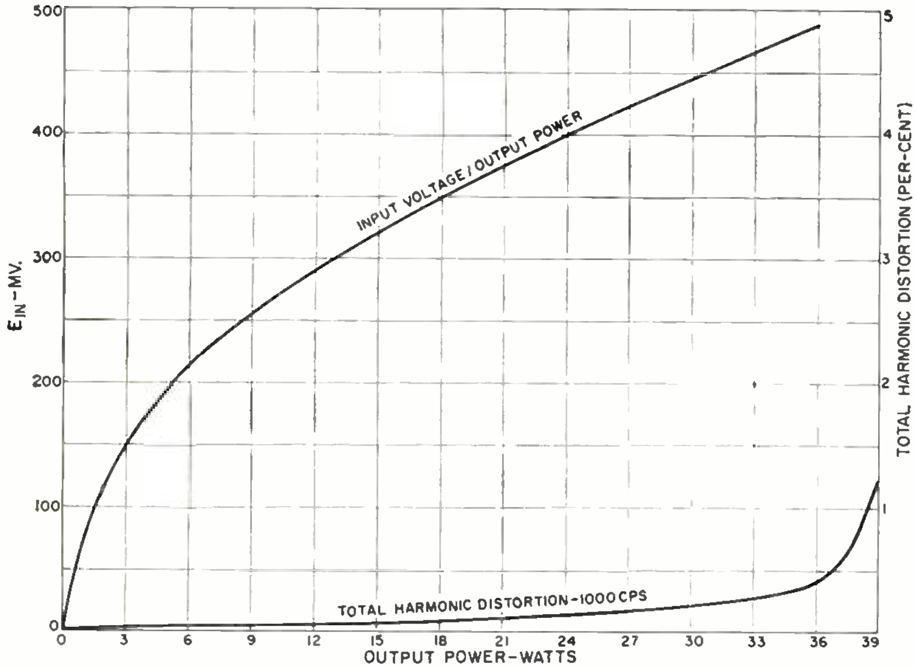


Fig. 3. Harmonic distortion at 1000 cps and input-output characteristics of amplifier.

small resistor (100 ohms) in the common plate lead and feed a sine wave into the amplifier. Set the "a.c.-balance" control for minimum amplitude indication on the scope.

2. The same results may be obtained by connecting an a.c. voltmeter or a headphone in the common plate lead through a step-up transformer instead of the 100-ohm resistor. The a.c. balance is indicated by minimum meter reading or minimum sound in the headphone.

3. Best accuracy in a.c. balancing will be obtained by adjusting for equal a.c. voltages at the plates of the power output tubes when a sine wave is fed into the amplifier. To make the adjustment, the a.c. voltage at pin #3 of V_2 and V_3 must be measured with a high-impedance v.t.v.m. The a.c.-balance control is varied until the a.c. voltage at pin #3 of V_2 is equal to the a.c. voltage at pin #3 of V_3. The a.c. balance for the other channel may be set in the same way by taking the measurements on pin #3 of V_5 and V_6.

Power Output	35 watts at 1000 cps. within ± 0.5 db of 1 kc. level at 35 watts over range 35 cps to 20 kc.
Frequency Response (at 35 watts)	± 1 db from 20 to 20,000 cps
Harmonic Distortion (at 1000 cps)	.1% at 20 watts .3% at 35 watts
IM Distortion (60 to 6000 cps, 4:1 ratio)	.8% with peak corresponding to 35 watts sine-wave power
Square Wave Response (at 35 watts)	Rise time on 10 kc.—7 microseconds; Overshoot on 10 kc.—none observed; Ripple on 10 kc.—approximately 2%; Droop on 100 cps—6.8%
Hum and Noise	83 db below rated output
Nominal Feedback	17 db
Feedback Stability Margin	7.5 db
Damping Factor	8
Sensitivity	.475 volt r.m.s. for 35 watt output

Table 3. Over-all summary of the performance characteristics of the power amplifier.

Performance

The measured performance of the amplifier is given in Table 3. Frequency response at 35-watt output is ±1 db from 20 to 20,000 cps. The square-wave response characteristics for 35-watt power output are also shown in the table. For 20-watt output, the following values were measured: rise time at 10,000 cps, 7 microseconds; overshoot on 10,000 cps, none observed; ripple on 10,000 cps, 1 per-cent; droop at 100 cps, 6 per-cent. A nominal feedback of 17 db was applied in the amplifier. In a feedback amplifier, it is always desirable to maintain a maximum amount of feedback stability in order to assure complete stability under all conditions of output power level and output load. The degree of stability of a feedback amplifier is rated in terms of "stability margin." This gives the amount of additional feedback, in db, that can be added before the amplifier becomes unstable and oscillates. A margin of 7.5 db was obtained in this amplifier which assures complete stability.

Fig. 3 shows the total harmonic distortion of the amplifier at 1000 cps. At the 20-watt level, distortion is .1 per-cent. The distortion at 1000 cps reaches 0.3 per-cent at 35 watts output. Fig. 2 shows the response curves of the amplifier at 5-, 20- and 35-watt power outputs. The amplifier is virtually flat within the range of 20 to 20,000 cps at 5 and 20 watts output. At 35 watts output, the amplifier is essentially flat from 35 to 20,000 cps. The power sensitivity of the amplifier is also apparent from the power response curves, *i.e.*, 0.475 volt r.m.s. for full 35 watts power output.

Construction Details

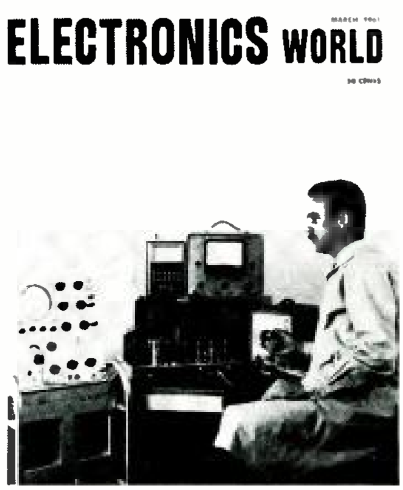
Little new can be said about the construction of an audio amplifier. There are, however, a few points that are well worth remembering when building this amplifier.

1. Keep all the leads just as short and

(*Continued on page* 85)

COVER STORY

(Cover photo by Bob Loeb)

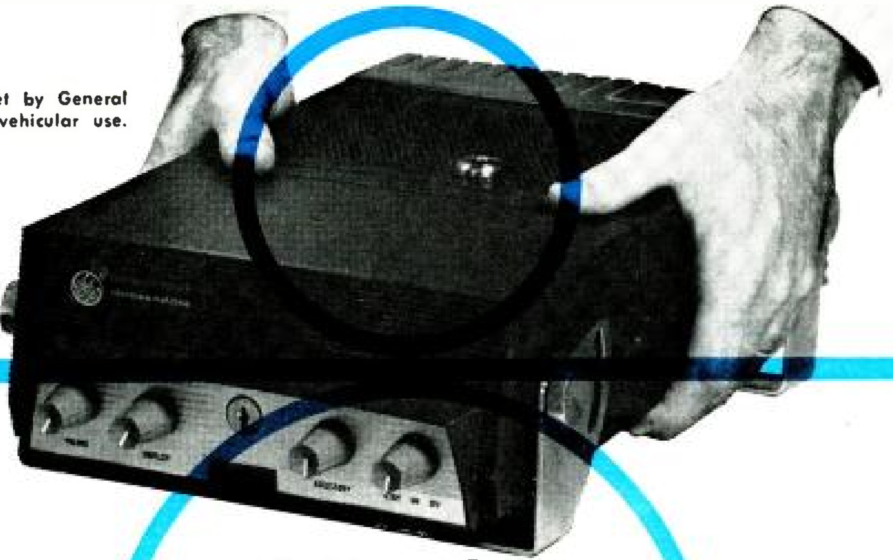


AT THE CENTER of the test bench shown on our cover this month is the dual 35-watt stereo amplifier described in the story above. We are running a few checks on the amplifier just to find out how good it really is.

We are applying the Hewlett-Packard Model 200CD wide-range audio oscillator (extreme right) to the input of one of the amplifier channels. The output of this channel is being applied to the Channel Master CM-10 coax speaker system right behind the amplifier.

The input signal is being monitored by the "Knight-kit" automatic a.c. v.t.v.m., located atop the speaker system and at the left. The Precision Model 98 v.t.v.m., right beside it, is being used to monitor the output signal. We are also looking at the 1000-cps output waveform on the Tektronix Model 931 scope.

Details on some of the measurements taken along with some scope traces showing the square-wave performance of the stereo amplifier are included in our story. —30—



This mobile, two-way set by General Electric is designed for vehicular use.

Adjusting Communications Transmitters

By EDWARD M. NOLL

Part 1. Procedures for required r.f. adjustments in the transmitter section of common two-way units.

THE TWO-WAY radio services—small boat, public service, land transportation, Citizens, and others—have been experiencing phenomenal growth in recent years. The number of repair installations handling two-way radio has correspondingly increased, and many electronic technicians who did not have much experience with transmitter circuits in the past have had to develop such knowledge.

An understanding of the circuits and maintenance procedures involved is obviously necessary to pass FCC first- and second-class radiotelephone license examinations; and such licenses are mandatory for those who deal with this equipment, especially the transmitter sections. The material presented here is intended for those who are just starting out and those who already have some background as well.

Although many details are included, initial concern will be with a general pattern of procedure and instrument use. In this article, the r.f. portion of the transmitter will be considered. The concluding article will include greater detail using an actual example and also cover the voice and modulating circuits.

A correctly tuned transmitter delivers a strong and stable signal to the antenna system. Not only must the transmitter be tuned correctly in terms of efficient operation, but its output must be made to comply with the technical standards of the FCC rules and regulations that apply to each specific service.

Transmitter power, frequency, and modulation levels are three factors of particular concern to the FCC. These three operating parameters must be measured by a second-class or first-class radiotelephone license holder when the transmitter is installed, whenever changes are made that can affect one or more of these parameters, and at scheduled intervals.

Except for Citizens Band equipment, FCC field offices maintain a list of approved equipment for the two-way radio services. In determining the transmitter power, the power input to the final stage is measured. This value should not exceed by more than 10% the rated power input as specified in the FCC approval of that particular model transmitter. Of course, for each radio service, the FCC has established certain maximum permissible power inputs that may not be exceeded under any circumstances. Most mobile radio transmitters operate with powers substantially lower than the maximum permissible value. Base and fixed stations are more likely to operate nearer the maximum power limit.

The frequency of operation is a very important consideration. Above 50 megacycles, a frequency tolerance of 0.0005% must be maintained. Thus the frequency stability of the crystal oscillator of the transmitter must be exceptionally good. The frequency meter used for measurement, in terms of stability and accuracy, must be even better. In fact, the frequency measurement can be best relied upon if the frequency meter itself has an accuracy of at least 0.0002%. It is to be anticipated therefore that the frequency-measuring equipment used to check out communications transmitters must be of high quality, and the measurement itself must be made carefully by a competent technician. Most crystal oscillators associated with communications transmitters have small trimmer capacitors that can be used to set the stage on a precise frequency. Most crystals are mounted in constant-temperature "ovens" to maintain the proper frequency of operation once it has been established.

The modulation level of a communications transmitter is also of concern. The higher the average modulation that can be obtained, the greater the range of transmission and the better the signal-to-noise and signal-to-interference ratios. However, too high a modulation percentage produces spurious signal outputs and distortion. Thus according to FCC technical standards, the modulation must not exceed 100%.

In the case of an AM transmitter, the average modulation level should be such that the modulation peaks exceed 70% while remaining under 100%. When an AM carrier is overmodulated, the interruption of the carrier by the modulation produces spurious signal components substantially removed from the carrier frequency and its desired sidebands. Distorted audio and interference to other units results.

Communications transmitters thus include special modulation limiter circuits. These must be adjusted to maintain a high average level of modulation without distortion and, at the same time, prevent peaks from exceeding 100% modulation. Rather simple AM modulation monitors and test set-ups are used to measure this percentage quite accurately.

In the FM bands, 100% modulation corresponds to the maximum permissible deviation. According to service, this maximum deviation is either ±15 kilocycles or ±5 kilocycles. As in the case of AM, the modulation level should be such that the peaks exceed 70% but are not in excess of 100%. Again special limiter circuits are associated with the audio amplifier system to prevent excessive peaks. FM deviation monitors are available to permit an accurate measurement of the FM deviation.

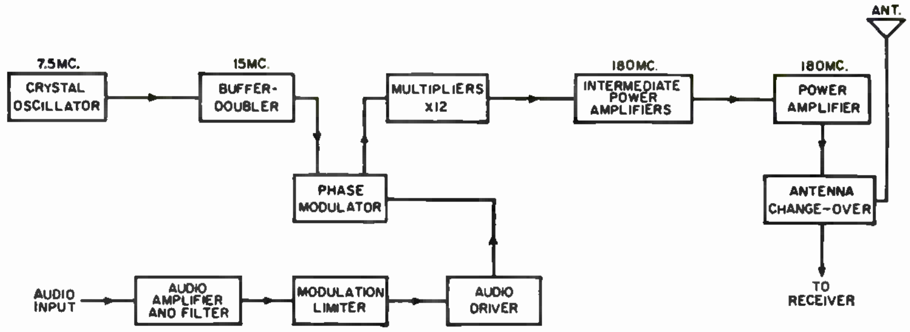


Fig. 2. In the transmitter, output of an oscillator is multiplied to obtain r.f.

Transmitter Functions

The three popular FM two-way radio bands are 25-50 megacycles, 150-174 mc. and 450-470 mc. As shown in Fig. 2, the crystal oscillator usually operates on some frequency below 8 mc. A series of multiplier stages then increases this frequency to the one assigned for transmission. A multiplier section with a total multiplication of 24 times would produce an output of 180 mc. when using a crystal operating at 7.5 mc. Although this transmission frequency is slightly above one of the bands used, it serves the purpose of illustration, in conjunction with Fig. 2.

At some early multiplier stage, a phase modulator is used to produce the desired deviation of the r.f. signal in step with the audio input. This initial deviation, however, is small; but it is also multiplied in succeeding stages. In our example, it is the output of the first doubler (15 mc.) that is modulated. The maximum deviation produced is only ±1.25 kc. However, it undergoes the remaining multiplication of 12 times, so that total deviation at the output frequency is ±15 kc.

One or more intermediate r.f. power-amplifier stages follow the last multiplier stage, because the signal must be built up to an adequate level for driving the final power amplifier of the transmitter. The latter develops the necessary power to supply the rated output to the transmitting antenna.

The voice-frequency signals are first increased in amplitude by an audio amplifier to a level that can drive the modulator properly. The already mentioned modulation limiter is placed between the audio amplifier and the final audio stage, which drives the modulator. Most communications transmitters also include an audio filter. Its function is to attenuate all voice-frequency components above 3000 cycles. In fact, the important voice range extends between 300 and 3000 cycles. The transmission of this frequency range provides the best intelligibility for strictly voice communications. The attenuation of higher frequencies narrows the transmitted bandpass by eliminating some sidebands. Consequently interference between channels is minimized.

Tuning the R.F. Section

The first major step involved in tuning most transmitters is to set the oscillator on a precise frequency. As shown in Fig. 3, most crystal-oscillator stages include a small trimmer capacitor that is connected into the crystal circuit. This capacitor is able to tune the oscillator over a limited frequency range, so that precise frequency can be obtained. As shown in Fig. 3, the most common method of setting such a crystal stage to a desired frequency involves the use of a heterodyne frequency meter, which is a calibrated variable-frequency oscillator. The crystal trimmer capacitor is varied until a zero beat is obtained, indicating that the crystal oscillator and the frequency meter are set to the same frequency, or some known harmonic relationship has been established.

The accuracy of this adjustment is a function of the calibration accuracy of the variable oscillator of the heterodyne frequency meter. Usually the latter employs some form of crystal oscillator and counter arrangement that can be used to establish the required accuracy within one part in a million. Often suitable facilities are available for checking the crystal oscillator of the meter itself using the standard-frequency transmission of the National Bureau of Standards' station, WWV.

Some transmitters use a tunable output circuit in the crystal-oscillator stage; others do not. If the output circuit is tunable, it too must be set for proper operation of the crystal stage. Usually this output is tuned to the second harmonic of the crystal frequency, as follows: The plate tank circuit is tuned through resonance until there is a dip observed in the plate current to the crystal stage.

When a plate tank circuit is tuned to resonance, it presents a maximum impedance. Hence a high-amplitude r.f. voltage is developed across this tank. With a high-amplitude voltage variation the minimum plate voltage, which occurs when the tube is drawing r.f. current, is very low. As a result, the d.c. plate current drawn by the tube and the plate dissipation are at a minimum. Thus the d.c. component of plate current drops to a minimum when the plate tank circuit is tuned to resonance. This dip indicates that maximum power is being transferred to the tank circuit and its load, and minimum energy is being dissipated at the plate of the tube.

If the plate tank circuit of the crystal oscillator is tuned to the frequency of the crystal, it is customary to detune the plate tank off of resonance slightly by detuning to the inductive side. The crystal stage then operates in a more stable manner.

Proper tuning of the crystal-oscillator stage makes itself evident as a maximum grid-current meter reading at the input of the next r.f. stage. In fact as the plate current dips, the grid cur-

Fig. 1. Base-station transmitters, like this COMCO 450-2T, often have integral plate and grid meters.

rent of the next stage increases, indicating that maximum power is being transferred to the succeeding class-C r.f. stage. If it is possible to control the coupling between the crystal stage and the next r.f. stage, an increase in the degree of coupling will cause an increase in the grid-current meter reading.

It is apparent that the use of grid and plate current meters are of the utmost importance in the tuning of a transmitter. The high-power stage of a

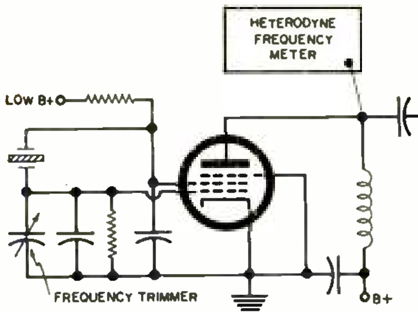


Fig. 3. Crystal trimmer is adjusted for exact frequency while checking at plate.

base or fixed-station transmitter like the *COMCO* unit shown in Fig. 1, often includes permanent meters in its grid and plate circuit. These are used for tuning and also for monitoring the operation of the high-power stage continuously. In the low-power stages of the fixed transmitter and also throughout the r.f. section of a mobile unit, test jacks are usually provided to permit the insertion of meters as the transmitter is tuned up. In some cases, a single internal meter is provided. Associated with this meter is a selector switch. The latter is used to switch the meter into various key circuits during adjustment.

Tuning the Multiplier

After a multiplier stage has been supplied with proper drive, its plate tank circuit must be tuned to the correct harmonic output frequency. In most communication transmitters, the multiplier stages used are either doublers or triplers. In our example of Fig. 2, the buffer functions as a doubler to develop a 15-mc. component. A tripler stage could follow to increase the frequency to 45 mc. The tripler stage could be followed by two doublers, bringing the final frequency to 180 mc.

In tuning the tripler stage, its plate tank circuit is again adjusted for a plate current dip. As shown in Fig. 4, a plate tank circuit can be tuned to resonance either by varying its capacitance or its inductance. As the tank circuit is brought to the third-harmonic frequency ($3f_o$), the plate current will dip and then rise again if the adjustment is continued in the same direction. Set the adjustment for a minimum plate-current reading.

It is important that the plate tank circuit of a multiplier be tuned to the proper harmonic. In some cases, when this tank tunes over a broad frequency range, it is possible that it can be tuned to other than the correct harmonic. In some transmitters it is advisable to use an absorption wavemeter, as shown in Fig. 4, to make certain that the correct harmonic is selected. This instrument is set to the desired output frequency and coupled as close as is necessary to the output tank circuit. The indicator of the absorption wavemeter will show a maximum when the plate tank circuit is tuned properly. Note that most absorption wavemeters do not have the required accuracy for checking the exact frequency of operation of the crystal oscillator. However, they serve well as a means of selecting a proper harmonic.

The same tune-up procedure is used to adjust the succeeding multiplier stages of the transmitter. Plate tank circuits are tuned for minimum plate current and maximum grid current at the succeeding stage. If the grid circuit is tunable, it is adjusted for maximum grid current, indicating maximum

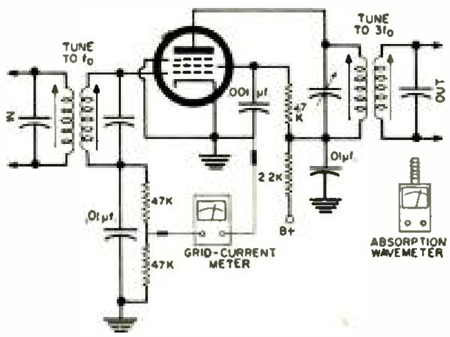


Fig. 4. Tank in tripler plate is tuned to third harmonic of input frequency.

transfer of energy between the plate of one stage and the grid of the next. The intermediate power amplifiers are tuned in the same way, with the exception that their output tank circuits are usually tuned to the same frequency as the input signal. They are being used as straight-through amplifiers instead of frequency multipliers.

The Final Power Amplifier

The final class-C power amplifier of the transmitter must be tuned carefully to permit the most effective transfer of power between its plate circuit and the antenna. As in the tune-up of the preceding stages of the transmitter, the input circuit is tuned to resonance as indicated by maximum grid current. In some transmitters, a specific amount of grid current is suggested. In this case, there is usually a method of regulating the degree of coupling between the driver stage and the final power amplifier. Here the coupling and the grid tank circuit are tuned until the stage draws the recommended grid current when the grid tank circuit is tuned to resonance. If the grid-current reading at resonance is more or less than the suggested value, the degree of coupling is varied correspondingly until the proper reading is obtained.

Many transmitters include facilities for tuning the final power amplifier stage at reduced power. This precaution prevents damage to the more expensive components associated with the higher-powered final stage. After proper grid drive has been obtained, the final power amplifier's plate supply is turned on at reduced voltage. The plate tank capacitor, as shown in Fig. 5, is now tuned for a plate-current dip. Usually there is some coupling between the final tank circuit and the load. This precaution prevents the generation of excessively high r.f. voltages in the output stage.

After the plate tank capacitor has been tuned for a plate-current dip, the high voltage can be turned on. The plate tank capacitor is now re-adjusted slightly for minimum plate current. It is now possible to increase the coupling between the plate tank circuit and the output load. Often the output load is initially in the form of a dummy antenna. Such a dummy antenna displays the same characteristics as the antenna usually used with the transmitter. Thus the transmitter sees a proper load without radiating a signal that could cause possible interference to other stations using the same channel.

With the dummy load attached, the degree of coupling is increased until the tube draws the rated plate current. Often there is some interaction between the plate tank tuning and the loading (degree of coupling). Thus both controls must be adjusted until the rated plate current is drawn when the plate tank circuit is tuned to exact resonance.

The final step in the tune-up of the r.f. section of the transmitter is to pro-

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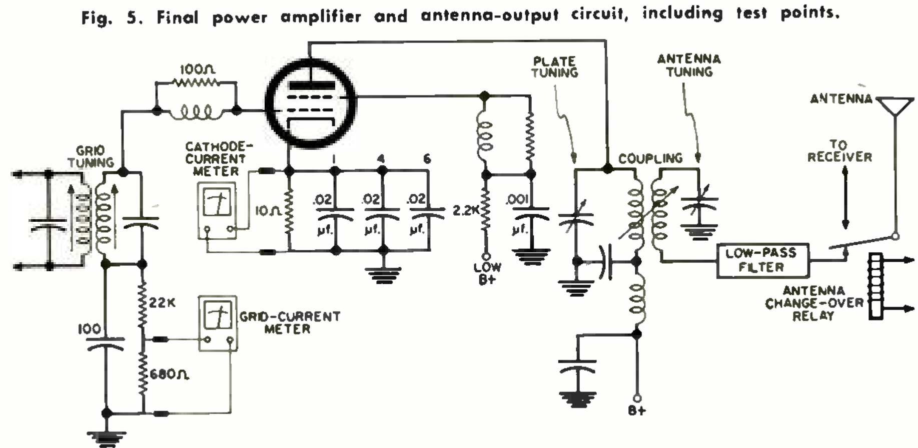
Fig. 5. Final power amplifier and antenna-output circuit, including test points.



A TECHNICIAN SOLVES TRANSISTOR MYSTERIES

By HAROLD DAVIS

Unhappy with conventional explanations, a service technician sweats it out in language he understands.

HOW DOES a transistor work? You mean you don't know either? Well, we have news for you. You have lots of company.

As a result of taking part in a round robin on this subject at the counter of a local parts distributor, the author started a private survey to see whether *anyone* knew, at least among the service fraternity. More than fifty technicians were questioned, including some top-notch men who had been in electronics practically since the field began. This check was rewarding in more ways than one. It not only confirmed the suspicion that there was widespread confusion, but also showed up some of the more common points of weakness.

One great trouble seems to be the matter of terminology. Dozens of books and pamphlets have been written to explain how transistors work. They may make sense, but they seldom use the language that the everyday technician, in service or out, understands. As a result, misunderstanding or confusion can creep in at many points along the way.

Some terms used are unfamiliar. Others are familiar, but have somewhat changed meanings in a new context. Some discussions, dominated by explanations of semiconductor theory, have given many technicians the notion that the transistor is powered by a mysterious self-contained reservoir of energy.

Even so usual a term as "bias" gives trouble. As a service technician often interprets it, bias is a potential applied to a tube to control or limit current flow, apart from other operating voltages. As the term is used in some explanations of transistor operation, he begins to think that perhaps the bias is a source of energy or that the transistor works on bias alone without other operating voltages.

Most technicians have a basic knowledge of electron theory—but the one they learned didn't have any "holes" in it. One such victim asserted he could go along until they started moving the holes; then they could include him out.

Whence the Energy?

It is only natural that the service technician, accustomed to power-consuming, tube-using circuits, wonders where the energy comes from. He has dealt with small radios that draw 30 or more watts off the line, but deliver only milliwatts to the speaker. This is "normal." He has always operated on the theory that you don't get something for nothing, so he doesn't quite see how the transistor gets away with it.

At this point, it helps to find out just how much energy we are talking about and what kind. If you attach leads to the terminals of a common penlite cell so that it can be used to scratch the terminals on the voice coil of a speaker, you can produce a clearly audible noise out of that speaker. You might even say that this sound was at room volume. If you did the same thing with two or three such batteries in series, the noise would be more than adequately loud. Moreover, you could perform this operation for many hours before the battery became exhausted, since energy is drawn from the battery only intermittently, during periods of contact. It is hardly necessary to point out that all of the energy being used to vibrate the speaker cone is coming from the battery.

Suppose you placed a semiconductor device in one of the leads from the battery to the speaker's voice coil. If the polarity of the device were correct with respect to the little voltage source, current would pass and you would get the same action. All the energy would still be coming from the battery.

A transistor is a semiconductor device. If you wired one into the simple circuit as shown in Fig. 1A (an *n-p-n* type would be connected as shown), you could still get similar action. There is another connection, to the base of the transistor, which is not used here, but a voltage fed in here would have a definite effect. It might block the action altogether, or it might encourage it. In fact, if you used a pulse type or varying voltage you could vary the otherwise direct flow of current from battery to speaker. Thus, you could leave the penlite cell connected to the voice coil and do your intermittent "scratching" at the base, which is a control point. Be that as it may, *all the energy is coming from the battery*, although its flow is being regulated through the inserted transistor.

In this light, the transistor can be looked on as basically a control device. It can be made to offer more or less opposition to current passing through it. It may be considered an adjustable resistor whose value can be varied by a varying potential applied to its base. Functionally speaking, you could say as much about a tube. You can vary the resistance of the latter by applying a varying potential to its grid.

The transistor itself has no built-in reservoir of energy. In fact, it doesn't even have an electrode that really emits. The so-called emitter is a misnomer, in the normally understood sense of emission. This is particularly confusing because the tube *does* have an electrode that can emit free electrons—but we have come to call that a cathode!

From this, in fact, we can begin to understand how the transistor "gets away with it." To get a tube to do the job of controlling, we have to do things to it that we don't have to do with a transistor. We have to get the tube's cathode hot to make it give up the electrons that are going to be used. To pull these through the tube, aside from the varying control voltage, we need quite a bit of voltage more or less steadily at the plate. A lot of energy used up in these ways does not show up directly in the work done by the tube. This is why an output tube, for example, uses up much more power than the milliwatts it feeds to a speaker. A transistor doesn't have to be coaxed quite so much to do the same job. For instance, you don't have to use up a lot of power to warm up anything with a heater. The transistor doesn't even have a heater. Most of the energy applied to the transistor is directly involved with the work it is doing.

All Kinds of Bias

The terms "forward bias" and "reverse bias" are not frequently encountered by the service technician. Their use in delineations of transistor circuits seems merely to have added complication to an already complicated business. Stopping to figure out which is forward and which is reverse interrupts a process in which the technician is already trying to figure out something else. What he wants to know and can readily understand is what polarity is applied where. Fortunately, the terms can be put aside in explaining things.

The important point is something we have known about semiconductors ever since we have been working with simple crystal devices—they will pass current in one direction but not in the other. If you put an ohmmeter across a crystal diode, it will show a high resistance connected one way, but a much lower resistance if the meter leads are reversed. In fact, this is our way of determining the condition of such diodes. We can thus avoid much confusion if, instead of forward and reverse bias, we think of applied negative and positive potentials. The transistor, which is often referred to as being two diodes back-to-back, shows similar characteristics with respect to the polarity of voltages applied.

Such terms as reverse, forward, or back bias are for the convenience of the writers and often at the expense of the reader. Moreover, considering the difference in the ways they are used by writers and understood by readers, such a bias isn't a bias at all. Technicians are more likely to understand it as an operating potential.

How Do They Amplify?

Another stumbling block is the often-raised question of how the transistor amplifies. The explanation is quite simple if we are willing to forget, at least for a while, all we have read about holes and hills. The process has its similarities to amplification in a vacuum tube, which is not unfamiliar. We have already mentioned that the d.c. flow through the transistor, which comes from the battery, can be varied to produce a series of pulses that look just like the ones being applied to the transistor's base. However, the pulses thus produced are quite large compared to the weaker ones being applied. In the long run, a tube accomplishes the same thing, with weak pulses applied to the grid varying current through the tube to produce stronger ones of the same shape. Within each of these devices however, the manner in which this is done is different.

At this point, it is helpful to consider what is inside a transistor. It consists of three electrodes: the emitter, the base, and the collector. These electrodes are actually very small blocks of semiconductor material sandwiched together. The base, which is in the middle of the sandwich between the emitter and the collector, is extremely thin, even when compared to the other two electrodes. Its thickness is measured in thousandths of an inch.

Of the two types of transistors, it will be easier to follow the action in an *n-p-n* type, as in Fig. 1B. Electron movement is from the battery's negative terminal, through the emitter (the first semiconductor), on to the collector (the second

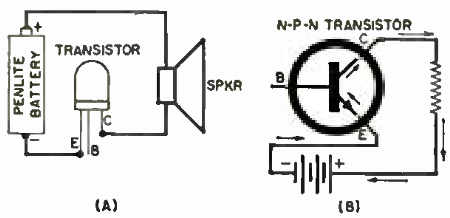


Fig. 1. All energy used (A) comes from battery but is controlled by the transistor. (B) Typical "n-p-n" relationships.

semiconductor), and through the latter back to the battery (positive terminal). To pass from emitter to collector, the electrons must go through the element in the sandwich that has been inserted between these two semiconductor elements. The inserted element, of course, is the base. This relationship puts the base in a position to control electrons going through it.

How is this control performed? Well, we have only to remember that like charges repel each other but that unlike charges attract. If the base is made relatively negative, it will repel or slow down the movement of electrons, which are negatively charged, as these particles try to move from emitter to collector. If the base potential becomes more negative, this action increases until the movement from emitter to collector is stopped altogether. Then the transistor is cut off.

On the other hand, if a voltage were applied to the base to make it relatively positive, this electrode would attract electrons coming from the battery and going to the emitter, since unlike charges attract. However, the electrons thus drawn to the base would not stay there. One reason for this is the extreme thinness of the base material, which helps it to act like a sieve. It attracts electrons with enough force to propel them through the base and beyond, with a little encouragement. Such encouragement is provided by the collector, which, being more positive than the base, quickly attracts from the latter the electrons that are drawn to it.

This ties in with the previous comparison between the transistor and a dynamically variable resistor. The base potential decides the opposition, or lack of it, that the transistor will show to current passing through, thus also determining and varying the effective resistance of the device. The base is like the variable arm of a potentiometer. You could get somewhat similar action from a potentiometer if you connected a battery across one fixed terminal and the movable arm; then hooked up a 60-cycle a.c. motor so that it moved the arm back and forth during rotation.

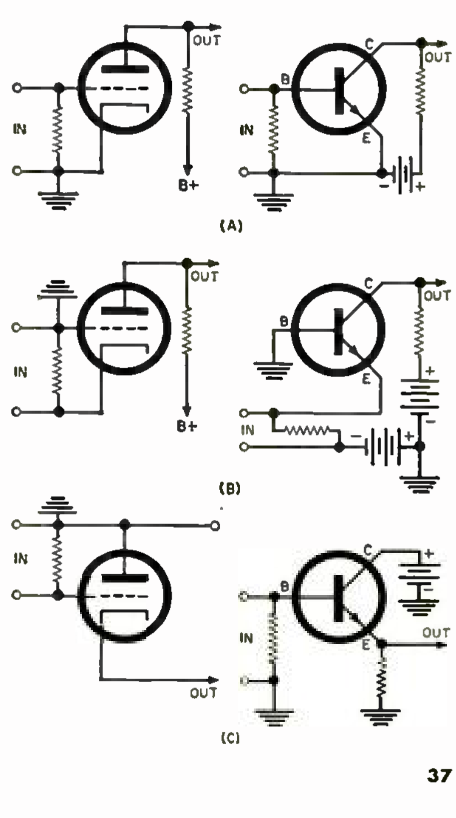
In the transistor, the weak signal applied to the base, which could be 60 cycles, does the job of the motor and the moving arm. The transistor's resistance goes up or down in direct proportion to the signal variation at the base. So battery current, as it passes through this resistance, goes up as resistance decreases and goes down as resistance increases, but it stays in step—that is, all of the battery current except for a small amount known as leakage current, which is used to fill up some of those holes.

About This "Hole" Thing

Well! We'd rather not bring up the subject at all, but it is better to face it

(*Continued on page* 96)

Fig. 2. Popular tube-using circuits, like the conventional amplifier (A), grounded-grid (B), and cathode-follower (C), have transistorized equivalents.



Easter Boosters For Service Business

Seasonal promotional ideas that have paid off for the alert shop owners who use them. Try them yourself.

By WILLIAM DUFER, Jr.

EASTER has long been associated, in people's minds, with the notion of rebirth or a fresh start. Chronologically it is close to the beginning of spring, or the spring-summer cycle of renewed activity and vitality. Many alert owners of service shops take advantage of this turning point, in more ways than one. Here are some actual examples of activities that have been successfully tied in with the holiday by radio-TV service establishments.

Cerone's TV of Syracuse, N. Y. gets the season under way in fine fettle with an Easter Housecleaning. Actually, this program involves more than one project. One of them is a housecleaning sale of used radios, TV sets, and car receivers that may have been gathering dust in the storeroom. On the other hand, there is a promotion directed to those who are conducting their own housecleaning operations at this time. *Cerone* invites them to bring in their own ancient radio and TV sets, no matter in what condition. He then evaluates them, with two possibilities in mind. He can put them in working shape for the present owners, for use as extra sets in the guest room or play room—all at very reasonable rates for this special promotion, of course. Or else, he will pay cold cash for them, re-condition them, and then sell them as part of his own housecleaning operation.

This shop owner takes advantage of the seasonal spirit in another way. Like every home, every service shop can stand a periodic housecleaning and reorganization. Easter is the logical time. If any interior or exterior painting is needed, this is the time to do it. Perhaps window and shop displays have become a little worn or dusty or perhaps they have lost their impact simply from having become too familiar. This is the time to re-arrange and spruce up. It fits in particularly well with the special business drive.

The functional portions of the shop also get close scrutiny. Work benches and test equipment get the once-over. Is everything working right and organized for optimum efficiency? This is a good time for checking stock and making out inventories.

The actual work required to launch the all-out campaign is begun some time before the holiday begins, of course. Then, one week before Easter, the shop is able to hold Open House, encouraging customers to drop in for any reason at all, or just to say hello. In this shop, the owner also promotes special reduced rates for inspecting and estimating repairs on any sets brought in during the period.

Ross Radio-TV, Binghamton, N.Y., sees the Easter season in another light. The owner's great hobby is fishing, and there are many people in his area whose interests correspond with his. As far as he is concerned, one meaning of Easter is that it is the prelude to the fishing season. He has worked out a cooperative arrangement with a local sporting-goods dealer. The displays in his shop windows feature a choice collection of rods, reels, tackle, and anything else that would interest the dyed-in-the-wool angler.

With posters and other means, he announces his unique fishing contest. Since this stunt lasts until after Labor Day, it has continuing promotional value for a large portion of the year, especially during the slow summer months. This shop keeps a set of accurate scales on the premises. Anyone may come in to have his or her catch weighed and confirmed at no charge. The angler receives a simple and inexpensive verification card, which attests to the true weight, kind of fish landed, the time and location of the catch, and the person who brought in this prize.

More to the point, this shop awards $2 each for the biggest "catch of the week" throughout the contest period. There is also a $5 grand prize, awarded shortly after Labor Day, for the biggest catch of the entire season. This contest keeps customer attention focused on the shop during a period when a boost is most needed.

The impact on service business is a little more direct than has been indicated so far. Window posters and other promotional materials suggest that this is a good time for all fishing enthusiasts—and any other people who expect to have some outdoor fun during the pleasant months—to prepare themselves in other ways. Car radios, transistor radios, and other portables should be checked to make sure that they are "ready to go" *before* they are taken along on the first trip. Are they in working condition? Do they need batteries? This is the kind of business the contest helps pull in. Of course, such radios that may be in tiptop condition at the season's start can also break down at some point along the way. The continuing attraction of the contest brings these in too. Once you have the customer, you can also do some far-sighted promotion to get the TV set in shape before the fall viewing season begins.

Still another seasonal stunt is used by *Ken's Radio Service*, also of Binghamton. The owner reasons that everyone—well, nearly everyone—replenishes his or her wardrobe at this time of the year. A drawing for service patrons is tied in with this widespread custom. Two-section coupons are issued to patrons on all cash deals. Technicians making house calls carry a supply. The stub from each coupon issued is removed by the member of the shop who handles the transaction and deposited in a container on the shop premises. This practice begins with the first day of Lent.

During the week before Easter, the shop holds its well-publicized drawing. Two fortunate individuals receive credit slips, made good by the shop, that may be used at either a well-known men's clothier or an equally well-known, local women's specialty shop. Each of these slips is good for $20 worth of Easter finery. A third prize in the form of a similar $10 slip is also offered.

News of *Ken's* apparel give-away is brought to the public's attention *via* a series of newspaper ads. The particular shop owner feels that the cost of this promotion is justified by the results. Others who are not too sure about the effectiveness this scheme will have for them or whose budgets will not allow such an expenditure can scale the costs down for the first try. Less generous amounts can be offered. If the service area is not a large one, handbills may be more practical for the announcement than newspaper ads.

(*Continued on page* 117)

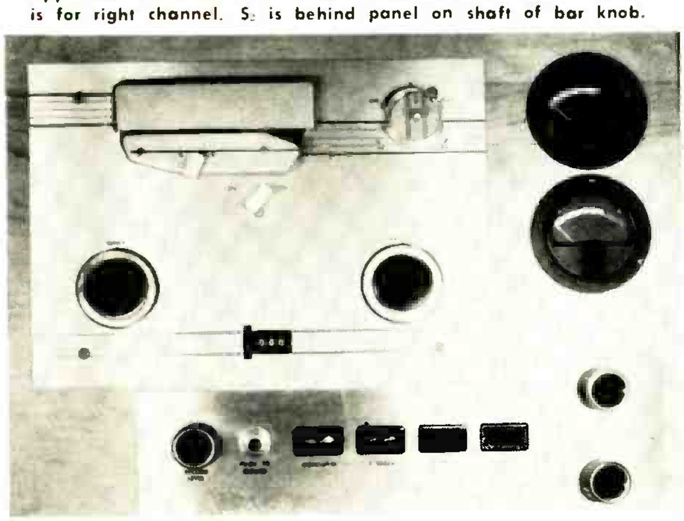
FOUR-TRACK TAPE SYSTEM

Complete construction details on the electronics portion of a home-built 4-track stereo record-playback system.

By **KENNETH F. BUEGEL**

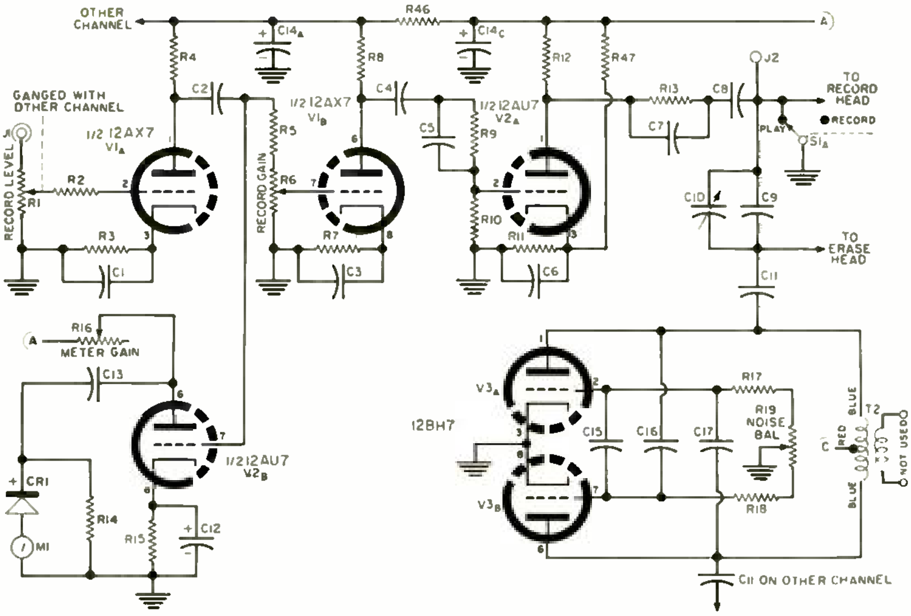
Part 1-Record Preamps

Upper meter on author's recorder is for left channel; lower meter is for right channel. S_2 is behind panel on shaft of bar knob.



THE AUDIOPHILE interested in recording his favorite discs or stereo broadcasts on tape soon discovers that his choice of equipment is somewhat limited. He may either purchase a system which includes a preamplifier for each playback channel and a recording amplifier for each channel plus a junction box to tie them together in a functioning unit, or settle for an expensive recorder which offers little hope of change for future requirements. Some combination record-playback tape amplifiers are available in kit or factory-wired form, but the author decided to design and build his own.

The new laminated-core four-track heads marketed recently open a new area of interest for the home recordist. The claims made on behalf of these heads include high-frequency response beyond that of any two-track head previously offered and crosstalk ratios not in excess of the previous values. Crosstalk in a two-track head used for stereo simplifies into a matter of channel separation and anything in excess of 25 db would be gilding the lily. In four-track tapes the adjacent track contains music played in reverse with respect to the desired track and if the crosstalk were not held to the stated values of



R_1—Dual 1 megohm audio taper pot*
R_2—330,000 ohm, ½ w. res.
R_3, R_{11}—5600 ohm, ½ w. res.
R_4, R_{10}—220,000 ohm, ½ w. res.
R_5—1 megohm, ½ w. res.
R_6—1 megohm audio taper pot
R_7—4700 ohm, ½ w. res.
R_8, R_{12}, R_{13}—100,000 ohm, ½ w. res.
R_9—2.2 megohm, ½ w. res.
R_{11}—2200 ohm, ½ w. res.
R_{14}—47,000 ohm, ½ w. res.
R_{15}—1000 ohm, ½ w. res.
R_{16}—100,000 ohm linear taper pot
R_{17}, R_{18}*—4700 ohm, ½ w. res.*
R_{19}—10,000 ohm linear taper pot*
R_{20}—22,000 ohm, 2. w. res.*
C_1, C_2—.01 µf., 200 v. paper capacitor
C_3—.0047 µf., 400 v. paper capacitor
C_4, C_6—.02 µf., 400 v. paper capacitor
C_5—25 µµf. disc ceramic capacitor ± 10%
C_7—82 µµf. disc ceramic capacitor ± 10%
C_8—.25 µf., 600 v. Mylar capacitor ± 10%
C_9—100 µµf., disc ceramic capacitor ± 10%
C_{10}—10-100 µµf. padder
C_{11}—1000 µµf., 600 v. Mylar capacitor ± 5%
C_{12}—1 µf., 6 v. elec. capacitor
C_{13}—.1 uf., 600 v. paper capacitor
C_{14A}-C_{14B}-C_{14C}-C_{14D}—40/40/20/20 µf., 450 v. elec. capacitor (two sections used for playback preamps)*
C_{15}—1000 µµf., 600 v. Mylor capacitor ± 5%*
C_{16}, C_{17}—330 µµf., 600 v. Mylar capocitor ± 5%*
J_1—Phono jack
J_2—Pin jack
S_1—3-pole d.t. rotary switch (see Fig. 2)*
T_2—Bias oscillator trans. (Ampex No. 58-0016)*
M_1—0-1 ma. meter, 3" (see text)
CR_1—1N34A crystal diode
V_1—12AX7 tube
V_2—12AU7 tube
V_3—12BH7 tube*
**Parts so marked are used once in the circuit. All other parts must be duplicated for the second channel of the stereo setup.*

Fig. 1. The bias oscillator, V_3 is common to both channels, but the remainder of the recording preamplifier, made up of V_1 and V_2, must be duplicated for other channel.

¼" bonding strap between the jack panel and preamplifier chassis will reduce hum to inaudible levels. The power supply (Fig. 2) is remotely located with the "B-" line grounded only at the preamp chassis. The power transformer primary is fused but no "on-off" switch is shown since it is connected to a controlled receptacle. R_{38} limits surges through the silicon rectifiers when power is first applied. The voltage divider, consisting of R_{36} and R_{37}, serves as a bleeder resistor and also applies about 25 volts to all heaters to eliminate leakage from heater to cathode.

Record Preamps

The recording signal from a stereo control center is applied through J_1 to R_1, a dual "Record Level" control for both channels, and amplified in V_{1A}. (See Fig. 1.) The output of V_{1A} is coupled to a chassis control, R_6, and to meter amplifier V_{2B}. The "Meter Gain" control, R_{16}, acting as the plate load of V_{2B}, varies the amount of audio applied to rectifier CR_1 and the 0-1 ma. meter. The 3" meters used in this equipment have had the scales removed and repainted with a white scale line extending to the 70% point and a red scale line from 70% to 100%.

The "Record Gain" control, R_6, allows adjustment of the signal applied to the tape for each track. R_9, C_5, and R_{10} form an equalizing network so that the signal to the grid of V_{2A} increases with frequency. C_7 and R_{13} in the plate circuit of V_{2A} serve a similar purpose. These networks are necessary since the recording head is a wide-gap (.00025-inch) type to effectively record low frequencies.

In the interest of conserving your investment in heads, it is recommended that the highest quality capacitors

-55 db, this might produce problems.

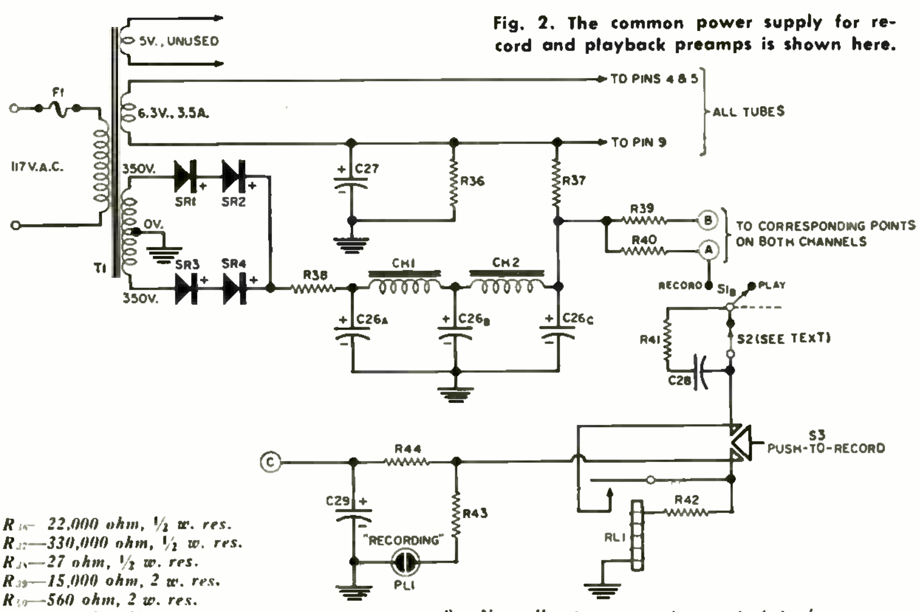
Investigation of the results obtainable with preamplifiers matched to a set of these new heads proved out all the claims for them. The unit described in this article and in Part 2, provides complete recording and playback facilities of excellent quality. Frequency response from record input to playback output is flat within ± 1 db from 50-10,000 cycles. The playback response alone is flat within ± .5 db over the same range, as determined from a professional-quality alignment tape.

The basic tape deck used in this construction is a *Viking* Model 85 with an 85Q5 erase head, 85RQ2 record head, and 85Q2 playback head. The tape deck with all four-track heads mounted at the factory is catalogued as the Model 85-RMQ. *Nortronics, Inc.*, manufacturers of magnetic heads, has the following head types for the same application: erase, SE50-1; record, TLB7R; and playback, TLB-2. These heads are available from the manufacturer in a variety of mounting styles to fit different tape decks.

Power Supply

All Model 85 tape decks are designed to use separate signal grounds for each head winding except the erase head. A

Fig. 2. The common power supply for record and playback preamps is shown here.



R_{36}—22,000 ohm, ½ w. res.
R_{37}—330,000 ohm, ½ w. res.
R_{38}—27 ohm, ½ w. res.
R_{39}—15,000 ohm, 2 w. res.
R_{40}—560 ohm, 2 w. res.
R_{41}—100 ohm, ½ w. res.
R_{42}—22,000 ohm, 2 w. res.
R_{43}—100,000 ohm, ½ w. res.
R_{44}—470 ohm, 1 w. res.
C_{26A}-C_{26B}-C_{26C}—50/40/30 µf., 450 v. elec. capacitor
C_{27}—4 µf., 60 v. elec. capacitor
C_{28}—.005 µf., 600 v. disc ceramic capacitor
C_{29}—8 µf., 450 v. elec. capacitor
S_{1B}—3-pole d.t. rotary switch (part of S1, Fig. 1)
S_2—S.p.d.t. Micro Switch (see text)
S_3—Normally open, momentary contact, push-button switch
CH_1, CH_2—15 hy., 85 ma. choke (Chicago RC 1585 or equiv.)
PL_1—¼ watt neon lamp
SR_1, SR_2, SR_3, SR_4—750 ma., 420 v. silicon rectifier (F6 or 60H)
F_1—1.2 amp fuse
RL_1—S.p.s.t. relay, 5000 ohm coil
T_1—Power trans. 350-0-350 v. @ 90 ma.; 6.3 v. @ 3.5 amps (Triad R11A or equiv.)

available be used for C_9 and C_{10} since a breakdown here will result in an open head winding. J_2 is a single-point test jack used when setting the gains of the record amplifiers. Two sections of S_1 short the record head windings in the "Play" position. Another section opens the "B+" line to the bias oscillator and prevents erasure of pre-recorded tapes. Note that "B+" is not switched in this preamplifier; thus one of the most common causes of head magnetization is entirely absent in this particular set-up.

The bias oscillator for both channels is a 12BH7 operating at 100 kc. The oscillator transformer is an *Ampex* No. 58-0016, obtainable through most dealers handling this company's product. The unused leads may be cut short and taped or unsoldered from their lugs. The "B+" de-coupling network, R_{11} and C_{23} in Fig. 2, allows the erase voltage to build up slowly and eliminates clicks on the tape.

S_2 is a small Micro Switch adjustable in slots cut in a piece of sheet metal attached to the tape-deck frame. This switch is actuated by a cam added to the tape deck, as shown in Fig. 3. The switch is normally closed and the cam opens the contacts whenever the tape motion switch is thrown from "Neutral" to "Play," or the reverse.

Since "B+" to operate the bias relay, RL_1, passes through these contacts and one section of S_1, whenever the deck tape motion is changed the relay contacts carrying "B+" to the bias oscillator will open, thus preventing erasure of a recording just completed. PL_1, a ¼-watt neon pilot assembly, is connected to the bias "B+" line through a 100,000-ohm resistor, R_{15}, and indicates when bias voltage is applied to the erase and record heads. To record it is necessary to depress the "Push-to-Record" button while setting the tape motion switch to the "Play" position. With S_1 in the "Record" position, "B+" will be applied through R_{12} and RL_1. The relay will stay closed until the tape motion switch position is changed. The bias adjustment of C_{10} may be set to operate in either of two modes. With C_{10} at maximum capacity the peak recording level is slightly reduced but frequency response is flat within the stated range. If the bias voltage is peaked, as read by v.t.v.m. at J_2, the level is higher but the high-frequency response will drop off more rapidly. For the flattest possible response C_9 and C_{10} may be replaced by a single 200 μμf., 10% disc ceramic capacitor.

The parts list for Fig. 1 is to be *duplicated* except for those parts marked with an asterisk. The parts listed are those needed for *each channel*. All filament wiring is #20 solid hookup wire, twisted. All other wiring under the chassis is #22 solid. Braided-shield single-conductor cable, with an outer insulating jacket, is used for leads to head windings. The input jacks are the double type with insulation to prevent a ground to chassis at the mounting point. The cable grounds are carried through and connected to the chassis at the tube ground point.

Part 2 of this series will cover construction of the playback preamps, physical alignment of the heads, and adjustment of the system, along with the simple change needed in most stereo control centers to fully utilize the exclusive features found in this system.

(Concluded next month)

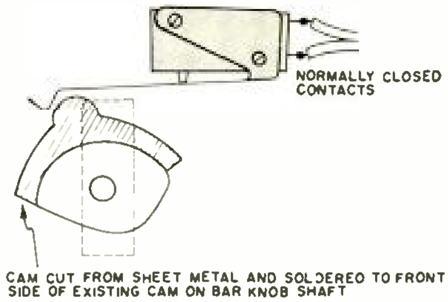
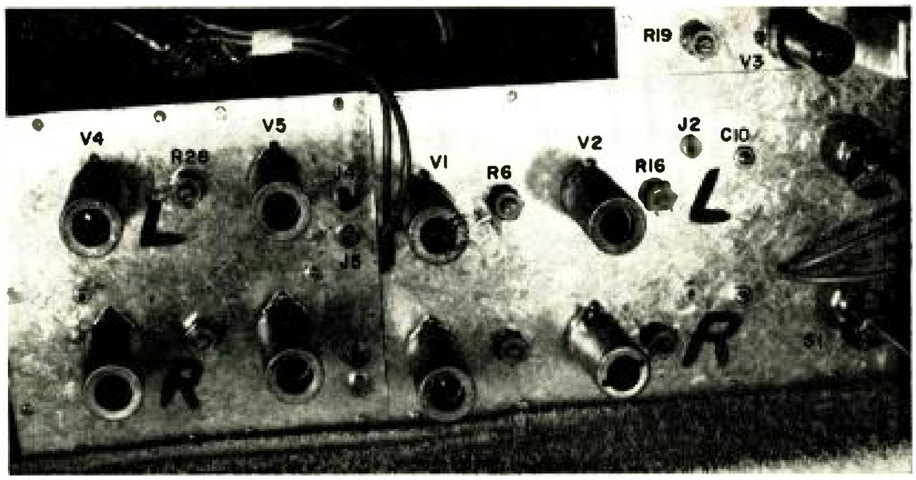
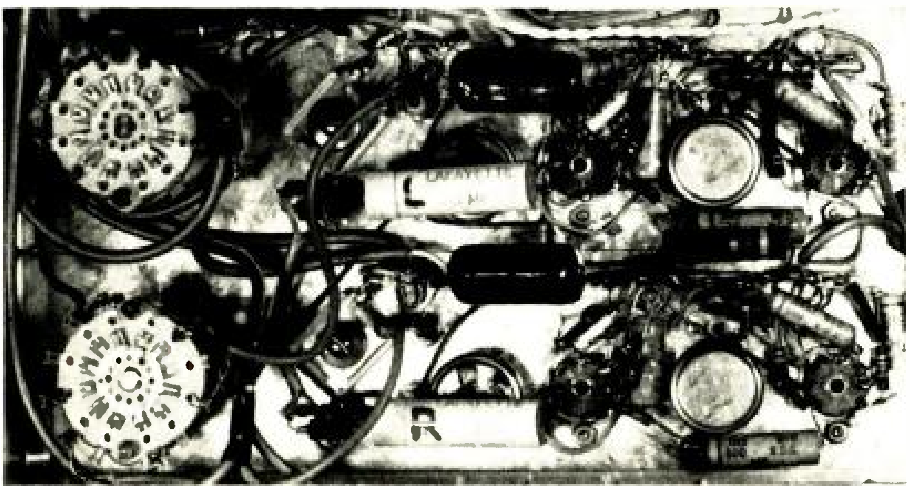


Fig. 3. Details of the switch S_2.

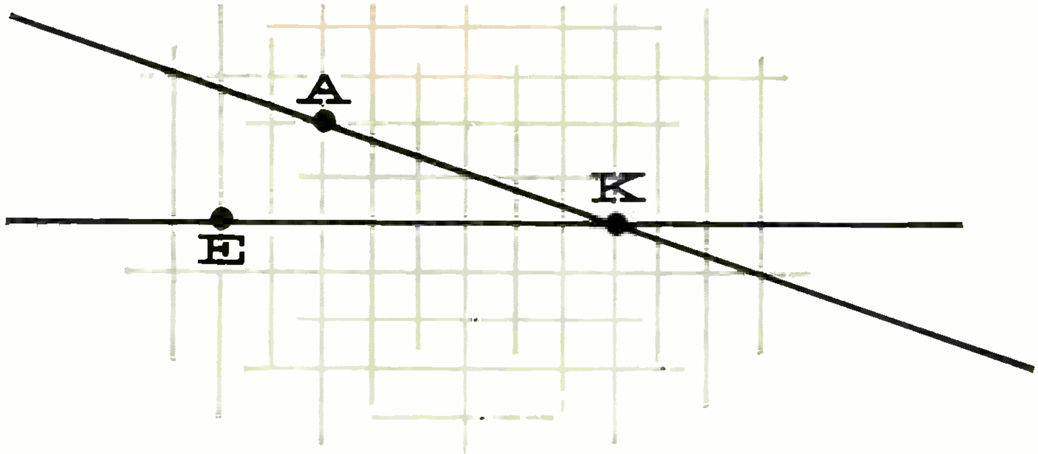


Top-chassis view. Recording section is at right and playback section is at left.



Inside view of the tightly wired recording preamps. Minimum lead lengths were used.

This type of deck, although not actually employed by the author, would have been suitable for use with the preamps. If a dual-purpose record/playback head is incorporated in the particular deck chosen, it will be necessary to add a switching circuit to connect the head to either record or playback preamp, as needed. Also, the equalization and bias oscillator circuits may have to be altered somewhat to match the characteristics of the heads.



VOLTAGE DIVIDERS MADE EASY

By JIM KYLE

Forget complex formulas or interminable trial and error substitutions with this quick graph method.

ONE OF the most widely used and apparently simple circuits in electronics is the voltage divider. Consisting of only two resistors (Fig. 1) in its most basic form, it can be employed to cut down voltage to a desired size in almost any conceivable application. The configuration is simple enough so that it seldom gives trouble. Service technicians, amateurs, and experimenters run across these dividers regularly—daily, if they are involved with electronics on any sort of "professional" basis.

However, running into a voltage divider is one thing, and designing one for a particular need is another. Problems arise, and they are not always fully anticipated. For example, one might cut down a voltage to a desired level by determining the ratio between the original one and the one desired. Then the values of resistors R_1 and R_2 in Fig. 1 would be selected to result in this ratio. But what happens to division when load current is drawn?

If a "stiff" divider is chosen—one in which load current is such a small fraction of bleeder current that the load causes little voltage variation—how stiff should it be? In other words, aside from the ratio between the two resistors, what should their total resistance be? The fact that the load is actually across the bleeder in the divider (R_2) changes relationships in the "simple" circuit. This factor may begin to make design a little tricky. Our purpose is to provide answers to such questions as these, thus making voltage-divider design no more complicated than Ohm's Law. As a matter of fact, virtually all of the relationships to be considered stem from Ohm's Law.

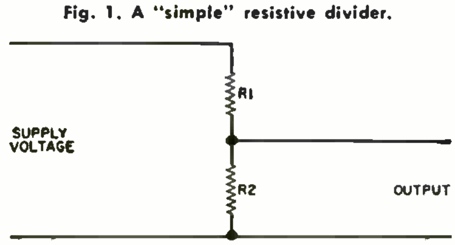
Since the drop across a resistor is proportional to the current flowing through it, any increase in current flow through the upper half of the divider (R_1 in Fig. 1) will increase the voltage drop across it, lowering the voltage at the output connection. For instance, if supply voltage is 300 and the divider consists of two 150,000-ohm resistors, output voltage across R_2 will be 150 volts—with no load. Total current drawn under these conditions will be 1 ma. Now if a load that draws .3 ma. is connected across R_2, the total current of 1.3 ma. through R_1 will produce a drop of 195 volts across the upper resistor. Output voltage will then be 105 instead of 150 volts. If the load were to draw half a milliampere, output voltage would drop to 75—half the original value.

This effect can be minimized by making the total current which passes through R_1 many times greater than the load current. This also improves regulation, since changes in the relatively small load current will have little effect on the voltage across the dropping resistor and therefore little effect on the output voltage. A rule of thumb frequently used on the bench is to make bleeder current at least ten times as large as load current. This works well with low-power devices, when total current drawn can be kept, say, below 50 ma. But such a solution is extremely wasteful when high-power circuits are involved.

Standard Divider Design

Let us consider the more sophisticated techniques used, such as those involved in the commercial design of voltage dividers. Three voltage levels are determined. First, the highest voltage that can be tolerated under no-load conditions is established. Then the working voltage under normal load is considered, and finally the lowest voltage that is tolerable under conditions of heavy load or overload. Finally, these three values are plugged into a set of mathematical equations. These equations are so devised that they will not only give resistance values that will meet the maximum and minimum requirements just described, but will also be as economical of power as is possible or practical.

Fig. 1. A "simple" resistive divider.



The calculations involved can become quite a chore. However, the same end can be achieved much more simply by projecting the problem geometrically on a piece of linear graph paper. The accompanying charts accomplish this, taking the place of the equations. If you follow the method to be described, you can design any divider according to approved, commercial engineering practice. The mathematics required this way will be no more than simple arithmetic, and there will be very little of that.

As in commercial practice, you will first have to decide on the three voltage levels already mentioned: the maximum, permissible no-load voltage; the normal operating voltage; and the lowest, permissible output voltage under overload. The normal current to be drawn at the regular operating voltage must also be known. The output voltage of the power supply will, of course, be known too.

Using the Graph

The next step is to locate these values on a graph like the one shown in Fig. 2. For the moment, ignore the actual case worked out on this chart. Simply note that we have linear divisions, with the vertical ones representing a voltage scale and the horizontal ones a current scale. While numbers have been shown on these scales, no units of measurement have been identified. This has been done because the magnitude of the quantities measured may be suited to the problem without any other changes in the graph. For example, the horizontal scale may represent amperes or microamperes, and the vertical scale may be in volts or millivolts. Also, it may be convenient to add zeros. For example, calibrations on the horizontal scale, shown extending from 1 to 15, could be changed to extend from 10 to 150. Results will be accurate as long as the same units are maintained consistently throughout the procedure.

The general method goes like this: the maximum no-load voltage, E_N (with no current drawn) is plotted along the voltage axis at the left, which is the zero-current point on the horizontal scale. Then plot the point where the normal-load voltage and current intersect. Next rule a horizontal line across the graph at the level of the lowest permissible (overload) voltage, E_O. Now draw a straight line connecting the first two plotted points and extend this diagonal to touch the current scale. Note the current value at the latter point, and convert it to read in amperes. This can be called I_M for convenience.

Now for some arithmetic. Divide supply voltage (E_S), in volts, by the current just determined, I_M. The answer is the value, in ohms, of dropping resistor R_1. With this information, the value of R_2 may now be determined. (If the value of R_1 is rather large, it may be convenient to convert it to kilohms or megohms for convenience in calculation, but voltage and current are still in volts and amperes.) Multiply R_1 by the supply voltage (E_S). Divide this product by the difference between the supply voltage (E_S) and the no-load voltage (E_N). The answer will be the value of R_2 in the same resistance units chosen for R_1. For those who find simple formulas to be convenient, $R_1 = E_S/I_M$, $R_2 = R_1E_S/(E_S - E_N)$.

This completes the design of the divider, but another check is advisable to determine whether bleeder current (I_B) is too high. Add the values of R_1 and R_2 (in ohms) and divide supply voltage E_S by this sum. This will give the bleeder current in amperes: $I_B = E_S/(R_1+R_2)$. Where this current seems too high—as may be the case where extremely close regulation has initially been chosen, reflected in the minimum and maximum voltage limits—it may be practical to sacrifice some regulation to reduce the current. In that case, set the maximum, no-load voltage (E_N) somewhat higher and repeat the process.

Establishing E_N involves some realistic considerations. The least expensive way is to choose a point just below the maximum-voltage ratings of capacitors, tubes, and other components in the load equipment. The higher the no-load voltage level used, the less power will be used in the divider circuit, but regulation will suffer. A compromise may be worked out that is on a practical basis.

A somewhat special case may arise in which the circuit or device that will draw power through the divider is on continuously. The no-load voltage level now becomes relatively meaningless with respect to component ratings and possible breakdown. In this case, we start with the current that will be drawn under minimum load, rather than zero current, and the maximum voltage that will be tolerated under this minimum-load condition, rather than the maximum voltage that would exist under no load at all.

From the current and voltage thus established, we project our first point on the graph. The rest of the graph is drawn up in the way already described, with one exception. When the diagonal load line is ruled, it is extended in both directions, so that one end touches the voltage scale and the other touches the current scale. The point where it intersects the voltage scale is E_N, the no-load voltage that would exist if the equipment that is being powered were not operating but still connected to the supply. We need this value for our calculations. Also, there is one change in calculating R_2. This will now be equal to $R_1E_N/(E_S - E_N)$.

Illustrating the Method

Examples of both procedures have been worked out in Figs. 2 and 3. The basic case is illustrated in Fig. 2. A divider is to be placed across a 650-volt supply to deliver 250 volts at 50 ma. under normal conditions. Maximum no-load voltage is to be 500; minimum voltage at overload is to be 200 volts. In this case, units on the voltage scale represent 100-volt steps, while current intervals are at 10 milliamperes. The first item plotted is point *A* for E_N, which is 500 volts at 0 ma. Point *B*, where the normal load voltage of 250 volts intersects the normal load current of 50 ma., is plotted next. Now horizontal line *C* is ruled at E_O, the minimum or overload value of 200 volts. Next, points *A* and *B* are connected by drawing the load line, which is extended to intersect the current scale at point *D*. The current read at this point is .095 ampere. This is the value, I_M, that will be used in calculations.

The first calculation can now be made. The value of R_1 in ohms is equal to supply voltage E_S, 650 volts, divided by the current at point *D*, I_M. This comes out to 6842 ohms. A standard value, 6800 ohms, is used with little error.

To find R_2, 6800 ohms is multiplied by the 650 volts of the supply and the product (4,420,000) is divided by the difference between the supply voltage (E_S is 650) and the no-load voltage (E_N, which is 500). Thus we divide by 150. The solution for R_2 comes to 29,467 ohms. We use a standard, 30,000-ohm resistor.

We can also determine the current that will be drawn at the overload point, without further calculation. Looking at the graph of Fig. 2, we note that line *ABD* intersects line *C* at point *E*. This is the overload or maximum current. Bleeder current is simply the supply voltage divided by the total resistance of the divider, R_1 and R_2. It comes to .0176 ampere.

For the second example (Fig. 3), we can start with the same power supply and the same device to be connected to it. However, the minimum-current, maximum-voltage level now used as a starting point is set at 10 ma. and 350 volts. This is plotted at point *V*. Once more the normal operating conditions (250 volts at 50 ma.) are plotted, this time as point *W*. The 200-volt line for overload is now drawn as line *X*. Load line *VW* is drawn and extended to intersect the voltage scale at *Y* and the current scale at *Z*. The voltage at *Y*, 375 volts, is now used as the no-load voltage for calculations.

Current at *Z* is now used to determine R_1, which comes out to 4700 ohms as the nearest practical value. To determine R_2, a change has been made in the formula. First we multiply R_1 by voltage E_N at point *Y* (instead of using supply voltage E_S). Then, as in the first case, this product is divided by the difference between the supply voltage and the theoretical no-load voltage at point *Y*. The answer is about 6400 ohms. The nearest standard value is 6200 ohms.

Bleeder current would, once more, simply be the supply voltage divided by the total resistance in the divider, which is 10,900 ohms. This current is .0596 ampere. Comparing this value to the one determined for the divider worked out using Fig. 2 brings up an interesting point. The divider worked out for our second example (Fig. 3) provides much better regulation, but the price is inevitably paid in that bleeder current goes up more than three times.

Power rating for the divider resistors is found simply from $P = E^2/R$. Just make sure that, for each resistor, you are using the maximum voltage that will appear across it for *E*. —30—

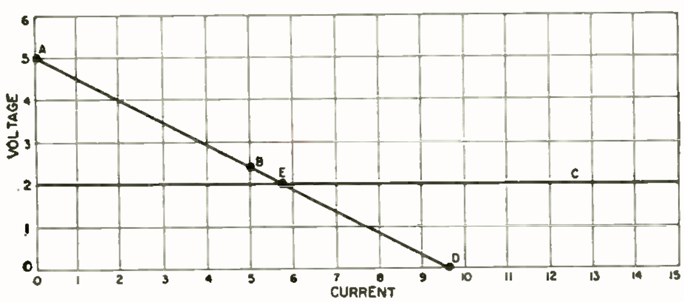


Fig. 2. How pertinent voltage-current relationships are plotted.

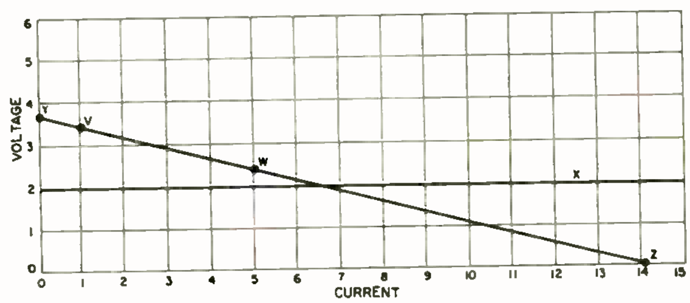
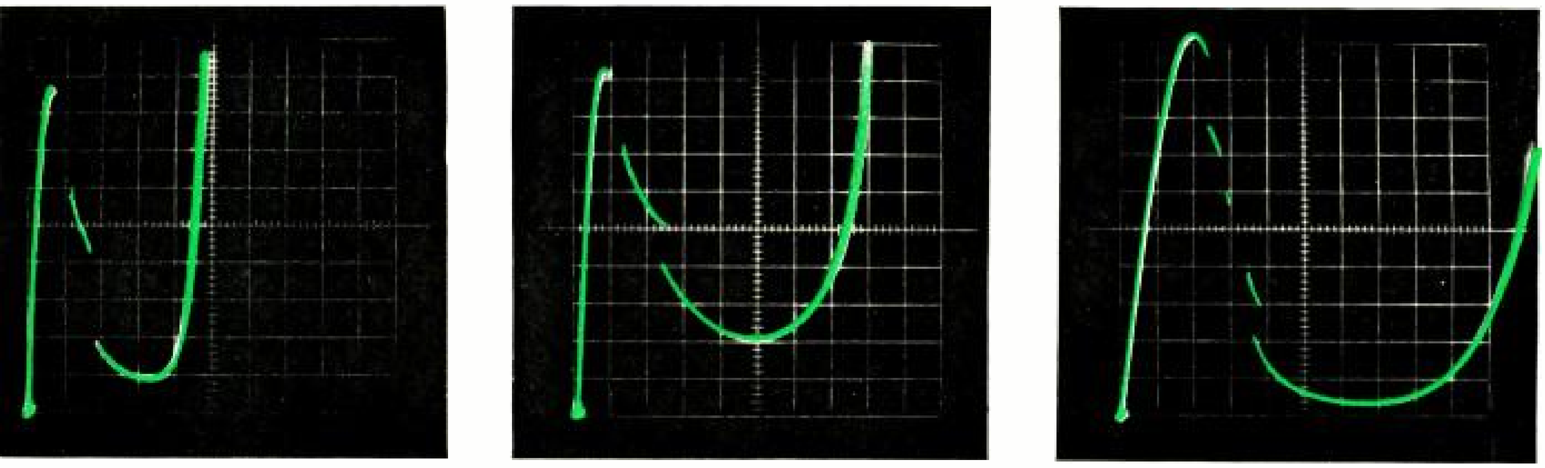


Fig. 3. An alternate method when equipment is on continuously.

Tunnel Diodes Simplified



GERMANIUM SILICON GALLIUM ARSENIDE

Scope traces illustrating the tunnel diode performance of germanium, silicon, and gallium arsenide units.

By DONALD L. STONER

These special crystal diodes may someday be as widely used as transistors. Here is how they work, along with some simple circuits demonstrating their application.

TUNNEL diodes, the latest tool of the design engineer, are now commercially available in production quantities to original equipment manufacturers. Before long, manufactured equipment will contain tunnel diodes. Since they may one day become as numerous as transistors, people in the electronics industry should have a working knowledge of how these amazing devices function.

The tunnel-diode effect was discovered by Dr. Leo Esaki. In a 1958 issue of *Physical Review* (Vol. 109, page 603), Dr. Esaki published his now-famous paper "New Phenomenon in Narrow Germanium *p-n* Junctions." Little did he realize the economic and scientific implications of his discovery.

Analogy

It is always easier to explain how something functions or how to complete a complex process by comparing it with a more common, easily understood device. So it is with the tunnel diode. As an example we will use the lowly neon bulb. Everyone is familiar with this device—a pair of electrodes in a gas-filled (neon or argon) atmosphere. When sufficient potential is applied to the electrodes, the gas ionizes and the bulb "lights up." Although they differ in many respects, there is a definite analogy which can be used to simplify the explanation of tunnel-diode action.

When the potential applied to most electronic components is increased, the current flow through the component increases proportionately. This is not the case with the neon bulb, however. As the voltage applied to a neon bulb is increased, nothing happens until the *firing potential* is reached. At this point the gas suddenly ionizes and the internal resistance of the bulb drops to a very low value. If the voltage is increased well beyond the firing point, excessive current flows and the atomic structure of the gas breaks down (avalanches) destroying the usefulness of the bulb. If the applied potential is reduced, the bulb will remain ionized until the *extinguishing potential* is reached. This point is noticeably lower than the firing point. The important thing to remember is the *increase* in voltage produces a *decrease* in resistance. This effect, called *negative resistance*, can be put to good use in *negative-resistance oscillators*.

Fig. 2A shows the circuit for a simple negative-resistance oscillator using an NE-51 neon bulb. Many amateurs and experimenters have constructed this device for use as a telegraph code-practice oscillator. By breaking the battery lead with a telegraph key, the circuit will produce a series of dots and dashes in the headphones connected to the output terminals.

Before the battery is connected, capacitor C_1 reacts much the same as a short circuit. The neon bulb is an infinitely high resistance since it is not ionized (or conducting). At the firing point, the bulb ionizes and capacitor C_1 starts to discharge through the low bulb resistance. This capacitor only partially discharges since when the bulb potential reaches the extinguishing point the gas is no longer ionized. Thus the initial conditions once again prevail and C_1 starts to acquire additional charge from the battery. This process continues, or cycles, until the battery is removed. Unfortunately the frequency of oscillation cannot be raised to very much above 1000 cycles due to the slow ionization and de-ionization time of the gas. Typical values for C_1 and R_1 would be 0.1 μf. and 1 megohm respectively with a 90-volt battery and an NE-51 bulb. This time-constant will produce a frequency of approximately 400 cycles.

Fig. 2B shows graphically what happens when the battery is connected to the circuit of Fig. 2A. You can observe this same waveform by connecting an oscilloscope to the output terminals of Fig. 2A. Note particularly that the working voltage is the amplitude between the firing peak and the extinguishing valley. This peak-to-valley potential determines the peak-to-peak amplitude of the output waveform produced.

By plotting voltage (E) against current (I) for one cycle of the negative-resistance oscillation, it is possible to illustrate several terms which will be useful later. The plot of voltage *versus* current is shown in Fig. 1A. The potential needed to induce peak current (ionization point) is E_p. The voltage required for the minimum current in the ionized bulb (valley current) is E_v. The bulb current for these two points is, of course, I_p and I_v. The region of negative resistance is shown by a dotted line.

The Tunnel Diode

To explain the action of the tunnel diode properly, it is necessary to lead the reader down the dark alleyways called "Fermi level," valance, and conduction bands, not to mention quantum theory.

Mental gymnastics can be avoided by taking a look at diodes in general. If you *forward bias* a diode (positive anode) with a very small potential (less than approximately 0.6 volt) no current will flow in the junction, just as if it were *reverse biased*. Inside the diode junction is a *potential barrier* which must be overcome. At approximately 0.6 volt (for silicon diodes and even less for germanium diodes), the junction starts to conduct and from this point up to the maximum operating potential, the diode conducts normally.

Fig. 1B shows an analogy of this situation for a junction diode. Even with a slight forward bias there is insufficient attraction to draw the electron current carrier over the potential barrier (or hill). By increasing the junction potential difference, the energy level of the electron is raised and it "goes over the hill," so to speak.

Dr. Esaki discovered that heavily doped germanium (3 mil dot of indium, gallium, and zinc on a 10^{-3} ohm-per-centimeter germanium base) exhibited a noticeably different effect in the potential barrier region. Rather than travel over the barrier, electrons are literally made to tunnel through the hill. What is more important, they did not drag their "atomic heels" like their fellow transistor electrons. The tunneling effect occurs at the speed of light.

As the potential applied to the tunnel diode is increased, current also increases due to normal conduction. At approximately 0.2 to 0.3 volt (200-300 millivolts) electrons suddenly start their tunneling action, at E_p. The resistance increases and the current decreases, even though the battery potential is increased.

The net result is a germanium diode which exhibits a negative resistance effect. The *EI* curve for a typical tunnel diode is shown in Fig. 1C. Note that as the current is increased E_p is reached. At this point the negative resistance characteristic takes over and the diode current suddenly drops to I_v. Unless the impedance of the power supply providing the tunnel current is less than the $-R$ slope, it is not possible to maintain the diode current on the slope. In other words, the sudden drop in current increases the power-supply voltage sufficiently to carry the diode current past I_v and up on the other slope. Thus the regulation of the power supply must prevent *any* change in voltage between E_p and E_v due to changing load current.

The tunnel diode exhibits the same instability in the negative-resistance region as the neon bulb. If a charge-discharge circuit (like the *RC* system in Fig. 2A) is connected to the tunnel diode, sustained oscillations will result.

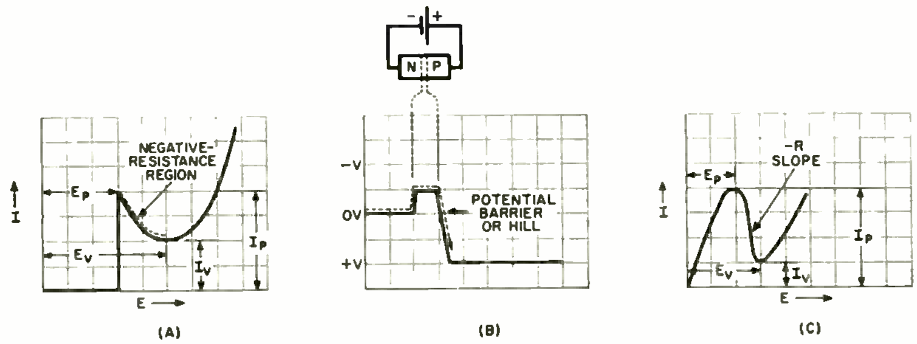


Fig. 1. (A) Neon lamp characteristics. (B) Potential barrier in junction diode. Battery drives electron over barrier. (C) E-I characteristics of tunnel diode.

R. F. Oscillator

What could be a better charge-discharge circuit than a tank coil? During high conduction periods the tank coil absorbs energy. When conduction diminishes (between E_p and E_v), the coil returns its energy to the circuit. In effect, the tunnel diode (like the neon bulb) acts as a switch to sustain oscillations in the tank circuit.

A new gallium arsenide tunnel diode that performs beyond 4000 megacycles.

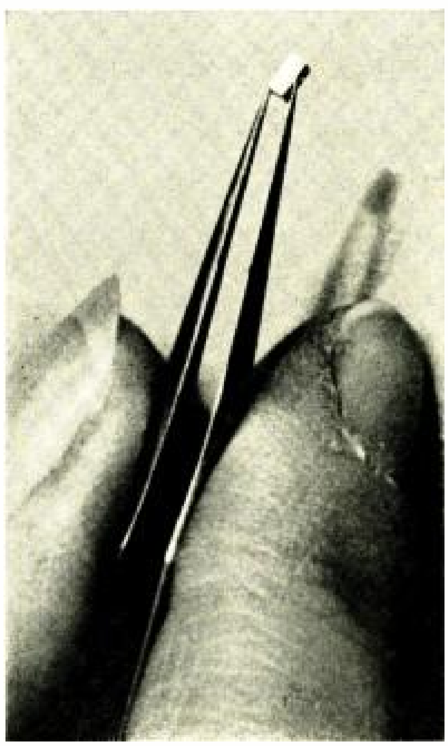


Fig. 3 is a practical, working circuit for a high-frequency tunnel diode oscillator. Capacitance for the tank circuit is supplied by the tunnel diode itself. If coil *L* is 8 turns of #18 enamel wire, ¼ inch in diameter and ⅝ inch long, the frequency of oscillation will be in the 15-meter amateur band. A one- or two-turn link can be used to obtain output.

Unlike the neon bulb, the tunnel diode is not limited by ionization time. Earlier it was stated that the tunneling action takes place at the speed of light. From this the reader might assume that the high-frequency performance limit of the tunnel diode is infinite. Practical considerations, however, limit present diode types to approximately 1000 mc., although occasional forays are made to 4000 mc. and over. One practical consideration is the junction capacity, which is on the order of 50 to 100 $\mu\mu$f. This is quite a bit of capacity for any high-frequency device and causes the tunnel diode to exhibit an abnormally low impedance at the higher frequencies. Any extra lead inductance will drastically reduce the oscillation frequency. For this reason manufacturers provide packages which have an absolute minimum of inductance.

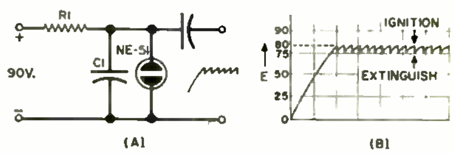


Fig. 2. Simple neon lamp negative-resistance oscillator, along with its waveform.

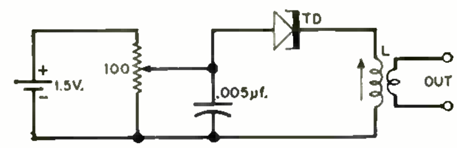
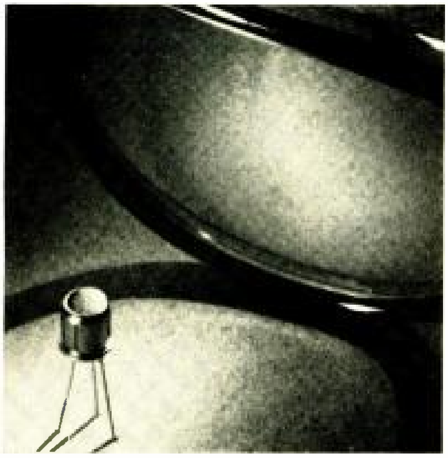


Fig. 3. Working circuit for a 15-meter transmitter using the tunnel diode.

One example is the *RCA* TD-series tunnel diodes shown in Fig. 4A. These tunnel diodes will oscillate at the ultra-high frequencies simply by connecting them as shown in Fig. 4B. The junction capacity plus the inductance of the gold-foil leads (quarter-wave lines) provide the tuned circuit. This type of device is known as a *stripline* oscillator and operates at the diode package self-resonant frequency. The junction capacity is current-sensitive and the bias potential can be varied to tune this (and other) oscillator over wide frequency ranges.

A. F. Oscillator

It is possible to connect a tunnel diode in a circuit similar to the neon-bulb oscillator, discussed earlier, to generate audio frequencies. Such a circuit is shown in Fig. 5, along with the characteristic saw-tooth waveform. It is much easier to observe the action of the tunnel diode at these frequencies. The diode is biased into the negative-resistance region by the battery. The inductance absorbs and releases energy in the circuit as the diode pops back and forth



This tunnel diode is a low-cost G-E ZJ-56 germanium unit that will be of interest to amateurs and experimenters. Two of the leads shown are connected to the anode.

between I_p and I_v. The oscillations will continue until the battery is removed.

R. F. Amplification

To understand how the tunnel diode can amplify, let's return to the example involving the neon bulb. To make this circuit "amplify," the battery voltage is reduced until it cannot ionize the bulb. If the bulb ionizes at 80 volts and extinguishes at 75 volts, the battery potential would be adjusted for 79.5 volts. Now, if a half-volt pulse is applied to the bulb, it will "fire," discharge the capacitor, and return to its initial deionized state. The pulse created by the bulb swinging between 80 and 75 volts would have an amplitude of 5 volts. Thus a 1-volt pulse has produced a 5-volt pulse or, in other words, the pulse has been amplified.

Actually, this example is not practical. The bulb is not stable enough to make such a circuit practical. The tunnel diode is, however. Fig. 6 shows a method of obtaining amplification from a tunnel diode, in this case the circuit is a 30-mc. amplifier or preselector. The unit is adjusted by setting the inductance to minimum and peaking C for maximum gain. Coil L is then increased until the desired amplification is reached, just below the point of oscillation. It is possible to obtain more than 30 db gain from such a circuit. Although it is a regenerative device (tending to oscillate), the noise figure is second only to the maser or parametric amplifier.

Power Output

Returning once again to our faithful example, the neon bulb, we recall that with an E_p of 80 volts and an E_v of 75 volts, the greatest oscillating voltage delivered by the circuit is 5 volts. This is a fixed value determined by the bulb characteristics. In tunnel diodes, the ratio of E_p to E_v will also determine the output voltage. Remembering that $P = EI$ (power equals voltage times current), it can be seen that E_p/E_v times I_p/I_v will determine the power capabilities of the diode. From this you can assume that anything done to increase either of these ratios will increase the power output that can be obtained.

The accompanying oscillograms show the *EI* curves for germanium, silicon, and gallium arsenide tunnel diodes. Note that germanium has the lowest peak current and the lowest valley voltage, thus it can be expected to produce the least amount of power output. Silicon, noticeably better, has a greater peak voltage and a higher value of E_v. Gallium arsenide tunnel diodes have the highest values of all three types.

Since the tunnel diode must operate in the potential barrier region, it is destined to remain a low-power device. The data sheet for an *RCA* TD-111 lists the peak current at 6.8 ma., maximum

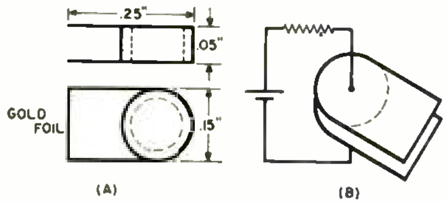


Fig. 4.(A) Size of RCA TD series of tunnel diodes. (B) Use of such a diode in a stripline oscillator operating at 1000 mc.

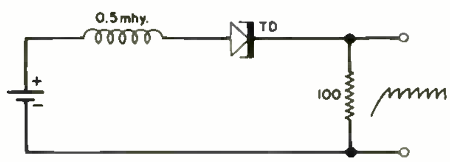


Fig. 5. An audio frequency negative-resistance oscillator using a tunnel diode.

voltage at I_p = 65 mv., and the minimum voltage at I_v at 280 mv. Thus the minimum I_p to I_v ratio (a figure of merit) is close to 4.5.

Computer Applications

If the impedance of the power supply is many times the negative resistance of the diode (by using a large series resistor), the diode will switch from the peak to the valley very rapidly. Tunnel-diode switching times exceed almost any commercially available component and therefore lend themselves to computer applications. Fig. 7 shows one of the many applications for tunnel diodes in computer circuitry. The diode is biased below I_p by a 6-volt battery and a 3600-ohm series resistor. This holds the diode in the "off" state (any voltage below E_p). A 1-ma. pulse, in either the *A* or *B* channel, switches the diode to the "on" state (any voltage greater than E_v across the diode terminals). The reset pulse supplies sufficient current to reset the diode to its original conditions, and reduces its terminal voltage to less than E_p. This is an "or" type gate circuit and the average computer uses a great number of these so-called "flip-flops."

It does not require a crystal ball to see that any device which will operate at 1000 mc. is capable of extremely fast switching times. In computer applications this allows the device to handle millions of "bits" of information. The small size of the tunnel diode allows the circuit to make decisions or conclusions from this information in a minimum of space.

A dynamic demonstration of this fact was shown by *RCA* at the IRE Convention in their simulated computer-memory system with bits of information stored in germanium tunnel diodes. In a micromodule display, *RCA* demonstrated a tunnel-diode 100-kc. multivibrator and a binary divider encapsulated in a cube measuring only 3/10th of an inch. The fast switching time of these tunnel diodes was demonstrated by a random-number generator which is capable of producing 30,000,000 digits per second or approximately 100 times more than can be produced in present-day computers.

Types Available

Experimenters and amateurs will be most interested in the germanium tunnel diodes for they are the least expensive but, even so, the reader would do well to investigate prices before starting any construction projects using these devices. By the time you read this, both *RCA* and *General Electric* will have made their tunnel diodes available through normal distribution channels. The *RCA* diodes carry numbers TD-100 through TD-111 and are germanium. This series varies only in the peak current. The minimum ratio is 4.5 to 1 for all types.

The experimental *General Electric* ZJ-56 and ZJ-56A are now in full production and these germanium tunnel diodes have been assigned JEDEC numbers 1N2941 and 1N2969. These diodes are also available at *G-E* distributors at around $6.00 each, in production quantities, to original equipment manufacturers.

Hoffman Electronics Corporation is marketing a series of silicon tunnel diodes (the HT series) and these should be available through the firm's regular distribution channels.

General Transistor is also manufacturing tunnel diodes but no information on types and prices is available at this time.

Texas Instruments, Inc. is currently (*Continued on page* 100)

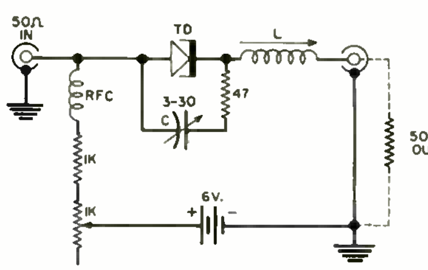
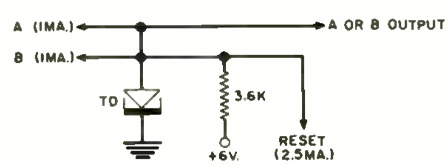
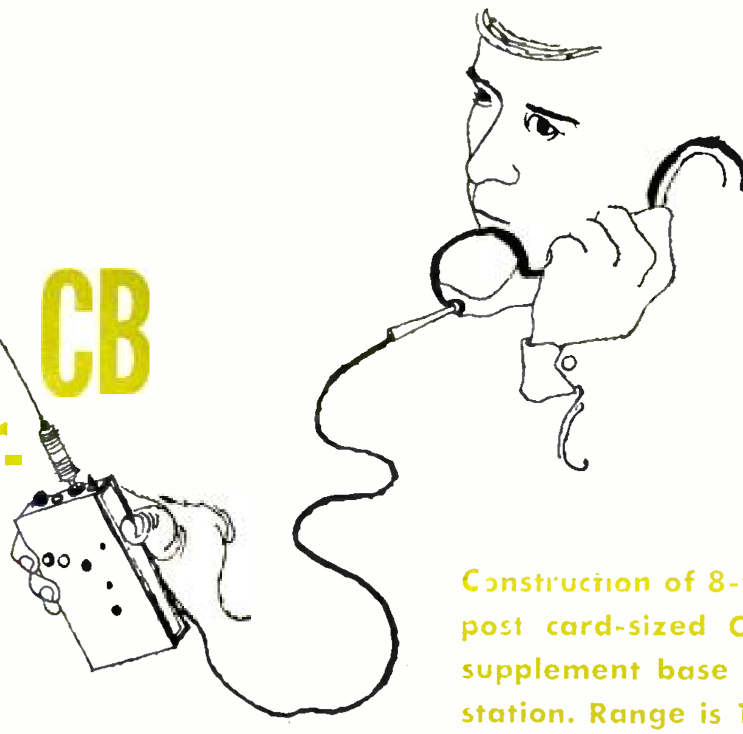


Fig. 6. A practical r.f. amplifier for the 10-meter ham band using a G-E ZJ-56 tunnel diode. See text for alignment.

Fig. 7. A computer "or" circuit using tunnel diode as the switching element.



Hand-Held CB Transmitter-Receiver



Construction of 8-transistor, post card-sized CB unit to supplement base or mobile station. Range is 1½ miles.

By THOMAS J. BARMORE

EDITOR'S NOTE: *If this unit is to be used with other Class D radio units, it must be licensed in the Class D service and meet all the technical requirements set forth in Part 19 of the FCC Rules and Regulations. We do not recommend such use because of insufficient oscillator stability and the frequency modulation that occurs.*

On the other hand, the transmitter-receiver need not be licensed at all if it is operated as a "low-power communication device" in accordance with Part 15 of the FCC Rules and Regulations. To meet these requirements, the carrier must be between 26.97-27.27 mc., all emissions outside this band must be down at least 20 db, the power input to the final r.f. stage must not exceed 100 mw., and the antenna must not exceed 5 feet in length.

HERE is an eight-transistor, post card-sized CB transmitter-receiver unit that can supplement your Citizens Band base or mobile station.

The maximum range of the unit has never been accurately determined, but the author has used it in two-way communication for line-of-sight distances of at least 1½ miles. This distance, of course, will be less in rough terrain but, again, communications were successful in an extremely hilly region, at a distance of ¾ mile. One must remember, however, that two-way contact may be established only if the receiving party is using a quality receiver.

For its size, the receiver is extremely sensitive. A 3-microvolt signal will completely block out the background hiss while a 1-microvolt signal is readable.

Receiver Circuit

The receiver circuit is straightforward, consisting of an r.f. amplifier, superregenerative detector, and two stages of audio amplification.[1] The r.f. stage is a 2N248 employed as a common grounded-emitter amplifier. The antenna is coupled to this stage through the center tap on coil L_1. Proper bias for the stage is furnished by resistors R_1 and R_2, while the emitter current is limited by the bypassed resistor R_3. The output of this stage is developed across coil L_2 and resistor R_7. Refer to circuit, Fig. 2.

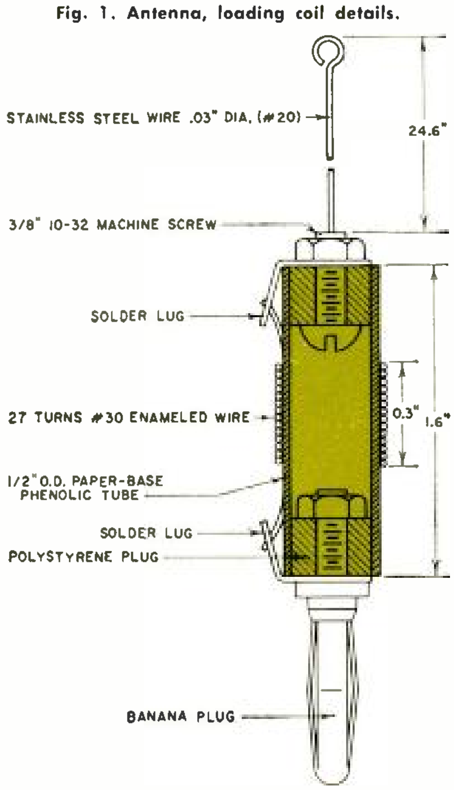
The r.f.-to-detector coupling might appear strange at first. Coils L_2 and L_3 are not coupled, but are shielded as indicated in the photographs. The r.f. voltage is developed across resistor R_7, while capacitor C_6 serves to determine the coefficient of coupling between the two stages.

The detector stage uses a 2N309 as a grounded-base superregenerative oscillator. The quench frequency is determined by capacitor C_7 and resistor R_4. A feedback loop is established between collector and emitter by capacitor C_8 to control regeneration. The audio voltage from this stage is developed across resistor R_5. Capacitor C_{11} couples this voltage to the quench filter, consisting of resistor R_6 and capacitor C_{15}. This network offers a high impedance path to the quench frequency, which would tend to saturate the audio stages, but presents a low-impedance path to the audio signal. The audio voltage is again developed across resistor R_{13} and then coupled to the first audio stage through capacitor C_{13}.

The first audio stage is conventional, with resistors R_{11} and R_{12} providing base bias, while resistor R_{10} furnishes the necessary emitter bias. The output of this stage is developed across resistor R_9 and coupled through capacitor C_{12} to the audio output stage.

The audio output stage is extremely simple, consisting of base-bias resistor R_8, the output transformer T_2, and transistor V_3. This transformer is a surplus "Ouncer" which is removed from its case and installed beneath the earphone cartridge in the handset. The primary impedance is about 5000 ohms with a secondary impedance of approximately 200 ohms. While the secondary is matched to the earphone, the primary is not a perfect match. Greater audio output may be obtained by using a more perfectly matched unit, say one with a primary impedance of 1000 ohms or so.

Fig. 1. Antenna, loading coil details.

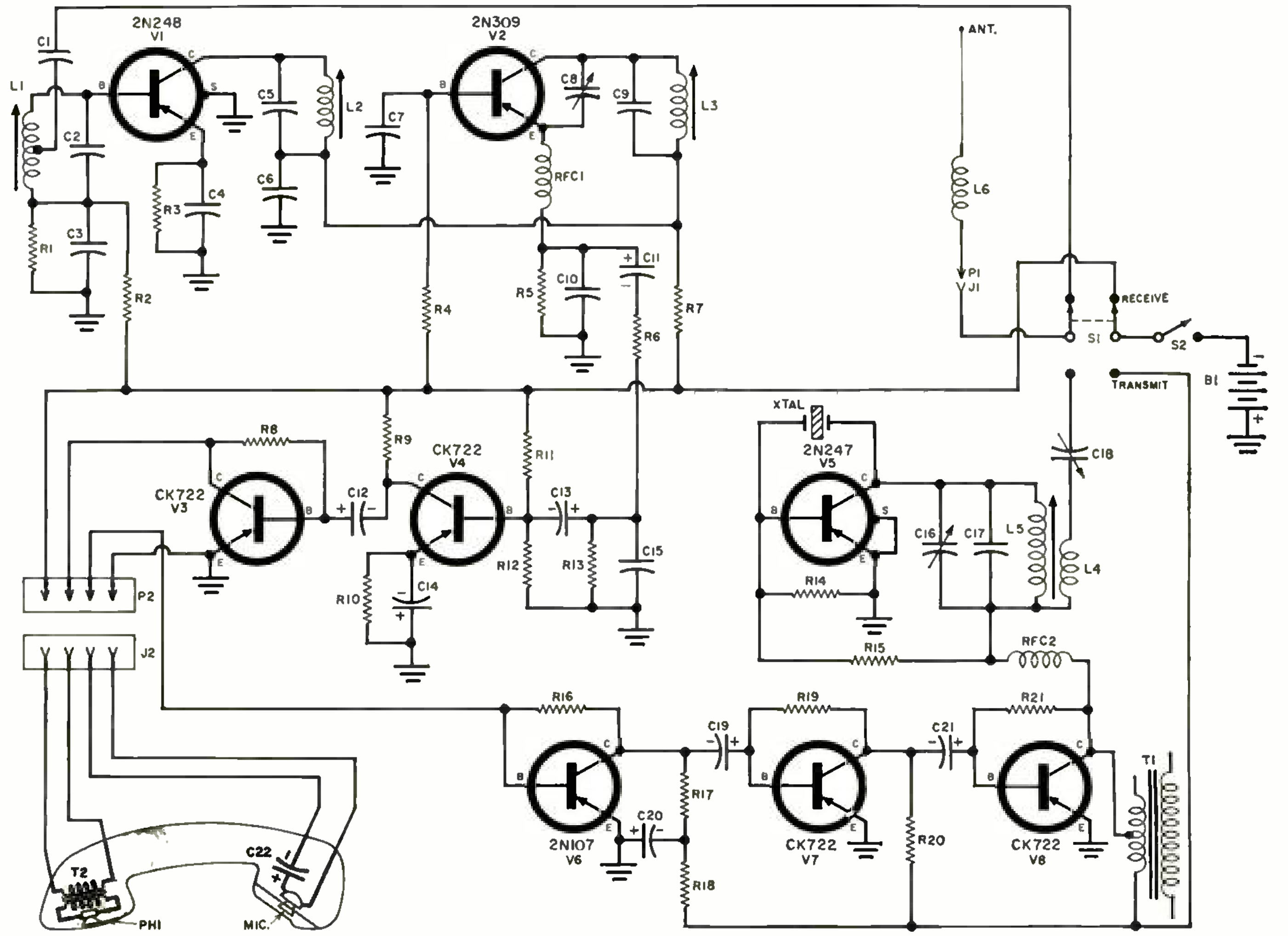


Transmitter Circuit

The transmitter is really a simple affair, consisting of a modulated crystal-controlled oscillator. There will undoubtedly be some "purists" who frown on this design, but it offers the easiest method of transmitting intelligence. There is some frequency modulation produced, but the frequency will only vary ±100 cycles or so.

The r.f. section of the transmitter uses a 2N247 drift transistor as a Pierce crystal-controlled oscillator. The crystal is of the third-overtone type, which oscillates more strongly at its third harmonic. Base bias for the oscillator is furnished by resistors R_{11} and R_{15}. The output stage is connected directly to the antenna through link L_1 and capacitor C_{18}.

[1] Hall, Donald B.: "Transistors for 10 Meters," Radio-Electronics, Feb. 1959.



R_1—3900 ohm, ½ w. res.
R_2, R_4, R_{14}, R_{19}, R_{21}—22,000 ohm, ½ w. res.
R_3, R_5, R_6, R_7, R_{10}, R_{17}—1000 ohm, ½ w. res.
R_8—220,000 ohm, ½ w. res.
R_9, R_{18}, R_{20}—2700 ohm, ½ w. res.
R_{11}—18,000 ohm, ½ w. res.
R_{12}—2000 ohm, ½ w. res.
R_{13}—10,000 ohm, ½ w. res.
R_{15}—39,000 ohm, ½ w. res.
R_{16}—33,000 ohm, ½ w. res.
C_1, C_3, C_4, C_{10}—.01 µf. disc ceramic capacitor
C_2—15 µµf. tubular ceramic capacitor
C_5—20 µµf. tubular ceramic capacitor
C_6—68 µµf. tubular ceramic capacitor
C_7—.001 µf. disc ceramic capacitor
C_8, C_{16}—1.5-7 µµf. ceramic trimmer (Erie 557-A or equiv.)
C_9—22 µµf. tubular ceramic capacitor
C_{11}, C_{13}—15 µf., 6 v. elec. capacitor
C_{12}—25 µf., 6 v. elec. capacitor
C_{14}—100 µf., 6 v. elec. capacitor
C_{15}—.1 µf. disc ceramic capacitor
C_{17}—27 µµf. tubular ceramic capacitor
C_{18}—8-50 µµf. ceramic trimmer (Erie 557-H or equiv.)
C_{19}, C_{21}—25 µf., 6 v. elec. capacitor
C_{20}, C_{22}—25 µf., 25 v. elec. capacitor
L_1—16 t. #30 en. closewound 3/16" form, c.t. @ 8 t. (J. W. Miller 4300)
L_2—16 t. #30 en. closewound on 3/16" form (J. W. Miller 4300)
L_3—14 t. #30 en. closewound on 3/16" form (J. W. Miller 4300)
L_4—3 t. #30 en. closewound at bottom end of L_5
L_5—14 t. #30 en. closewound on 3/16" form (J. W. Miller 4300)
L_6—27 t. #30 en. closewound on ½" form ("Ant. Loading")
RFC_1—20 µhy. r.f. choke
RFC_2—100 µhy. r.f. choke
T_1—Transistor driver trans. 10,000-20,000 ohm pri.; 2000 ohms c.t. sec. (Use one-half sec.)
T_2—Miniature trans. 5000 ohms to 200 ohms
Mic.—High-impedance crystal mike cartridge
PH_1—Magnetic earphone cartridge
Xtal.—27.255 mc. third-overtone crystal
S_1—D.p.d.t. slide switch
S_2—S.p.s.t. slide switch
B_1—9-volt battery (RCA VS-304)
J_1, P_1—Jack and banana plug
J_2, P_2—Jack and 14-pin plug (only 4 pins used)
1—Telephone handset shell (Kellogg Switchboard)
1—5½" x 3" x 1¼" aluminum box (LMB 135 or equiv.)
V_1—2N248 transistor (Texas Instruments)
V_2—2N309 transistor (Texas Instruments)
V_3, V_4, V_7, V_8—CK722 transistor (Raytheon)
V_5—2N247 transistor (RCA)
V_6—2N107 transistor (G-E)

Fig. 2. Receiver consists of V_1 r.f. amplifier, V_2 superregenerative detector, and V_3 and V_4 as audio amplifiers. The transmitter uses V_5 as crystal oscillator, modulated by V_8. Transistors V_6 and V_7 are utilized as speech-amplifier stages.

The oscillator is choke-modulated to about 85 per-cent by the three-stage modulator consisting of transistors V_6, V_7, and V_8. Bias for these stages is furnished by resistors R_{16}, R_{19}, and R_{21} respectively. Resistor R_{18} and capacitor C_{20} form a decoupling network for the first stage to prevent the modulator from breaking into oscillation.

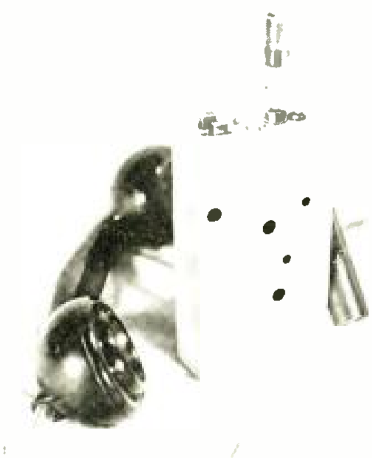
The modulation choke, T_1, consists of the inductance between the center-tap and one side of the secondary of a 2000-ohm transistor driver transformer—an impedance of about 500 ohms. The microphone used is a crystal cartridge feeding through capacitor C_{22} to the base of V_6. Although this represents a mismatch of several hundred thousand ohms to several hundred, enough signal is generated by the microphone to be useful. An input transformer may be used in place of the first stage of audio amplification, but may add considerably to the cost of the unit.

Construction

The housing for the unit is an aluminum box measuring 3" x 5½" x 1¼". The antenna jack, "on-off" switch, and the "transmit-receive" switch are mounted on the narrowest side, as shown in the photographs. The handset cable is brought out on this same side, through a small grommet.

The receiver is constructed in three separate pieces. Each small chassis consists of a piece of cloth-base phenolic sheet about 1/16" thick. Each part is mounted by means of small hollow brass leather eyelets. All components are mounted on one side, while the necessary wiring is done on the opposite side.

The first piece of phenolic holds coil L_1 and its associated components; the second, the r.f. stage and L_2; the third, the detector and the two audio stages. In this way, each shield may be fastened to the case and each small circuit board inserted between them, as shown in the photographs.



Openings in one side of small metal box that houses the compact CB unit permit access to various trimmer adjustments.

The transmitter is wired on a board as one piece. No crystal socket is used, but rather the crystal is simply soldered in place. The modulation choke, transformer T_1, is glued in position with model airplane cement.

Each circuit board is held in place by a number of ⅜" 4-40 machine screws. The boards are raised about ¼" off the bottom of the case by spacers. A small piece of thin plastic is placed under the boards to eliminate the accidental shorting of the wiring to the metal case that is used.

The 9-volt battery is held in place at the rear of the unit between the edge of the circuit boards and the side of the case. A small piece of sponge rubber cemented to the cover of the unit will keep the battery secure when the cover is in place.

The antenna loading coil is a piece of paper-base phenolic tubing, ½" in diameter, wound with 27 turns of #30 enamel wire, closewound on the form. A 10-32, ⅜" machine screw is drilled out and a piece of #20 stainless-steel wire, 25 inches long, is sweat-soldered into it. A hole about ⅛" in diameter is drilled in each of two plastic plugs of the correct diameter to fit into the ends of the tube. The antenna with its attached screw is bolted to one of the plastic plugs while a banana plug is affixed to the other. The ends of the antenna coil are then attached to these two points by means of solder lugs. The last step is to form a small loop in the end of the antenna so that its over-all length is just 24.6 inches, as shown in Fig. 1.

The handset may be permanently connected to the unit or by means of a small plug. If the builder wishes, a small plug may be built into the case. The only reason one wasn't used in the author's unit was the unavailability of a small enough component.

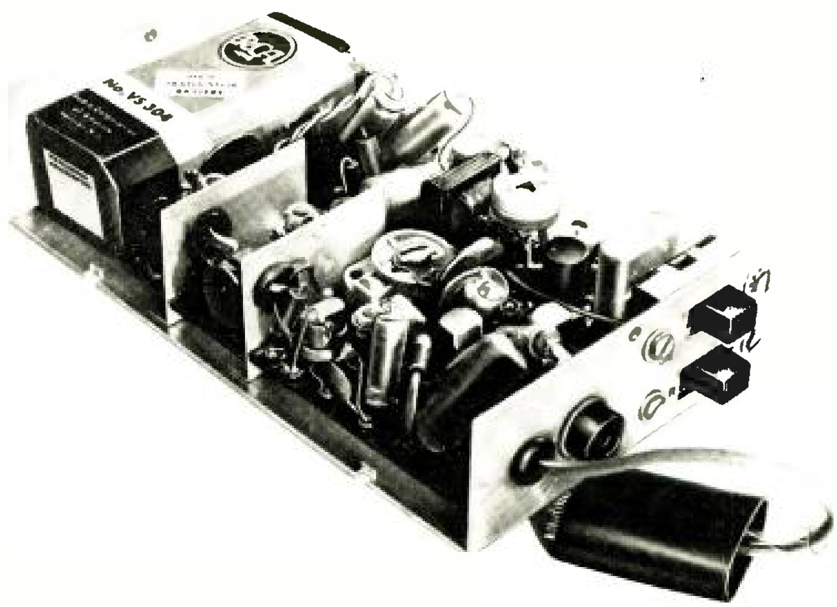
Alignment

Receiver alignment should be accomplished with a grid-dip oscillator, a signal generator, or other low-signal source. When voltage is applied to the receiver, a loud rushing noise should be heard in the headphone, indicating that the detector is oscillating properly. This should occur at the maximum capacitance setting of C_8.

The slug in coil L_1 should be screwed in until a signal is heard and then the regeneration control should be re-set for maximum received signal. Coil L_2 should then be aligned for maximum signal. The antenna coil, L_6, should be set in the middle of the band since its tuning is very broad due to the low input impedance of V_1.

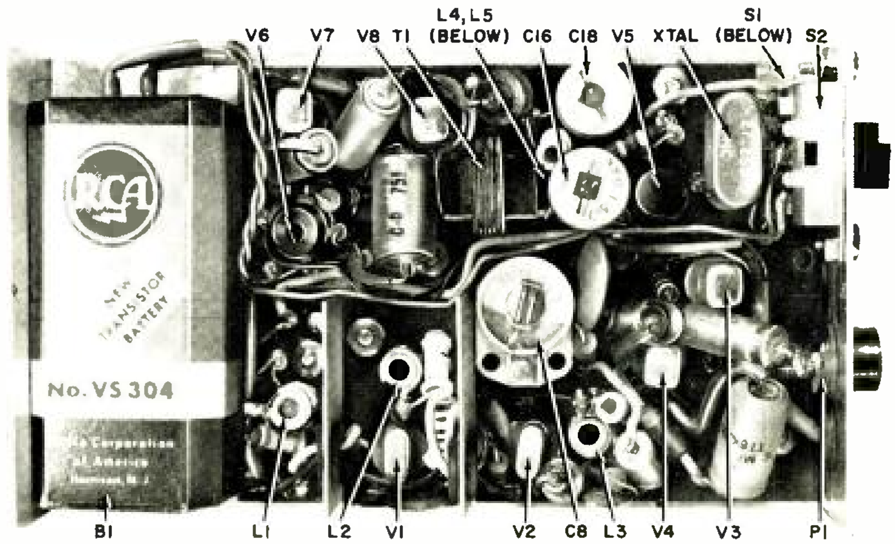
Transmitter alignment is facilitated by use of a sensitive field-strength meter (the "S" meter of a receiver will do nicely). If the transmitter will not oscillate, a small capacitance (2 or 3 $\mu\mu$f.) connected across the crystal will probably cure the problem. Set capacitor C_{18} to minimum value and adjust the slug in coil L_3 or capacitor C_{16} for maximum signal strength. When this point is reached, adjust capacitor C_{18} for maximum reading on the field-strength meter. It might be necessary to re-adjust the tuning of the slug in L_3 or the setting of capacitor C_{16}. Modulation should cause the signal strength to increase, indicating positive modulation. If this doesn't happen, changing the value of resistor R_{15} may help since its value will vary with individual transistors.

The transmitter draws about 15.6 milliamperes. The modulator takes 13.4 ma. of this, while the oscillator consumes 2.2 ma.—a power input of 14.1 milliwatts. (Power input to the oscillator stage is equal to $6.4 \times 2.2 \times 10^{-3} = 14.1 \times 10^{-3}$ watts. There is a drop of 2.6 volts across the modulation choke.) The receiver loafs by on a current drain of 3 ma., so battery life will be quite long while receiving, but will be reduced to one-fifth of this time while transmitting. —30—



Over-all view of the unit with the box cover removed. Note use of the shields.

Top view of the chassis board showing very compact arrangement of components.



An Electronic Resistive Load

By W. F. GEPHART

This adjustable unit takes the place of a drawer full of power resistors, saves time.

THERE IS often the need around the shop for a high-wattage resistive load with which to check power supplies, voltage regulation, to determine bleeder resistances, and dropping-resistor values. Using high-wattage resistors on a trial-and-error basis is a cumbersome, time-consuming method. With the unit shown in Fig. 3 all this can be done by turning knobs.

The basic circuit of the electronic resistive load is shown in Fig. 2A. Two beam tetrodes, operated in parallel, as triodes (screen grids connected to plates), serve as a variable load. By varying the grid bias voltage on the tubes we can easily and smoothly vary their d.c. resistance.

Fig. 1 is the schematic for the complete instrument. As you can see, we have arranged for variable bias voltage on the load tubes. There is also a three-range milliammeter to measure the current being drawn, and a five-range voltmeter with which to measure the power-supply voltage, and also to measure the voltage drop across either the high-resistance rheostat or the low-resistance rheostat when these resistors are switched into the load circuit as voltage-dropping resistors. Construction details will be given later. Right now let us consider the problems we can tackle and solve with our test job.

Suppose we want to design a power supply for an amplifier, and we want the amplifier to be linear over a range of input signals. If the voltage output of an amplifier power supply decreases excessively under peak load signals, the output will, of course, not be linear.

Let us consider what causes the voltages to drop when the current drawn is increased in a power supply. Fig. 2B illustrates a common power supply. There is a voltage drop, E_T, across the tube, and another, E_C, across the choke. There will also be a voltage drop, E_X, across the transformer itself. The voltage drop due to the d.c. resistance of the power-supply circuit is fairly simple to compute, but the voltage drop due to the transformer depends upon a number of factors that vary with load and are rather difficult to calculate. The easy way here is to hook up the power supply, breadboard style, and try it out with the electronic load.

In some power supplies, gaseous or other tubes are often used as voltage regulators, but their range is limited: here the electronic load can be used to check the current that can be drawn before the regulator tube loses control. When the load is connected to this type of power supply, the voltage output should remain fairly constant as the current drawn by the load increases. At some given point, however, the regulator loses control, and the voltage drops suddenly. The amount of current that can be drawn without the voltage falling off is the current limit of the regulator circuit.

Often a power-supply voltage will be too high even at full or peak load. In such cases a dropping resistor (R_D in Fig. 2C) may be used. The voltage drop E_D across this resistor at load current is the amount by which the supply voltage, E_S, must be reduced to provide the desired load voltage, E_L.

Suppose this is our problem. We want to drop the power-supply voltage by a given amount at full load, and we would like to know what value of resistance we should use (R_D in Fig. 2C) without pencil and paper.

This is the way it may be done. The power supply is connected to the Supply Input terminals of the test device. Both power supply and test load have their power turned off. The Load Control, R_2, is turned all the way down. Our substitute load is turned on with switch S_1. The Milliamperes switch, S_2, is set to 200 milliamperes, and the Volts switch, S_3, is set to 200 or 400 volts, depending upon the voltage of the power supply under test. The power supply is now turned on. The Load control rheostat R_2 is slowly turned to the right, which decreases the bias voltage on the pair of tubes, and thus increases the amount of current passing through them. When the desired full-load current is reached as indicated by the milliammeter, M_1, the voltmeter indicates the power-supply voltage at the noted current.

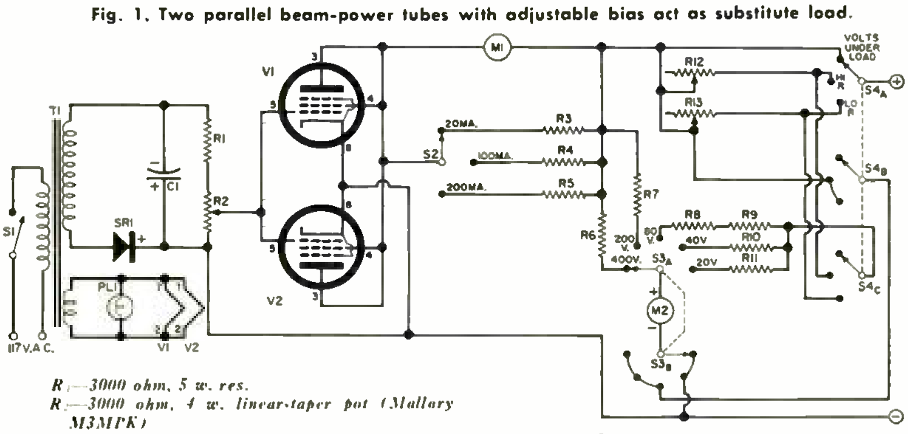
If the required voltage drop is large, 50 volts or more, we leave the Volts switch on 200 or 400 volts. The Check switch, S_4, is set to either "Hi" or "Lo" depending upon the amount of current to be drawn. For low currents use the "Hi" resistance rheostat, and for high currents use the "Lo" resistance rheostat. You now rotate the rheostat that has been selected by the position of the Check switch until the voltmeter indicates the desired power-supply voltage. You may have to adjust the Load control to maintain the proper current drawn.

Once the desired output voltage at the correct current flow has been secured, the resistance needed to drop the power-supply voltage to the required level can be read directly on the calibrated scale of the appropriate rheostat.

Note that, with the voltmeter on its 200- or 400-volt scale, you are reading the reduced power-supply voltage after the load current has gone through either of the selected rheostats. If you wish to read the actual *voltage drop* across the selected rheostat, you simply switch the voltmeter to one of its lower scales: 80, 40, or 20 volts. Reading the voltage across the dropping resistor (R_D in Fig. 2C) is more useful for lower voltage drops and lower currents. In the case of extremely small load currents, where substantial voltage drop is required, it may be necessary to adjust for one tenth the voltage drop required, and then to multiply the resistance reading by ten.

If a bleeder resistor is desired in the power supply to discharge the filter capacitor when the power supply is turned off, our substitute load can be used to

Fig. 1. Two parallel beam-power tubes with adjustable bias act as substitute load.



R_1—3000 ohm, 5 w. res.
R_2—3000 ohm, 4 w. linear-taper pot (Mallory M3MPK)
R_3—2.63 ohm, ½ w. res. ±1%
R_4—.5 ohm, ½ w. res. ±1%
R_5—.25 ohm, ½ w. res. ±1%
R_6—.4 megohm, 1 w. res. ±1%
R_7—.2 megohm, ½ w. res. ±1%
R_8,R_9,R_{10}—40,000 ohm, ½ w. res. ±1%
R_{11}—20,000 ohm, ½ w. res. ±1%
R_{12}—2500 ohm, 25 w. rheostat (Ohmite 0160)
R_{13}—250 ohm, 25 w. rheostat (Ohmite 0154)
C_1—40 µf., 150 v. capacitor
S_1—S.p.s.t. switch
S_2—S.p. 3-pos. rotary switch
S_3—D.p. 5-pos. rotary switch
S_4—3-pole, 3-pos. rotary switch
SR_1—65 ma. selenium rectifier
T_1—Power trans. 120 v. @ 50 ma.; 6.3 v. @ 2 amp.
PL_1—6.3 v., .15 amp. pilot light (#40 or #47)
M_1,M_2—0-1 ma. meter
V_1,V_2—See text
1—10"x 6"x 3½" metal cabinet (Bud "Minibox" CU-2110A or equiv.)

determine the value of this component too. The bleeder resistor, R_B, is connected as in Fig. 2D.

Usually bleeder currents of 2 ma. are satisfactory. For a bleeder drain of 2 ma. across 250 volts, we would require a resistance of 125,000 ohms. We do not have a resistor of this value in our instrument, but we can readily make do. This is the way it is done.

We hook the Electronic Load to the power supply. We flip the Check switch to either "Hi" or "Lo," and switch the voltmeter to 20 or 40 volts. Now we gradually bring up the Load adjustment until our milliammeter shows *ten times* the current we want; in this case 10 × 2 ma. or 20 ma. Next we adjust the rheostat in the circuit, whichever one it may be, until we show a voltage drop across the rheostat of 1/10 of the total power-supply voltage. In this case the figure would be 1/10 of 250, or 25 volts. (When we vary the rheostat we will, of course, have to vary the load to maintain the desired 20-ma. reading.) All we need to do now is to multiply the rheostat reading by 100 to get the bleeder resistance for the desired 2 ma. at 250 volts.

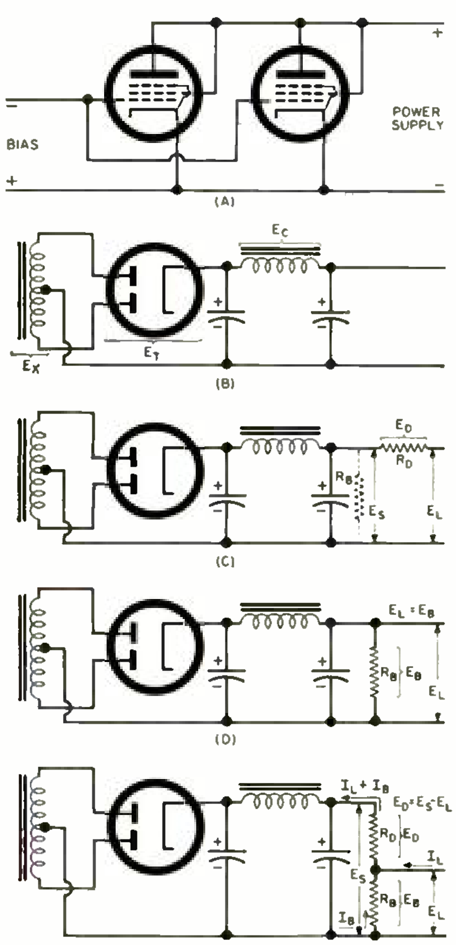
Sometimes both a dropping and a bleeder resistor will be used, as shown in Fig. 2C, where the added bleeder resistor is shown in broken lines. In this case, the value of dropping resistor R_D is calculated first, in much the same way as already described, with one exception. The value of supply voltage E_S is determined at a current value that is the sum of the load current *plus* the bleeder current that will be drawn. Once this voltage is established, the value of dropping resistor R_D can be determined—but this time only the load current (which is the only current that will go through this resistor) is used.

Sometimes it is desirable to use a resistor with a sliding tap as a combined dropping-bleeder resistor, or a divider that otherwise arranges these two components, as shown in Fig. 2E. First the value of supply voltage E_S is determined with the total current (load plus bleeder) to be drawn. Then the value of dropping resistance R_D is determined in the usual way, except that the load control is adjusted once more for the total current, since all of it goes through R_D. The bleeder resistance is then determined in the conventional way already suggested, but the voltage used for this determination is the already dropped voltage for the load, E_L.

Fig. 2E also suggests the method for finding values in a multi-tap divider. You would work in the same way, making certain to adjust the instrument for the particular current-voltage conditions at each point. For example, if you had several taps, the top section of the

(*Continued on page* 104)

Fig. 2. Simplification (A) of how the tubes act as a power-supply load. Voltage-current relationships (B to E) in common power-supply configurations.



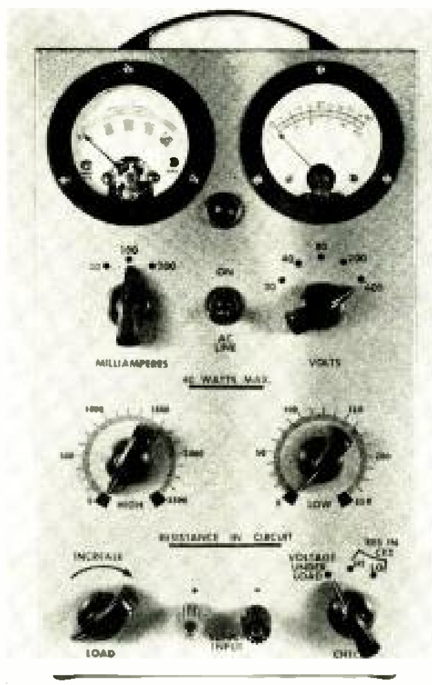


Fig. 3. Turning knobs on the completed unit quickly solves some knotty problems.

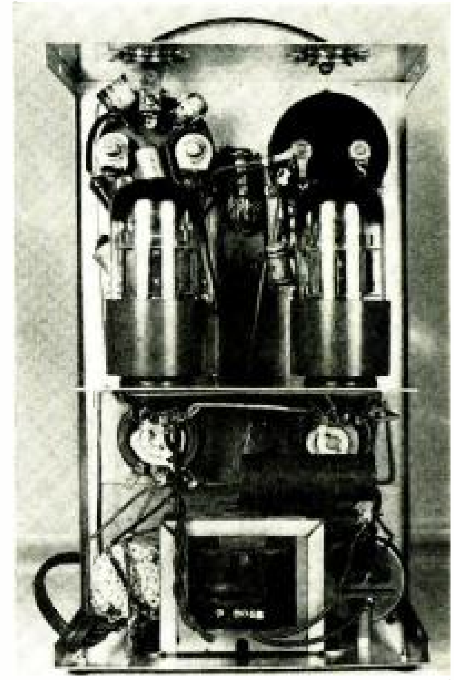
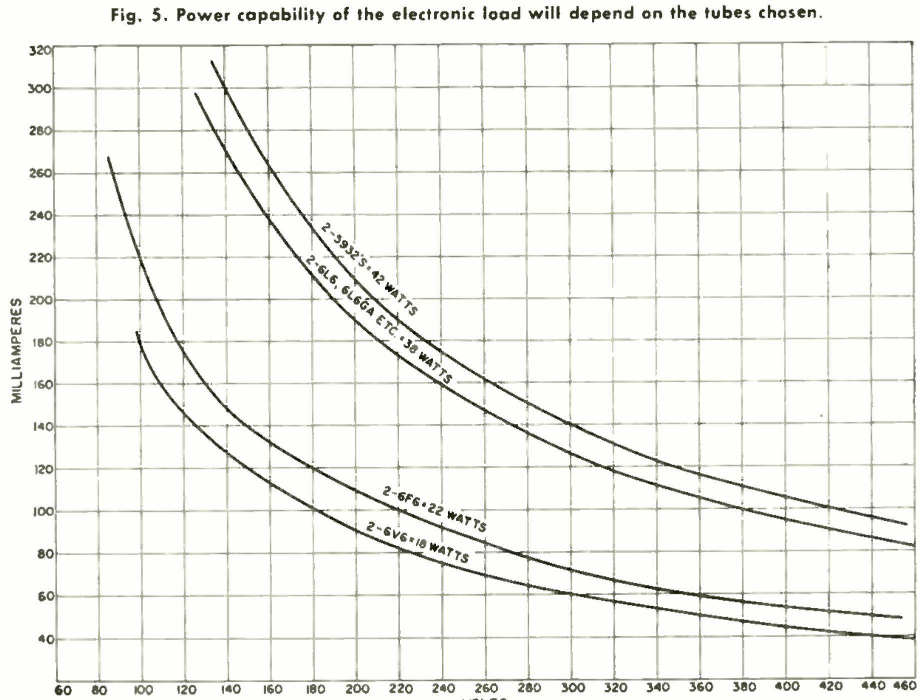
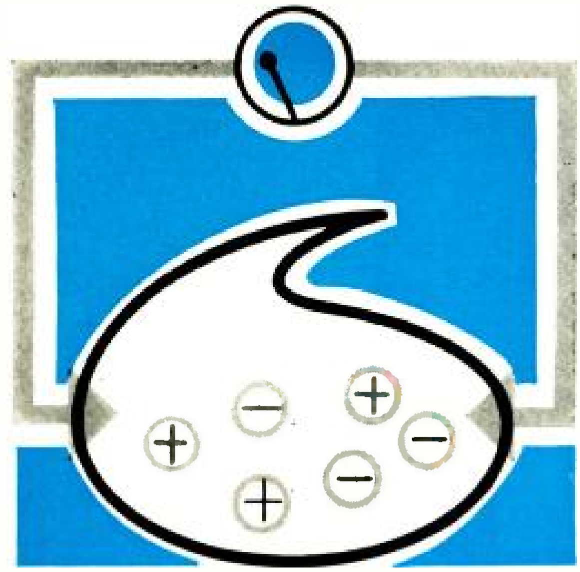


Fig. 4. Vertical layout of the compact tester takes up very little bench space.

Fig. 5. Power capability of the electronic load will depend on the tubes chosen.





Measuring Conductivity of Solutions

By JOHN R. COLLINS

This electrochemical property is a key factor in the check and control of many chemical and other industrial processes.

As MORE industries look to electronics for help with their problems, technicians find it profitable to know more about apparatus outside their usual sphere of knowledge. In the chemical process industries, for example, the need for uniformity of product with economy has led to greatly increased use of electrochemical measuring instruments. The installation, operation, and maintenance of such instruments constitute a growing segment of the electronics industry.

Electrochemical measurements pertain to the electrical effects associated with solutions. When accurately monitored, these effects provide information on the composition and characteristics of solutions. Depending on the associated equipment, they can be used either for analysis or control. This discussion will be confined to conductivity, the most basic electrochemical measurement.

What Conductivity Is

Conductivity, as the name implies, is a measure of the ability of a solution to conduct an electric current. It is the reciprocal of resistance (that is, $1/R$) and, as in other electrical circuits, the unit of measurement is the mho. Since the mho is a large unit, most conductivity values are expressed in micromhos.

A solution capable of conducting an electric current is called an electrolyte. Conduction takes place because of the presence of charged particles, ions, which migrate through the solution under the impetus of an applied voltage. This is in contrast to metals, where conduction results from the movement of electrons.

The standard unit for comparing solutions is called specific conductance and is denoted by the symbol L. It is defined as the conductivity of a column of liquid one centimeter high and one square centimeter in cross section, at 25 degrees centigrade.

Pure water has a specific conductance of about .05 micromho—or a resistance of 20 megohms. Its poor conductivity results from a lack of ions. If a small quantity of an acid, an alkali (base), or a salt is added, however, the conductivity increases because ions are formed from the added compounds.

Conductivity increases with the number of ions in solution. Some ions, especially the positive hydrogen ion ($H+$) and the negative hydroxyl ion ($OH-$), are more mobile than others. A solution containing these highly mobile ions will have a higher conductivity than a solution with an equal number of less mobile ions, such as the positive sodium ion ($Na+$) or the negative chlorine ion ($Cl-$).

Conductivity also varies directly with temperature. This variation depends on the type of electrolyte, but it averages about 2.5 per-cent per degree centigrade.

How It Is Used

Thousands of different uses for conductivity measurements have been found in both laboratory and industry. They are fast, easy to make, and highly reliable if care is taken to insure accuracy and to compensate for temperature variations.

The chief limitation of conductivity as an indicator is the fact that it is nonspecific. Since all ions in a solution contribute to its conductivity, no information is gained on the chemical composition. Nevertheless, conductivity measurements provide a rapid check on the concentration of solutions where the chemical ingredients are known. They are widely used for maintaining a stable level of concentration of chemical-process liquids, pickling baths, anodizing solutions, and detergents in the chemicals, food, textiles, and metals industries.

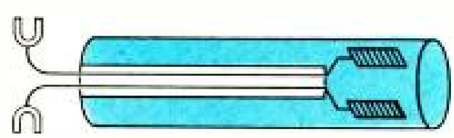
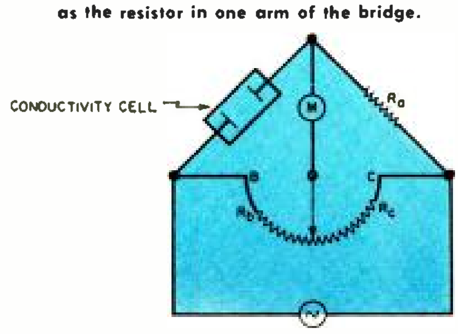


Fig. 1. The conductivity cell has two electrodes between which fluid passes.

Fig. 2. The type of bridge circuit used to measure conductivity. The cell acts as the resistor in one arm of the bridge.



For most chemical reactions, the "end point" is the point of least conductivity. Suppose, for example, that hydrochloric acid (HCl) is gradually mingled with a solution of sodium hydroxide ($NaOH$). When the two are precisely in balance, the result is a solution of salt ($NaCl$) and water (H_2O). On either side of this point, however, there will be an excess of either hydrogen ($H+$) ions or hydroxyl ($OH-$) ions, both of which are highly mobile and make for a very conductive solution. Thus, conductivity measurements provide a way of utilizing chemicals in the most efficient amounts.

Since pure water has an extremely low specific conductance, conductivity measurements are useful for detecting the presence of impurities in condensed steam from boilers, or in distilled or demineralized water. Detection of one part per million or better is feasible. This principle is used as a basis for monitoring rinse water in industrial plating and cleaning processes to detect contamination; for checking the caustic content of can washing solutions; and for checking streams for contamination or brackishness.

Conductivity Cells

The heart of all conductivity measurements is the conductivity cell, pictured in Fig. 1. The two general kinds are flow-type, designed for mounting in a pipeline, and dip-type, for insertion in a vat or tank. The body of the cell may be either glass or plastic, as long as it is chemically inert. It contains two electrodes, which also must resist the chemicals in the solutions. The usual materials for electrodes are graphite or platinized nickel.

If the electrodes are made with an area of exactly one square centimeter and are spaced one centimeter apart, specific conductance can be measured directly. This is often inconvenient, however, because of the wide range of conductivity measurements that are encountered. Resistance can be measured most accurately over a relatively narrow range, from about 50 to 100,000 ohms. In order to bring conductance measurements within these limits, it is customary to use cells with large electrodes closely spaced for measuring low-conductivity solutions, such as pure water, and cells with small electrodes spaced far apart for measuring high-conductivity solutions, such as concentrated acids or bases. This difference can be observed from Figs. 3 and 4. A glass cell for low-conductivity solutions is shown in Fig. 3. One used for highly conductive solutions appears as Fig. 4.

A factor called "cell constant" and designated by the letter k is used to describe the characteristics of conductivity cells. It is defined as the distance (d) between the electrodes in centimeters divided by the area (A) of an electrode in square centimeters. That is, $k = d/A$.

The cell constant of any unit can be determined experimentally by placing the cell in a solution of known specific conductance (L) and measuring the resistance (R) between electrodes. The cell constant is then calculated from the relationship, $k = LR$.

Once its cell constant is known, the cell can be used to measure the specific conductance of unknown solutions. This is done by re-arranging the last formula as follows: $L = k/R$.

Conductivity cells are supplied with cell constants ranging from .01 to 100. Cells in the range from .1 to 2 are suitable for most purposes.

The Apparatus

The basic elements necessary for conductivity measurements are shown in Fig. 2. They are a conductivity cell, an a.c. Wheatstone bridge, and a null-detecting device, in this instance a galvanometer. The conductivity cell provides the resistance for one leg of the bridge. Resistor R_a is selected to have a value in the same range as the solution. Practical bridges are often equipped with an assortment of resistors and a switching arrangement for connecting them into the circuit. A resistance wire is connected between points B and C, and the bridge is balanced by moving the contact until no current flows through the galvanometer. The cell resistance can then be calculated from the relationship, $\textit{Cell resistance} = \frac{R_a \times R_b}{R_c}$. It is customary, however, to calibrate the instrument to read the specific conductance directly, rather than resistance.

An example of a commercial, portable conductivity bridge is shown in Fig. 5.

An a.c. power supply is used to prevent inaccuracies that would result from polarization if d.c. were employed. When batteries are used for portable instruments, a vibrator or chopper is used to convert the d.c. to a.c. A 60-cycle source derived from a transformer tap is preferred for high-resistance electrolytes, such as demineralized water or steam condensates. Higher frequencies, usually about 1000 cycles, are used for highly conductive solutions. Vacuum-tube or transistor oscillators are the usual voltage sources.

In the laboratory, earphones are sometimes used in the center leg as a null detector, and the bridge is balanced by adjusting for minimum sound. For more accurate work, an amplifier can be used to amplify small unbalance signals.

Fig. 6 shows a typical, industrial, conductivity arrangement for automatically preventing the contamination of a rinse tank by the waste products removed in rinsing. As long as the water is within the permissible range of purity, the bridge remains in balance and no current flows through the center leg. However, if the electrolytic content of the water increases beyond a certain point, the bridge is unbalanced and current flows through the center leg (Fig. 2). This trips a relay which, in turn, energizes a solenoid valve, admitting fresh water to the tank. When enough fresh water has been admitted, the conductivity cell returns to its original resistance, the bridge circuit is rebalanced, and the solenoid valve again closes, shutting off the water supply.

Many industrial installations use self-balancing bridges. One type is illustrated in Fig. 7. A dual, split-stator air capacitor (C_1 and C_2) forms two adjoining legs of the bridge, and resistances (one of which is the conductivity cell) form the opposite two legs. A 1000-cycle voltage source supplies the power for

(Continued on page 116)

Fig. 5. Portable conductivity bridge by Leeds & Northrup measures conductance from .1 to 12,000 micromhos per centimeter.

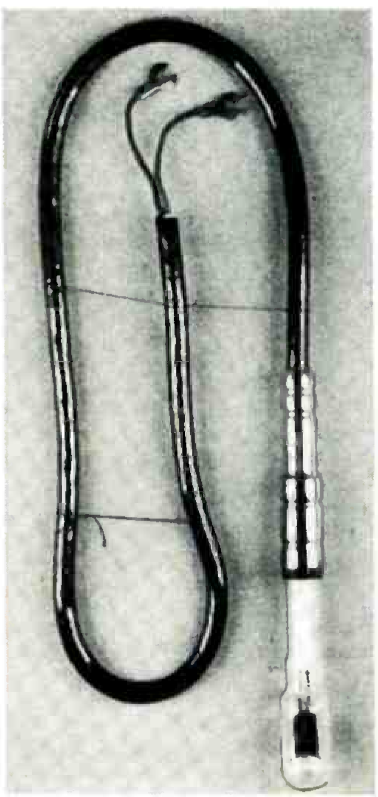


Fig. 3. Glass cell by Leeds & Northrup for use in low-conductivity solutions.

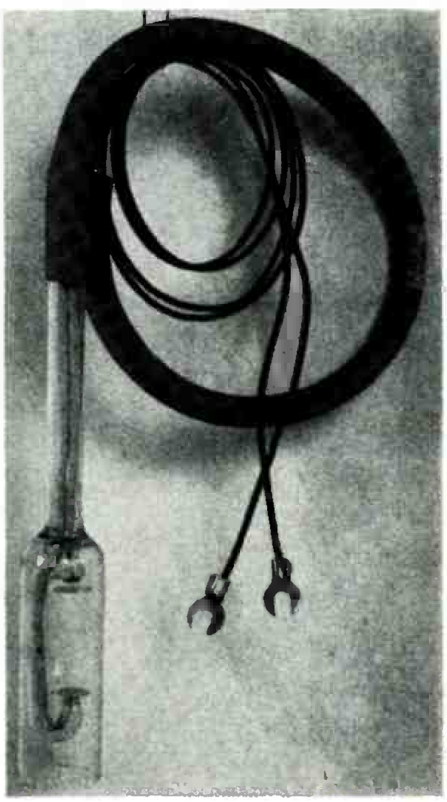


Fig. 4. Glass cell for high-conductivity solutions. Note wide electrode spacing.

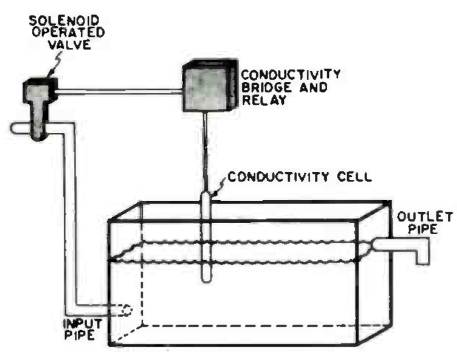
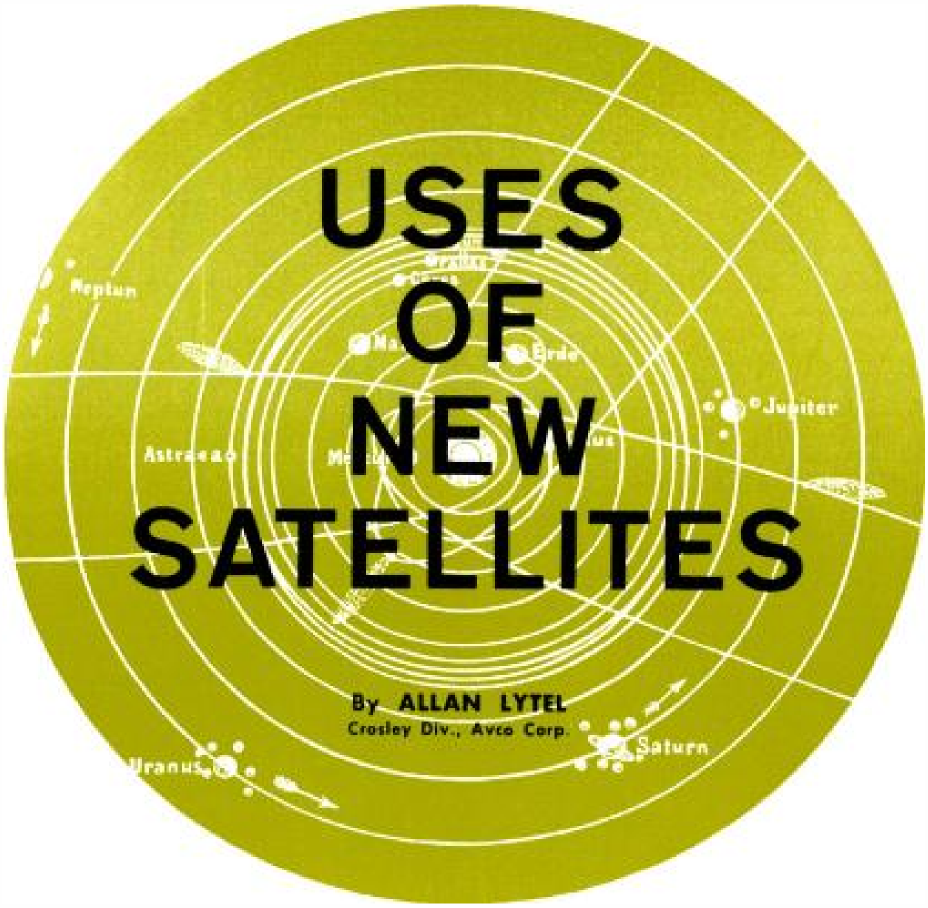


Fig. 6. An industrial application: the bridge and relay automatically feed water to tank as needed to rinse away wastes.

Description of some of our recent satellites and the jobs they are doing in the important fields of weather forecasting, communications, navigation, surveillance.

USES OF NEW SATELLITES



By ALLAN LYTEL
Crosley Div., Avco Corp.

THE ROAR of the missile carrying "Midas II"—the "eye in the sky"—into orbit was the sound of a new era in space. "Midas II" (*M*issile *D*efense *A*larm *S*ystem) weighs 5000 pounds and has a payload of 3600 pounds. Included in its instrumented package was an infrared detector designed to spot missile flames and sound a warning. Although radio contact with the earth was broken soon after launching, the system inaugurated a new generation of satellite vehicles. Earth satellites are providing new and important information regarding our environment—both near and remote. The successful and still-orbiting earth satellites launched by this country, exclusive of our "space probes," are listed in Table 1. These satellites mark the beginning of a new series of orbiting electronic "laboratories."

This new generation of satellites has four special missions: (1) weather forecasting, (2) missile-launch detection and surveillance, (3) communications, and (4) navigation.

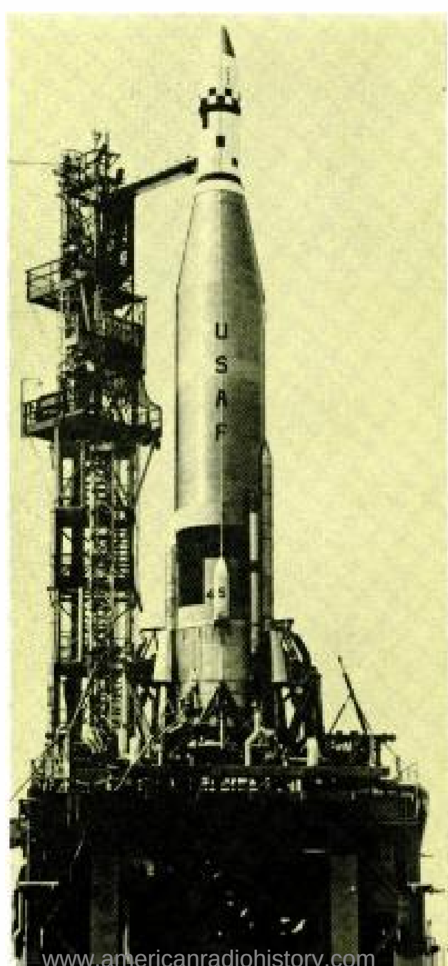
Electronics forms the core of missile technology for without electronic equipment it would be impossible to fire a missile, track a satellite, or receive information gathered from outer space.

The first U.S. satellite, "Explorer I" launched in January 1958, sent back vital information regarding the fields of intense radiation surrounding the earth. Valuable as this information was, data being supplied by "Explorer I's" more sophisticated descendants is even more important.

With the emergence of these new satellites, bigger and better launching vehicles were made available. In addition to the "Atlas" and "Jupiter," there is the "Thor-Able-Star" version of the "Thor" missile which was used to launch the Navy's "Transit I-B," to be discussed later.

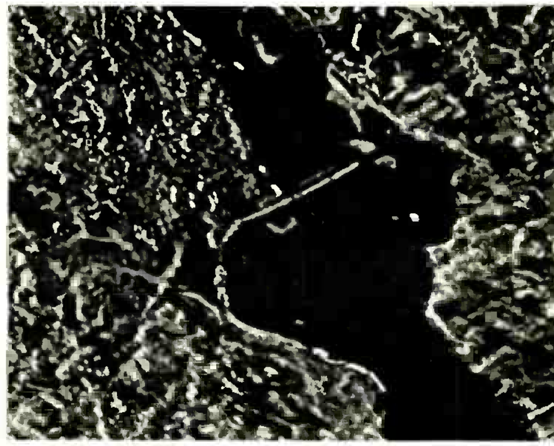
Weather Forecasting & Surveillance

Weather forecasting is only one of the valuable by-products of space research. "Tiros I," launched in April 1960, has transmitted thousands of photographs showing the cloud patterns over a large portion of the earth's surface. "Tiros," developed by *RCA*, was sponsored by the National Aeronautics and Space Administration under the technical direction of the U.S. Signal Corps. This particular application is an extension of earlier techniques using balloons for obtaining weather data.

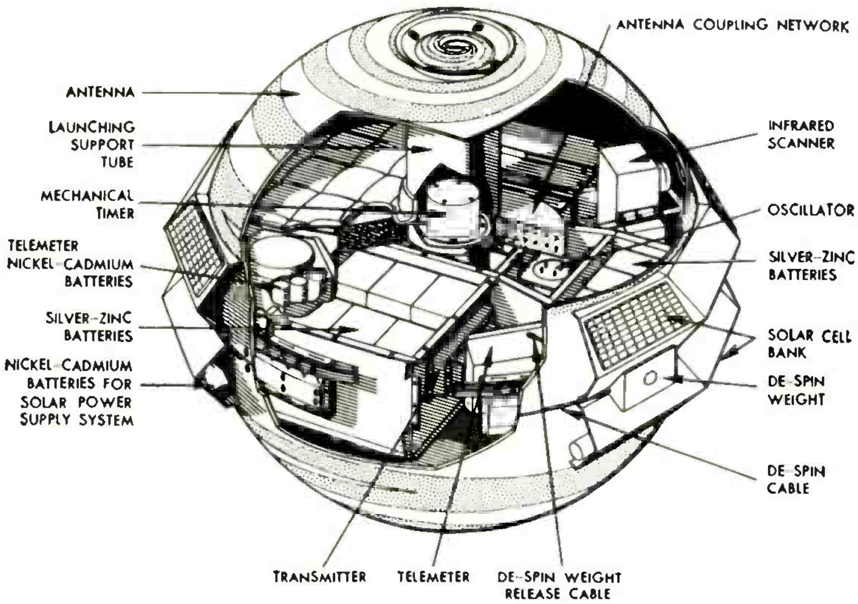


The Air Force "Midas II" aboard an "Atlas-Agena" stands ready on its Cape Canaveral launch pad. Successfully placed in orbit, "Midas II" was the first test of an Air Force surveillance satellite system concept.

Army-developed rocket-borne radiosonde is loaded into the nose cone of a 77-pound rocket for its trip 40 miles into the atmosphere. After separation from the rocket, the radiosonde parachutes slowly to earth, transmitting weather information to earth.



High-resolution radar picture of Washington, showing New Jones Point Bridge in center. The details begin to approach a photograph.



Cut-away drawing of "Transit I" showing shell with painted antenna and internal gear. The satellite sphere itself is 36 inches in diameter and weighs about 265 pounds.

Radiosonde systems have been used for years to provide vital weather information. Some types use a radar-like tracker for following the airborne device. The gas-filled balloon can be used either with or without an attached instrument package. Without a payload, the free-flying balloon drifts with the wind currents. By tracking its path from a ground station, the direction and strength of the wind at different altitudes may be determined. When instrument payloads are carried, coded signals indicating temperature, precipitation, and pressure are transmitted back to earth.

Small rockets are also used as radiosondes. One such unit, the "Arcos" rocket, which was produced for the Signal Corps by *Atlantic Research Corporation*, weighs 77 pounds and travels 40 miles into the sky. After separation, a parachute returns the radiosonde to earth, transmitting weather data during its descent. Other rockets, such as the "Aerobee," have also been used for high-altitude research.

Missile-launch detection and surveillance was the primary purpose of the "Midas" experiment. The infrared detection system is designed to pinpoint the plume from missiles just after launching. In addition to this type of infrared detection, both film and radar photography will be used for missile surveillance. The high-resolution photograph shown above illustrates the remarkable detail possible with such techniques. While this radar photo of Washington was taken from a low altitude, radar offers many possibilites because of its ability to "see through" clouds or other adverse conditions which would make ordinary photography impossible.

A satellite which could take and transmit radar photographs would indeed be an effective "aerial watchdog."

Communications & Navigation

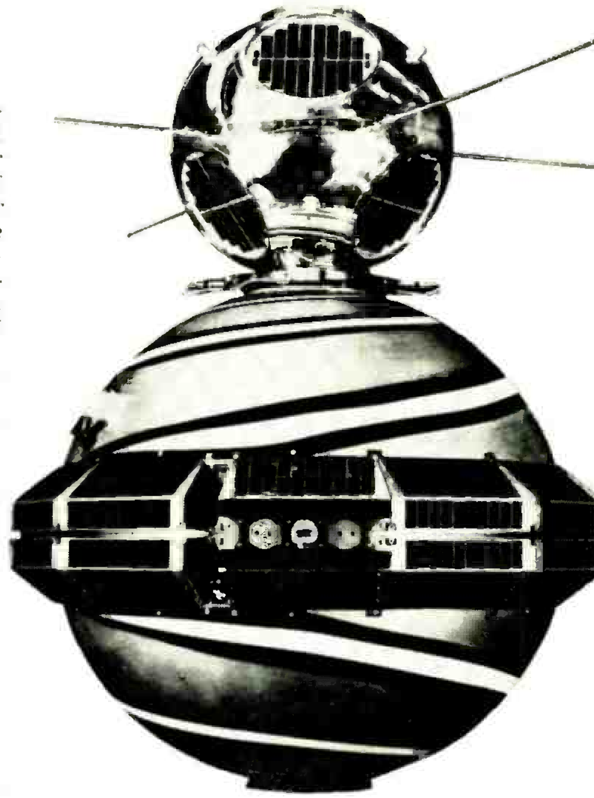
Communications satellites may one day make possible world-wide radio and television without the handicap of repeater stations. There are two techniques which are useful for communicating by means of satellites: passive and active.

Passive communications satellites are actually only reflectors of energy. This idea is used in the Air Force's Passive Satellite Relay Link. In addition, voice and coded signals, using a high-frequency carrier, have been bounced from a 100-foot plastic, aluminum-skinned balloon. This balloon, part of NASA's "Project Echo," was placed in a 1000-mile-high earth orbit to facilitate such experiments.

Assume that a satellite is placed in orbit at a distance 22,300 miles from the earth and that it takes exactly one day to make one revolution around the earth. If it were placed in orbit moving from west to east in the plane of the equator, the satellite would appear to

(*Continued on page* 102)

Naval Research Lab's solar radiation measuring satellite held in piggyback fashion atop "Transit II-A" satellite. After being orbited, the smaller top sphere is released to travel alone.



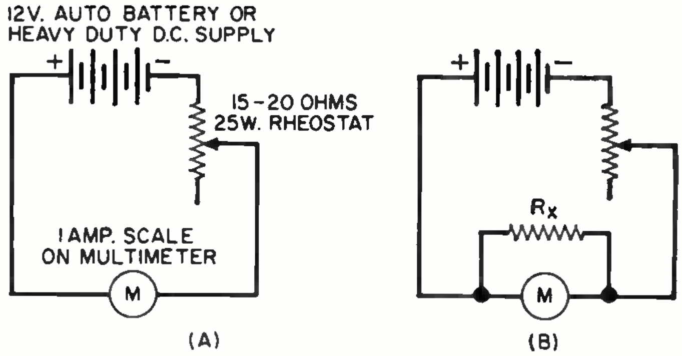


Fig. 1. In the first method, the meter is adjusted (A) for full-scale deflection and then shunted (B) by the unknown resistor. Value is found from the change in reading.

ULTRA-LOW RESISTANCE MEASUREMENTS

By **TOM JASKI**

Your multi-purpose meter may not give you usable low readings on its ohms scales, but it can be made to do the job in other ways.

THERE ARE many occasions in electronics work in which it becomes necessary to measure very low resistances, say in the order of only a few ohms or perhaps even less than one ohm. The ohmmeter ranges of the average v.o.m. or multimeter do not extend so low as to make readings in this magnitude practical. In some cases, there may be no perceptible deflection. Where there is, it may be almost impossible to read with any degree of accuracy. Yet it is quite feasible to use the instrument to obtain the desired readings, although indirectly, and this may be done with good accuracy. In fact, this cat can be skinned more than one way.

What are the occasions when it becomes important to know low resistances? Well, one case would be in checking transformers. The d.c. resistance of step-down secondaries or other low-voltage windings is often very low. One shorted turn or more in a low-resistance winding could have a substantial effect on operation. Although the specification for this resistance may be available, a check with an ordinary ohmmeter may only confirm continuity, but it is doubtful that one could read with sufficient reliability to note that resistance has dropped due to the short. You could try a replacement transformer for comparison, but this is quite a job—even if you have such a replacement available. Also accurate matching of certain systems or circuits, particularly when different makes of transformers are involved, might require some knowledge of the d.c. resistance of windings. And this same knowledge can be extremely useful when you have a good transformer but its windings are not properly identified.

Just in case you are getting the idea that the only time such very low resistances are important is when you are dealing with transformers, let's continue the list. You might want to know the contact resistance of a switch to be used in a measuring circuit or in some application where heavy current will go through it and the voltage drop may become important. You may wish to know the resistance of a ground return made through a chassis. This could be useful in troubleshooting where some elusive symptom may be due to an unsuspected ground loop. Perhaps you are hopeful of making up a low-resistance meter shunt from some wire or other promising material whose precise characteristics are not known. For all of the applications mentioned here, and for many others, it is extremely useful to be able to measure just a few ohms accurately—or even a fraction of an ohm.

How can you use an ordinary multimeter for this purpose? Two methods are described here. In the first one, the instrument is used on its current ranges and is supplied with a specified current. It is then shunted with the unknown, low resistance and the change in reading is used to determine the resistance. In the second method, the basic meter movement is used, but it is applied as though it were a millivoltmeter. For the first method, you need to know the internal resistance of the current scale of the instrument, particularly on the higher current ranges. Fortunately, this information is available from the instrument's instruction manual or can be obtained from the manufacturer. You may have to calculate it from the millivolt rating usually given for the particular current range. For example, if the manual tells you the 1- and the 10-ampere ranges are rated at 250 millivolts, you can use Ohm's Law to figure that internal resistance on the 1-ampere scale is (.25/1) .25 ohm and, on the 10-ampere scale, .025 ohm.

For the second method, all you need to know is the millivolt rating for the lowest current range. Generally this will be the same.

Method one is shown in Fig. 1. You need a heavy-duty source of current, a heavy-duty rheostat, and the instrument set at one of the higher current ranges. Step one consists of setting the current through the meter by means of the rheostat to secure a maximum-deflection indication of exactly 1 ampere. Step two, illustrated in Fig. 1B, consists of adding the unknown low resistance (R_x) in parallel with the meter, and then reading the current. Let's use an example.

Suppose you suspect the unknown to be less than .1 ohm. You start by using the 1-ampere scale of the instrument. The voltage source should be a 12-volt auto battery or a heavy-duty d.c. supply, well filtered, with at least 12 volts output. The rheostat should be a 25-watt job, with about 15 to 20 ohms resistance. Set the rheostat for full-scale deflection (1 ampere) on the meter.

Now you parallel the meter with the unknown (R_x). The meter now reads .15 ampere. Say the meter's internal resistance is .25 ohm. The unknown resistor is then carrying .85 ampere. (1 ampere total, less the current now flowing through the meter: .15 ampere.) The ratio between the internal resistance of the meter, and the unknown resistance is the inverse of the current ratio, and thus the unknown resistor is $.15 \times .25/.85$, or .04412 ohm. However there is a small error in this measurement of about 1%.

This error happened because the total current in the circuit increased a little when the unknown resistor was connected in parallel with the meter. You cannot calculate the error exactly unless the battery voltage or the rheostat resistance is known precisely. But we do know that the parallel combination of meter and unknown is about $(.04412 \times .25)/(.04412 + .25) = .037$ ohm. (We say "about" because the error has just been included in this calculation.)

When the unknown resistor was connected, the resistance of the circuit decreased .223 ohm. If the battery voltage was 12 volts, and the total circuit was 12.25 ohms (rheostat plus meter), the unknown resistance caused the current to increase from 1 ampere to about 1.01 ampere, or 1% more. In other words your measurement of the unknown resistor is low by that percentage. Adding 1% would bring it up to .04456 ohm. However, being able to read such a low resistance to an accuracy of 1% is asking a lot anyway.

With careful reading, so that say .02 ampere on the 1-ampere scale can be a reliable measurement, you can measure resistances down to .005 ohm. But remember that the lower you read on the scale, the less likely you are to read accurately. Also, the greater the current through the unknown, the greater the error due to increased total circuit current. For such low resistances it would be better to use the 10-ampere scale. Also you must keep in mind the ability of the unknown to take the current needed to measure it.

The second method avoids the use of high currents that are involved in the first. The arrangement for making the measurement is shown in Fig. 2. Here the voltage source required is similar to the one already described. However unknown resistor R_x is placed in series with a "standard" slide-wire resistor and the two are across the test voltage. The "standard," low-value, variable resistor can be made up and calibrated accurately without much difficulty. How this may be accomplished will be described later. First we will get on with the method itself.

As in the first technique, the rheostat is used to adjust current through the unknown resistor and the series "standard" to a convenient value. This value is not predetermined. The rheostat is simply adjusted so that perceptible meter deflection is obtained. In practice, however, the current through the resistors under this condition will be much less than in the first method, so that more resistance will be required of the limiting rheostat. About 150 ohms maximum value should suffice.

After the control has been set so that there is readable deflection across the unknown resistor, the "standard" resistor is adjusted so that the reading across it is equal to the reading across the unknown. As shown in Fig. 2, a switch may be used to alternately put the meter across the unknown and the standard during this adjustment. When the readings are equal, we know that the value of the two resistances in the circuit are equal. The calibrated standard then gives us the value of the unknown.

In this arrangement, the multimeter is used as though it were a millivoltmeter, but the actual function and range used is the lowest current range. Once more, let us clarify with an actual example. Suppose the lowest range is 50 microamperes, full scale, and the millivolt rating for this range is 250 millivolts. From this, it is easy to convert dial indications into voltage readings. Suppose the meter indicated 20 microamperes during a test. The actual voltage across the meter would be $20/50 \times 250$, or 100 millivolts.

In practice, we would not have to make this calculation since we would not have to know the voltage to determine the resistance. We would simply have to determine that the reading across both resistors is the same, whatever that reading is. However, making a few calculations gives us an idea of the low order of magnitude of resistances that can be read and the small currents involved. Suppose that the unknown resistance turned out to be .15 ohm and that, in order to determine this, we had obtained a reading of 3 microamperes (which means 15 millivolts) on the meter. From Ohm's Law ($I=E/R$) we can determine that the actual current going through the resistor under these conditions is 100 milliamperes, which is quite low. In practice, resistances of only a few hundredths of an ohm could be determined with rheostat settings that would still limit current through the resistor to well below 1 ampere.

Now the problem of making up the "standard" slide resistor remains. This can be fabricated from a length of copper wire fastened to a board. What makes the method possible is the fact that readily available wire tables give the resistances of conventional wire types quite accurately. For example, #34 annealed copper wire (which can easily carry .5 ampere) has a resistance of 260.9 ohms per 1000 feet at 20 degrees C (or 68 degrees F). This would come out to .2609 ohm per foot, or .0217 ohm per inch. The actual wire size you would use would depend on the range of resistance in which you would be measuring. You could "read" resistance values on the slide wire with a ruler calibrated in inches, or you could make up a scale on the board calibrated directly in resistance per inch.

Notice that the resistance is given, however, at one particular temperature. Since there will be some variation with temperature change, let us see how much of a difference this will make. The formula used to determine this change, for copper wire, is $R_2=R_1(1+.0039[T_2-T_1])$; where R_2 is the temperature-altered resistance value we wish to determine, R_1 is the nominal resistance at 20 degrees C given in the table, T_2 is the actual temperature of the wire, and T_1 is the rated temperature of 20 degrees C.

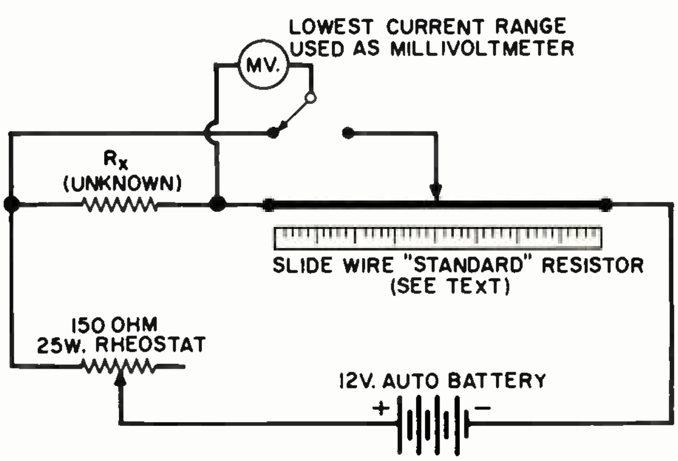
Now let us say that a length of wire whose resistance is one ohm is heated by current through it so that it is raised 10 degrees C (18 degrees F) above ambient temperature. Using the formula, we find that its resistance has increased to 1.039 ohms. This is a change of nearly 4 per-cent. Now whether a relatively small shift of this order is significant or not depends on how critical the values are that you are measuring. You may choose to ignore the change brought about by temperature altogether.

If you are making critical measurements, you might want to take this difference into account by taking a temperature reading and doing some calculation. Or else, you might choose to eliminate this extra work by using a wire that is not so much affected by temperature. For example, it is possible to buy manganin wire for making up the "standard." The resistance per inch of this type can be determined exactly and it has a low temperature coefficient.

There is another error that creeps into the second method shown, but it is very small. It results from the fact that the meter is shunted across the unknown resistor, changing the current across the latter somewhat. However, this error can pretty well be ignored even where high accuracy is desired. The 50-microampere, 250-millivolt meter range would provide an internal resistance of the instrument of 5000 ohms. With some multimeters, the internal resistance in this function would be lower, but it is not likely to drop much below 2000 ohms. Such a value shunted across a fraction of an ohm, or even several ohms, will not produce any change in reading that is visible to the eye.

With the methods described here, the measurement of very low resistances is not only possible, but it may be done with reasonable accuracy. Some accessory materials are required and obtaining a reading involves more trouble than direct ohmmeter use. However, you have increased versatility of an inexpensive instrument by adding a couple of resistance ranges. The extra trouble seems worthwhile. –[30]–

Fig. 2. In the second method, the unknown and a "standard" resistor are in series across a battery. The standard is adjusted to produce the same meter reading noted across the unknown.



ADJUST CURRENT UNTIL REASONABLE (READABLE) DEFLECTION IS OBTAINED ACROSS UNKNOWN RESISTOR. THEN MATCH THIS READING ACROSS "STANDARD" BY MOVING SLIDE. MEASURE LENGTH OF SLIDE WIRE AND COMPUTE RESISTANCE.

SOVIET RADIOS & TV SETS

How Good Are They?

By **THEODORE M. HANNAH**

Poorly designed and constructed parts plus inadequate quality control lead to service troubles in Russian sets.

THERE IS little doubt that the Russians can build good, reliable electronic equipment—the various Sputniks and space probes have proved that. But does the same high quality carry over to the home electronics field? How do Soviet radios and TV sets compare with those produced in the West? How reliable are they? What kind of service does the set owner get? What are some of the other problems?

Before looking at the sets themselves, it might be useful to look briefly at radio and television broadcasting as it is in the Soviet Union.

The Broadcasting System

For reasons of efficiency and economy, the Russians have found it advantageous to build a vast network of wired-radio broadcasting in preference to the usual network of broadcast stations. In the Soviet system, a relatively small number of strategically located transmitters relay the programs of Radio Moscow and certain regional centers. (The programs are also carried by wire line.) Received in thousands of wired-radio receiving stations, the broadcasts are amplified and distributed to loudspeakers set up in public squares, parks, street corners, in homes, apartments and public buildings, and in farm villages. The listener can adjust the volume but he cannot change programs. There are now 30 million such "radio points" (speakers) in the U.S.S.R.—this is about one speaker to every seven persons. There are about 25 million radios in use; 1959 production was 4 million sets.

As with many European countries, the Soviet Union is now placing considerable emphasis on FM broadcasting. By the end of 1960, FM stations were to be in operation in 65 cities. FM is intended to supplement the wired-radio system, particularly in the major cities.

At the beginning of 1960 there were 83 TV stations in operation in the U.S.S.R. These served an area with a potential audience of 75 million. There are now about 4 million TV sets. The current Seven-Year Plan calls for 160 stations and 15 million receivers by 1965. The 1959 production of TV sets was 1.3 million.

The Sets

Generally speaking, Soviet radios and television sets are well-designed and incorporate many of the latest features found in American sets. They are, however, plagued with an inordinate amount of service trouble. This is due primarily to poorly designed and constructed components.

Soviet radios tend to be larger and heavier than the usual American set. They are generally a.c.-powered (a.c.-d.c. sets are not common) or, particularly in rural areas, are battery-operated. Console and table-model radio-phono combinations (of the kind not generally made in the U.S. since the war) are produced in fairly large numbers. The deluxe radios cover several bands: long-wave (150-415 kc.), medium-wave (520-1600 kc.), and short-wave (5.5-12.2 mc.). The FM broadcast band (64.4-73 mc.) is also often included.

High-fidelity is stressed in the more expensive sets. Separate bass and treble controls, wide-range frequency response, 10-20 watts of audio output, and four to seven speakers are all common in the deluxe model radios.

Transistor portables have proven to be as popular in the U.S.S.R. as in the U.S. and are in short supply.

A word about stereo. The first stereo records and players were produced at the end of 1959. Also, experimental stereo multiplex broadcasts have recently begun.

Soviet TV sets are designed for the 625-line, 25-frame standard which is in use throughout most of Eastern Europe. Channel width is 8 mc. Standard i.f.'s are 34.25 mc. for video and 27.75 mc. for audio. There are 12 channels—the first five between 49 and 100 mc. and the other seven between 174 and 230 mc. (Not all 12 channels are in use, however. The Moscow telecenter broadcasts on two channels; other cities have only one channel.) A u.h.f. band (470-850 mc.) is planned for the future.

The newer sets feature 110° picture tubes, printed circuits, and remote control. Semiconductors are widely used (at least one all-transistor set is being developed). The most common screen sizes in the new sets are 14, 17, and 21

The Russians are poking fun at the poor reliability of their TV sets in this cartoon from a recent issue of the Soviet magazine "Radio." The sets are shown "in orbit" between the set owner and the repair shop.

inches; many 7- and 10-inch sets are still in use, however.

A typical TV set, called the "Voronezh," covers all 12 TV channels (many earlier sets received only the first five channels), but does not receive the FM broadcast band. The set uses printed circuits and has keyed a.g.c. and automatic fine tuning. Some other specifications: sensitivity, 200 microvolts; horizontal and vertical resolution, 500 lines; tonal gradations on standard test pattern, 8; audio frequency response, 120-6000 cps; and power consumption, 140 watts.

A typical new, deluxe TV receiver has a 23-inch screen, 21 tubes and 19 diodes, seven speakers, remote control, and provisions for FM broadcast reception.

Color television is not yet in regular use in the U.S.S.R. Experimental colorcasts have been made, however, and one plant is making pilot models of a color receiver. To acquaint service technicians with color TV, the electronics magazines are carrying articles on the subject.

Service

"If the electronic equipment in our Sputniks can operate so reliably, hasn't the consumer the right to expect the same reliability in his radio, television set, record player, or tape recorder?" This complaint in a Soviet newspaper is typical of many others and points up the fact that Russian radios and TV sets are often not very reliable. The radio equipment in Sputnik III operated for 16,500 hours, yet new television sets often fail within two or three days of purchase. More than half of the radio-phono combinations handled by Moscow's largest department store had to be sent back to the repair shop—even before being sold. Up to 75 per-cent of some TV sets require service during the warranty period.

The reason for this appears to lie in poor quality control during production. Inferior parts plus careless assembly add up to major headaches for the consumer and the service technician.

Soviet electronic products (radios, TV sets, recorders, etc.) carry a six-month factory warranty; during this period repairs are made without charge in "warranty repair" service shops. The foreman of one of these shops blamed premature failures in TV sets on factory workers who simply do not care enough about reliability. He found particular fault with poor construction and alignment of TV front ends. Other service headaches include: coils wound with enameled wire from which the enamel wears off, causing shorts; poorly constructed controls on which the stops break, permitting the shafts to spin all the way around; speaker voice coils

A new deluxe Soviet TV set with a 23-inch screen, 21 tubes and 19 diodes, 7 speakers, remote control, and FM broadcast reception.

which break loose from the cone; fuses which fail to blow under overload, causing burned-up power transformers; poorly constructed phono motors, etc.

An official study found that tube failure was responsible for 31 per-cent of TV failures; picture tubes, 4 per-cent (these are guaranteed for 750 hours); selenium rectifiers, 5 per-cent; other defective components, 9 per-cent; and defects in manufacture and assembly, a whopping 18 per-cent.

The electronics industry is frequently exhorted by the government to improve the reliability of its products. As an official of the Ministry of Communications put it:

"The unsatisfactory quality of television sets now being produced has resulted in a corruption of the very concept of the factory warranty. Today the factories guarantee not the reliability of the sets but the purchaser's right to free repairs for a period of six months. The service shops must fix the factories' defective merchandise."

The high cost of supporting the "free" factory warranty is also criticized. It has been calculated that the warranty feature automatically adds 80 rubles ($8-$20, depending on the exchange rate) to the cost of every TV set produced. The 11 million sets to be produced by 1965 will thus cost an additional $88 to $220 million!

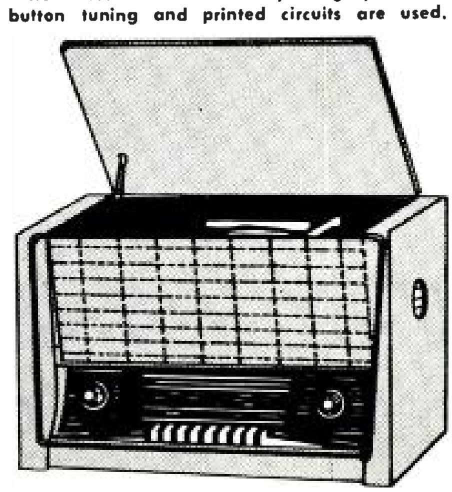
Greater standardization is also proposed as a means of reducing repairs on TV sets. To date, about 50 models have been produced. It is suggested that if fewer models were made, the technician could learn to service them better.

To keep Russia's 4 million TV sets in working condition there are about 200 service centers (all, of course, government-operated) and 7000 technicians. To serve Moscow's 5 million residents there are perhaps 25 TV service shops. There are about the same number for repairing radios, record players, and recorders. The shops are so specialized that a TV repair shop seldom repairs radios and a radio repair shop usually will not work on a TV set.

In addition to poor-quality sets and parts, the service technician is faced with another problem—that of *obtaining* parts. The supply of certain types of tubes, resistors, capacitors, switches, and transformers does not meet the demand. In addition, parts distribution, a responsibility of the Ministry of Trade, is often less than perfect. The result is that the set owner, particularly in the smaller towns, must often wait weeks for his radio or TV set to be repaired in the government-operated shop.

Given these conditions, it is not surprising that the set owner sometimes looks elsewhere for service. This has led to instances of technicians doing repair work on their own time. While such "free enterprise" has been condemned in the press, it has at the same time led to promises of better service in the government service shops. —30—

A new Russian AM-FM radio-phonograph. Push-button tuning and printed circuits are used.



By **JOHN T. FRYE**

A Pound of Prevention

MATILDA, the office girl of Mac's Service Shop, looked up to see Barney, the Number Two Technician, coming through the front door. His lanky figure was silhouetted against the glare of the early-March sunshine behind him, but she could see he was carrying something in his hand covered with an inverted paper bag. He marched to the front of her desk, clicked his heels together, and with a flourish whipped off the sack to reveal a half-dozen bright yellow jonquils on long green stems.

"Saw 'em in a greenhouse window while I was making that last call," he explained gruffly. "They reminded me so much of the green blouse and yellow necklace and earrings you're wearing today that I decided you should have 'em. Where's a vase?"

"Why, Barney, you sweet, lovable, impulsive Irishman!" Matilda exclaimed as she jumped to her feet and planted a quick kiss on the boy's blushing cheek. "That's the nicest compliment I've received in months!"

"Hey, what goes on here?" Mac called through the open door of the service department. "No necking during working hours except with the boss!"

"Aw, we weren't—she was just—I mean—" Barney struggled.

"Mac, you let Barney alone," Matilda said sternly as her grinning boss sauntered out and perched himself on a corner of her desk. "Instead of teasing him, you ought to be thinking about what that last customer said when she picked up her radio."

"What was that?" Mac drawled lazily. "Men don't eavesdrop, you know."

Matilda ignored the bait as she answered: "She said service technicians ought to tell their customers things that would help keep their electronic equipment working. She pointed out doctors don't just cure you when you get sick; they also advise you how to stay healthy. A good lawyer doesn't just get you out of trouble; he keeps you from getting into trouble. She argued that if service technicians were as 'professional' in their attitude as they like to think they are, they would do the same thing."

"Hm-m-m," Mac said as he thoughtfully tugged at his ear; "that's kind of a new idea. You mean we're supposed to tell our customers how to avoid our services?"

"In a manner of speaking, yes; but remember the equipment will still fail eventually and have to be repaired. By the time that happens, though, the customer will be thoroughly convinced we're concerned with his welfare as well as our own. He will have become that next-best-thing to money in the bank: a loyal client who would not dream of letting anyone but us touch his electronic equipment."

"We got some customers nobody could tell *nothin'*!" Barney said with more conviction than grammar.

"True," Matilda agreed; "but you'd be surprised how many others, especially women, ask me if anything they did caused their radio, TV, or record player to go bad."

"OK," Mac said; "just for the heck of it, let's see if we *could* tell them anything that would help. Tube failures account for a lot of trouble; so what could they do to prolong tube life?"

"Not let little kids play with the on-off switch," Barney said promptly. "Heating and cooling of filaments, with accompanying expansion and contraction of tube elements, contribute to most tube failures. If the brat has to turn something to acquire manual dexterity, spike a spool to a piece of board and let him play with that. It's cheaper."

"Makes sense," Mac agreed; "but Matilda will have to do a bit of editing before giving that to the doting mammas. Jarring is hard on tubes, too; so the less radio and TV sets are moved about, the better. When they are moved, they should be handled gently and sharp jars avoided."

"How about dial cords?" Matilda asked. "We replace lots of those."

"Don't let the kids play with the tuning knob," Barney again said promptly. "If you run the pointer up against the stop and keep turning the knob, the cord either breaks or starts slipping on the shaft. Slipping polishes the shaft and destroys the gripping 'tread' of the cord. Once that happens, the cord will continue slipping during normal operation and must be replaced."

"Line cords take quite a beating, too," Mac remarked. "Taking hold of the plug instead of the cord when unplugging a device would add years to the life of the cord. So would keeping it off hot radiators or warm-air registers. Not mauling it with dustmops or sweepers and keeping floor-wax solvents and cleaners off it help, too. You'd think anyone would know better than to let pets chew on the cord—especially if they *like* pets—but we've seen the teethmarks to prove different."

"Keeping little plastic radio cabinets and electric toasters apart is a good idea, apparently," Matilda chimed in. "I remember seeing several kitchen-casualties of that nature."

"Right," Mac said. "And it's also a good idea not to place objects on top of these cabinets. When the plastic is cold, it is very strong and gives little under the weight of even a moderately heavy object; but if the object is left in place while the tubes heat the plastic, it may sag like the back of Wash Funk's horse and acquire a permanent set. And you have to be pretty careful about cleaning agents used on many of these cabinets and dial windows. Some of them will be permanently damaged by carbon tet, acetone, or any sort of abrasive cleaner. When in doubt, it's best to stick to plain soap and water."

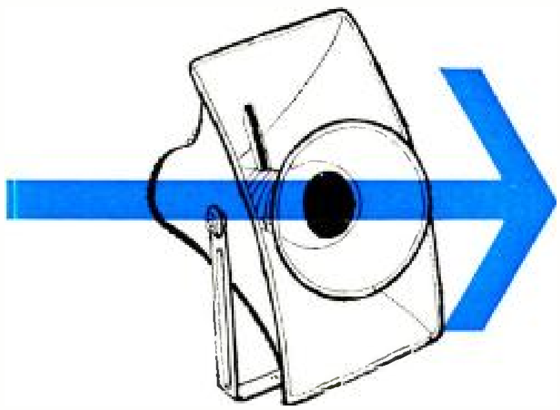
"Heat is an arch-enemy of electronic equipment," Barney continued. "A radio may 'just fit' that little cabinet opening above the stove, but if it is operated there it will be subjected to heat and fumes and steam from the stove plus the heat that will build up inside the cabinet for lack of proper ventilation. This heat shortens tube life, melts the sealing wax from capacitors, dries out electrolytics, and softens the wax on coils, causing them to change their inductance value. Cutting off the proper circulation of air through a radio or TV set is a dan-dan-dandy way to insure our getting it quickly and often."

"Moisture is darned near as bad," Mac suggested. "We have found that out since basement recreation rooms have become popular. Unless a basement is kept drier than most of them are, a radio or TV chassis coming from there testifies to the effect of dampness. There are rust spots on the chassis; moisture has seeped into capacitors and made them leaky; the insulation on wires is moldy; and coil failure, due to electrolytic action, and warped speaker cones are very common. This condition is especially bad in the summer when the heat is turned off and when the device is not used enough to keep itself dried out. Using electronic equipment in a damp place is bad enough, but leaving it unused in such a place is far worse."

"You boys got any suggestions just for the TV owners?" Matilda wanted to know.

"What we've said about electronic equipment in general applies here, of

(Continued on page 106)



Here is some practical working knowledge for the electronics technician who wants to break into the important public-address system field.

Commercial Sound System Fundamentals

By RUSS PAVLAT
Communications Engineer, State of Wisconsin

Part 2

Wiring Up the System

IN LAST month's article, we covered sound-system requirements, equipment selection, and speaker connections. Now we will go into some of the practical problems involved in wiring up the sound system.

Audio Lines

An ordinary audio line is long compared to the wavelength of the audio signals carried on it. For example, a 100-cps signal has a wavelength of 1860 miles; a 1000-cps signal, 186 miles; and a 10,000-cps signal has a wavelength of 18.6 miles. The impedance of the ordinary audio line may be considered to be the parallel sum of the impedances of the loads on it and, for practical calculations, the losses depend only on the actual resistance and shunt capacity of such a line. For the scope of the problem covered here, this theory is considered valid for voice lines of 3 miles or less, music lines of 2 miles or less, and hi-fi lines of 1 mile or less, such distances being practical maximums for ordinary designs. In actual practice this theory may be used on lines of several times these lengths, depending on the cable used and the type of distribution employed.

Table 5 is a chart showing practical resistance values for ordinary audio cable installations. The values in the last column are loop resistances per 1000 feet of stranded, twisted-copper-wire pairs. Approximately 20% has been added to the values in column 3 because of twisting. Since the loop resistance is directly proportional to the line length, loop resistance of other line lengths can be easily calculated, *e.g.*, the loop resistance of 100 feet of #20 cable would be 10% of 25 or 2.5 ohms.

The power loss due to line resistance may be expressed in per-cent of the power fed into the line by use of the following expression:

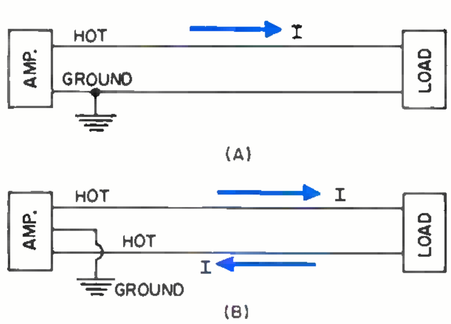
$$\textit{Per-cent loss} = \frac{\textit{line resistance} \times 100}{\textit{line resistance} + \textit{line impedance}}$$

The line impedance is the load impedance. From Table 5, the loop resistance of 1000 feet of #18 line is 16 ohms. If the load on the end of the line is a 16-ohm speaker, the power loss in per-cent of the power fed into the other end of the line would be $(16 \times 100)/16+16 = 1600/32 = 50\%$.

Under these conditions, irrespective of the power fed into the line, 50% would be lost and dissipated by the line as heat. Considering only the line resistance and speaker load, and since the line resistance is in series with the speaker, the actual impedance of the load, as presented to the amplifier output, would be the sum of the line resistance and speaker impedance, or 32 ohms. If this combination is connected to the 16-ohm output tap of an amplifier, by the impedance formula, only 50 per-cent of the amplifier power would be fed into the line. Thus, line resistance makes it difficult to feed power into the line, and the over-all effect of line resistance and mismatch would be that only 50% times 50% or 25% of the power would be delivered to the speaker. 75% might be an acceptable loss if only one or two watts were needed at the speaker. However, if high power is needed, a 75% loss is not very attractive.

If this line were operated as a 70-volt system (with a suitable matching transformer and speaker), resistive losses at one watt would be only .3 of 1% and resistive losses at ten watts would be 3%. Mismatch losses would be .3 of 1% and 3% respectively. The similarity between resistive line losses and mismatch losses on both the 16-ohm line and the 70-volt line is general and if compensation by changing output taps is not feasible, the mismatch loss (expressed in per-cent or decibels loss) due to line resistance is approximately equal to the resistive loss (expressed in per-cent or decibels loss) on ordinary audio lines. Using this method of calculating resistive losses, such losses may be calculated for each individual load on the system. The losses may be added for cables or cable sections common to more than one load. The factors of cable cost and resistive losses can then be evaluated and the most economical cabling selected for each part of the system.

Fig. 1. (A) Unbalanced, (B) balanced lines.



Although line resistance ordinarily wastes more power than other line characteristics, inductance, capacitance, and leakage should be considered in designing a distribution system. Power wasted because of leakage can be held to a minimum by using good quality cable and by carefully installing line terminations. The largest leakage losses are due to moisture which causes losses to ground in cables and terminals. Untreated wooden cable terminals tend to absorb moisture; plastic terminal boards and barrier strips are recommended.

Frequency distortion is the distortion occurring when the line transmits some frequencies with less loss than others. Line inductance, transformer inductance, and line capacitance all contribute to frequency distortion. Inductive current and capacitive current are opposite in phase and their resulting voltages tend to cancel each other. Inductive current is 90 degrees behind in-phase resistive current and capacitive current is 90 degrees ahead of in-phase resistive current. These currents can be summed by the use of vectors and relatively complicated mathematics. In the systems being considered, line capacitance is a primary cause of frequency distortion, and considerable insight into the effects of line capacitance can be obtained without undue complication.

Good quality audio cable in sizes from AWG 16 to 22 has a capacitance between wires of about .045 μf. per 1000 feet. The reactance of .045 μf. is 3600, 720, and 360 ohms at 1000, 5000, and 10,000 cycles respectively. The capacitance between one line and the other line connected to the shield (unbalanced line operation) is about .08 μf. per 1000 feet. The reactance of .08 μf. is 2000, 400, and 200 ohms at 1000, 5000, and 10,000 cycles respectively. Although the capacitance is distributed along the line, for estimating capacitive losses these reactances may be considered to be approximately in parallel with the line. An unbalanced line operating at 200 ohms would have a 2000-ohm capacitive loss reactance in parallel with it at 1000 cycles; 400 ohms in parallel at 5000 cycles; and 200 ohms in parallel at 10,000 cycles.

Thus the line impedance, far from being constant, actually varies with frequency. This is the primary reason why line impedance should be designed to be as low as practical, consistent with the resistive losses that can be tolerated. If broad frequency response is of primary importance, high resistive losses can be tolerated to enable use of the smoother and better frequency response characteristics of a low-impedance line. Line inductance causes high-frequency losses and the inductances of transformers wired across the line cause low-frequency losses, but these effects are usually minor compared to the effect of line capacitance.

Resistors, capacitors, and inductors are combined in equalizers which can be designed and constructed at virtually any impedance and any desired frequency characteristic. Line equalizers introduce losses over a frequency range such that when they are used with distribution lines, the combination of equalizer and line results in the desired frequency range being transmitted over the line. The use of equalizers lowers the over-all impedance of a distribution line, wastes power, and is justifiable only if frequency response requirements are broad. In general, equalizers are easier to construct and less expensive when designed for high impedances and low power. Their design and use are relatively complicated.

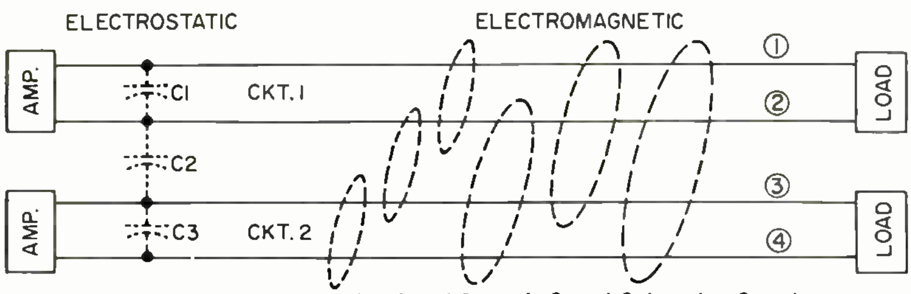


Fig. 2. Capacitance between wires 1 and 3 equals C_1 and C_2 in series. Capacitance between wires 2 and 4 equals C_2 and C_3 in series. Capacitance between wires 1 and 4 equals C_1, C_2, and C_3 in series. Electromagnetic coupling decreases as the distance between wires increases, and all wires are influenced by field around each.

The Decibel

The decibel is commonly used to express gains and losses in sound systems. The decibel is logarithmic in character and the over-all characteristic of a system may be determined by adding gain and subtracting losses expressed in decibels. A decibel is defined as 10 log_{10} (P_2/P_1) where P_2 is the larger power and P_1 the smaller power. If the power fed into a system is greater than the output power, *e.g.*, a distribution system, the expression represents a loss. If the power taken out of a system is greater than the power fed into the system, *e.g.*, an amplifier, the expression represents a gain. If the voltages and currents involved in these examples operate *in equal impedances*, decibels may be expressed in terms of voltage and current as follows:

$$db = 20\ log_{10}(E_2/E_1)$$

and

$$db = 20\ log_{10}(I_2/I_1)$$

where E_2 and I_2 are larger than E_1 and I_1.

Adding decibel gains is the same as multiplying certain gain percentages and adding decibel losses is the same as multiplying certain loss percentages.

Table 6 gives decibel losses and gains for voltage, current, and power expressed in practical percentages. A 2 db voltage loss, for example, indicates a 20% voltage loss with 80% of the voltage level remaining. To calculate the voltage level after an 8 db loss, consider this a 2 db loss plus a 6 db loss, and multiply the 2 db remaining level (80%) by the 6 db remaining level (50%) and the result is 80% times 50% or 40% of the voltage remaining after an 8 db loss. To calculate the power level after a 14 db gain consider this a 10 db gain plus a 3 db gain plus a 1 db gain and the power level is 1000% times 200% times 125% or 2500% (25 times) of the original power level.

Table 6 supplies enough information to enable level calculations of other decibel values within the range of the table with four multiplications or less. The small inaccuracies resulting from the use of the "practical" percentage rather than the absolute values (not shown) are not significant in sound-system work. The table shown is small and can be readily memorized, if desired. In terms of voltage and current, a 6 db loss halves and a 6 db gain doubles the voltage or current. In terms of power, a 3 db loss halves and a 3 db gain doubles the power.

If a reference level is specified, the decibel system can be used to determine actual levels of voltage, current, and power. Table 7 is a chart of actual voltages, current, and power when a dbmv. is specified as a decibel level referred to one millivolt; a dbma. is specified as a decibel level referred to one milliampere; and a dbm. is specified as a decibel level referred to one milliwatt. The present commonly accepted dbm. is referred to one milliwatt. An earlier use of the dbm., principally in telephone communications, referred the dbm. to a 6-milliwatt level. To change from a 1-milliwatt reference to a 6-milliwatt reference, 7.8 db should be subtracted. To change from a 6-milliwatt reference to a 1-milliwatt reference, 7.8 db should be added. 8 db is commonly used in both cases. "Volume Units" (vu) are the same level as decibels referred to one milliwatt. Such vu meters differ from ordinary db meters in that true vu meters have controlled impedance, controlled damping, and controlled scale length so that all true vu meters will have the same "throw of needle" and period of swing. This enables standardization of peak readings.

Selection of Wiring

The selection of audio wiring and the proper use of such wiring is an important consideration in the economics and operation of a distribution system. In addition to the problems of resistive and capacitive losses, noise and crosstalk from poor wire positioning, interference from other electrical cabling, and interferences from metallic conduit because of induction, corrosion, or poor physical conduit connections, may reduce the over-all quality of a system if the audio wiring is improperly designed or installed.

The use of a single conductor with a shielded or metallic conduit ground return is not good practice. Metallic conduit cannot be depended upon to provide a good ground return, and the presence of audio currents in the shield or conduit can cause corrosion due to electrolysis and rectification at points exposed to moisture. These types of corrosion are progressive, and any small starting point soon develops into a major resistive problem or an open circuit. Cable with exposed shielding should never be used in metallic conduit. Corrosion at points where the exposed shielding touches the conduit, due to electrolysis and rectification, can cause noise and reduce or eliminate the shield effectiveness with resulting interference and crosstalk problems. Multiple cables with exposed shielding create troubles in any conduit. The variation in audio current in shielding and even a small amount of moisture (moist air is sufficient) can cause corrosion due to electrolytic action and rectification between exposed shields. Shielded cable should always have a plastic or rubber cover. To prevent corrosion and for other reasons to be explained later, shield splices in junction boxes and terminals should always be electrically isolated from metallic conduit. Shielding should be used for its protective values only, and should never be the only return path for audio currents in a sound distribution system.

Balanced & Unbalanced Lines

Two-conductor cables are commonly used in sound distribution systems. They are frequently used in what is termed unbalanced-line operation as illustrated in Fig. 1A. Audio currents flow to the load *via* the single hot conductor and return through the grounded conductor. If shielded cable is used, the shield may also be connected to ground and some audio current returns *via* the shield. It is possible to provide additional ground return paths but it is usually undesirable to do so. The ground terminals of amplifiers and associated audio equipment are also connected to the system ground. All ground points are theoretically at zero voltage with reference to each other and to the earth.

Wire Size AWG	Ohms/1000 Ft. Single Wire	Ohms/1000 Ft. Pair	Ohms/1000 Ft. Twisted Pair
14	2.63	5.26	6
16	4.18	8.36	10
18	6.64	13.28	16
20	10.56	21.12	25
22	16.78	33.56	40

Table 5. Resistance table and loss resistance value for twisted stranded copper wire.

In practical applications, however, because of wire and shield resistances and due to return audio current, parts of a system which are connected to ground may carry voltage with respect to other ground points of the system. The differences in voltage among ground points can cause crosstalk and interference problems.

The balanced-line system of operation is shown in Fig. 1B. Equal audio currents flow in opposite directions in the two conductors and ground is at the electrical center of the line system. A ground-return path is not needed and a ground is not required to transfer power to the load. The chief purpose of the ground in balanced-line operation is to maintain the proper voltage relationships between the line and other parts of the system. In balanced-line systems, a third conductor or the shield can be used to carry the ground to the electrical center of the load end of the line to reduce or eliminate undesirable induced voltages at that point.

In systems where two or more audio cables are placed in the same duct or conduit, disturbances in a circuit may be caused by characteristics of other circuits and/or by characteristics of the system in general. The degree of disturbance can depend on the difference in power levels between a disturbing circuit and a disturbed circuit or, in the case of balanced-line operation, on the degree of unbalance in the system.

Cables which are close together for appreciable distances may interfere with each other because of electrostatic or electromagnetic coupling. Fig. 2 shows the capacitance which may cause interference among the four wires of a two-circuit system and illustrates the effect of electrostatic coupling. In an unbalanced-line system, if we consider wires #1 and #3 as the hot wires and wires #2 and #4 as the ground wires, the capacitance which will cause interference is between wires #1 and #3. A grounded shield on either cable would reduce or eliminate electrostatic interference because of the capacitance existing between wires #1 and #3.

If this system were a balanced-line system, all capacitances could cause interference with some cancellation due to opposite induced voltages. If, for example, wires #2 and #3 remained close together for any appreciable distance, the capacitance between them would be relatively large, and a net interference voltage would develop. In balanced-line systems, a well balanced system with frequently twisted (transposed) wires to insure uniform capacitances among wires, will contain little or no net interference voltages. A grounded shield, however, is again the best way to reduce or eliminate electrostatically induced interference.

Fig. 2. also shows that electromagnetic coupling produces interference voltages in adjacent cabling. Electromagnetic coupling is different from electrostatic coupling in operation, but it produces interference voltages similar to those induced electrostatically. As the name implies, it is a magnetic effect similar to the action of a transformer, and ordinary non-ferrous shielding gives little or no protection against such interference. Magnetic shielding of ferrous metals or special magnetic alloys would help, but it is usually impractical to apply in sound-system work. Under certain conditions steel conduit can provide some magnetic shielding from interference originating outside an audio conduit.

Where an unbalanced line is used, interference between circuits due to electromagnetic coupling can be severe if adjacent circuit power levels are substantially different. An extreme example would be a 70-volt line next to a microphone line. A power level difference of 60 db or more could exist, and if the two lines were close for even a short distance, crosstalk would develop in the microphone line.

Balanced lines reduce interference and crosstalk substantially. Reduction of crosstalk does not occur because electromagnetic (or electrostatic) coupling is made ineffective but rather because the voltages induced by a balanced line in another conductor (refer to Fig. 1B) are equal and opposite in sign, and cancellation occurs. A well-balanced 70-volt line could operate next to a microphone line for a considerable distance without objectionable interference.

If the wire positions in a circuit causing interference are interchanged or transposed at regular intervals, the voltages induced electrostatically and/or electromagnetically in other conductors will be partially or totally neutralized.

If the wire positions in a circuit being disturbed are interchanged or transposed at regular intervals, the transposition brings about phase shifts which partially or totally neutralize interference and crosstalk.

In audio distribution work, twisted wire is commonly used to take advantage of both of these phenomena for reducing disturbances among circuits of a system.

In multiple-conductor cable, twisting also provides a uniform capacitance between each conductor and each other conductor and a uniform capacitance to ground for all conductors in the cable. This is especially important when balanced lines are used and/or when extended high-frequency response is required.

Where an unbalanced line is quite long, the hot wire will induce voltages in its own ground wire and shield because of the definite resistance in the ground wire and the shield between the source and the load. This induced voltage may cause trouble, especially if speakers are being switched at the load end. To avoid trouble from this interference, all switching on unbalanced lines should be double-pole switching, *i.e.*, both the hot wire and the ground wire should be switched. Thus, the safe procedure is to use double-pole switches on both unbalanced and balanced lines, balanced lines requiring double-pole

Table 6. Per-cent loss or gain using voltage, current, and power decibels and showing per-cent of original signal remaining after decibel loss and the per-cent of the original signal that still remains after a certain decibel gain. See text.

Voltage or Current DB.	Per-cent Loss	Per-cent Remaining	Per-cent Gain	Per-cent Now Existing
1	10	90	12	112
2	20	80	25	125
6	50	50	100	200
10	68	32	215	315
20	90	10	900	1000
Power DB.	**Per-cent Loss**	**Per-cent Remaining**	**Per-cent Gain**	**Per-cent Now Existing**
1	20	80	25	125
3	50	50	100	200
10	90	10	900	1000

DBMV. or DBMA.	Volts or Amperes	Millivolts or Milliamperes	Microvolts or Microamperes
+100	100	100,000	100,000,000
+80	10	10,000	10,000,000
+60	1	1000	1,000,000
+40	.1	100	100,000
+20	.01	10	10,000
0	.001	1	1000
−20	.0001	.1	100
−40	.00001	.01	10
−60	.000001	.001	1
−80	.0000001	.0001	.1
−100	.00000001	.00001	.01
DBM.	**Watts**	**Milliwatts**	**Microwatts**
+50	100	100,000	100,000,000
+40	10	10,000	10,000,000
+30	1	1000	1,000,000
+20	.1	100	100,000
+10	.01	10	10,000
0	.001	1	1000
−10	.0001	.1	100
−20	.00001	.01	10
−30	.000001	.001	1
−40	.0000001	.0001	.1
−50	.00000001	.00001	.01

Table 7. Decibel table showing the actual levels of dbmv. (reference level 1 mv.), dbma. (reference level 1 ma.), and dbm. (reference level 1 milliwatt).

switching because both lines are hot with respect to ground.

Interference Effects

Interference from conductors carrying other electrical services can be caused by electromagnetic and electrostatic induction. Voltages may be induced in the audio conductors or the audio conduit. Because of poor installation techniques or corrosion, audio conduit sections may be only partially grounded or possibly ungrounded. The voltages induced in such conduit sections by a.c. lighting and power circuits can be substantial. If an audio cable shielding (grounded) is allowed to come into contact with such a conduit section, hum and noise in the audio system and arcing and corrosion at the contact point will occur.

Close proximity between audio cables and a.c. power cables can result in hum and harmonic interference in the audio circuits. The fundamental and the odd harmonics of the power frequency cause the most trouble. Electrostatic and electromagnetic induction is more efficient at higher frequencies, and the human ear is more sensitive to harmonic power-line frequencies than to the fundamental power-line frequency. As a result, power-line harmonics up to 3000 cycles may cause objectionable interference.

If balanced-line audio conductors near a power cable are closely grouped, induction will be about the same for the two conductors of a circuit, raising the potential of the entire circuit and causing little if any difference voltage to interfere with the audio system. Therefore, if compatible with the audio system requirements, small-sized closely spaced balanced-line conductors may be used to aid in reducing a.c. power line interference.

Any extraordinary occurrence on a power line such as arcing, leakage to ground, shorting, or special signalling can cause high levels of interference in audio circuits which function properly under normal power line conditions.

Because of the small potential differences among the various points of an audio system which might be used for grounds, such potentials being due to resistance and induction as discussed, it is good practice to ground an audio system at only one point. All cabling should have an over-all shield cover and shielding and shield splices should be carefully insulated from conduit to facilitate grounding at one point only. This is the same technique employed for basically the same reasons as the practice of using only one ground point in a high-gain amplifier.

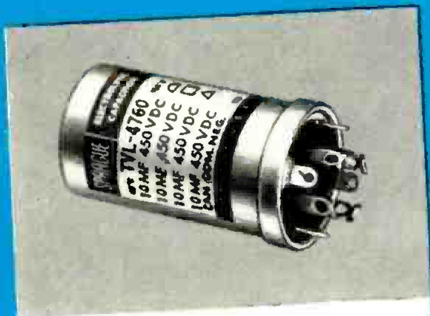
Many quality components of standard manufacture are available for use in audio sound systems. Until recently, a standard amplifier with 70-volt balanced line output was not available. At least one manufacturer now incorporates a 70-volt balanced line output in a school sound system, and another manufacturer has indicated interest in building a high-power amplifier of this type.

Low-Power Systems

The design of headset systems and low-power systems presents some unique component problems, *e.g.*, a transformer to match a 70-volt line to a headset with 3000 ohms d.c. resistance (approximately 12,000 ohms audio impedance) would require a 1 milliwatt transfer of power from a 5-megohm primary to a 12,000-ohm secondary. This is an expensive, if not impractical, device to construct. However, a 1-watt transformer with a 5000-ohm primary and a 12-ohm secondary has the same turns ratio, and while it is capable of delivering 1 watt of audio power, a headset (12,000 ohms audio impedance) connected to the 12-ohm secondary would draw only 1 milliwatt. As established earlier, this is a permissible connection, since the 12,000-ohm load impedance is higher than the 12-ohm secondary impedance. In this case the transformer may be regarded as acting to reduce the constant-line voltage of 70 to a constant-line voltage of 3.46, and using the formula $P=E^2/Z$ the power drawn by the headset would be $3.46^2/12{,}000$ or 1 milliwatt. Any number from one to a thousand similar headsets could be wired in parallel to the secondary of this transformer, and each would draw about a milliwatt. Overload would not occur until more than a thousand headsets were used. A transformer with a primary of 5000 ohms and secondary taps of 0, 4, 8, and 16 ohms would provide a 12-ohm secondary between the 4- and 16-ohm taps. An ordinary quality headset develops normal full output with a 1-milliwatt input. Because of the fine wire used in headset construction and because of the relatively high powers available from most sound systems, care must be taken to avoid headset burnouts.

Conclusion

The increasing pace of modern business and the need for the communications associated with business growth provide a fast-growing market for sound systems. Sound-system maintenance requires no more test instruments or tools than those owned by the average radio and TV service shop. An understanding of the basic fundamentals of sound systems is all that is necessary to allow the technician to supply this additional profitable service and possibly a "breakthrough" into the field of industrial electronics. —30—



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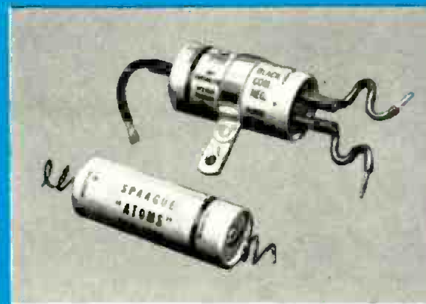

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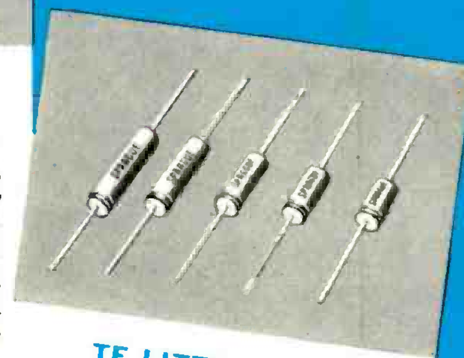

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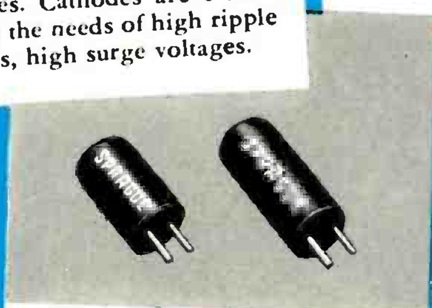

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Modest only in size and price, this new Heathkit Stereo-Phono Console amazes every listener with its room-filling, true-to-life stereo sounds. Proportioned to fit any room, it's less than three feet long and only end-table height, yet it houses a complete stereo-phono system with features usually found only in much larger consoles. There's *six* speakers . . . two 12" woofers for smooth "lows," two 8" speakers and two 5" cone-type tweeters for "mid-range" and "highs". The 4-speed automatic stereo/mono record changer is equipped with an "anti-skate" device and a turn-over diamond and sapphire styli cartridge. On the front panel are separate, dual bass and treble controls plus a concentric volume control. The handsome cabinet with solid genuine walnut frame, walnut veneer front panel, and matching "wood-grained" sliding top measures just 31¾" L x 17⅝" D x 26¾" H. Whether you buy the ready-to-play or kit form, the cabinet is factory assembled and finished. 70 lbs.

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Assembled Model HFS-26 . . . 215 lbs. **$475.00**
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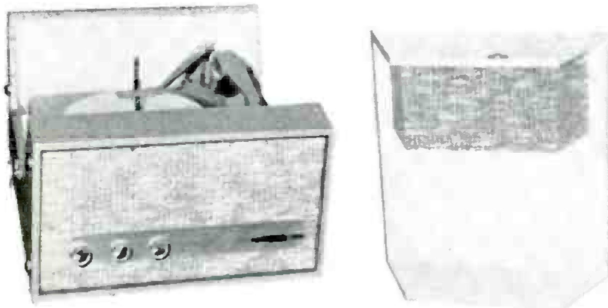

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Now you can thrill to magnificent stereo wherever you are, wherever you go! The smartly-styled cabinet with two-tone aqua and white durable vinyl covering comes completely preassembled. In closed carrying position the speaker wing and main cabinet blend into a single handsome unit in dazzling aqua and white vinyl. In use, the detachable speaker-wing top may be spaced at any distance for maximum stereo effect. The completely preassembled automatic changer plays your favorite stereo and mono records at speeds of 16, 33⅓, 45 and 78 rpm, while controls on the amplifier section give you complete command of volume, stereo-balance and tonal quality. 28 lbs.

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Plays and records 4-track stereo tape for endless hours of delight! Can even be used as a hi-fi center to amplify and control tuners, record players, etc. Has "record," "play," "fast-forward" and "rewind"; 2 speeds (3¾ and 7½ IPS); tone balance and level controls; monitoring switch for each channel to let you hear programs as they are recorded; pause button for editing; and two "eye-tube" recording level indicators. Speaker wings are detachable. Cabinet and tape mechanism are preassembled; all amplifiers and speakers included. 49 lbs.

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Model AD-80B, Shure M8D cartridge . **42.95**

REVERBERATION SYSTEM

Add a thrilling new "cathedral" dimension to listening! Reverberation supplies the dimension of spaciousness to sound, as heard in concert halls, etc. where "echoes" enrich and reinforce the original sounds. The GD-61 adds reverberation acoustically, not by electronic mixing, thus it doesn't disrupt your present system and it may be placed anywhere for best listening effect. Can be connected to speaker terminals of hi-fi systems, radios, TV sets, etc. Control lets you add just the right amount of reverberation. The GD-61 consists of Hammond type IV reverberation unit, amplifier with power supply and 8″ speaker. Preassembled birch cabinets in mahogany or walnut finishes. Measures 11½″ H x 23″ W x 11¾″ D. 30 lbs.

Kit Model GD-61M (mahogany) or
GD-61W (walnut) each **$69.95**

NOW ONLY HEATH BRINGS YOU ALL 3!

1. HEATHKIT for do-it-yourself hobbyists.
2. HEATHKIT factory-built, ready to use.
3. HEATHKIT learn-by-doing Science Series for youngsters.

HEATH COMPANY / Benton Harbor, Michigan

TWO AND SIX METER TRANSCEIVERS

The "ham on the go" will find the new Heathkit "Shawnee" 6-meter and "Pawnee" 2-meter transceiver kits irresistible! Both of the handsome units offer complete AM and CW facilities with: single knob tuning . . . tracked VFO and exciter stages; 10 watt output; built-in low pass filter; three-way power supply built-in for 117 VAC, 6 VDC or 12 VDC with separate DC and AC plugs and cables included; dual-purpose modulator . . . 10 watts for high level plate modulation or 15 watts for PA operation; double conversion receiver . . . crystal controlled first oscillator; tuning meter . . . auto-switched for received signal strength or relative power output; VFO or crystals . . . front panel switch of VFO or four crystals for novice, CAP, MARS or net operation; "spotting" switch; complete shielding of power supply, final and receiver front end; ceramic microphone . . . push-to-talk with coiled cord. And many more outstanding features . . . write for information. 34 lbs.

Kit Models HW-10 (6 meter) and HW-20 (2 meter) each................................$199.95

look forward to the happy months ahead
of outdoor living with Heath equipment

6-TRANSISTOR PORTABLE RADIOS

These award-winning, smartly-styled portables are ready to go anywhere! Both feature vernier tuning; 6-transistor circuit; 4" x 6" speaker for big set tone; prealigned transformers. 6 flashlight cells furnish power. (less batteries).

Kit Model XR-2P (plastic) . . . 6 lbs................$29.95

Kit Model XR-2L (sim. leather & plastic) . . . 7 lbs.....34.95

"WALKIE-TALKIE" CITIZEN'S BAND TRANSCEIVER

Ideal companion for the outdoorsman . . . talk to friends up to a mile away. No license required . . . anyone can use it . . . Features 4-transistor circuit, superregenerative receiver, crystal controlled transmitter. Powered by single long-life battery. Case included. 3 lbs. (less battery)

Kit Model GW-30 each...........................$32.95

Assembled Model GWW-30 each...................50.95

"WARRIOR" GROUNDED-GRID KILOWATT LINEAR

Attention Amateurs! Compare it feature for feature, the Warrior paces KW rigs at double this low price! Completely self-contained, the amplifier, HV, filament and bias supplies are built-in. Drives with 50 to 75 watts, no matching or swamping network required. Stable g-g circuit with up to 70% efficiency. Oil-filled capacitor and 5-50 henry swinging choke. Bands: 80 through 10. Max. power input; SSB—1,000 watts PEP; CW—1,000 watts; AM—400 watts (500 using controlled carrier mod.); RTTY—650 watts. Write for information.

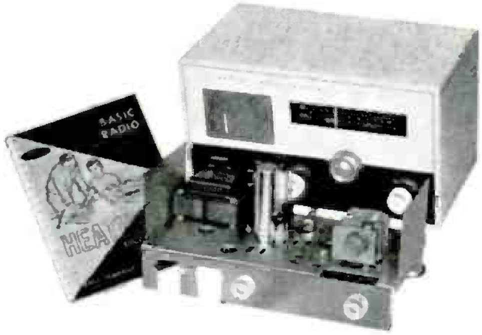
Kit Model HA-10 . . . 100 lbs...........$229.95

TRANSISTOR DEPTH SOUNDER

For summer boating fun and safety, the MI-10 is your best buy by far in a dependable depth sounder . . . and you can buy it in kit form or factory wired and tested, ready to use. Gives reliable depth indications to 100' or more over "hard" bottoms; somewhat less over "soft" bottoms. Rotating neon light gives clear indications on hooded dial face. Six long-life flashlight batteries are used for power. Transducer may be mounted through hull, or temporarily outboard. 10 lbs. (less batteries).

Kit Model MI-10.......................$ 69.95

Assembled Model MIW-10...............107.95



HEATHKIT BASIC RADIO COURSE

Here's a new 2-part series in basic radio for youngsters and adults. "Basic Radio—Part I" teaches radio theory in every-day language, common analogies, and no difficult mathematics. Experiments performed with radio parts supplied result in a regenerative radio receiver. "Part II" of the series advances your knowledge of radio theory and supplies additional parts to extend your Part I receiver to a 2-band superheterodyne.

Model EK-2A . . . "Part I" . . . 8 lbs. $19.95

Model EK-2B . . . "Part II" . . . 4 lbs. . . .
Available March 24 . . . . **$19.95**

Model AK-8 . . . Cabinet for Part II Receiver . . . 4 lbs. . . .
Available March 24 . . . . **$3.95**

DELUXE CITIZENS BAND TRANSCEIVER

Get the GW-10 for superior 2-way communication: superheterodyne receiver with switch selection of crystal control of any one channel or continuous vernier tuning of all 23 channels; automatic "series gate noise limiter"; adjustable squelch control; press-to-talk mike with coil cord; illuminated dial. Crystal controlled transmitter has switch selection of 3 crystals (one furnished). Hardware supplied for under dash mounting. Built-in power supply, 117 V. AC and 6 or 12 V. DC models 11 lbs.

Kit Model GW-10 . . . . $62.95

Assembled Model GWW-10 . . . 99.95

3-BAND RADIO DIRECTION FINDER

Now, at big savings, a deluxe completely transistorized portable RDF in your choice of kit or assembled models. The DF-3 operates on marine beacon, standard broadcast and ship-to-shore bands to offer you both portable radio entertainment and reliable direction finding facilities. Featured are: 9-transistor circuit; 6 flashlight battery power supply; preassembled prealigned tuning section; new sense antenna for non-ambiguous bearings; lighted dial and tuning meter. 13 lbs.

Kit Model DF-3 . . . . $ 99.95

Assembled Model DFW-3 . . . 169.95

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HEATH COMPANY / Benton Harbor 15, Michigan

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Please send the following items:

ITEM	MODEL NO.	PRICE

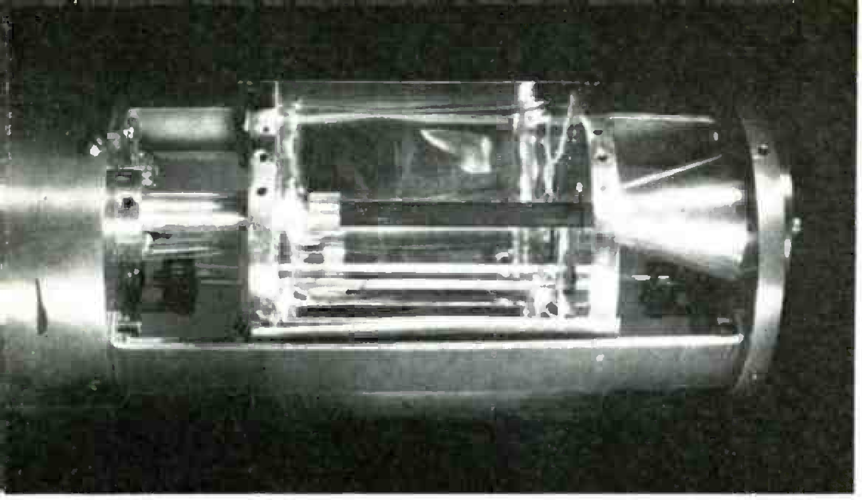
NAME

ADDRESS

CITY ZONE STATE

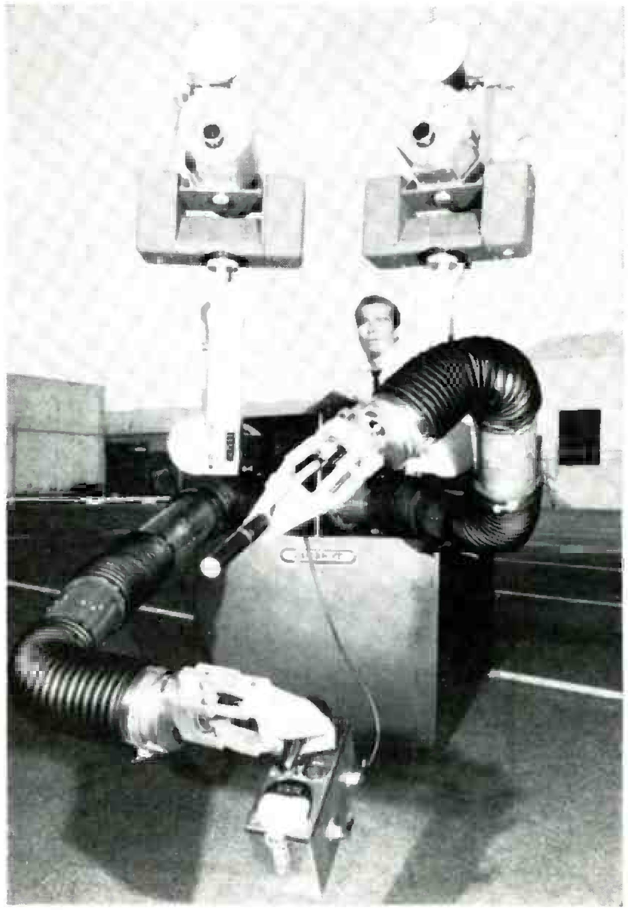
Order direct by mail or see your Heathkit dealer.

Ship via ☐ Parcel Post ☐ Express ☐ C.O.D. ☐ Best Way



New Laser Optical System
A new method for achieving optical maser (laser) action with less than one-tenth the power formerly required has been developed by *Raytheon Co.* By utilizing a reflector system that directs light more efficiently into the laser's synthetic ruby, scientists have been able to substitute a small pencil-shaped flash tube for the large helical flash tube used before. In the photo, the ruby rod is at the center, while the pencil-shaped flash tube is directly below it.

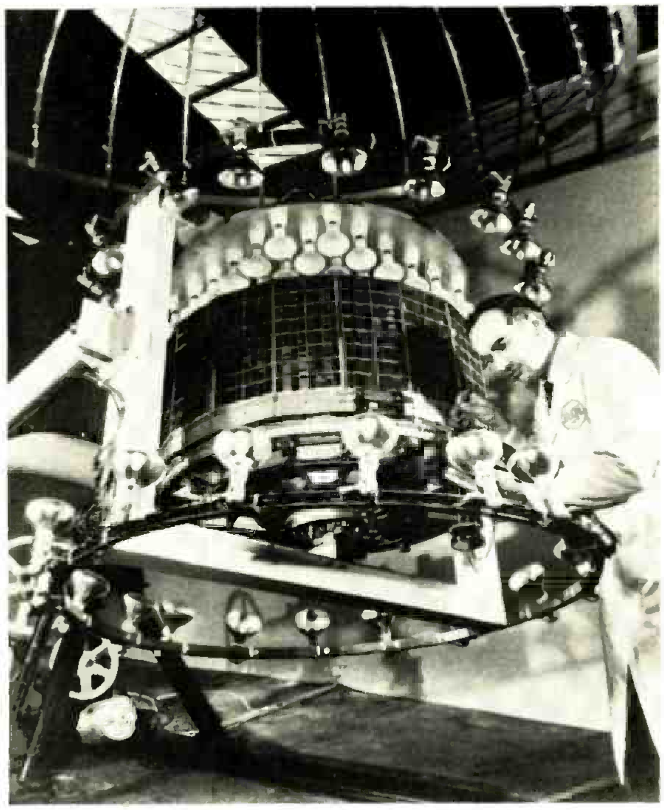
Recent Developments in Electronics



Mobile Robot with TV Eyes
Holding a Geiger counter in its "hands," Mobot Mark II demonstrates how it could substitute for man in dangerously radiated areas. Latest mobile robot built by *Hughes Aircraft Co.* is double-jointed at wrists, elbow, and shoulder, and has television camera "eyes." The TV cameras focus on the work the hands are performing and transmit a picture to the operator at a control console, who may direct Mobot's actions from a safe position more than 100 feet away.

Electronic Weather Maps
The Weather Bureau's recently installed *Electronic Associates'* map maker is able to produce a 30 x 30 inch weather map in less than 3 minutes, compared with 20 minutes required by the former hand-drawn method of drawing in the isobars.

Ultraviolet Communications System
Photograph of *Westinghouse* experimental system for transmitting video information *via* modulated ultraviolet radiation. Input signals from TV camera (to left of subject) are impressed on ultraviolet output of cathode-ray tube in right foreground. Bearing video information, the modulated ultraviolet is directed to tripod-mounted photometer at the rear. Demodulated signal produces image of subject on screen of the receiver at the rear. This work is being done to develop methods for using ultraviolet light to communicate over great distances in free space.

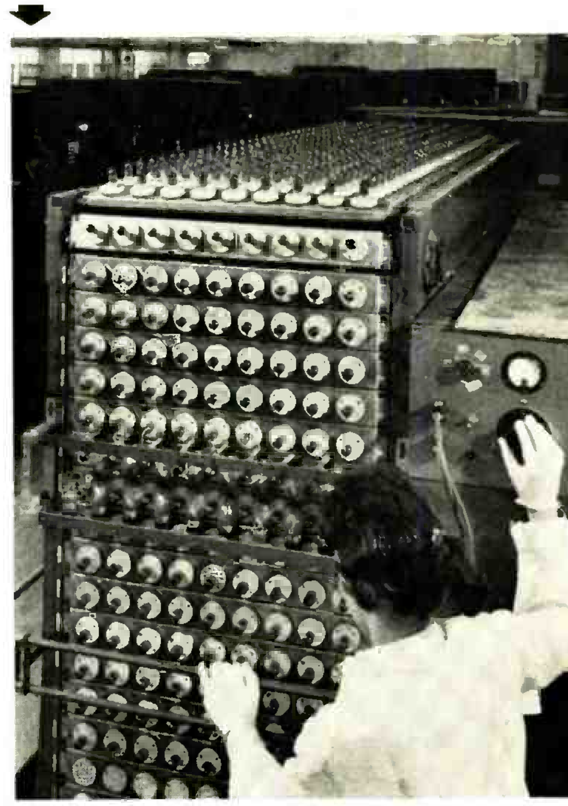


Testing the "Tiros II"

The second weather observation satellite developed for NASA by *RCA* is mounted on a special machine to test a new magnetic orientation system that will permit control of the satellite's attitude in space. The engineer is making an adjustment before the assembly is enclosed in the spherical cage, visible at top of photo, which creates a magnetic field similar to that surrounding the earth in space. Lights above and around the satellite are used to test operation of the solar cells on the top and sides of "Tiros II."

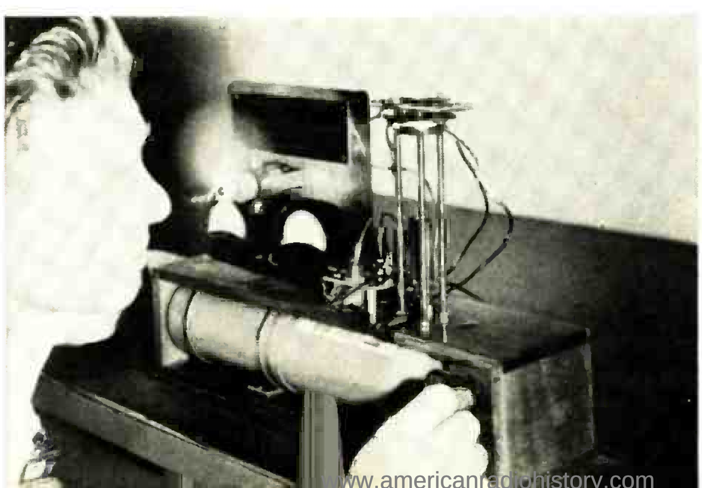
Two Billionth Receiver Tube

Sylvania recently announced the production of its two billionth electronic receiving tube. A technician is shown below checking the voltages of receiving tubes for television applications on an automatic aging conveyor prior to final testing. The company began the manufacture of receiving tubes in 1924 and produced its one billionth unit in 1952. The company has also produced nearly 25 million TV picture tubes.



Missile-Tracking System

Inside this cluster of white radomes at Cape Canaveral, Fla., a battery of precision antennas now enables the Air Force to track missiles with an accuracy of a few feet at hundreds of miles. This is the "Azusa Mark II" system, installed by *Convair*, which also developed the earlier "Azusa Mark I," in use at the Atlantic range since 1954.



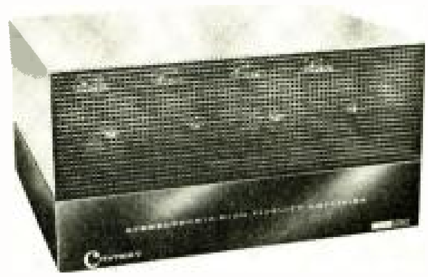
Thermionic-Thermoelectric "Sandwich"

Perched atop the tripod at right, *G-E's* developmental cascaded thermionic-thermoelectric energy converter produces twice as much power from a given amount of heat as either a thermionic converter or thermoelectric generator operated singly. In the demonstration, power from the thermionic converter (bottom of sandwich) is running the propeller while power from the thermoelectric generator is indicated by the meter needles. Heat is supplied by gas.

Hi-Fi-Audio Product Review

NEW "CITATION" AMPLIFIER

Harman-Kardon, Inc., Plainview, N.Y. has announced availability of the "Citation V" stereo power amplifier. Designed by Stewart Hegeman, the "Citation V" is an 80-watt (dual 40-watt)



basic amplifier, described by the company as a compact version of the earlier "Citation II," which is a 120-watt (dual 60-watt) basic.

Also available now is the "Citation IV" (not illustrated here), a stereo preamp, closely patterned after the "Citation I" stereo preamp. All "Citation" units are available as kits or as factory-wired units.

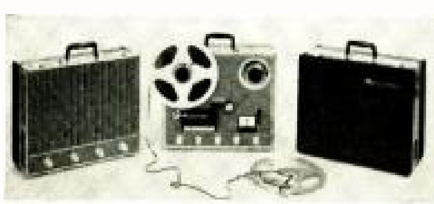
STEREO HEADSET

Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill. has brought out a stereo headset, suitable for private listening and for monitoring during recording. Designated as "Knight" Model KN-840, the headset is designed to match low-impedance outputs, from 16 to 600 ohms. A matching transformer, Model No. KN-842, is available to match the headset to high-impedance outputs. Response is given as 20 to 16,000 cycles per second.

STEREO TAPE RECORDER

American Concertone, Division of *American Electronics, Inc.*, 9449 W. Jefferson, Culver City, Calif. is now producing the "Mark VII" a machine designed for "professional results" that will handle all reel sizes up to 10½ inches at either 7½ and 15 ips or 3¾ and 7½ ips speeds.

The "Mark VII" uses separate record,



erase, and playback heads. Its three-motor transport design eliminates clutches, belts, and pulleys. Direct capstan drive is accomplished by a hysteresis-synchronous motor, said to give 99.8 per-cent timing accuracy. Two capacitor-induction motors drive the supply and take-up reels.

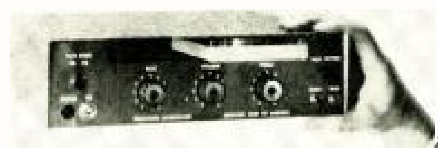
Internal construction includes a unit amplifier chassis with two separate record and playback channels and a bias oscillator. Various "Concertone" speaker-amplifier combinations are available in cases matched to the basic recorder.

The "Mark VII" has, as an optional feature, the ability to play, without moving heads, both two-track stereo tapes and the newer four-track stereo tapes. Machines so equipped include a fourth head.

CARTRIDGE TAPE RECORDER

Amplifier Corp. of America, 398 Broadway, New York 13, N.Y. has introduced a completely automatic, compact tape player for handling the Fidelipac plastic cartridge tapes. These tapes operate on the endless loop principle and are single-reel types. The cartridge is merely inserted into the player and a button is pressed to play it.

Known as the "Magnematic," the new machine is available in two models. One,



the "Bookshelf" (illustrated here) is 3½ inches high, 10 inches deep, and 11½ inches wide. The other model, the "Broadcaster," comes in rack panel form for professional use. These machines are available with stereo or mono record-play facilities, utilizing 1, 2, 3, or 4 tracks operating at speeds of 1⅞, 3¾, 7½, or 15 ips. Depending on tape speed, maximum record-play time ranges from 30 minutes to eight hours. All units are a.c. operated.

AUTOMATIC CHANGER

United Audio Products, 12 W. 18th St., New York 11, N.Y. has introduced its Dual-1006 "custom turntable/changer." Similar in external apperance to the original Dual-1006, which it supersedes, the new Custom Dual-1006 features what are termed "a number of internal advances in engineering design and materials." Additionally, the new 1006 carries a five year guarantee on all parts against manufacturing defects.

The Dual-1006 may be used as a fully automatic turntable, as a manual turntable, and as an automatic changer. Among its features are its roller-feeder indexing action which measures each record individually to find the exact lo-


Viking
76
INPUT 1
INPUT 2
LEVEL 1
LEVEL 2
MIC
HEAD
STEREO
MON

cation of the lead-in groove, and the elevator-action changer spindle which operates without pusher arms or offset spindles. Its tone-arm tracks and trips at pressures as low as 1½ grams.

AUTO RADIO SPEAKER

Utah Radio & Electronics Corp., Huntington, Ind. has announced a new model replacement speaker for use in many 1961 automobiles.

The speaker, Model SP410E, is a 4-inch x 10 inch type and features a 2.15-

ounce Alnico V magnet. It is said to be capable of handling 8-watts and may be used in 1961 cars by *Buick*, *Cadillac*, *Chevrolet* (except *Corvair*), *Studebaker* (except the *Lark*), *Pontiac*, and *Oldsmobile*.

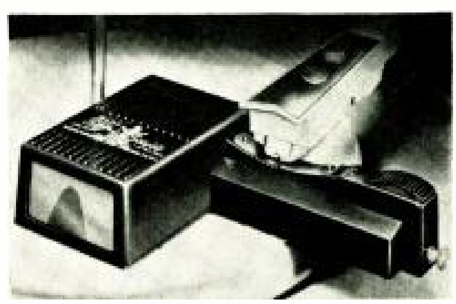
75-WATT STEREO AMPLIFIER

Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill. has introduced its "Knight" Model KN-775, a stereo basic amplifier that provides 37.5 watts per channel and has a minimum IHFM music-power rating of 96 watts. Output tubes consist of four EL34's used in what is described as an "advanced output circuit, with extremely linear operation."

The KN-775 features an optional center-channel output, dual phasing switches, special headphone jack, and a tape-monitor switch. A selenium-bridge filament rectifier, and hermetically sealed silicon high-voltage rectifiers are used in the power supply. The amplifier is protected by a circuit-breaker rather than a fuse. Response at 37.5 watts per channel is stated as 25 to 20,000 cps. ± 0.5 db.

STYLUS INSPECTION DEVICE

Robins Industries Corp., Flushing 54, N.Y. has introduced its "Syl-A-Scope," an optical magnifier with built-in illumination. The instrument provides a mag-



nified image on a ground-glass screen that shows every detail of a phono stylus, so that the user may detect chips, cracks, or other flaws that could downgrade record performance.

Two models are available. Model SG-33 is a compact unit that operates on two penlight batteries. The "Professional," Model SG-66, operates on a.c. line voltage and has been designed for service technicians, broadcast studios, serious record collectors, and others requiring precise examinations of small parts, tools, or instruments.

4-SPEED MANUAL PLAYER

Lafayette Radio Corp., 165-08 Liberty *Ave., Jamaica* 33, N.Y. has introduced what it calls a "broadcast quality" 4-speed transcription turntable and tone-arm combination.

Designated as Model PK-449, the player comes on a single mounting plate, with the arm pre-installed.

The 12-inch turntable uses a heavy-duty 4-pole induction motor, and is free-floating and shock-mounted. It weighs

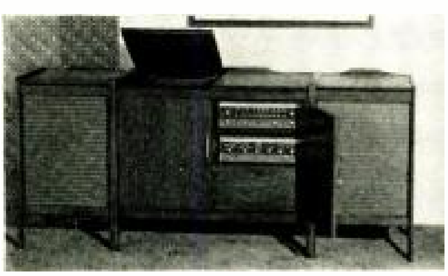
three pounds and is made of aluminum. In addition to the speed selector, there is a speed control which allows for ±7 per-cent variation of each speed. Noise and rumble are given as −50 db below average recorded level, with wow and flutter less than 0.2 per-cent.

The 12-inch arm is said to track perfectly at the lowest pressures recommended by cartridge manufacturers. A knurled knob at the rear of the arm sets stylus force. The arm has a plug-in head and a unique arm-rest that serves "double duty" when the arm is lifted from the lock position, the motor is started. The unit is supplied with a strobe disc, a 45 rpm adapter, shielded hook-up cables, and a.c. line cord. It measures 16¼ x 12¼ inches and requires four inches below the motorboard.

STEREO CONSOLES

Heath Co., Benton Harbor, Mich. announces two stereo hi-fi consoles.

Shown here is Model HFS-28, a 50-watt stereo unit that includes the



Heathkit AD-60B changer with *Shure* M8D stereo cartridge; the AJ-30 stereo AM/FM tuner; and Model AA-100 stereo amplifier. Two *Jensen* H-223F coaxial 12-inch speakers are installed, each in its own Model AE-40 speaker enclosure. The speaker systems flank the console housing, itself *Heathkit* Model AE-20.

The same equipment cabinet is avail-

able as a 28-watt stereo console. This model includes the AJ-10 tuner, the SA-2 amplifier, the AD-50A changer with the *G-E* VR-227 stereo cartridge, and two Model US-3 coaxial speakers mounted in a pair of AE-30 speaker enclosures.

Either console is available completely assembled, or with the cabinets assembled and finished and the equipment in kit form. Cabinets may be ordered finished in walnut or mahogany.

WIRELESS MICROPHONE

Vega Electronics Corp., 10781 N. Highway 9, Cupertine, California has introduced a new wireless microphone that is claimed to surmount the problems encountered with this type of unit, such as weight, bulk, low fidelity, noise, and "dead spots" in radiation pattern.

Weighing 7½ ounces, the 5-inch long device may be worn around the neck. According to the manufacturer, it actually is a self-contained miniature FM broadcast station, including transistors and battery. The neck strap that supports it serves as an antenna element.

ORGAN IN KIT FORM

Electronic Organ Arts, Artisan Hall, 4949 York Blvd., Los Angeles 42, Calif. has announced what it terms the world's first three-manual home organ kit.

Known as the "Regal," it brings to 24 the number of "Artisan" models offered by the company in "do-it-yourself" kit form. The new organ contains 64 stops and couplers, 61-note manuals, and 32-note pedal board. The console is only 29 inches in depth.

According to the manufacturer, accompanying building instructions are so simple that even non-technical persons can build this instrument. The company also points out that kits seldom are sold for the complete organ at one time. There are many component units and the builder can purchase one of these component kits at a time and proceed as his time and budget allow. For details, write direct to the manufacturer.

STEREO RECEIVER

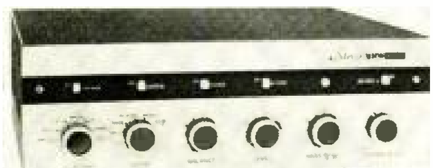
Fisher Radio Corp., 21-21 44th Drive, Long Island City 1, N.Y. has begun production of a new stereo FM-AM receiver.

Designated as the 500-S, it includes a sensitive FM tuner, a high-quality AM tuner, and a dual-channel amplifier with controls. Music power rating is listed as 45 watts. The amplifier has thirteen inputs and five outputs, including a "center channel" output for a composite stereo signal.

NEW STEREO AMPLIFIERS

Electronic Instrument Corp., Inc., (EICO), 33-00 Northern Blvd., Long Island City 1, N.Y. has announced two new integrated stereo amplifiers. Both models—the 70-watt ST70 and the 40 watt ST40—feature the company's new high styling and are available in kit form or as factory-wired units.

Both amplifiers are built to handle any stereo program source. Controls include: selector switch, tape monitor



switch, separate level and balance controls, balance check switch, scratch and rumble filters, loudness/level switch, and full individual feedback-type bass and treble tone controls for each channel. The ST70 has, additionally, a tape speed equalizer and speaker phase-reversal switch.

Power amplifiers in the ST70 use cathode-coupled, phase-inverter circuitry, preceded by a direct-coupled voltage amplifier. Response is given as ± ½ db, 10 to 50,000 cps. Power amplifiers of the ST40 are based on Williamson-type circuits. Response is ± ½ db, 12-25,000 cps.

AUDIO CATALOGUES

TAPE HEAD GUIDE

Robins Industries Corp., Flushing 54, N. Y. has issued a revised version of its 16-page "Tape Recording Head Reference Guide," which includes information for repair, upgrade, or conversion to stereo of up to 85 per-cent of all tape recorders. Price is 50 cents.

SPEAKER SYSTEMS

R. T. Bozak Sales Co., Darien, Conn. is offering, free, its new catalogue of high-fidelity loudspeaker systems. The 8-page illustrated booklet describes this company's drivers, networks, cabinets, and "unitized" stereo speaker systems.

LEONARD CATALOGUE

Leonard Radio, Inc., 69 Cortland St., N. Y. 7, N. Y. is offering its "Stereo Guide for 1961," a 180-page catalogue giving comprehensive product information and price data on a wide variety of stereo, hi-fi, and other audio equipment. Copies are free on request.

AIREX CATALOGUE

Airex Radio Corp., 64 Cortlandt St., N. Y. 17, N. Y. has issued its "1961 Stereo Hi-Fi Guide," a 100-page book which contains product data and prices on a wide variety of audio components and accessories. Copies are free. -30-

83 YX 929. Stereo Tape Record-Play Preamp Kit. $79.95 (less case)

One of the many great Knight-Kit stereo component kits. Professional quality; superb performance with virtually any 3-head tape transport; separate dual-channel recording and playback preamps; permits tape monitoring, sound-on-sound and echo effects. Packed with quality features for every possible stereo and monophonic function...

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A PRODUCT

a pleasure to build...

83 YX 928. FM-AM Hi-Fi Tuner Kit. $49.95

Typical Knight-Kit hi-fi value—incomparable at the price. With AFC, tuned RF stage on FM, multiplex jack. Straight FM tuner kit also available at $38.95. For deluxe Stereo FM-AM and FM tuner kits, see the Allied catalog...

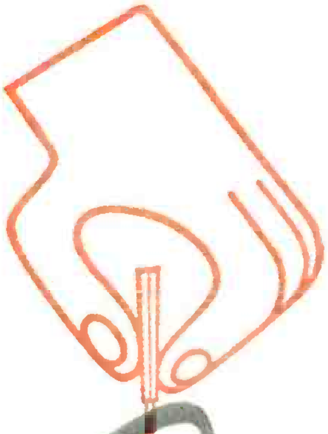
83 YX 927. 20-Watt Stereo Hi-Fi Amplifier Kit. $39.95

Biggest bargain in quality Stereo hi-fi. Has special clutch-type dual-concentric level control; simplified control facilities; DC preamp filaments. Similarly styled 32-Watt Stereo Amplifier Kit with full frequency center channel available at a low, low $59.95...

The most satisfying do-it-yourself experience awaits you when you build a Knight-Kit! You'll marvel at the sheer ease of assembly, absolutely assured by exclusive "show-how" manuals, wall-sized picture diagrams, step-by-step do-and-check instructions, pre-cut wire, "visi-packed" parts and an engineering perfection that eliminates guesswork. You'll get perfect results. You'll enjoy with pride a true custom-built electronic product, professionally engineered and styled—the best you can own. And to top off your pleasure, you'll save substantially at the unbeatable Knight-Kit price...

83 YU 934. Deluxe 70-Watt Stereo Hi-Fi Amplifier Kit. $119.95

Super-power to drive any of today's speakers, a do-it-yourself stereo masterpiece, featuring: special "blend" control; full-range center channel; tape-source monitor; dual phasing switches; Stereo paralleling switch. For deluxe 40-watt Stereo amplifier at only $76.95, and 60-watt Stereo amplifier, see the Allied catalog...



83 YX 712-2. Superhet Citizen's Band Transceiver Kit. $79.95

Dual-conversion for highest sensitivity and selectivity; crystal-controlled operation on any 2 channels, plus manual tuning. Another Knight-Kit Citizen's Band Transceiver is available at an amazing low $39.95—see the Allied catalog for full details...

Great!

other money-saving

-kits®

OF ALLIED RADIO

and you own the best

83 YX 258. 4-Band "Span Master"® Receiver Kit. $25.95

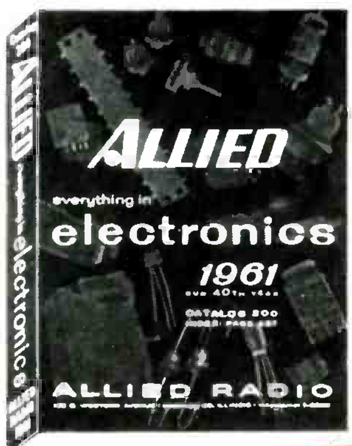
Fabulous performer for world-wide reception; thrilling shortwave adventures, plus fine Broadcast; band-switching, 540 KC to 30 MC; with cabinet. For additional receiver kits, radio-intercom, clock-radio, transistor radios, intercom systems, electronic labs and other great hobbyist Knight-Kits, see the Allied catalog...

money back guarantee

Every Knight-Kit is unconditionally guaranteed to meet our published specifications for performance or your purchase price is refunded in full.

only $2 down

It's easy to buy any Knight-Kit: only $2 down on orders up to $50; $5 down up to $200; $10 down over $200—up to 24 months to pay.



83 Y 125. Electronic VTVM Kit. $25.75

High sensitivity general-purpose VTVM; 11 meg input resistance; balanced-bridge circuit; 4½" meter. One of many fine instrument kits including 5" scopes, AC VTVM, tube checkers, signal tracer, audio generator, sweep generator, and others, described in detail in the Allied catalog...

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A.D.BLUMLEIN—
Father of Modern Stereo

By **PATRICK HALLIDAY**

One of electronics' most brilliant circuit engineers, he devised and pressed the first single-groove stereo disc and proposed present 45/45 stereo recording.

Alan Dower Blumlein, 1904-1942

THE DATE is June 7, 1942. In the sky over war-scarred Britain a four-engined Halifax bomber is returning from an electronics testing flight for the newly developed H2S radar bombing aid. Aboard are the Royal Air Force crew and a team of research scientists—known as "boffins" to the British servicemen. But all is not well. The engines are giving trouble: the aircraft is losing height. Soon the pilot has no choice but to attempt a crash landing. A field looms up . . . the sudden sharp splintering moment of impact, followed immediately by deadly flames. There are no survivors.

So died Alan Dower Blumlein, one of electronics' most brilliant circuit engineers—a still largely unacknowledged genius. An engineer who in his twenties evolved the first complete theory of two-channel stereo using loudspeakers, solved the complex sum and difference mathematical relationship, devised and pressed the first single-groove stereo discs; but who was to die so tragically more than 15 years before his stereo system blossomed into world-wide use.

In 1929 Alan Blumlein was a 25-year-old research engineer with the *British Columbia* recording company (which was shortly to become part of the large *Electric and Music Industries* concern). He became interested in the problem of practical stereo and soon realized that for two-channel reproduction over loudspeakers—a problem that differed fundamentally from the earlier experimental systems using headphones—it was necessary to convert the outputs of two spaced microphones into two different outputs having the correct amplitude differences before feeding them to the speakers. Blumlein believed that the main factor in locating a source of sound was the difference in the time of arrival of the sound at the two ears at low frequencies and in intensity differences at higher frequencies. He therefore devised means of converting phase differences in the microphone outputs into amplitude differences—the basis of modern two-channel stereo systems.

To carry the two channels in a single groove he developed the complex lateral and vertical cutting, proposed by earlier workers, and also showed that the cutting plane could be turned through 45 degrees to form the now universally adopted 45/45 system. Stereo cutting heads and pickups were developed and a number of discs successfully cut. In 1931 Blumlein filed his historic stereo patent application, the 22-page specification listing 70 claims. He was granted British Patent No. 394,325 covering two-channel stereo for disc recording and for motion pictures—a patent which lapsed before commercial use was made of his system.

Some of his original stereo records, pressed almost thirty years ago, are still in existence. When played on modern stereo equipment, they show surprisingly good channel separation and frequency range. Not so good, judged by modern standards, was his moving-coil stereo pickup with two coils fixed to a hollow aluminum coil held horizontally by a thin diaphragm. The substantial magnet and pole pieces resulted in a heavy unit with an upper cut-off around 4000 cps.

The restricted audio range of this pickup and the high surface noise of the shellac pressings played with the then-current steel needles impaired the stereo illusion, and this contributed to the reasons why these discs were never marketed. Blumlein recognized the limitations of shellac as a pressing material and in his patent claim clearly foresaw the need to develop a new material of the cellulose acetate type and the use of a sapphire stylus.

But soon, although some work continued on stereo for motion pictures, the idea of stereo records was pigeon-holed. Not until 1955 was his stereo recording system put in practice, first for *EMI*

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"Stereosonic" tape recordings and soon afterwards for the modern stereo disc.

With stereo shelved, Blumlein did not remain idle. He was a man who quickly transformed every project he touched. In 17 working years, until his death at the age of thirty eight, 132 patents were granted to him solely or in collaboration with other engineers—an average, as writer Marcus Scroggie has pointed out, of one every 46 days. His circuit developments in instrumentation, recording, slot antennas, television, and radar were often so far in advance of his time that even now it is claimed that many of the circuits which he evolved are still not being fully exploited.

But some of his work now affects millions of homes. He pioneered the "ultra-linear" screen feedback amplifier as a method of reducing plate impedance—although not apparently as an aid to high-fidelity amplification. He devised the frequency-selective feedback method of linearizing vertical deflection amplifiers in television receivers. He helped determine the waveform for the world's first high-definition television service which opened in London in 1936. He made important advances in television camera design. But some consider his greatest single contribution to television was the part he played in the development of flyback high-voltage systems.

At a National Television Convention in London a few years ago, the German engineer Dr. R. Urtel spoke warmly of this work: "Among his inventions—the scope and value of which become increasingly apparent—there is one of special importance. I refer to the generation of the saw-tooth circuits with a resonant flyback. Furthermore the second essential ingredient of this type of circuit was found by Blumlein together with E. L. C. White—the method of using the recovered energy for boosting plate voltage. After the war, the ideas of Blumlein found their way across the Atlantic and were incorporated in millions of television receivers, if not in the original form, at least basically."

Such was the quality of Blumlein, circuit engineer and inventor. What of the man? His hobbies—flying, astronomy, music, and the theater. The author spoke recently to his former colleague—H. A. M. Clark of *EMI*, one of Britain's foremost recording engineers. "Alan Blumlein," he said, "was a perfectionist in everything. No detail was too small to escape his attention and interest. Even when building prototype pieces of equipment, he would take the greatest care to see that his soldering was of the highest possible standard." The mark of a genius, it is said, is an infinite capacity for taking pains.

Blumlein constantly reached for the stars. In his brief working life he achieved more than a whole team of modern research engineers could reasonably hope for. But he lived to see only a small portion of his fundamental discoveries in full use. In his lifetime his stereo work was applied in practice for only one purpose—the design of aircraft sound locators for a war which was to cause his death. —30—

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(Continued from page 32)

direct as it is possible to make them.

2. Twist filament leads and keep them close to the chassis. Start out by wiring up the filament, switch, and power-supply circuits. Proceed with "B+" circuits and next the signal circuits. Add the coupling capacitors last.

3. Make sure that the power-output transformer is correctly connected to the plates of the output tubes. Incorrect placement of these leads will result in oscillation of the amplifier. This can be cured by reversing the connections of the output transformer to the plates of the output tubes.

4. No high-frequency oscillation was experienced in this amplifier. In case such an oscillation occurs, grid, screen, and plate blocking resistors, connected close to the pins of the output tubes, will stop this. The same remedy must be applied in case parasitic oscillations are experienced.

In conclusion, it may be observed that the stereo amplifier described here will be an extremely rewarding project for the home builder. In addition, all of the components used are standard and readily available. The performance data indicates that this amplifier can be used in the best hi-fi systems without apology.

OPERATING SUGGESTIONS

1. *After the amplifier is completed, plug in all the tubes except the GZ34's and apply line voltage to the amplifier. Adjust bias voltage (R[illegible], R[illegible]) across C[illegible], C[illegible] to approximately -18 volts.*
2. *Plug in both the GZ34's and allow a few seconds for the 0A3's to glow. Then adjust bias (R[illegible], R[illegible]) and d.c. balance (R[illegible], R[illegible]) for .9 volt across the cathode resistors (R[illegible], R[illegible] and R[illegible], R[illegible]) of the 7591's.*
3. *Apply a small audio signal (1000 cps) to the input and adjust R[illegible], R[illegible] for a.c. balance at tests points J[illegible], J[illegible], J[illegible], J[illegible] using high-impedance-type v.t.v.m. If a v.o.m. is used, do not check for a.c. balance at these test points but, instead, use test points J[illegible], J[illegible], J[illegible], J[illegible].*
4. *In case the output tubes are extremely unbalanced so that the adjustment range of balancing pot R[illegible] (or R[illegible]) is insufficient, R[illegible] (or R[illegible]) may be changed to 10,000 ohms. R[illegible] and R[illegible] (or R[illegible] and R[illegible]) should then be changed to 100,000 ohms.*
5. *The amplifier is very sensitive as it requires less than .5 volt to drive it to the full output of 35 watts. It may be more convenient to use a good-quality 500,000-ohm potentiometer, such as the* Ohmite *CU-5041, in place of R[illegible] (R[illegible]).*
6. *The d.c. voltages under "no-signal" condition are given at various points on the circuit diagram as a guide to proper operating conditions. If, due to high line voltage, the voltages across C[illegible] and C[illegible] exceed 490 volts, higher values of R[illegible] and R[illegible] may be used in order to increase voltage drop across them.*

—30—

Within the Industry

(Continued from page 24)

Laboratories' scientist will receive the "Founders Award 1961" for outstanding service to the IRE and the radio engineering profession. Ernst A. Guillemin, Webster Professor of Electrical Engineering at MIT, will receive the "Medal of Honor 1961" for his outstanding scientific and engineering achievements.

The Liebmann Memorial Prize will go to Leo Esaki; the Thompson Memorial Prize has been awarded to Eiichi Goto; Diamond Memorial Prize to Helmut L. Brueckmann; W. R. G. Baker Prize to Manfred Clynes; Zworykin Prize to Peter C. Goldmark; and Morlock Memorial Prize in Bio-Medical Electronics to Britton Chance.

The awards will be made at the banquet to be held March 22nd in connection with the 1961 IRE International Convention in New York.

* * *

ROBERT G. DAVIS has been named director of operations for the *Radio Shack Corporation*. In this post, he will direct and co-ordinate the company's Boston headquarters, their five retail outlets, and their four industrial electronic distribution centers.

Mr. Davis left *Montgomery-Ward's* mail-order department in Chicago as assistant operations manager to join the *Radio Shack* staff. He is a Colorado State College graduate and has done graduate work in business administration at the University of Colorado.

* * *

DR. L. V. BERKNER, president of Associated Universities, Inc., has been elected 1961 president of the Institute of Radio Engineers. Serving as North American vice-president is J. F. Byrne, manager of *Motorola's* Research Laboratory in Riverside, California while Dr. Franz Ollendorff, research professor at the Israel Institute of Technology in Haifa will serve as vice-president for areas outside of North America.

Delegates-at-large and directors-at-large who will serve from 1961-1963 are Dr. E. Finley Carter, president of Stanford Research Institute and Dr. L. C. Van Atta of the U.S. Department of Defense.

* * *

U.S. DEPARTMENT OF COMMERCE's Electronics Division has reported that the shipments of electronic components continued at first quarter levels during the second quarter of 1960.

A decline in shipments of receiving tubes, transistors, capacitors, and connectors was counterbalanced by increased shipments of diodes and rectifiers, power and special purpose tubes, TV picture tubes, transformers, and quartz crystals. Shipments of other components continued at first-quarter levels. —30—

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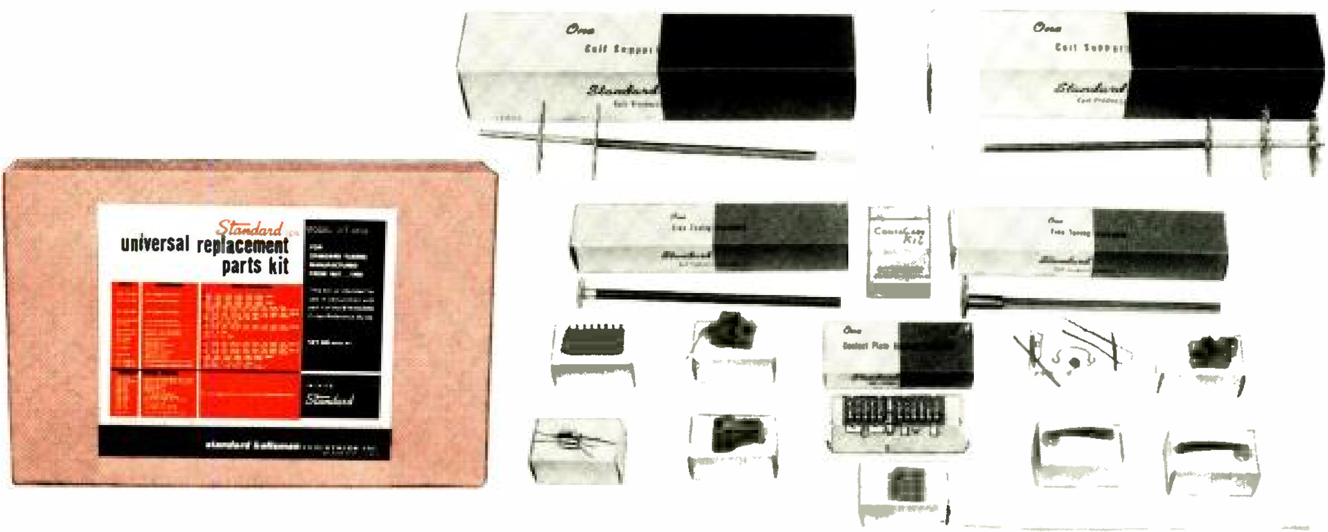

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Sound on Tape

By **BERT WHYTE**

STEREOPHONIC sound has been a commercial entity for about seven years in the case of tape and about 3 years in the case of disc. In this year of 1961, stereo has become a common thing, virtually a "household word," and there is a multitude of equipment on the market which all purports to reproduce stereo sound. And yet, in spite of this, when one probes a little below the surface in an attempt to evaluate what degree of "stereo sophistication" the average person has attained, it is shocking to find what an abysmal lack of knowledge exists. Of all consumer products in general use . . . the automobile, TV, dishwashers, freezers, etc. . . , stereo equipment seems the least understood and it is likely that there is more confusion and misinformation about stereo than any other product in the home.

The situation is not exclusive with people who are not technically oriented . . . it is surprising how many "knowledgeable audiophiles" and engineers and technicians have either a very sketchy idea of the stereo process or are saddled with wrong information and obsolete concepts. It would appear that much of this misinformation has been applied to the ubiquitous stereo consoles and portables of the department-store variety and even, to a small extent, with component stereo. It is all very well to blame "commercial considerations" for the almost total disregard of channel separation, for example, but the fact remains that a certain minimal separation of speakers is one of the prime requisites in the perception of stereo.

Also born of "commercial considerations," was the "satellite stereo" system. It is certainly a laudable thing if manufacturing costs can be cut on a stereo system by using lesser amounts of material, providing no degradation of the stereo effect is involved. And admittedly in several rare instances, where the engineers were thoroughly conversant with the stereo process, ingenious "satellite" systems were evolved which worked quite well.

As you probably know, the typical "satellite" stereo system is based on the concept of a single woofer centrally located and flanked left and right by either tweeters or a tweeter/mid-range combination. The single woofer is used on the premise that below a certain point bass frequencies have no directionality. This crossover point has been the subject of considerable argument. In a conventional monophonic speaker system, the bass crossover is very commonly set at 800 to 1000 cycles, or in the case of three-way mid-range systems, the bass crossover has usually been around 400 cycles. Now even at this lower crossover, most people fail to realize that, in actual fact, this range is still fairly high in the musical scale. For example the standard pitch of "A" is 440 cycles, while *middle "C"* on the piano is 256 cycles.

It is well known that the ear responds most easily to the middle range frequencies and thus, in many systems, what is considered the bass speaker is putting out quite a lot of energy in the middle range spectrum. In any case, rather empirically, the woofers in many of the "satellite" systems have been set for 300 to 350 cycles crossover. In the light of some recent studies, it would appear that this is much too high a crossover, and thus a good deal of directional information is lost to the auditor.

It now appears, on the basis of new experiments by *Bell Telephone* and *RCA Princeton Laboratories*, that bass directionality can be perceived as low as 100 cycles, which invalidates all but a few of the "satellite" systems. It is perfectly true that on a sine-wave basis bass frequencies are highly non-directional, for example a sustained organ pedal note such as low "C" which is approximately 37.5 cycles is largely sinusoidal in character and is essentially non-directional. The "satellite" boys also put forth the argument that what we think we hear as low-frequency directionality is, in reality, the harmonics of the bass fundamental, and these harmonics would be reproduced by the higher frequency satellite speakers.

Experiments with both trained auditors and lay listeners, showed that on the basis of subjective listening tests and stated preferences, a tympani or bass drum radiating, say, 40 cycles as a transient beat, could be aurally positioned. These same tests elicited such information as that 20 db of channel separation was necessary for optimum directional effects when the auditor was listening in an included angle of approximately 60 degrees from the base line of the speakers.

In the case where a three-channel master tape had been mixed down to two channels with the central channel as the "ghost image" in the middle, it appears that if the ghost central image is to be firmly positioned in the middle, with no apparent "wandering" to left or right that amplitude differences in excess of 3 db will require level adjustment. Furthermore, if the auditor is at the optimum central listening position, in order to maintain the illusion of the ghost channel in the middle, the time differential between the two speakers is critical. A two-inch displacement of the speakers forward or back, requires either speaker or auditor adjustment, since this deplacement represents a 0.2 millisecond differential between channels. In this situation the listener would have to be careful not to move his head laterally more than plus or minus 4 inches, or risk displacing the central image.

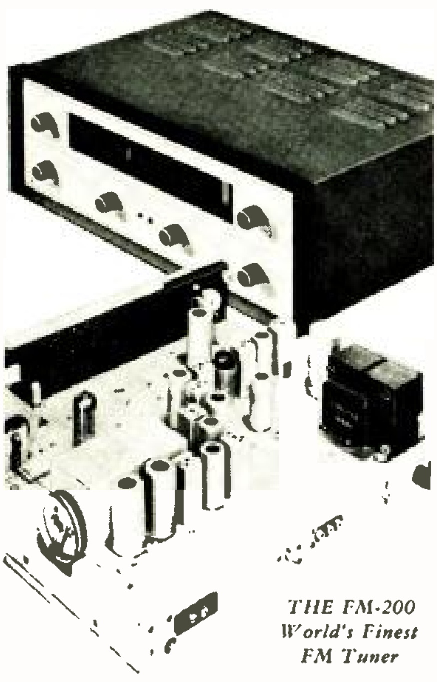
Applied to the "satellite" system, would mean that (*A*) the left and right speakers should be separated a sufficient distance to ensure a minimum of 20 db isolation between them at the listener's position; (*B*) the left and right speakers should be as nearly identical in output and efficiency and positioned as much in the same plane as possible in order to offset any time differentials and to maintain the integrity of the central image; (*C*) the left and right speakers should have flat response to 100 cycles with a 6 db-per-octave roll-off below this point; and (*D*) the central woofer should be operable from 100 cycles down to its maximum bass capability.

This would be a workable satellite system and, as such, might find wide application. On the other hand, with the requirements for this system being somewhat stringent, the cost differential might not be as great between it and a system employing full-range woofer/tweeter combinations on each side. I personally still prefer the full range two woofer concept as optimum for stereo reproduction . . . and will use it until some happy day in the future we can set up a true stereo system with three full-range channels. *Western Electric* and *Bell* proved a long time ago that there was marked listener preference for three channels over two, but that desirable though even more channels might be, up to the "infinite microphone/infinite speaker" range, anything past three was gilding the lily.

Well, perhaps we will soon see some new and brilliant stereo systems, inspired by the new work and experiments now going on in the area of stereo perception. The aforementioned papers on stereo perception by McCoy of *RCA's Princeton Laboratories*, and Harvey and Schroeder of *Bell Telephone*, should be required reading for those involved in stereo design parameters.

TCHAIKOVSKY SYMPHONY #4
Boston Symphony Orchestra conducted by Pierre Monteux. Victor 4-track Stereo FTC2031. Price $8.95.

I find it rather odd that this very popular symphony has received so little attention from the stereo viewpoint. Certainly it has every element needed to make a spectacular stereo vehicle. Yet, this recording is only the 5th or 6th since the beginning of the stereo era and, in relative terms, the only record-



ing which utilizes the most modern technical resources. In any case, it is most welcome and those of you who are particularly addicted to this work will find new delights in this stirring performance.

"Papa" Pierre Monteux has had a long association with this score and unless I've mislaid a recording somewhere, this is about the 5th time this venerable Frenchman has recorded this work. At 85, Monteux shows little sign of losing his vitality, and his performance here is as youthful and vigorous as some of his earlier essays. Perhaps it does not have quite the passion and fire in the same measure of expression, but here is obviously the mature master, secure in his beat and respectful of tempi.

He elicits superb playing from the Boston men, who you feel instinctively are not just traversing another warhorse, but are playing for "Papa" with devotion and zeal. The *Victor* engineers have produced one of their most splendid Boston Symphony sounds to date. The over-all production is very well balanced, directionality is easily apparent but not overdone, there is a well-projected ghost center channel. The orchestral disposition and the moderately close pick-up make for good depth perception and the over-all reverb is such that it lends spaciousness and roundness to the sound without obscuring orchestral detail.

The first and second strings have a lovely smooth sheen, the celli and violas a rich mellowness, the brass was big and bright and declamatory, woodwinds very pure-toned, and percussion, while not overwhelming, was adequate and accurate.

The *scherzo* which is almost entirely *pizzicato*, is beautifully done and is an excellent test of the transient response of your system.

Good wide frequency response and dynamics and throughout very clean except for some slight overload in the last few bars of the finale. Crosstalk here was just barely discernible on my big system and should not be audible on the average system. As a final bonus, at a good room-filling level, tape hiss was present, but commendably low.

RIMSKY-KORSAKOV
SCHEHERAZADE
L'Orchestre de la Societe des Concerts du Conservatoire de Paris conducted by Ernest Ansermet

CHRISTMAS EVE SUITE
SADKO
FLIGHT OF THE BUMBLEBEE
CHANSON RUSSE
L'Orchestre de la Suisse Romande conducted by Ernest Ansermet. London "Twin-pak" LCK80058. Price $11.95.

For you lovers of the exotic music of Rimsky-Korsakov, this is certainly a bonus and liberal helping. I wish that I could report to you that this is an unqualified success, but unhappily I cannot. In performance values, this rates high, as music of this genre is Ansermet's meat and his readings are as serviceable as any and better than most.

In matters of sound we run into some troubles I'm afraid. I must say once again that I am at a loss to understand this extreme variance in the quality of these *London* 4-track tapes. Some are superb in all respects, others not only have the faults usually found, but others peculiar to this company's output on tape. The powers that be insist that the NAB/*Ampex* and the British CCIR equalization are practically identical so that takes care of that.

Forgetting such things as equalization, you run across the doggondest things, which to my ear are very obvious and should be to those who are in charge of producing the tape. Let me interject at this point the fact that my tape machine and system were in perfect balance and working order and played other tapes faultlessly. Anyhoo, what is one to think when he starts this tape through the playback and finds that the sound is so heavily oriented to the right channel as to doubt whether the left channel is even operative? Subsequent investigation reveals that it is necessary to boost the left channel perhaps as much as 4 or 5 db in order to balance the orchestra between the speakers. Then after having accomplished this, you realize that over-all directionality and aural positioning are rather diffuse and it is difficult to pinpoint a given instrument.

The next thing you realize is that the sound seems rather compressed, not at all full and open in the best *London* tradition. Only in the brass fanfares was there any real weight or brilliance. The pickup sounds rather distant which probably heightens this feeling. There was also a lack of really low bass response.

As far as "Scheherazade" is concerned, the sound puts it out of contention. The other Rimsky-Korsakov pieces are interesting and colorful trifles, and unhappily they too suffer from the channel displacement. However, they are somewhat more open and cleaner in sound and in the "Sadko" the bass response is deep and solid. There was a moderate amount of crosstalk in all the works and tape hiss wasn't too bothersome at full room level. Of all things, I detected some of that noisome "sputphut" of d.c. nodule noise . . . something I haven't encountered on any tape for some time. Hope it was just a fluke.

In summation . . . there is always the possibility that I received a bad copy but I have a sneaky hunch that these troubles have their root somewhere in the dubbing process. Comments are invited.

SAINT-SAENS
SYMPHONY #3 ("The Organ")
Boston Symphony Orchestra conducted by Charles Munch. Victor 4-track Stereo FTC2029. Price $7.95.

This is a rather puzzling recording. It is at one and the same time, a quite thrilling musical experience with reasonably good sound, and a recording with many sonic faults. To get to the performance . . . it is somewhat slower paced than I have heard Munch do it before, but still has a high level of inspiration. The *allegros* and *prestos* are imbued with excitement and the slow sections are lovely in their measured eloquence.

The playing of the orchestra, especially the strings is sheer poetry. Now as to sound . . . on an average playback system, I would say that it would be more than passable . . . but on a big system there are sore spots. While I agree that it is nice to be able to get a rich full "concert hall" sound and yet retain orchestral detail, it does take considerable "doing."

I think that they went a little overboard on the pick-up here. For one thing the orchestra is not on the stage, but is on the floor of Symphony Hall with the seats removed. In some works this would have definite advantages, and it could have worked with this piece too with a slightly different approach. Naturally, with the orchestra out in the hall, there is a certain loss of reflected sound, and normally the strings are much reinforced with reflection off wood or plaster. I suspect that some reflective portable "goboes" were used, but perhaps not quite enough.

Then I believe the mike pickup was too high and too far back. This gives a very vast, reverberent sound, but tends to wash out detail. Directionality is affected somewhat, being apparent but a little diffuse. According to the disposition of the orchestra in the hall, the woodwinds and the trumpets, trombones and horns are all supposed to be in the central ghost channel. The ghost image is quite diffuse and more often than not you hear the woodwinds disposed left and right and the brass similarly, but at greater depth.

In the important organ parts of the work, the magnificent instrument in Symphony Hall has great rumbling pedals, right down where Saint-Saens wrote in these great musical buttresses. Unhappily, the organ is not balanced to the rest of the sound for maximum presence and power. It requires a judicious 3 or 4 db bass boost to bring the pedals into proper focus. To further add to our sonic misery, crosstalk was quite evident at certain parts of the score and here too was that old devil, d.c. nodule noise.

As I said before, many of these faults are not apparent on smaller stereo systems, but on the big jobs, it is most disheartening. I suggest you make arrangements to try this tape out before you buy it, if you have a yen for this work with these participants.

SPECTACULAR HARPS
Robert Maxwell, his harps and his orchestra. MGM 4-track Stereo STC3836. Price $7.95.

Robert Maxwell has been making harps do what they ain't supposed to, for many years now. In this latest stereo effort, he really pulls out all the stops and if you listen real carefully, now and then you can recognize a harp. Seriously, though, this man is a proper virtuoso and even if you don't like this sort of fooling with the harp, you must admire his tremendous technique. He is at his best and the sound is best too, when he plays the pure and open harp. For the most part however, he "gimmicks" the instrument to sound like a guitar and mandolin. etc.

On most of the numbers he plays, he uses multiple recording for self accompaniment and other effects and is augmented by a rhythm section. Maxwell is heard in such evergreens as "Caravan," "Ebb Tide," "Lime House Blues," and others.

The directional effects here are deliberately heightened but the rhythm stays in the center ghost channel. Artificial reverb is used in varying amounts on each channel . . . thus the harp on the left may sound like it is way out in the north 40, while at the same time the right harp is heard in ultra-close up.

All in all, clean sound except for some fuzzy overload at very high levels. It certainly makes a good test for transient response. Tape hiss was moderate at full room level. —30—

Electronic Materials Quiz

By JOE TERRA

The list of substances in the first column below includes nineteen elements, gases, metals, and other materials. All of these have important applications in the field of electronics. Can you match them with their descriptive characteristics or uses given in the second column. The correct answers appear on page 123.

1. Alnico	( )	A.	Highly emissive metal. Used for filaments and electrodes of vacuum tubes
2. Aguadag	( )	B.	Lead-tin alloy used in making permanent connections between wires
3. Barium	( )	C.	Mineral used in piezoelectric or crystal oscillators
4. Carbon	( )	D.	Hard, molded insulating material consisting of ground mica and lead borate
5. Ceramic	( )	E.	Occasionally used in cathode coating of vacuum tubes
6. Galena	( )	F.	Substance such as zinc silicate. Used for coating of cathode-ray screens. Produced in wide range of colors
7. Mercury	( )	G.	Soapstone talc. Has excellent insulating properties
8. Mica	( )	H.	Element found as graphite or diamond. Used in resistors, potentiometers, and microphones
9. Mumetal	( )	I.	Pure variety of corundum used for phonograph needles
10. Mycalex	( )	J.	Colloidal suspension of graphite in water. Used as cathode-ray tube coating
11. Neon	( )	K.	An inert gas. Tubes filled with it are used as voltage regulators
12. Phosphor	( )	L.	Clay-like substance used in insulation. Will withstand high temperatures
13. Polystyrene	( )	M.	Metallic alloy. Permeability is high and hysteresis loss is low
14. Porcelain	( )	N.	Lead sulphide. Used as crystal in crystal detectors
15. Quartz	( )	O.	Clear thermoplastic material. Has excellent dielectric properties particularly at high frequencies
16. Sapphire	( )	P.	Glazed ceramic insulating material
17. Solder	( )	Q.	Silver-colored metal. Its vapor is highly conductive when ionized
18. Steatite	( )	R.	Alloy which holds magnetism indefinitely
19. Tungsten	( )	S.	Transparent flaky material. Used to separate the plates of capacitors

Vital assistance for under-developed countries is coming from sources other than American foreign-aid dollars. William Inkumsah (left) of Ghana discusses the needs of his native land with Dr. L. J. Rosenkranz, president of National Technical Schools in Los Angeles. Inkumsah has just completed 18 months of technical training in electronics and will return to Ghana to assist in setting up its technical training program.

Adjusting Transmitters

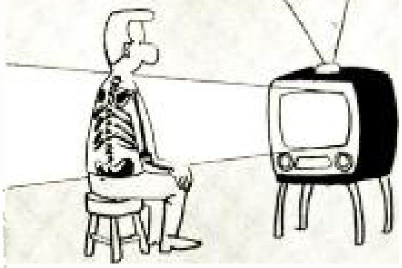
(*Continued from page* 35)

vide proper excitation of the antenna. The dummy antenna is now replaced by the actual antenna. If the final amplifier plate current remains the same rated value when the plate tank circuit is set to exact resonance, the antenna is being driven correctly. The plate power input is now the product of the plate supply voltage and the plate-current meter reading. This power must be known to determine, as mentioned earlier, whether it falls within prescribed limits.

Some communications transmitters include a tunable antenna. In this arrangement, there are three output adjustments—plate tank, loading, and antenna tuning. In adjusting the three controls, the plate tank capacitor is first tuned as already noted. There is some light loading (coupling) made between the plate tank capacitor and the antenna circuit. The antenna circuit is now tuned for maximum plate current. This adjustment makes certain that the antenna is so tuned that it can extract energy from the plate circuit in the most efficient manner. The loading or degree of coupling is now varied until there is the most efficient transfer of energy between plate tank circuit and antenna, as indicated by the tube drawing rated plate current when the plate tank is set to exact resonance.

It should be mentioned that most communications transmitters do not employ any triode straight-through class-C stages. Whenever a triode r.f. stage is used in a transmitter, and it is not of the grounded-grid type, a special neutralizing circuit must be used to prevent self-oscillation and instability. The neutralizing capacitor or adjustment for such a stage must be set to a point at which there is minimum transfer of r.f. signal between grid and plate tank circuits when the stage is operated with the plate power turned off. Some base and fixed-station transmitters operating in the low-frequency marine, police, or aviation bands do use triodes in such amplifier stages.

(*Concluded next month*)



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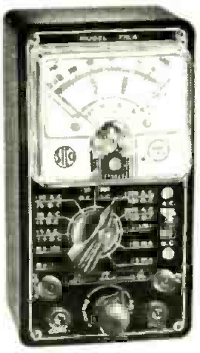
VOLT-OHM MILLIAMMETER



FEATURES:

- Compact—measures 3⅛" x 5⅞" x 2¼".
- Uses "Full View" 2% accurate 850 Microampere D'Arsonval type meter
- Housed in round-cornered, molded case.

SPECIFICATIONS:

6 A.C. VOLTAGE RANGES: 0-15/30/150/300/1500/3000 Volts.

6 D.C. VOLTAGE RANGES: 0-7.5/15/75/150/750/1500 Volts.

2 RESISTANCE RANGES: 0-10,000 Ohms, 0-1 Megohm.

3 D.C. CURRENT RANGES: 0-15/150 Ma., 0-1.5 Amps.

3 DECIBEL RANGES: —6 db to + 18 db, + 14 db to + 38 db, + 34 db to + 58 db.

The Model 770-A comes complete with test leads and operating instructions. **Price is $15.85. Terms:** $3.85 after 10 day trial then $1.00 monthly for 3 months.

SUPERIOR'S NEW MODEL 79

SUPER-METER

WITH NEW 6" FULL VIEW METER

SPECIFICATIONS:

D.C. VOLTS: 0 to 7.5/15/75/150/750/1,500.
A.C. VOLTS: 0 to 15/30/150/300/1,500/3,000.
D.C. CURRENT: 0 to 1.5/15/150 Ma. 0 to 1.5/15 Amperes.
RESISTANCE: 0 to 1,000/100,000 Ohms. 0 to 10 Megohms.
CAPACITY: .001 to 1 Mfd. 1 to 50 Mfd.
REACTANCE: 50 to 2,500 Ohms, 2,500 Ohms to 2.5 Megohms.
INDUCTANCE: .15 to 7 Henries, 7 to 7,000 Henries.
DECIBELS: —6 to + 18, + 14 to + 38, + 34 to + 58.

The following components are all tested for **QUALITY** at appropriate test potentials. Two separate **BAD-GOOD** scales on the meter are used for direct readings.

All Electrolytic Condensers from 1 MFD to 1000 MFD.
All Selenium Rectifiers. All Germanium Diodes.
All Silicon Rectifiers. All Silicon Diodes.

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SUPERIOR'S NEW MODEL 77

VACUUM TUBE VOLTMETER

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

SPECIFICATIONS:

- **DC VOLTS**—0 to 3/15/75/150/300/750/1500 volts at 11 megohms input resistance.
- **AC VOLTS (RMS)**—0 to 3/15/75/150/300/750/1500 volts.
- **AC VOLTS** (Peak to Peak)—0 to 8/40/200/400/800/2000 volts.
- **ELECTRONIC OHMMETER**—0 to 1000 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.

Model 77 comes complete with operating instructions, probe and test leads and carrying case. **Price is $42.50. Terms: $12.50 after 10 day trial then $6.00 monthly for 5 months.**

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20,000 OHMS PER VOLT <u>ALL</u>METER

NOTE The line cord is used only for capacity measurements. Resistance ranges operate on self-contained batteries

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MIRRORED SCALE permits fine accurate measurements where fractional readings are important.

SPECIFICATIONS:

7 D.C. VOLTAGE RANGES: (At a sensitivity of 20,000 Ohms per Volt) 0 to 15/75/150/300/750/1500/7500 Volts.

6 A.C. VOLTAGE RANGES: (At a sensitivity of 5,000 Ohms per Volt) 0 to 15/75/150/300/750/1500 Volts.

3 RESISTANCE RANGES: 0 to 2,000/200,000 Ohms, 0-20 Megohms.

2 CAPACITY RANGES: .00025 Mfd. to .3 Mfd., .05 Mfd. to 30 Mfd.

5 D.C. CURRENT RANGES: 0-75 Microamperes, 0 to 7.5/75/750 Milliamperes, 0 to 15 Amperes.

3 DECIBEL RANGES: —6 db to +18 db, +14 db to +38 db, +34 db to +58 db.

Model 80 Allmeter comes complete with operating instructions, test leads and portable carrying case. **Price is $42.50. Terms: $12.50 after 10 day trial then $6.00 monthly for 5 months.**

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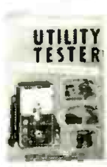
FOR REPAIRING ALL ELECTRICAL APPLIANCES MOTORS ★ AUTOMOBILES



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• Both 6 Volt and 12 Volt Storage Batteries • Generators • Starters • Distributors • Ignition Coils • Regulators • Relays • Circuit Breakers • Cigarette Lighters • Stop Lights • Condensers • Directional Signal Systems • All Lamps and Bulbs • Fuses • Heating Systems • Horns • Also will locate poor grounds, breaks in wiring, poor connections, etc.

Model 70 comes complete with 64 page book and test leads. **Price is $15.85. Terms: $3.85 after 10 day trial then $1.00 monthly for 3 months.**

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SUPERIOR'S NEW MODEL 82A
MULTI-SOCKET TYPE

TUBE TESTER

SPECIFICATIONS:

- Tests over 1000 tube types.
- Tests OZ4 and other gas-filled tubes.
- Employs new 4" meter with sealed air-damping chamber resulting in accurate vibrationless readings.
- Use of 22 sockets permits testing all popular tube types and prevents possible obsolescence.
- Dual Scale meter permits testing of low current tubes.
- 7 and 9 pin straighteners mounted on panel.
- All sections of multi-element tubes tested simultaneously.
- Ultra-sensitive leakage test circuit will indicate leakage up to 5 megohms.

Model 82A comes housed in handsome, portable, saddle-stitched Texon case. **Price is $36.50. Terms: $6.50 after 10 day trial then $6.00 monthly for 5 months.**

SUPERIOR'S NEW MODEL TW-11
STANDARD PROFESSIONAL

TUBE TESTER

- Uses the new self-cleaning Lever Action Switches for individual element testing. Because all elements are numbered according to pin-number in the RMA base numbering system, the user can instantly identify which element is under test.
- Free-moving built-in roll chart provides complete data for all tubes. All tube listings printed in large-easy-to-read type.
- **NOISE TEST**: Phono-jack on front panel for plugging in either phones or external amplifier will detect microphonic tubes or noise due to faulty elements and loose internal connections.
- **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.

The Model TW-11 comes housed in a handsome, portable, saddle-stitched Texon case. **Price is $47.50. Terms: $11.50 after 10 day trial then $6.00 monthly for 6 months.**

SUPERIOR'S NEW MODEL 83A

C.R.T. TESTER

Tests and Rejuvenates ALL PICTURE TUBES

ALL BLACK AND WHITE TUBES
From 50 degree to 110 degree types—from 8" to 30" types.

ALL COLOR TUBES
Test ALL picture tubes —in the carton —out of the carton —in the set!

Model 83A provides separate filament operating voltages for the older 6.3 types and the newer 8.4 types.

Model 83A properly tests the red, green and blue sections of color tubes individually—for each section of a color tube contains its own filament, plate, grid and cathode.

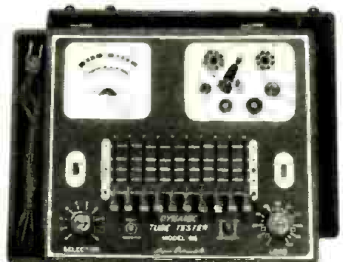
Model 83A will detect tubes which are apparently good but require rejuvenation. Such tubes will provide a picture seemingly good but lacking in proper definition, contrast and focus.

Rejuvenation of picture tubes is not simply a matter of applying a high voltage to the filament. Such voltages improperly applied can strip the cathode of the oxide coating essential for proper emission. The Model 83A applies a *selective* low voltage *uniformly* to assure increased life with no danger of cathode damage.

Model 83-A comes housed in handsome portable Saddle-stitched Texon case—complete with socket for all black and white tubes and all color tubes. **Price is $38.50. Terms: $8.50 after 10 day trial then $6.00 monthly for 5 months.**

SUPERIOR'S NEW MODEL 85
TRANS-CONDUCTANCE TYPE

TUBE TESTER



- Employs latest improved **TRANS-CONDUCTANCE** circuit. Test 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**: 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 necessary and advantageous.
- **"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.
- **FREE FIVE (5) YEAR CHART DATA SERVICE.** 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.

Model 85 comes complete, housed in a handsome portable cabinet with slip-on cover. **Price is $52.50. Terms: $12.50 after 10 day trial then $8.00 monthly for 5 months.**

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
- ✓ Bar Generator
- ✓ Cross Hatch Generator
- ✓ Color Dot Pattern Generator
- ✓ Marker Generator

A versatile all-inclusive **GENERATOR** which provides **ALL** the outputs for servicing:

A.M. Radio • F.M. Radio • Amplifiers • Black and White TV • Color TV

The Model TV-50A comes absolutely complete with shielded leads and operating instructions. **Price is $47.50. Terms: $11.50 after 10 day trial then $6.00 monthly for 6 months.**

SUPERIOR'S NEW MODEL 88

TESTS ALL TRANSISTORS AND TRANSISTOR RADIOS

AS A TRANSISTOR RADIO TESTER
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 is located and pinpointed.

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!*

Model 88 comes housed in a handsome portable case. Complete with a set of Clip-on Cables for Transistor Testing; an R.F. Diode Probe for R.F. & I.F. Tracing; an Audio Probe for Amplifier Tracing and a Signal Injector Cable. Complete—nothing else to buy! **Price is $38.50. Terms: $8.50 after 10 day trial then $6.00 monthly for 5 months.**

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Transistor Mysteries

(*Continued from page 37*)

bravely. To do this we must go back to what we know about atomic theory, and also recall something about the difference between theory and fact. When scientists can explain a phenomenon fully and prove what they say is true, their formulation of this knowledge is called a law. Ohm's Law is an example. When they are only at the point where they are taking an educated guess about things, their opinion is called an hypothesis. If this hypothesis seems to work well, is improved upon, gets widely accepted, and acquires at least some evidence to give it probable support, it becomes a theory. If it is finally proved beyond question, it is a law.

But our concept of atoms is still considered a theory, and theories undergo change. Initially, it stated that the smallest particle of any element is an atom made up of protons (positively charged particles) in the center, around which orbit a number of electrons, which are negatively charged. The total number of protons normally equals the total number of electrons so that the atom is electrically balanced.

Then someone realized that the helium atom, which contains only twice as many of these particles as the hydrogen atom, was four times larger. To keep the theory going, a third particle with no electrical charge, the neutron, was introduced. The helium atom was larger because it also had some neutrons to make up the difference. The theory still works well for us, but it keeps getting changed. We have to work out and introduce new concepts in this way to preserve, even improve, good theories. And that's why we have holes.

During the study of semiconductors, a force was discovered that seemed to move in a direction opposite to that of the electron and under opposite conditions. It could not be directly explained in terms of what was already believed concerning atoms and electrons, so, to keep everything from getting messed up, a new term was coined—the hole.

The literature on the subject agrees on only one point—that the hole is a hole. The least irritating explanation offered was that the hole is a place where an electron had been but isn't anymore. Another source said it was something that had all the properties of a positively charged particle although it wasn't. In other words, whatever it is, it acts as an electron in reverse. Without delving deeply into the physicist's guess as to what goes on, let's go back to the first explanation of a hole as being a place where an electron no longer is. While the electron was there, things were pretty much in balance. When it leaves, there is a deficiency of negative charge—or a hole—leaving the immediate area positive. This hole can then act to attract an electron.

"N-P-N" versus "P-N-P"

So far, we have only considered the

n-p-n transistor. Before considering its opposite number, we should find out what *n* and *p* mean. Basically there are two types of semiconductor materials. In one, the atoms will give up their electrons (negative charges) rather easily. This is the *n* type. The other can be more readily induced to take on or accept electrons. In so doing it acts like a positive element and is called the *p* type.

In the *n-p-n* sandwich, emitter and collector are *n* types, while the base sandwiched between them is a *p* type. In the *p-n-p* type (positive-negative-positive), the reverse is true.

At first thought, it may not seem that the polarity of applied voltages makes sense. However, if the collector of the *n-p-n* type (Fig. 1B) will yield electrons with little encouragement, then we would provide that encouragement by attraction by applying our positive potential to this element, which is the important point where we get the results we are looking for. Even though the emitter is of the same material, it is at the other end of the transistor. So, to get the greatest potential difference across the entire device, the most negative potential goes to the emitter. The base potential is fairly close to that of the element it controls, the emitter, but usually not as negative.

In a *p-n-p* transistor, things are generally reversed. The *p* collector material is full of holes (positive) and will attract electrons, so the most negative potential is applied here, with the most positive generally going to the emitter. Using Fig. 1B as a starting point, the battery terminals would be reversed and electrons would flow through the transistor in the opposite direction. The base potential would be close to that at the emitter, but not usually as positive.

There are some tricks for remembering this. To determine voltage relationships, one service technician adds another, alternate letter to the transistor type (*n-p-n-p* and *p-n-p-n*, for example). The last letter gives the polarity of voltage applied to the collector. The emitter is at the opposite potential, with the base very close to it but generally not quite as extreme. To avoid confusion with what you see on circuit diagrams, remember that these are *relative* voltages with respect to the various electrodes. Voltage as measured from ground will depend on how the battery voltage is distributed above and below ground.

Other Configurations

Just as tubes can be used in various configurations, so can transistors. Fig. 2A shows a conventional, grounded-cathode, grid-input amplifier and its corresponding grounded-emitter, base-input transistor circuit, using a *n-p-n* type. Fig. 2B shows the grounded-grid and corresponding grounded-base configurations. Fig. 2C shows the grounded-plate (cathode-follower) and grounded-collector (emitter-follower) arrangements. As with tubes, matters can get more complicated than shown, but at least we have a starting point. —30—

SERVICE INDUSTRY NEWS

IF YOU raise your voice long enough and loud enough, it seems that it has to do a little good eventually. The service profession has unremittingly hammered away at certain gripes against set manufacturers, for example, over the years. Suddenly we find that more than one member of the manufacturing segment of electronics is becoming responsive to long-standing plaints and offering balm to be used on old sores.

From Indianapolis, Indiana, and other points comes evidence that *RCA* is undertaking some de-emphasis of its own service company in favor of independents. In response to charges by the Indianapolis Television Technicians Association that the *RCA Service Co.* is exploiting an unfair advantage growing out of its association with the set-manufacturing affiliate, an agreement has been reached under which local independents will be designated as "Authorized *RCA Victor* Service Dealers." To our knowledge, this manufacturer is among those who have never conferred such a status on independents in the past.

The designation may seem like an empty gesture, but ITTA foresees a practical advantage. In the past, independents could never advertise themselves in association with the *RCA* name. An owner of an *RCA* set seeking service would often look in the yellow pages and be attracted by this manufacturer's trade mark, under which only the affiliated service company would be listed. From now on, "authorized" dealers will be listed in the yellow pages along with the affiliated service agency under the well-known trade mark. Participating dealers will also get certificates, large enough to be displayed, attesting to their status.

Also encouraging is some evidence that this move is more than a local measure in response to strong pressure. Evidently this basic plan is to be carried to other parts of the country. TESA of Miami states that a similar arrangement for authorizing independents through the local *RCA Victor* distributor is in the works.

Westinghouse Helps

The "CSEA Countdown," organ of the California State Electronics Association, reports a new system introduced by *Westinghouse* to make it easier for service technicians to get replacement parts for ailing receivers. This manufacturer is issuing credit cards to service dealers to facilitate procurement procedures. These cards will be issued to service dealers who are members of recognized associations, on application made through these associations.

Here is a typical situation in which possession of the card will be a boon: You are in an area where you are not readily accessible to a distributor that carries *Westinghouse* parts, or the local man doesn't happen to have the specialized component on hand that you need. You phone in or write in an order, giving your card number. The part is shipped out promptly and your account is billed.

In the past, it was necessary to fill out a number of papers and much processing time was required. Dealers who do not bother to obtain credit cards will still be in this position. The plan is expected to be a particular boon in handling parts that are still under warranty. The red tape in which warranty work often becomes entangled has been a major gripe with service dealers for a decade and a half. At last, somebody came up with a bright idea.

Manufacturers and Licensing

That portion of the service industry which favors licensing was pleasantly surprised by recent pronouncements from two manufacturers. Manufacturers have traditionally opposed governmental regulation, despite many pleas from service groups. The *Finney Co.*, antenna manufacturers, and *Raytheon Manufacturing Co.* have announced themselves in favor. Neither of these is a set maker, of course, but the stand is nevertheless significant. Spokesman for *Finney* was Morris L. Finneburgh, president, at the last NATESA convention in Chicago. Jack Cattaral took his position on behalf of *Raytheon*. Both men called attention to the damage often done to independents by selfish activity on the part of manufacturers and distributors. Also cited was the harm done by the unfettered operations of ill-equipped, poorly trained people who designate themselves as service technicians.

Cattaral went so far as to state that federal licensing might be the best answer. He compared this to the need for an FCC ticket for work on various types of transmitters.

The *Finney Co.* has shown that it means business in another area. It recently lifted the antenna franchise of an Ohio distributor who was found to be selling direct to the retail trade, in competition with service dealers. Other manufacturers maintain similar formal stands against distributors who are guilty of retail selling, but most show extreme reluctance to do anything in the way of enforcing the rules, even under pressure. The *Finney* action was prompt and decisive.

The actions to which we have called attention here involve four different manufacturers, two of them set makers. Are these people beginning to give long overdue acknowledgment to the importance—to them—of the service industry?

FTC Takes Action

The Federal Trade Commission has ruled that all advertising that crosses state lines and may induce business to come across state lines is subject to its jurisdiction, even though such advertising may appear in local newspapers. As NATESA sees it, this should have far-reaching implications with respect to "bait" and other phony advertising involving TV and other electronic repair work.

A case in point was discussed in our September issue ("Service Industry News," page 106). A dealer in Monon, Indiana was being barraged by his customers for what they believed to be excessive service fees and unreasonable prices on picture and other tubes. The basis for their complaints was the fact that they received and read the daily and Sunday newspapers being published over the border in Chicago, Illinois.

Ads were promoting $2 service calls and picture tubes (reconditioned, but not identified as such) at prices lower than what the service dealer had to pay for the new ones he was installing in his customers' sets. As a result of sad experience and active campaigning by associations in Chicago, the truth behind such advertising was no secret to many Chicago set owners. However, there was no way for the good people of Monon to know what the real story was. The grass simply looked greener in Chicago. The Monon dealer had to suffer for a situation over which he had no control but which was having considerable effect on his business.

The formal acknowledgment that such an effect can occur across state borders is an important gain. NATESA has been trying to drive this point home with federal agencies for some time. Let us hope that enforcement will follow promptly now that jurisdiction has been acknowledged. How far such jurisdiction will be assumed, however, is a matter of interpretation. In the case of the Monon-Chicago matter, for example, the advertisers were not soliciting business across state lines. There was no direct attempt to persuade people outside of Chicago to obtain tubes from the advertising firms by mail. Will the FTC consider that this advertising is effectively crossing state lines? Also, what happens with advertising run in papers that are distributed out of the state where the advertiser is not located near a border with another state? In practice, this advertising does have some effect. Ask the man in Monon—he knows.

As we said, a matter of interpretation is involved here. Perhaps the FTC action is a first step that will be followed by broader efforts. -30-

Tunnel Diodes Simplified

(*Continued from page 46*)

marketing the 1N650 series of gallium arsenide tunnel diodes which feature peak-to-valley ratios greater than 15 to 1.

In addition to the germanium tunnel diodes, both *RCA* and *General Electric* produce engineering samples of the high-ratio gallium arsenide tunnel diodes, in experimental quantities.

Advantages

By way of summing up, the following advantages can be claimed for tunnel diodes:

1. The tunnel diode is a two-terminal device. When hundreds of thousands are wired into a computer, this is an important consideration.
2. The device is capable of extremely high frequency performance, for a semiconductor. The present-day high-frequency limit is 1000 to 4000 mc. with 10,000 mc. expected in the near future.
3. Low power consumption (in the microwatt region) which also means low heat generation.
4. Noise generation, exceeded only by the maser and parametric amplifier, is extremely low and, in addition, no pump generator is required.
5. Extremely fast switching time. The tunnel diode can handle pulses having a time duration of less than 1 millimicrosecond.
6. High-temperature operation, particularly the gallium arsenide diode, which operates as high as 660 F. There is no need for the elaborate cooling systems used with conventional tube-type computers. In addition, the tunnel diode is not affected by nuclear radiation.

This article has only scratched the surface of the tunnel diode picture. In the near future you can expect some fantastic developments in this field. The old "saw" about little acorns and big oaks was never more true than with the amazing tunnel diode. Given half a chance, this little negative-resistance acorn is going to grow some mighty big oaks.

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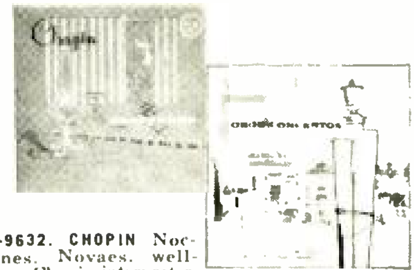

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Uses of New Satellites

(*Continued from page* 55)

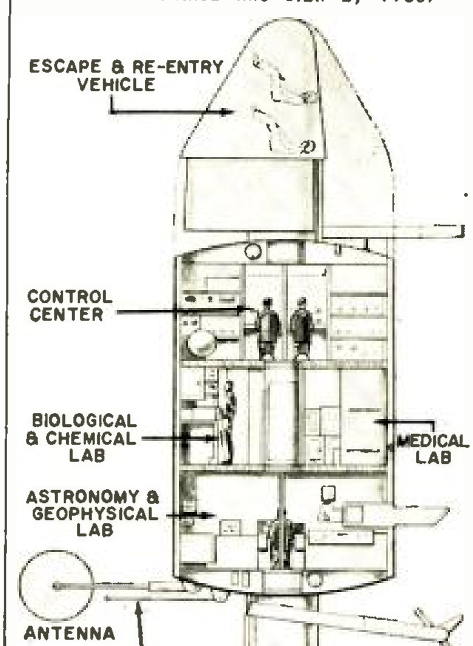
be motionless. From the point of view of the satellite, the earth too would seem to be standing still. Three satellites, 120 degrees apart, would be sufficient to cover the earth (except for the polar regions) as passive communications satellites.

Active satellites can also be used for communications. For example, "Project Score" orbited a cylindrical satellite in December 1958 which was used to broadcast a tape-recorded message from President Eisenhower to the world. With such a set-up it is possible to transmit a message from the ground, have it recorded by the satellite, and then re-transmit this message to another distant ground station as the satellite passes over.

Navigation presents a number of problems as yet unresolved by any existing system. Loran, valuable as it is, requires a number of land-based stations which limits its usefulness in many applications. Precise world-wide navigation is closer to reality with the development of the Navy's "Transit" satellites. When this system is in full operation (four satellites in orbit by 1962), it will provide complete coverage of the earth. Every 90 minutes a navigational fix, accurate to one-fourth mile, will be possible. An antenna, small computer, and a receiver are all that will be required at each ground location (ship) to provide complete navigational information.

A photograph of the "Transit" satellite is on page 55. Painted on the surface are the candy stripes which comprise the antenna. Bands about the center contain the solar cells which are used to recharge the satellite's batter-

Drawing of 16-ton space laboratory which engineers of the Martin Co. say could be launched into orbit by 1965.



ies. Operation of this navigational satellite is a three-stage process.

1. After it has been placed in orbit, the "Transit's" transmitter sends a signal to ground station #1. The signal shifts in frequency because of the Doppler effect. This Doppler shift provides valuable information about the satellite's speed. After receiving this information and reducing it to digital form, the data is sent to a central computer.

2. At the central computer, the Doppler information is used to compute the future path of the satellite. This information is sent to station #2 which transmits the new path information to the satellite where it is stored.

3. Ship stations desiring a navigational fix receive the information broadcast intermittently by "Transit." This current data, together with previous information about the satellite, is fed to a computer which calculates the present position of the ship.

As part of this program, the Navy recently sent two satellites into orbit with a single "Thor-Able-Star" rocket. This was the first time that two satellites had been launched simultaneously. One of the units, the "Transit II-A," is a 223 pound navigation satellite while the second payload is a 42 pound sphere designed to examine ionospheric radiation. After being placed in orbit, the two satellites were separated.

Weather forecasting, missile-launch detection, communications, and navigation are all being aided by the "electronic labs in space." On the other hand, the time is coming when man himself will travel in space. Instruments alone, while they provide valuable data, can never take the place of a true space laboratory. One such laboratory has been proposed by *Martin Co.* A drawing showing this proposed space lab is on previous page.

"Project Mercury"—the man-in-space project—is designed to orbit a vehicle which can be safely recovered. The "Discoverer" project, which ejects a capsule for recovery, and which has already been successful, is one step along the way to the "Mercury" project. With a manned space station, possibilities are virtually unlimited.

No matter by what means man extends his knowledge of the earth and space, electronics is sure to play a vital role. —30—

NAME	LAUNCHED
Explorer I	January 1958
Vanguard I	March 1958
Vanguard II	February 1959
Explorer VI	August 1959
Vanguard III	September 1959
Explorer VII	October 1959
Tiros I	April 1960
Transit I-B	April 1960
Midas II	May 1960
Transit II-A	June 1960
Echo I	August 1960
Courier I	October 1960
Explorer VIII	November 1960
Tiros II	November 1960

Table 1. U.S. satellites now in orbit.

Electronic Resistive Load

(Continued from page 51)

divider would carry all the current for all taps plus the bleeder current. The second section would carry all of this current, at a reduced voltage, except for the current taken off at the first tap, and so on.

Where the voltage has to be reduced but slightly, a bleeder resistor can sometimes fulfill two functions. It can discharge the capacitor and may, by increasing the total current drawn, cause the power-supply voltage to drop the desired amount. All we need to do to check this out is to turn the Load control up a little farther so that the milliammeter shows the full-load current and the bleeder current. By varying the Load control and watching our meters, we can see what adding a few more ma. to the load will do.

The unit is built in a small aluminum cabinet, with a small chassis held in place by the two rheostats. See Fig. 4. To save bench space, a vertical arrangement is used. The cabinet and the chassis should be insulated from the wiring. This prevents shock hazard and short circuits should the cabinet of the device touch other, grounded equipment.

In wiring, the binding posts, R_1, and R_2 should be wired before the transformer is bolted in place. Care should be taken to place the meter multipliers well away from the tubes, both from a clearance and a heat standpoint. Due to the heat generated, vent plugs are used in the cabinet back, near the tube bases, and at the top of the tubes.

The schematic, Fig. 1, lists the milliammeter multipliers based upon a 1-ma. meter with an internal resistance of 50 ohms. Where the movement used has some other resistance, the values of the shunt resistors, R_3, R_4, and R_5, will have to be changed accordingly.

The meters, meter switches, and the multipliers can be eliminated, if desired, and test jacks for external meters can be used. However, both a separate milliammeter and a voltmeter are desired since it is necessary to make simultaneous measurements.

The capacity of the voltage and the current that can be handled by the unit depends upon the tubes used. Various beam-power tetrodes such as the 6L6 series, the 6F6, 6V6, 6K6, and others can be used without circuit changes. Fig. 5 shows the wattage capacity of some of these tubes in pairs, as used in this device, expressed in voltage and current. The 5932 type is a premium version of the 6L6.

If a heavy-duty version using higher-power tubes is desired, some changes in parts and layout will have to be considered. A somewhat larger transformer will be needed to handle the extra current. This will add expense and take up more space. Also, the higher-power tubes may interfere physically with the meters in the layout shown in Fig. 4. A larger chassis and housing will thus be needed. —30—

ELECTRONIC CROSSWORDS

By **BRUCE BALK**

(*Answer on page* 123)

ACROSS

1. Device to convert rotary to longitudinal motion.
4. Triangular group of three primary color phosphor dots.
9. Painting.
12. _____ Kahn.
13. Unit of inductance.
14. Voltage-current-resistance (abbr.).
15. Examiner.
17. Heat or light, for example.
19. Pertaining to musical sound.
21. Voltage-resistance-current (abbr.).
22. Afresh.
24. Type of fastener.
26. Consumes.
29. Centers of coils.
31. Magnetic or electric separation.
33. Rim, edge.
34. The color gold.
35. Color code for number two.
37. Tattered cloth.
39. Island near Manhattan (abbr.).
40. Effective value of a.c. corresponding to d.c. value that will produce same heating effect (abbr.).
42. Applied portion of a soldering iron.
44. It makes holes.
46. Type of fastener used in carpentry.
48. Adult male.
50. Measuring device (abbr.).
51. Slang for oozy matter.
53. Means for production.
55. Segmented connector shaped like a fruit.
58. Types of pulleys or gears.
61. One (Italian).
62. Near: shut.
64. Tear.
65. Apothecaries' measure denoted by "C" (abbr.).
66. Theoretical conductor of electromagnetic radiation.
67. Plaything.

DOWN

1. Whisker used in crystals.
2. Ripen, mature.
3. Phonograph record mold.
4. At that time.
5. Showed again, as a TV movie.
6. Preposition.
7. Common verb.
8. Unit of kinetic energy.
9. What the British call an antenna.
10. Slang for transmitter or receiver.
11. Attempt.
16. Supporting structure for an antenna.
20. Device for connecting a wire to terminal strip.
22. Early miniature high-frequency tube.
23. Bellini heroine.
25. First of the potting compounds.
27. Cash registers.
28. Overflowed.
30. Rig.
32. Attenuator.
36. Pale, faint (as of light).
38. External cover of a loudspeaker.
41. Generated electromagnetic radiation.
43. _____ on the back.
45. Place inside.
47. The volcano Mauna _____.
49. Random electromagnetic radiation.
52. One time only.
54. River in Germany.
55. Telegraph key (colloq.).
56. Literary collection.
57. Height above sea level (abbr.).
59. River (Span.).
60. Secret agent.
63. Exclamation of surprise.

1	2	3	■	4	5	6	7	8	■	9	10	11
12			■	13					■	14		
15			16			■	17					
■	■	19				20	■	21			■	■
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29				30	■	31		32	■	33		
34		■	35		36	■	37		38	■	39	
40		41	■	42		43	■	44		45		
46			47	■	48		49	■	50			
■	■	51		52	■	53		54			■	■
55	56				57	■	58				59	60
61			■	62		63			■	64		
65			■	66					■	67		

Mac's Service Shop

(*Continued from page 60*)

course," Mac replied; "but most TV owners are especially solicitous regarding their picture tubes. Placing a set so that light falling on the screen makes necessary the use of excessive brightness and contrast will shorten picture tube life."

"Yeah, and if you want to give the tuner a rough time, all you have to do is to change channels as though you were spinning the wheel on Groucho's *Bet Your Life* program," Barney added. "Unnecessary roughness with any of the controls pays off—not for the owner but for us."

"I suspect that reasonable care on the part of the user pays off more with record players than with radios and TV sets," Mac said thoughtfully. "There are so many ways to abuse record players."

"Sure," Barney agreed; "like letting the little monsters manhandle the tone arm while the changer is trying to go through its cycle, or by dropping the needle on the record or motor board, or by trying to change a needle yourself when you don't know what you're doing, or by operating a portable player with the lid closed so that all the heat from the motor and amplifier is trapped inside the turntable compartment with a crystal cartridge that simply won't take heat."

"Transistor radios are tough, but they also require reasonable care," Mac took up the theme. "Lots of folks think because these radios have high-impact cases that are practically unbreakable it does not hurt to drop them."

"And if they could see the damage the goo that leaks out of spent batteries does when it gets on a compact printed circuit chassis, I'll bet they'd never lay a transistor set away with batteries in it or fail to take exhausted batteries out at once," Barney added.

He was interrupted by a low rumble of thunder.

"There's the cue for one last suggestion," Mac said as he stood up. "The set owner who wants to stay away from our door will always unplug his radio, TV set, and record player when a thunderstorm is in progress or when he is going to be away from home for any length of time during the thunderstorm season. Let him know that the lightning arrester on the TV antenna lead-in *does not* protect his set from lightning surges coming in over the line and leaping across the set switch. This kind of damage is far, far more common than that resulting from lightning coming in on the antenna; yet it can be prevented so easily just by leaving the plug out of the wall socket while the storm is in progress."

"Got every word of it!" Matilda said triumphantly as she snapped shut the shorthand book in which she had been busily writing. "Now I can hardly wait until some unwary customer asks me for an ounce of prevention. I'll give him a whole pound!" —30—

Great Britain's Radio Hobbies Show

By PATRICK HALLIDAY

Description of some of the items seen by the 10,000 radio hobbyist attendees.

AMATEUR communications receivers and kits manufactured by U.S. firms —including *Hallicrafters, Hammarlund, Heath,* and *National*—were prominent at the recent four-day International Radio Hobbies Exhibition in London. This annual show, sponsored by Radio Society of Great Britain, combines displays of home- and factory-built ham gear, kits, electronic music, and hobbyists' equipment; attendance was around the 10,000-mark.

Products attracting attention ranged from a four-section, telescopic, alloy, antenna mast extending to 45 feet and priced at $145 to a neat 10-watt, 2-meter phone transmitter for fixed or mobile operation and measuring 6 inches wide, 5 inches high, and 7 inches deep at under $70. Several compact transmitters intended solely for "top-band" (1.8-2 mc.) were shown for the first time; this band is popular in Britain for local club and group networks as power is limited to 10 watts input. Several designs were shown using series-gate screen modulation which is finding increasing favor in Europe for low-power phone operation.

Awarded the Silver Plaque for factory-built equipment was a complete 180-watt p.e.p., 3.5 - 30 mc. SSB transmitter using a crystal-filter generator; this rig, which uses a pair of 6146 tubes in the final stage, sells in Britain for about $350. Also shown for the first time was equipment using the new TT21 power r.f. tubes, developed from the well-known KT88 audio tube. A single TT21 has a c.w. rating of 215 watts input up to 30 mc. with a plate voltage of 1250 volts and bears a maker's price tag of under $5.

Amateur TV

Special displays were staged by Army, Navy, and Air Force communications units; ham-built gear shown included equipment for amateur television complete with a demonstration of pictures received from the United States by amateur slow-scan television and recorded on a standard type recorder. The television exhibit was handled by the British Amateur Television Club which is actively promoting interest in TV transmissions in Britain; several networks of stations transmit regularly in the 70-centimeter band, sending 405-line pictures over distances up to about 30 miles to viewers using domestic TV receivers fitted with u.h.f. converters.

The exhibition was opened by British stage and screen star, Brian Rix, who holds the ham call G2DQU. —30—

CALENDAR of EVENTS

MARCH 20-23

1961 IRE International Convention. Woldorf-Astoria Hotel ond New York Coliseum. Detoils from IRE Heodquorters, 1 E. 79th St., New York 21.

MARCH 27-31

1961 Symposium on Temperoture. Sponsored by Americon Institute of Physics, Instrument Society of Americo, ond Notionol Bureou of Stondords. Columbus, Ohio. Progrom informotion ovoiloble from V. W. Sikorn, ISA, 313 Sixth Ave., Pittsburgh 22, Po.

APRIL 4-6

Symposium on Electromagnetics ond Fluid Dynamics of Goseous Plosmo. Sponsored by Polytechnic Institute of Brooklyn, IRE, Institute of Aeronoutical Sciences, ond U.S. Defense Agencies. Engineering Societies Bldg., 33 W. 39th Street, New York City. Detoils from PIB, 55 Johnson St., Brooklyn, N.Y.

APRIL 4-7

Spring Convention ond Exhibit. Sponsored by the Audio Engineering Society. Ambossodor Hotel, Los Angeles. Detoils from AES, P.O. Box 12, Old Chelseo Stotion, New York 11, N.Y.

APRIL 4-9

1961 Los Angeles High Fidelity Music Show. Sponsored by the Institute of High Fidelity Monufocturers. Ambossodor Hotel, Los Angeles. Detoils from IHFM, 125 E. 23rd St., New York 10.

APRIL 5-7

Symposium on Moteriols ond Electron Device Processing. Sponsored by Americon Society for Testing Moteriols. Benjomin Franklin Hotel, Philodelphio, Po. Informotion from ASTM, 1916 Roce St., Philodelphio 3, Po.

APRIL 19-21

SWIRECO. Sponsored by the S.W. (Region 6) Section of IRE. Dollos Memoriol Auditorium ond Boker Hotel, Dollos, Texos. Progrom informotion ovoiloble from Dr. L. D. Strom, Texos Instruments, 6000 Lemmon Ave., Dollos, Texos.

APRIL 26-28

Seventh Region Technicol Conference ond Trode Show. Sponsored by Region 7 of the IRE. Westword Ho Hotel, Phoenix, Ariz. Progrom informotion from H. W. Welch, Jr., Motorolo Inc., P.O. Box 1417, Scottsdole, Arizono.

MAY 2-4

Electronic Components Conference. Sponsored by PGCP, AIEE, EIA, WEMA. Jock Tor Hotel, Son Froncisco, Colif. Detoils from Doniel Breoding, Foirchild Semiconductors Inc., Polo Alto, Colif.

Sixth Biennial Midwest Industry & Lighting Exposition. Sponsored by The Electric Associotion of Chicogo. McCormick Ploce, Chicogo. Industry only. Detoils from Associotion, 14D S. Deorborn, Chicogo 3, Ill.

MAY 4-5

Second Notionol Symposium on Humon Foctors in Electronics. Sponsored by PGHFE of IRE. Morriott Twin Bridges Motor Hotel, Arlington, Vo. Detoils from R. R. Riesz, Bell Telephone Lobs, 2D-452, Box 262, Murroy Hill, New Jersey.

MAY 6

Workshop in Groph Theory. Sponsored by PGCT of IRE. University of Illinois, Urbono, Illinois. Prof. M. E. Von Volkenburg, Deportment of Electricol Engineering, University of Illinois, Urbono, Ill. for progrom informotion.

MAY 8-9

Fifth Midwest Symposium on Circuit Theory. Sponsored by PGCT of IRE. Allerton Pork & Urbono Compus, University of Illinois. Prof. M. E. Von Volkenburg, Deportment of Electricol Engineering, University of Illinois, Urbono, Ill. for progrom informotion.

MAY 8-10

Thirteenth Annuol Notionol Aerospoce Electronics Conference. Sponsored by the IRE. Biltmore & Miomi Hotels, Doyton, Ohio. Progrom detoils from Ronold G. Stimmel, 809 Lorriwood Ave., Doyton 29, Ohio.

MAY 9-11

Western Joint Computer Conference. Sponsored by PGEC, AIEE, ond ACM. Ambossodor Hotel, Los Angeles, Colif. Prof. Cornelius Leondes, Deportment of Electricol Engineering, UCLA, 4D5 Hilgord Ave., Los Angeles 24 for progrom detoils.

MAY 10-13

Notionol Science Foir-Internotionol. Sponsored by Science Service, Municipol Auditorium, Konsos City, Mo. Detoils from sponsor ot 1719 "N" Street, N.W., Woshington 6, D.C.

MAY 15-17

1961 Notionol Symposium on Microwove Theory & Techniques. Sponsored by PGMTT of IRE. Sheroton Pork Hotel, Woshington, D.C. Informotion on progrom from Gustove Shopiro, NBS, Woshington, D.C.

MAY 22-24

1961 Electronic Ports Distributor Show. Conrod Hilton Hotel, Chicogo. Closed Show. Hours 9 o.m.-6 p.m. Detoils from Electronic Industry Show Corporotion, Suite 1501, 11 S. LoSolle St., Chicogo 3, Illinois.

Notionol Symposium on Globol Communicotions. Sponsored by the AIEE ond IRE. Shermon Hotel, Chicogo. Detoils from Donold G. Compbell, ITT Kellogg, 5959 S. Horlem Ave., Chicogo, Ill.

Notionol Telemetering Conference. Sponsored by PGSET, AIEE, IAS, ARS, ISA. Sheroton Towers Hotel, Chicogo. Jock Becker, AC Spork Plug Div., Generol Motors, Milwoukee, Wisc. for progrom informotion.

MAY 22-26

1961 Conference of Society of Photogrophic Scientists & Engineers. Sponsored by SPSE. Arlington Hotel, Binghomton, N.Y. Detoils from SPSE, Box 1609, Moin Post Office, Woshington, D.C.

MAY 30-JUNE 2

Rodio ond Electronic Component Show. Sponsored by Rodio ond Electronic Components Monufocturers' Federotion. Olympio, London, Englond. Informotion ond tickets from the Federotion, 21 Tothill St., London S.W. 1.

Transistor Audio Distortion

By ROBERT JAMES

Slight bias error is critical.

WHENEVER the *Emerson* Model 838 transistor-output portable was turned up loud, its output was distorted. This set is a hybrid using tubes all the way except for the push-pull output where two power transistors are employed. See diagram of the output stage below.

Voltage and resistance measurements were made but did not reveal any great departure from the expected ±20% tolerance. However, on closer consideration, the base voltages seemed to be too close to the emitter voltages. Each base read about 3.4 volts and the emitters (tied together) indicated a hair under 3.5 volts. The schematic called for a base voltage of 3.3 volts (under load) and an emitter voltage of 3.45 volts. The ailing set had less than a tenth volt difference instead of the 0.15 volt indicated on the diagram.

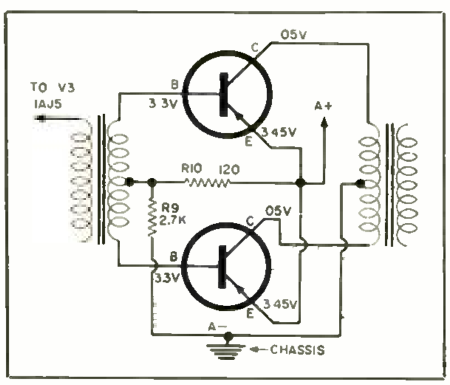
Resistance checking with the ohmmeter showed that R_9 read roughly 3000 ohms while R_{10} was about 105 ohms. While this departure from nominal value would not mean much in tube circuits, it can cause trouble in a transistor stage. Correct voltage and resistance values appear below.

Accordingly, the resistors were doctored. One end of R_{10} was lifted and a 22-ohm series resistor installed. A 33,000-ohm resistor was shunted around R_9 to lower its value. The set played normally after the transistors were plugged into their sockets again and the batteries re-installed.

The foregoing case history points up the necessity for having the specified bias on the transistor base irrespective of the values of the resistors, even though they are within tolerance or very nearly so. If confronted with the question as to whether base bias is out enough or resistors are out enough, "doctor" the resistors. You can find out quickly with miniature pots for shunting and small ohmage fixed resistors for series insertion.

In this case the variation between 0.05 and the specified 0.15 volt made all the difference even though the resistors were within ±10%! —30—

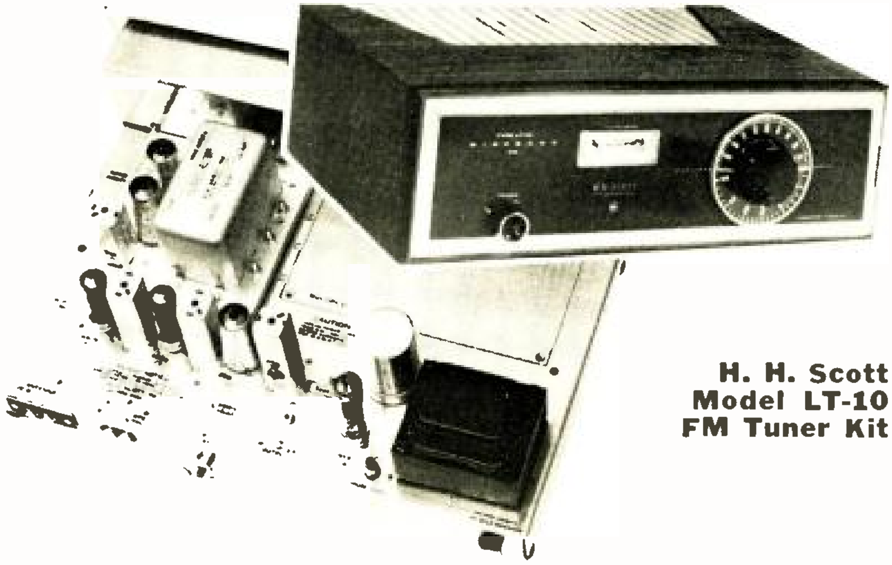
Transistor output of Emerson portable.



New Audio Test Report

LAB TESTED ELECTRONICS WORLD

H. H. Scott Model LT-10 FM Tuner Kit
Dynaco Models 50 and 53 Stereo Microphones



H. H. Scott Model LT-10 FM Tuner Kit

H. H. SCOTT'S first venture into the kit field is characterized by the same high standards which have always been associated with this manufacturer's audio equipment. The packaging of the FM tuner kit itself is an outstanding example of neatness, originality, precision, and careful planning. For example, the carrying-case package serves as mounting and storage place for the chassis and parts during the construction process. The tuner front-end is preassembled and pre-aligned, and, along with all tube sockets, terminal strips, and jacks, is pre-mounted on the chassis. All parts are mounted on special charts, one for each page of the novel, full-color instruction manual. Even the interconnecting wires are cut, stripped, and tinned—all ready to be soldered in by the constructor.

The deluxe features of this kit are apparent by the fact that the inside of the aluminum chassis has sheet copper bonded to it, while the packaged r.f. section is silver-plated and sealed. "B+" filtering is excellent, consisting of three *RC* sections for all r.f. and i.f. stages and a fourth filter section to provide very low hum level d.c. to the audio-output stage. The heater of that stage operates from a 5-volt winding on the power transformer and uses a hum-balancing potentiometer to keep hum at an absolute minimum.

In these and many other features the LT-10 kit is very similar to *H. H. Scott's* Model 314 FM tuner which was described in a previous issue. Like that unit the LT-10 has only an "on-off" switch and the tuning dial as front controls, while the hum and the output controls are mounted on the chassis as secondary controls. The tuning dial is driven through a planetary drive and contains both a logging and frequency scale. In place of the tuning eye of the Model 314, the LT-10 uses a small tuning meter like that used on the company's Model 310 D.

The limiter and detector circuits are very broadband and the oscillator is temperature-compensated, eliminating the need for a.f.c. and permitting relatively simple alignment. As a matter of fact, the tuner was first aligned without instruments and, when checked in our laboratory, it was found that only very little touch-up was needed for perfect tuning. This is quite a tribute to the design of the kit, as the unit we checked was assembled by a novice. Although no measurements were taken before the final instrument alignment, we feel that such measurements would have been quite close to the figures given below.

Since the r.f. portion is factory-aligned and tested, excellent tracking, tuner gain, and noise figure can be expected. This is borne out by the following test results:

Usable sensitivity (30-db quieting and distortion): at 90 mc., 2.0 μvolts; at 98 mc., 2.0 μvolts; at 106 mc., 2.5 μvolts.

I.f. bandwidth: 180 kc.

Detector peak separation: 2.3 mc.

Detector linear portion: 1.1 mc.

Oscillator drift (10 minutes warm-up): ±25 kc. (approx.)

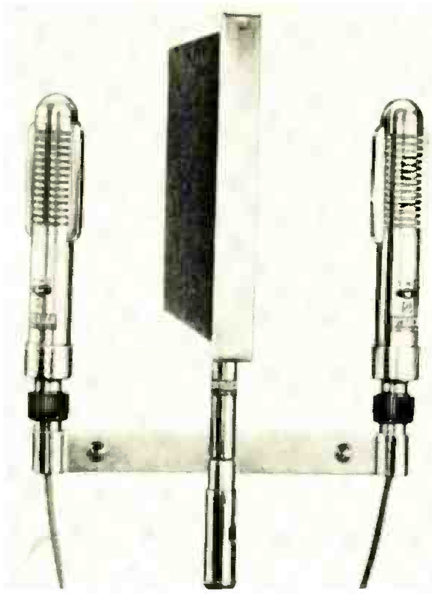
Maximum undistorted audio: 1.6 volts, r.m.s.

Audio response: ±1 db from 30 cps to 15,000 cps (our test limits), with respect to the standard de-emphasis curve.

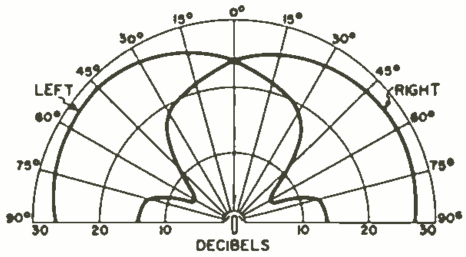
The excellent sensitivity of the tuner is due to the r.f. portion which uses a cascode amplifier, and to the use of two i.f. amplifiers. To avoid overloading on local stations, the r.f. amplifier and the first i.f. stage are controlled by the limiter bias voltage.

Actual on-the-air tests confirmed the results obtained with laboratory instruments in a screened booth. Sensitivity was excellent and even very distant stations were received with full limiting. The price of the kit is $89.95, without case. —30—

Dynaco Models 50 & 53 Stereo Microphones



THE Danish-made, *Dynaco*-imported *B&O* stereo microphone system follows the European philosophy in its use of closely spaced microphones (to minimize phase differences) with highly directional pickup patterns (to yield marked intensity differences). The *Dynaco* system uses a pair of Model 50 or 53 bidirectional (figure-8) microphones mounted at opposite ends of an 8-inch spacer bracket. The fronts of the microphones aim forward and outward, while their rear pickup is suppressed by an acoustically absorbent separator panel. The directional pattern of each mike causes it to favor the sounds it is aimed directly at, and to weaken the intensity of those arriving from either side of its axis. When the two microphones are aimed outwards at the proper angle, their pickup patterns will intersect at the point where each mike's sensitivity is down about 3 db. This means that a sound coming from midway between them will be attenuated by 3 db by each mike, so that when both loudspeakers emit the −3-db sound, their total output will add to produce a full-volume signal. Thus, regardless of the direction from which a sound is coming, the two signals from the mikes will add up to about the same value, even though one mike may be receiving a stronger signal than the other. The resulting stereo reproduction should therefore be free of the annoying "hole-in-the-middle" effect that gives the impression that the left- and right-hand instruments are close to the mikes while the middle ones are way off in the dis-



Polar response of the microphone system.

tance and shoved over to the sides.

The microphones used with the *Dynaco* stereo system are identical ribbon velocity types. Each has a switch on the front to select music response (full range), voice response (3 db/octave roll-off below 2000 cps), or an "off" position that shorts out the output leads. In a recessed hole at the rear of each Model 53 mike is an impedance selector for low, medium, or high-impedance output. (The Model 50 microphone does not have the impedance-selector switch.) Frequency response is rated at ±2.5 db from 30 to 13,000 cps, and the rated output is −56 dbv from the high-impedance output.

With the mikes angled outward at 90 degrees from one another (and they must be symmetrical with respect to the separator panel), the stereo effect was found to be excellent. There was plenty of spaciousness, very satisfying directionality, freedom from "instrument wander" with varying pitch, and superlative center fill-in. The *Dynaco* system came as close to creating the ideal integrated "curtain of sound" as anything the writer has used, including arrangements employing a third, center microphone for fill-in. A moving sound source was reproduced with virtually no change in quality for most of the distance across the "stage," and only when the source neared the axes of the microphones was it possible to observe an increase in intimacy. This was no doubt due to a tendency for the mikes to exhibit increased treble response to on-axis sounds.

Their over-all sound was very smooth and free from roughness, with a rather soft sweetness and warmth that was distinctly flattering to voices and to most musical instruments. Their low-frequency range sounded as if it rolled off slowly below about 50 cps, although there was still enough bass output from some deep organ pedal tones to pin a vu meter. Highs also sounded as if they rolled off very gradually above about 4000 cps although, again, there was still enough extreme upper-range response to pick up some of the sheen of stringed instruments. On the other hand, sounds originating from squarely in front of either mike were picked up with excellent detail and clarity, which suggests that the manufacturer's frequency response rating is for on-axis pickup. This would apply if either mike were used singly, for monophonic pickup. But in stereo recording with these mikes, the performing artists should be kept well between the axes of the outwardly-directed mikes to avoid "hot spots" on the axes that would tend to diminish the illusion of adequate center fill-in.

The *B&O* mikes have moderately high output—more, in fact, than most velocity mikes. Hum was no problem when using low- or medium-impedance outputs, but in high-impedance operation it is necessary to keep the cables well clear of all a.c. power lines, including those in the walls and floor, in order to avoid serious hum interference.

The writer has heard more natural-sounding stereo microphones than these, but must add that the others cost well over $600 per pair. At its $135 price, the *Dynaco* stereo mike system is going to be hard to equal, let alone surpass; it is quite superior to many systems costing several times as much. Price for an individual Model 50 mike is $49.95, while the Model 53 sells for $59.95. The stereo spacer mount costs $14.95 separately. -30-

FLORIDA "AUCTION FEST"

BROWARD Amateur Radio Club of Ft. Lauderdale, Florida will hold its Fifth annual "Auction Fest" on Saturday, March 11th at the Armory, S.W. Fourth Avenue at S.W. 24th Street in Ft. Lauderdale.

Doors open at 8 a.m. with the auctioning taking place from 10 a.m. to 5 p.m. with time out for lunch.

According to the sponsors, past attendance and equipment turnover indicate that this event is one of the most popular ham auctions in operation.

Additional details may be obtained by writing the Auction Chairman, F. G. Schmidt, W4NYF, at 405 N.W. 30th Terrace, Ft. Lauderdale, Fla. -30-

SHURE PROMOTION OFFERS STEREO DISC

A PRIVATELY commissioned stereo recording, which demonstrates the spatial relationships of the instruments in the orchestra, is being offered by Shure Brothers, Inc. to purchasers of its M3D or M7D cartridge, Stereo Studio Dynetic integrated arm and cartridge, or Professional tone arm.

Conceived and supervised by Dr. Kurt List, musical director of Westminster Recording Co., the disc features the Vienna State Opera Orchestra, playing works by Cimarosa, Debussy, Dittersdorf, Handel, Haydn, Lalo, Mozart, Rachmaninoff, Respighi, Rimski-Korsakov, Tschaikovsky, Wagner, and Weber.

First desk musicians play the solo parts of the excerpts from the positions the musicians normally occupy in the orchestra. This is done to show the particular solo instrument in its natural orchestral position, rather than in the center-stage position it would occupy in a concert solo. Not only does the recording demonstrate the stereo effect but it also portrays the extreme ranges of which each instrument is capable.

Among the familiar works heard on this 12-inch disc are excerpts from Tschaikovsky's "Fifth"; Lalo's "Symphony Espagnole"; Wagner's "Siegfried"; Respighi's "Feste Romane"; Debussy's "Afternoon of a Faun"; Rachmaninoff's "Second Piano Concerto"; etc.

Cards entitling the purchaser of the specified Shure products to a copy of the disc are enclosed in each component package. Local audio dealers should be consulted for complete details. -30-

Technical BOOKS

"HI-FI/STEREO KITS" by Norman Eisenberg. Published by *Maco Magazine Corp.*, N.Y., N.Y. 128 pages. Price 75 cents. Soft cover.

This is an informative, easy-to-read, and liberally illustrated guide to the world of quality sound reproduction for the do-it-yourself enthusiast. Every category of component available in kit form is discussed and its use in a hi-fi system explained. The author also provides step-by-step photo sequences detailing the construction of representative kits. A glossary, directory of manufacturers, and section on basic troubleshooting are included.

Separate chapters are included on: amps and preamps; tuners; turntables, arms, changers; speakers and enclosures; tape recorders; and hi-fi furniture of various types.

* * *

"PRINCIPLES OF FEEDBACK CONTROL" by Charles H. Wilts. Published by *Addison-Wesley Publishing Co., Inc.*, Reading, Mass. 271 pages. Price $8.75.

Essentially a textbook for advanced engineering students and practicing engineers, this volume furnishes a rigorous treatment of some of the analytical methods used in the design of feedback systems. It assumes that the reader has a good background in ordinary differential equations and complex variable theory. The emphasis is on mathematical analysis rather than actual circuitry, with the problem of stability being the main theme of the work.

* * *

"TUBES AND CIRCUITS" by George J. Christ. Published by *Gernsback Library, Inc.*, New York. 192 pages. Price $3.45. Soft cover.

The theory behind electron tubes and the circuits in which they are used is the subject matter of this volume. Topics covered include: electronics, tube characteristics, diode applications, amplifiers, oscillators, miscellaneous applications, multi-purpose tubes, gas tubes, photoelectric emission, and industrial applications.

The author uses some math in his explanations although most of the text is presented in relatively lay terms. The many diagrams and other illustrations enhance a generally lucid style.

Practical technicians who feel the need for a solid grounding in basic theory would do well to consider this book.

* * *

"THE STORY OF STEREO: 1881—" by John Sunier. Published by *Gernsback Library, Inc.*, New York. 160 pages. Price $2.95. Soft cover.

The first thing that strikes you about this interesting book is its title, but actually you soon learn that a patent for stereo was indeed issued in 1881, although it was not until nearly 80 years later that stereo, as we know it, came into full flower. What happened in that time, as well as much of what is going on now, is covered by the author in a thoroughly engaging treatment that is as enjoyable to read as it is well documented. In fact, the exhaustive references indicated make of this book something of a real work of scholarship, albeit one written in a lucid and popular style.

Among the subjects covered are general considerations of stereophonic sound, its early developments, its use in movies, stereo tapes, stereo discs, broadcasting, and stereo (and pseudo-stereo) techniques in recording and playback. The book is liberally illustrated. In sum, highly recommended reading for those interested in the reproduction of sound.

* * *

"101 KEY TROUBLESHOOTING WAVEFORMS FOR HORIZONTAL-SWEEP CIRCUITS" by Robert G. Middleton. Published by *Howard W. Sams & Co.*, Indianapolis. 126 pages. Price $2.00. Soft cover.

Second in a new series, this volume furnishes quick reference material on the causes of horizontal sweep troubles in TV receivers. Like its predecessor volume which dealt with horizontal a.f.c.-oscillator circuits, this new book presents photos of actual waveforms, analyzing each one and indicating the specific defect that would be most likely to cause it.

This book, as well as others of its type, illustrate the importance and versatility of the oscilloscope as a piece of service test equipment.

The four most popular horizontal-sweep circuits are analyzed. These include the 90°, 110°, direct-drive, and primary-secondary transformer types.

* * *

"ELIMINATING MAN-MADE INTERFERENCE" by Jack Darr. Published by *Howard W. Sams & Co.*, Indianapolis. 190 pages. Price $2.95.

This is a practical book on noise and interference problems confronting the service technician. Twelve chapters cover the entire field of man-made interference—what it is, how it is transmitted, how it originates, how to track it to a source, and finally how to eliminate or minimize its effects in home radios, TV sets, audio amplifiers, two-way mobile radios, auto, aircraft, marine sets, and electromechanical equipment.

Among the many illustrations are actual photographs of many types of interference as they appear on TV screens as well as diagrams and "how to" information such as building a noise filter to eliminate interference.

* * *

"DIAL CORD STRINGING GUIDE" by Sams Staff. Published by *Howard W. Sams & Co.*, Indianapolis. 80 pages. Price $1.00. Soft cover. Vol. 8.

With this volume, the coverage of radio and TV receivers in this series is brought up to date through 1960. Included are 214 new dial cord diagrams as well as a comprehensive index covering Volumes 5 through 8. All diagrams are done in clear, easy-to-follow manner, with key points labeled. —30—

Conductivity Measurements

(*Continued from page* 53)

the bridge and also furnishes a reference signal for the unbalance detector circuit.

The air capacitor is coupled directly to a balancing motor whose rotor, of north polarity, is pivoted between two projecting south poles, which are wound so as to produce equal but opposite magnetic fields when equal current is applied to each coil.

In operation, the motor rotor (and the capacitor) remains in the same position as long as the bridge is in balance. However, if the resistance of the conductivity cell *increases*, an unbalance voltage appears which is amplified and fed to the unbalance detector circuit. The phase of the unbalance voltage in this case is the same as the phase of the reference voltage and therefore adds to it. When the resistance of the conductivity cell *decreases*, however, the unbalance voltage is 180 electrical degrees out-of-phase with the reference voltage and therefore subtracts from it. Since a broad picture of operation is being presented, specific circuit details are omitted here.

The function of the unbalance detector circuit is to determine whether the measured variable is increasing or decreasing and to feed the proper signal to the power amplifier. When the resistance of the measured variable is increasing, the current in the left-hand coil increases and the rotor then moves in the direction of the stronger field. The variable capacitor is directly connected to the motor rotor. As a result, the air capacitor's rotor is moved in such a way as to decrease the capacitance of C_1 and increase the capacitance of C_2. This brings the bridge back into a state of balance.

When the unbalance signal results from a decrease in the measured variable, the current in the right-hand coil increases, and the rotor moves in the opposite direction in order to rebalance the bridge.

The variable-capacitor shaft is usually linked to a recording pen to continuously monitor and record fluctuations in the conductance. An instrument to provide automatic control can also be coupled to the shaft, if desired, to alter rather than record conditions.

A related type of self-balancing bridge utilizes a slide-wire resistor instead of the capacitor. The unbalance signal is applied to a servo motor which is coupled to the movable contact on the slide wire. The servo rotor turns in such a direction as to maintain constant balance.

Installation, Maintenance

When installed in a tank or vat, a conductivity cell should be located where the liquid surrounding the cell will be a representative sample. It should be a location where the solution is completely mixed and where it will be in motion past the electrodes. Furthermore, there should be no bubbles in the area to interfere with the conductive path. Finally, the cell should be located where it can be reached for cleaning or replacing.

Temperature measuring or compensating cells should be located close to the conductivity cell. They are sometimes mounted in the cell itself.

If sample solutions are allowed to dry on the cell, insoluble deposits may form and cause inaccurate readings. Accordingly, when a cell in a pipeline is to be in intermittent service, it is best to mount it at the bottom of a U-bend in the pipe. Dip-type cells used intermittently should be stored in clean water between runs or rinsed thoroughly in clean water and allowed to dry.

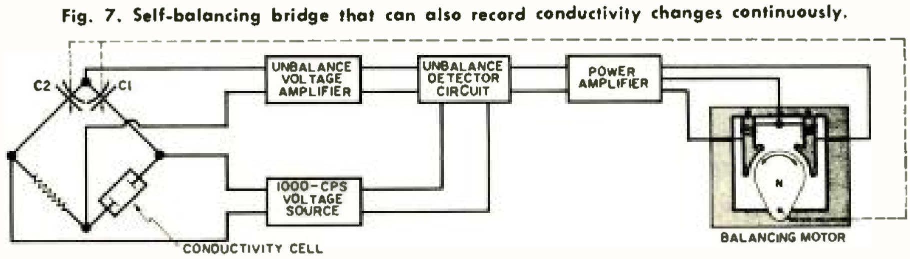
Conductivity cells require no regular maintenance. If it is suspected that they are giving inaccurate readings, they can be checked by using a solution of known conductivity. If contaminating deposits form, the electrodes should be cleaned with a dilute solution of hydrochloric or nitric acid, using a brush. Afterwards, they should be thoroughly rinsed with clean water.

Platinized electrodes should have a dull, black finish. When they become shiny they must be replatinized. This is done by immersing the cell in a solution of platinic acid and lead acetate, which can be obtained from suppliers of conductivity cells. The d.c. current is passed through the cell in one direction for about 30 seconds, then the polarity is reversed and current is passed in the opposite direction. This process is repeated for several minutes; then the cell is removed and rinsed. The electrodes should be a uniform, dull black. A power supply of about 12 volts is adequate for all cells except those with very high cell constants. If too high a voltage is used, the surface will be rough and will flake off.

Conductivity measurements are based on ratios rather than on absolute values. For that reason, their accuracy is not affected by fluctuations in the power supply, oscillator frequency drift, or changes in vacuum-tube characteristics. Consequently, the electronic equipment requires only routine maintenance to replace worn-out tubes or components.

—30—

Fig. 7. Self-balancing bridge that can also record conductivity changes continuously.



Easter Service Boosters

(*Continued from page 38*)

Ken's has also worked out an arrangement with a friendly, neighborhood florist whereby he can get inexpensive bouquets of flowers in quantity. On all house calls involving $10 or more, the service technician leaves a small bouquet of Easter posies, usually with the surprised and pleased lady of the house, with the cordial, seasonal compliments of the shop. In addition, from Lent onward, there is a fresh floral display every week in the shop window and about the premises. This atmosphere goes well with customers. In fact, something as prosaic as a window display planned around picture tubes has been given color and glamor with flowers.

Finally, there is a shop that features its annual Easter Bunny antenna check. The immediate tie-in with this mythical creature is the symbolic rabbit-ear TV antenna. However, this starting point is slanted toward the promotion of complete inspection and rejuvenation or improvement, if necessary, of existing antenna systems.

This is the Easter Parade as it has been joined by many radio-TV service shops, where it is felt that this is the time of year to make new friends, cement relationships with old customers, and earn some carry-through for the entire year among all service patrons.

Why not join this successful parade? If they fit in with your business, you can pick up some of the suggested ideas exactly as they have been described here. Of course, if you want to, nobody will stop you from working out your own variations. —30—

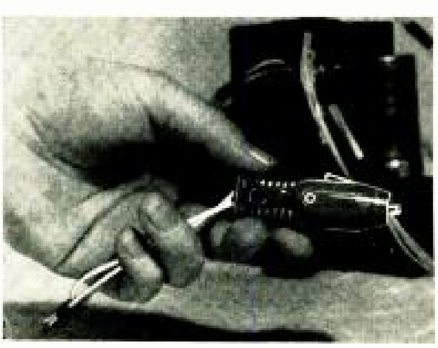
MOBILE POWER PLUG

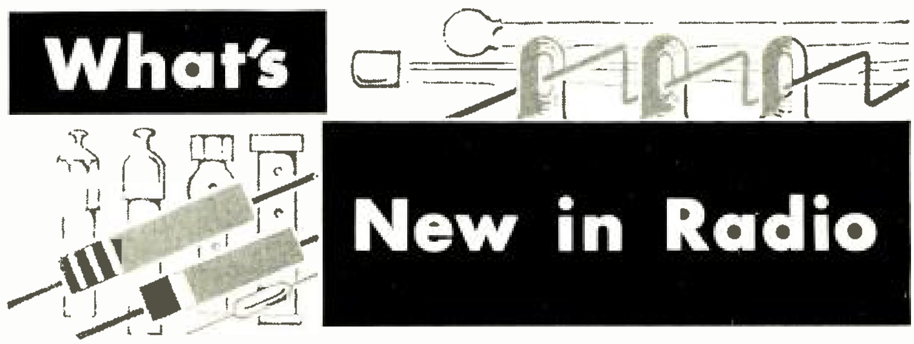
By KENT A. MITCHELL, W3WTO

MANY mobile CB and amateur transmitter-receiver combinations have three-way power supplies which allow them to be used with either six- or twelve-volt automobile battery systems or the 117-volt source in the home.

For added ease and convenience when transferring the set to or from the car, use an inexpensive (19-cent) plug, as shown in the photograph, to obtain power via the cigar lighter. These plugs are available in most auto supply stores.

Incidentally, if you have the urge to operate aeronautical mobile, don't overlook the fact that private, light aircraft have twelve-volt systems and, in most cases, a cigar lighter. —30—





What's New in Radio

HALLICRAFTERS KITS

The Hallicrafters Co., 4401 W. Fifth Ave., Chicago 24, Ill. has introduced a line of new "Halli-kits."

Model SX-140K is a receiver in "do-it-yourself" form which offers six bands—80, 40, 20, 15, 10, and 6 meters—for c.w., AM, and SSB signals.

Matching this unit is the Model HT-40K transmitter, which provides 75-watts peak input, with the AM slightly less on the 6-meter band. According to the manufacturer, the kit versions of these units enable customers to save up to 20 per-cent on their factory-wired equivalents.

The kits are furnished with parts, step-by-step instructions, and diagrams.

AUTO RADIO CONTROLS

Centralab, division of *Globe-Union, Inc.*, 900 E. Keefe Ave., Milwaukee 1, Wis. has added five new units to its line of exact replacement auto radio controls.

The new controls are replacements for use in 1959 *Delco* radios, with specific models covering sets used in 1959 *Buicks*, *Chevrolets*, *Oldsmobiles*, and *Pontiacs*. Details are available from the manufacturer.

V.T.V.M. IN KIT FORM

Lafayette Radio Corp., 165-08 Liberty Ave., Jamaica 33, N.Y. has announced a new vacuum-tube voltmeter kit. Designated as Model KT-174, the new instrument is claimed to have been designed to rigid laboratory standards of accuracy and sensitivity.

The meter uses a 200-microampere movement with balanced-bridge push-pull circuitry. It is calibrated in an easy-to-read two-color scale incorporating a direct db scale as well as a zero-center scale. Scope terminals at the rear provide for simultaneous waveform observation while making a.c. measurements. Calibration controls are accessible at the rear without removing the cover.

Special "Low AC" ranges are included to facilitate noise and gain measurements as low as 1 mv. for audio and high-fidelity applications. An "Omni-Probe" provides quick selection for type of service. The instrument measures a.c. peak-to-peak, a.c. r.m.s., d.c. voltage, and resistance.

MICRO-MINIATURE PARTS

Essex Electronics Div., Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N. J., now is producing a line of subminiature choke coils. These units are so small that they may be packaged 200,000 to a cubic foot and stored compactly, as shown in the photo. The miniaturization facilitates filling of orders; the clerk readily selects the container according to the electrical value desired, wraps the container, and addresses it.

The company maintains 300 different types of chokes in open stock, ranging in inductance values from 0.068 to 56,000 microhenrys.

RESONANT REED RELAY

Mallory Electromagnetic Co., a division of *P. R. Mallory & Co., Inc.*, Du Quoin, Ill. has introduced a new self-holding resonant-reed relay, claimed to improve reliability and reduce system costs in remote control applications.

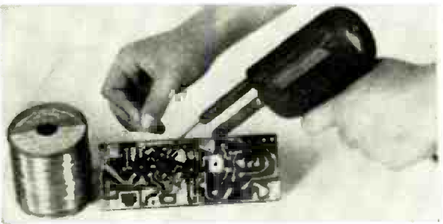
The relay is equipped with four reeds which respond to frequencies of 75, 95, 115, and 135 cps. It can be made available for narrow or broad response bandwidth, and reeds can be provided for any frequency between 50 and 400 cycles, allowing for adequate separation between reed frequencies. Response time is 500 milliseconds maximum, and the relay rejects transients up to 25 milliseconds' duration.

While the relay is adaptable to wireless remote control of TV receivers and record players, it is also intended for use in a variety of both wired and wireless remote-control systems in many fields.

SOLDER-TYPE ALLOY

Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N.Y. announces a new solder-type alloy designed especially for electrical and electronic work.

Known as "Neu-Tec-Tronic" 157BN alloy, it is said to be 50 per-cent more



electrically conductive than the standard 50-50 lead-tin solder. According to the manufacturer, its highly active flux core is inert after carbonization, with residues which are non-corrosive and non-conductive and do not support fungus growth. Other features of the alloy are its low melting point, and high solidification rate.

The alloy can be applied with soldering iron, torch, by hot plate, or induction heating. It is available in 0.030 and 1/16-inch sizes.

CB TRANSCEIVER

De Wald Radio, 35-15 37th Ave., Long Island City 1, N.Y. announces a new transceiver for use on the Citizens Band.

Designated as Model TR-910, the new equipment features a push-to-talk mi-

crophone, full squelch control, automatic noise limiter, five-channel transmitter, 22-channel vernier-tuned receiver, high selectivity, built-in "S" and plate current meter, new styling, trunion bar for easy mobile mounting, and accessible, easily changed crystals.

COAXIAL RELAY

Allied Control Co., Inc., 2 East End Ave., New York 16, N.Y. announces a low-cost coaxial relay. Listed applications include: mobile and stationary radio transceiver, v.h.f., u.h.f., and video studio switching. For antenna transfer, the new s.p.d.t. relays are rated at 150 watts maximum up to 470 mc. when inserted in a properly terminated 50-ohm line.

Crosstalk is 40 db minimum from zero to 470 mc.; v.s.w.r. is less than 1.2, zero to 1000 mc. The relays can be supplied with any length coaxial leads in the RG58A/U and RG188/U cable sizes. Minimum weight is 3 ounces, with the maximum weight determined by the cable type and length.

TWO-WAY HAM SET

Heath Co., Benton Harbor, Michigan has announced a new mobile or fixed transmitter-receiver combination which provides complete AM and c.w. facilities on the 2-meter ham band.

Designated as Model HW-20 and known as the "Pawnee," the new set

features a built-in three-way power supply, four switch-selected crystal positions for Novice, CAP, and MARS operation, tracked v.f.o. and exciter stages for convenient single-knob tuning, v.f.o. "spot" switch, 10 watts r.f. output to antenna, and a built-in low-pass filter.

The modulator also serves as a 15-watt p.a. amplifier. The superhet receiver uses double conversion with its first oscillator crystal-controlled for high stability. The "Pawnee" comes complete with built-in speaker, two power cables, heavy-duty power cables, primary fused relay for mobile installation, mounting bracket, and push-to-talk ceramic-element microphone.

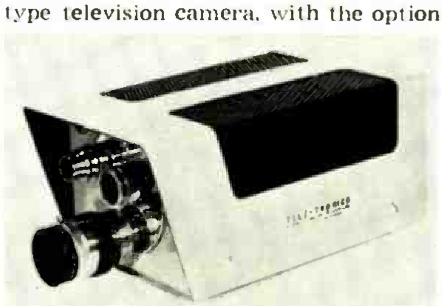
COLOR-TV FUSE KIT

Sightmaster Corp., 50 Aleppo St., Providence, Rhode Island has announced nine fuse types used exclusively in all color TV sets.

The fuses are available to service technicians in a low-cost kit that includes an assortment of 60 fuses packaged in a plastic box which also contains a table telling which fuses are needed for each make of color TV set.

TV CAMERA

Tele-Tronics Corp., Garden Grove, Calif. has announced a high resolution type television camera, with the option



of built-in sound channel for intercom and education TV applications requiring "crisp" voice communication. Designated as Model 700, it features a low-noise cascode video input; 8-mc. video bandwidth amplifiers that provide 600-line horizontal resolution; linear phase type aperture correction; automatic target sensitivity control; interlacing sync generator; no-scan protection circuitry for the vidicon; high-level video output; and remote control of beam, target, and focus.

RANDOM-NOISE GENERATOR

Gonset Div., 801 S. Main St., Burbank, Calif. has introduced a new "reasonably priced" random-noise generator.

Intended for operation in the v.h.f.

range, the new unit provides direct readings of sufficient accuracy for average laboratory use, according to the manufacturer. Said to be inherently stable and easily operated, it is also suited for production-line testing.

The instrument provides direct reading to 25 db into 50-ohm impedances. Operation is controlled by a variable autotransformer, and rapid checking of residual starting noise is expedited by a panel switch. The instrument's self-contained power supply operates from 117 volts a.c.

COLORED MARINE ANTENNAS

Webster Manufacturing, 317 Roebling Rd., So. San Francisco, Calif. has introduced a line of marine antennas in a variety of colors and finishes.

Loading coil sections of most models are now available in port red or Palm Beach blue in addition to standard black. A choice of support column finishes is offered.

Complete information on the new antennas, as well as on the company's CB two-way radio and depth sounders, may be obtained by writing direct to the manufacturer.

COMPACT TWO-WAY SET

Allen B. Du Mont Laboratories, Clifton, N.J. has brought out a 15-watt version of its recently developed "Transicom" two-way radio for use in the 144-174 mc. band. The new under-the-dash mounted unit features a fully transistorized power supply.

Suggested applications of the new equipment include two-way mobile communications for business, commercial, municipal, and emergency serv-

(*Continued on page* 122)

ices. The set is designed for split-channel frequencies. It has a 3 x 5-inch speaker built into the front panel, and two basic operating controls.

Details are available from the Mobile Radio Sales Dep't., at the manufacturer.

MINIATURE CAPACITORS

Arco Electronics, Inc., 64 White St., New York, N.Y. is offering a kit of precision miniature capacitor standards with a tolerance of ±0.1 per-cent. In a carrying case, they are said to be 50 per-cent smaller and lighter than standards of comparable accuracy.

The kit consists of 32 plug-in type standards ranging from 0.0001 to 0.5 μf., and is equipped with a four-position adapter. The kit, 12¾ x 4⅞ inches, is designed for use in laboratories and calibration centers.

NEW FM "HANDIE-TALKIE"

Motorola Inc., 4501 W. Augusta Blvd., Chicago 51, Ill. has introduced its "Handie-Talkie" pocket transmitter, said to be the first fully transistorized

FM radio transmitter to operate on standard v.h.f. two-way mobile communications frequencies.

Providing 500 milliwatts r.f. power output, the unit operates on frequencies between 25-54 mc. and 132-174 mc. Using eleven transistors, the set is self-contained and includes a microphone, antenna, and batteries. Two antennas are available.

"WIDE-RANGE" ELECTROLYTICS

Cornell-Dubilier Electronics Div., 333 Hamilton Ave., South Plainfield, N. J. announces a compact, cardboard-sleeved, plug-in type capacitor, Model ESS-7515, intended to serve as an exact replacement for eight original, standard 150-volt capacitors commonly used in printed-circuit radio and TV receivers. These values are: 50-30 μf., 70-30 μf., 60-40 μf., 80-40 μf., 50-50 μf., 70-50 μf., and 80-50 μf.

Additionally, the ESS-7515—claimed to be the most versatile single unit ever available to service technicians—will replace any single-section unit rated between 40 and 80 μf., 30 and 60 μf., and 30 and 140 μf., all at 150 volts.

Service technicians desiring complete details on this new replacement line should contact their local *CD* distributors or write the manufacturer direct at the address given on the previous page.

SERVICE TOOL HOLSTER

Xcelite, Inc., 28 Bank Street, Orchard Park, New York has added a new saddle-leather hip-holster to its line of professional hand tools. Featuring an electrical tape holder, knife clip, and five tool pockets, the new holster is designed to carry a variety of screwdrivers, wrenches, pliers, and other tools used in the installation and repair of various electronic or electrical equipment items.

The holster also features a comfortable hip-contoured back, hot-waxed stitching for durability, brass riveting, and pliable belt slots. It comes in a natural cowhide finish.

For details on this new item of professional equipment for the service technician, as well as information on a complete line of hand tools for various electronic service applications, write the manufacturer direct.

—30—

Answer to Materials Quiz appearing on page 92

1. R	7. Q	14. P
2. J	8. S	15. C
3. E	9. M	16. I
4. H	10. D	17. B
5. L	11. K	18. G
6. N	12. F	19. A
	13. O	

ANSWER TO PUZZLE APPEARING ON PAGE 105

C	A	M	■	T	R	I	A	D	■	A	R	T
A	G	A	■	H	E	N	R	Y	■	E	I	R
T	E	S	T	E	R	■	E	N	E	R	G	Y
■	■	T	O	N	A	L	■	E	R	I	■	■
A	N	E	W	■	N	U	T	■	E	A	T	S
C	O	R	E	S	■	G	A	P	■	L	I	P
O	R	■	R	E	D	■	R	A	G	■	L	I
R	M	S	■	T	I	P	■	D	R	I	L	L
N	A	I	L	■	M	A	N	■	I	N	S	T
■	■	G	O	O	■	T	O	O	L	S	■	■
B	A	N	A	N	A	■	I	O	L	E	R	S
U	N	A	■	C	L	O	S	E	■	R	I	P
G	A	L	■	E	T	H	E	R	■	T	O	Y

INVITATION TO AUTHORS

Just as a reminder, the Editors of ELECTRONICS WORLD are always interested in obtaining outstanding manuscripts, for publication in this magazine, covering the fields of audio and high-fidelity and radio-TV-industrial servicing. Articles in manuscript form may be submitted for immediate decision or projected articles can be outlined in a letter in which case the writer will be advised promptly as to the suitability of the topic. We can also use short "filler" items outlining worthwhile shortcuts that have made your servicing chores easier. This magazine pays for articles on acceptance. Send all manuscripts or your letters of suggestion to the Editor, ELECTRONICS WORLD, One Park Avenue, New York City 16, New York.

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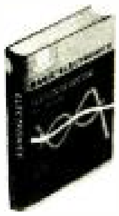
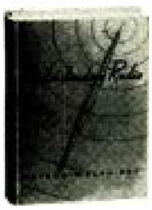
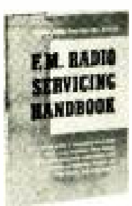


2500. BASIC ELECTRONICS, Grob
An introductory text on the fundamentals of electricity and electronics for technicians in radio, television and industrial electronics. $9.25

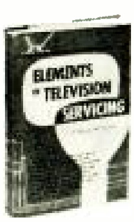


2511. UNDERSTANDING RADIO, 3rd Ed., Watson, Welch and Eby
For those with little or no technical knowledge who wish to know the fundamentals of radio theory and servicing. $8.25

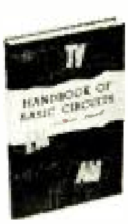


2404. FM RADIO SERVICING HANDBOOK, King
A practical guide to FM V.H.F. receivers, their design, construction, alignment and repair. $5.00

2442. BASIC ELECTRONIC TEST INSTRUMENTS, Turner
Over 60 instruments described, their uses fully explained and valuable work-saving short-cuts outlined. $6.25

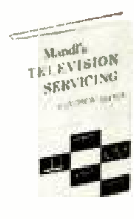


2425. ELEMENTS OF TELEVISION SERVICING FOR BENCH AND FIELD, Marcus and Gendler
Up to date discussion of installation, servicing and repair of T.V. receivers, designed for the practicing serviceman. $8.15



2519. HANDBOOK OF BASIC CIRCUITS, Mandl
A basic guide to circuitry combining comprehensive coverage of major circuits with detailed information on circuits used in TV, FM and AM. Simply written and easy-to-understand. $7.95

2667. ELECTRIC MOTOR REPAIR, Rosenberg
A unique and practical book that explains all details of modern motor repair work; shows what to do—and why. Designed for bench use with duo-spiral binding that lies flat, making text and illustrations visible at same time. $9.25



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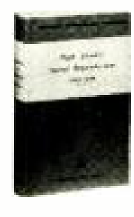
2651. MAJOR APPLIANCE SERVICING, Brockwell
Gives essential information for a career in major appliance servicing. Explains methods of repairing appliances, organizing and managing a service business. $5.95

2407. HOW TO GET AHEAD IN THE TELEVISION AND RADIO SERVICING BUSINESS, Marcus
Shows the easy way to get started as a TV-Radio repairman, how to earn while you learn, how to get and keep customers. $3.50

2652. HOW TO REPAIR HOME APPLIANCES, Campbell
For the do-it-yourselfer, a handy, easy-to-read reference book with chapters on all kinds and types of appliances. Concise, thorough instructions with many useful illustrations. $2.50

2011. STEREO & HI-FI DIRECTORY, 1961, Ziff-Davis
New! Complete buyers' guide of over 1200 component listings, 800 photos; latest models, prices! World's most complete reference. Entire sections on every phase of stereo and monaural high fidelity. $1.00



2752. HIGH QUALITY SOUND REPRODUCTION, Moir
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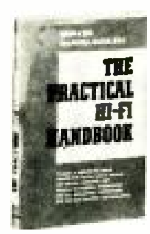

2755. THE PRACTICAL HI-FI HANDBOOK, King
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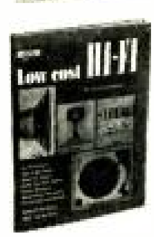

2753. LOW-COST HI-FI, Hoefler
Hundreds of hints for budget hi-fi will be found in these fourteen chapters with over 300 detailed photographs, drawings and diagrams. Will save you money in starting or improving your system. $2.50

2010. AUDIO YEARBOOK, 1961, Ziff-Davis

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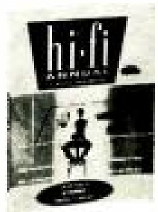
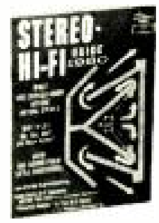


2004. HI-FI ANNUAL & AUDIO HANDBOOK, Ziff-Davis

1960 edition. Prepared by the editors of Electronics World. An excellent advanced guide to theory, construction and circuitry. Over 40 pages on stereo amplifiers and equipment. $1.00



2000. STEREO HI-FI GUIDE, 1960, Ziff-Davis

1960 edition features 60-page exclusive by Joseph Marshall on components and how they work. Includes "what you should know before buying stereo". Complete, interesting, invaluable! $1.00

2002. ELECTRONIC KITS DIRECTORY, Ziff-Davis Publishing Company

New 1960 edition lists over 750 kits, latest models, prices and features for hi-fi, ham radio, SWL, shop improvement, Citizen's Band, fun and education. $1.00

2501. ELEMENTS OF ELECTRONICS, Hikey and Villines

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2901. HAM RADIO, Hertzberg

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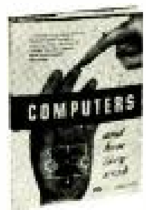
2006. ELECTRONIC EXPERIMENTER'S MANUAL, Findlay

With a few dollars worth of basic tools and this book to guide you, you can explore electronics experimentation more completely than ever before. 10 big sections. $4.95

2008. CLASS D CITIZENS RADIO, Sands

First complete book on Citizens Radio operation. Covers Class D history, rules, applications, how it works. Many illustrations. $4.95



2007. COMPUTERS AND HOW THEY WORK, Fahnestock

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2351. RADIO PROJECTS, Marcus

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2601. TRANSISTORS IN RADIO, TELEVISION AND ELECTRONICS, Kiver

A descriptive, non-mathematical text for radio, television, electronics technicians and for those who want a working knowledge of transistors and circuits. $7.95

2001. 1960 ELECTRONIC EXPERIMENTER'S HANDBOOK, Ziff-Davis Publishing Company

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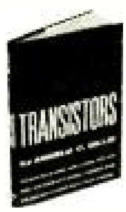

2600. TRANSISTORS, Gillie

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3700. ELECTRONICS & NUCLEONICS DICTIONARY, Cooke & Marcus

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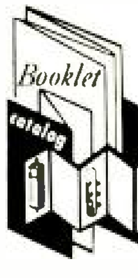

Manufacturers' Literature

SEMICONDUCTOR RECTIFIERS

International Rectifier Corp., 1521 East Grand Ave., El Segundo, Calif. has issued a 24-page "Semiconductor Short Form Catalogue" listing semiconductor rectifiers. For a copy, write to the manufacturer using your company letterhead.

TABTRON CATALOGUE

Technical Apparatus Builders, 6 Church St., N.Y. 6, N.Y. has issued a pricing and information catalogue covering its line of silicon junction and selenium rectifiers. Listed as Catalogue 116 H, it includes a replacement and cross-reference guide on rectifiers.

ENGINEERING TRANSLATIONS

U.S. Dept. of Commerce, Office of Technical Services of the Business and Defense Services Administration, Washington 25, D.C. has announced the release, for sale to the public, of ten translations of foreign literature on various types of engineering. Included are papers on electronic devices, electron microscopes, and Russian satellites. Prices range from 50 cents to $3.00. For additional information, write to the above address.

PC BOARD CONNECTORS

A six-page folder which describes a complete line of one-piece and two-piece multiple connectors for printed-circuit boards has been published by *AMP Incorporated*, Harrisburg, Pa.

Detailed lists of the features of both the one- and the two-piece printed-circuit connectors are given. Line drawings of each of the five types of "snap-in" contacts are shown, along with a description of the design features of each type.

Copies of this folder are available without charge upon written request to the manufacturer.

TRANSFORMER CATALOGUE

Sterling Transformer Corp., 510 Driggs Ave., Brooklyn 11, N.Y. has announced publication of a new 12-page brochure containing details for specifying transformers for power supplies and for temperature rise measurements on transformers.

Dielectric strength test voltages and working voltage definition and calculation are also explained in this new publication, which is available without charge on request.

HEATHKIT CATALOGUE

Heath Company of Benton Harbor, Mich. has issued a colorful 36-page catalogue listing and illustrating every kit currently available in its "Heathkit" line.

Included are high-fidelity equipment, general products, marine gear, amateur radio equipment, and test equipment for the experimenter and professional technician. The line is being offered in both kit and wired-and-tested versions.

For a copy of this complete and up-to-the-minute listing of all units in the firm's line, write the company direct.

1961 "MASTER" OUT

The 25th edition of "The Radio-Electronic Master" is now available at leading electronic parts distributors.

Virtually all standard radio, TV, audio, and electronic parts sold through distributors are included in this silver anniversary issue. More than 175,000 items—with specifications and prices—are featured throughout its 1600 pages. Over 12,000 illustrations are included.

The "Master" is published by *United Catalog Publishers, Inc.*, 60 Madison Ave., Hempstead, N.Y. who will supply a list of distributors offering this edition upon request.

"DB MEASURING STICK"

Decibel Products Inc., P.O. Box 10764, Dallas 7, Texas is now offering a new mechanical aid to facilitate the measurement of antenna tower site latitude and longitude from commonly used maps.

The "Measuring Stick" is basically a ruler with various scales to quickly and accurately measure latitude and longitude from the Sectional Aeronautical Charts and three scales of USGS maps.

The company will supply this "DB Measuring Stick" without charge on request.

PHOTOSENSITIVE DEVICES

The Electron Tube Division, *RCA* Commercial Engineering Department, Harrison, N.J. has just published a new and completely revised booklet containing technical information on its phototubes, photocells, image-converter tubes, camera tubes, storage tubes, CR units, and special-purpose kinescopes.

Contents include, for quick reference purposes, the latest JEDEC spectral energy emission curves and persistence descriptions of phosphors as well as dimensional outlines and spectral response curves for each of the phototubes and photocells.

Data is given on 151 different tubes, including dimensions, basing diagrams, ratings, operating values, typical and recommended uses, as well as photographs of representative types.

Copies of this 36-page book, CRPD-

THE SIGN OF RAD-TEL'S QUALITY PERFORMANCE

BUY DIRECT FROM RAD-TEL!!

ORDER RAD-TEL'S FIRST QUALITY TUBES TODAY!

NOT USED!! NOT PULLED OUT OF SETS!!

SERVICEMEN: HUGE SAVINGS!! COMPARE!!
FAST ONE DAY SERVICE.

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UP TO 75% OFF ON BRAND NEW TUBES

SEND FOR FREE TROUBLE SHOOTER GUIDE AND NEW TUBE & PARTS CATALOG

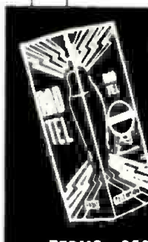
EACH TUBE INDIVIDUALLY & ATTRACTIVELY BOXED

Qty. Type	Price	Qty. Type	Price	Qty. Type	Price
___0Z4M	.79	___6AW8	.89	___12AF6	.49
___1AX2	.62	___6AX4	.65	___12AJ6	.46
___1B3GT	.79	___6AX7	.64	___12AL5	.45
___1DN5	.55	___6BA6	.49	___12AL8	.95
___1G3	.73	___6BC5	.54	___12AQ5	.52
___1J3	.73	___6BC7	.94	___12AT6	.43
___1K3	.73	___6BC8	.97	___12AT7	.76
___1L6	1.05	___6BD6	.51	___12AU6	.50
___1LN5	.59	___6BE6	.55	___12AU7	.60
___1R5	.E2	___6BF6	.44	___12AV5	.97
___1S5	.51	___6BG6	1.66	___12AV6	.41
___1T4	.58	___6BH6	.65	___12AV7	.75
___1U4	.57	___6BH8	.87	___12AX4	.67
___1U5	.50	___6BJ6	.62	___12AX7	.63
___1X2B	.82	___6BK7	.85	___12AZ7	.86
___2AF4	.96	___6BL7	1.00	___12B4	.63
___3AL5	.42	___6BN4	.57	___12BA6	.50
___3AU6	.51	___6BN6	.74	___12BD6	.50
___3AV6	.41	___6BQ5	.65	___12BE6	.53
___3BA6	.51	___6BQ6GT	1.05	___12BF6	.44
___3BC5	.54	___6BQ7	.95	___12BH7	.73
___3BE6	.52	___6BR8	.78	___12BL6	.56
___3BN6	.76	___6BU8	.70	___12BQ6	1.06
___3BU8	.78	___6BY6	.54	___12BY7	.74
___3BY6	.55	___6BZ6	.54	___12BZ7	.75
___3BZ6	.55	___6BZ7	.97	___12C5	.56
___3CB6	.54	___6C4	.43	___12CA5	.59
___3CF6	.60	___6CB6	.54	___12CN5	.56
___3CS6	.52	___6CD6	1.42	___12CR6	.54
___3CY5	.71	___6CF6	.64	___12CU5	.58
___3DK6	.60	___6CG7	.60	___12CU6	1.06
___3DT6	.50	___6CG8	.77	___12CX6	.54
___3Q5	.80	___6CM7	.66	___12DB5	.69
___3S4	.61	___6CN7	.65	___12DE8	.75
___3V4	.58	___6CR6	.51	___12DL8	.85
___4BC5	.56	___6CS6	.57	___12DM7	.67
___4BC8	.96	___6CU5	.58	___12DQ6	1.04
___4BN6	.75	___6CU6	1.08	___12DS7	.79
___4BQ7	.96	___6CY5	.70	___12DZ6	.56
___4BS8	.98	___6CY7	.71	___12EL6	.50
___4BU8	.71	___6DA4	.68	___12EG6	.54
___4BZ6	.58	___6DB5	.69	___12EZ6	.53
___4BZ7	.96	___6DE6	.58	___12F5	.66
___4CS6	.61	___6DG6	.59	___12F8	.66
___4DE6	.62	6DQ6	1.10	___12FM6	.45
___4DK6	.60	___6DT5	.76	___12K5	.65
___4DT6	.55	___6DT6	.53	___12SA7M	.86
___5AM8	.79	___6EU8	.79	___12SK7GT	.74
___5AN8	.86	___6EA8	.79	___12SN7	.67
___5AQ5	.52	___6H6GT	.58	___12SQ7M	.73
___5AT8	.80	___6J5GT	.51	___12U7	.62
___5BK7A	.82	___6J6	.67	___12V6GT	.53
___5BQ7	.97	___6K6	.63	___12W6	.69
___5BR8	.79	___6S4	.48	___12X4	.38
___5CG8	.76	___6SA7GT	.76	___17AX4	.67
___5CL8	.76	___6SK7	.74	___17BQ6	1.09
___5EA8	.80	___6SL7	.80	___17C5	.58
___5EU8	.80	___6SN7	.65	___17CA5	.62
___5J6	.68	___6SQ7	.73	___17D4	.69
___5T8	.81	___6T4	.99	___17DQ6	1.06
___5U4	.60	___6U8	.78	___17L6	.58
___5U8	.81	___6V6GT	.54	___17W6	.70
___5V6	.56	___6W4	.54	___19AU4	.83
___5X8	.78	___6W6	.69	___19BG6	1.39
___5Y3	.46	___6X4	.39	___19T8	.80
___6AB4	.46	___6X5GT	.53	___21EX6	1.49
___6AC7	.96	___6X8	.77	___25BQ6	1.11
___6AF3	.73	___7AU7	.61	___25C5	.53
___6AF4	.97	___7A8	.68	___25CA5	.59
___6AG5	.65	___7B6	.69	___25CD6	1.44
___6AH6	.99	___7Y4	.69	___25CU6	1.11
___6AK5	.95	___8AU8	.83	___25DN6	1.42
___6AL5	.47	___8AW8	.93	___25EH5	.55
___6AM8	.78	___8BQ5	.60	___25L6	.57
___6AN4	.95	___8CG7	.62	___25W4	.68
___6AN8	.85	___8CM7	.68	___25Z6	.66
___6AQ5	.50	___8CN7	.97	___35C5	.51
___6AR5	.55	___8CX8	.93	___35L6	.57
___6AS5	.60	___8EB8	.94	___35W4	.52
___6AT6	.43	___11CY7	.75	___35Z5GT	.60
___6AT8	.79	___12A4	.60	___50B5	.60
___6AU4	.82	___12AB5	.55	___50C5	.53
___6AU6	.50	___12AC6	.49	___50DC4	.37
___6AU7	.61	___12AD6	.57	___50EH5	.55
___6AU8	.87	___12AE6	.43	___50L6	.61
___6AV6	.40	___12AF3	.73	___117Z3	.61

TRANSISTORS — AT FABULOUS DISCOUNTS

	PRICE	TYPE	RATING	ELECTRICAL CHARACTERISTICS		hfe
				ICBO max.	IEBO max	
☐ ☐	RF 49¢ AF 39¢	GE PNP ALLOY JUNCTION GENERAL PURPOSE RF/AF	200 MW	20 μa VCB = -3V	20 μa VEB = -3V	VCE = -1.5 Ib = 5 ma 20 min
☐	80¢ ea.	Power AF Mgd. Freq. to 3		20 ma VCB = -16V	20 ma VEB = -16V	VCE = -1.5 Ib = 1 ma 40 min
☐	1.40 ea.	Hi Power 15 AMP to 36	MIN. POWER OUTPUT 2.25 W	40 ma VCB = -100	40 ma VEB = -100	VCE = -1.5 Ib = 1 ma 30 min
				Series 830 OHMS		

SILICON RECTIFIER
35 AMP
50 PIV
(max. 20 ma)
$2.50 ea.
Lots of 10
$2.25 ea.
(No Hardware)



NOT AFFILIATED WITH ANY OTHER MAIL ORDER TUBE COMPANY

RAD-TEL TUBE CO.

55 CHAMBERS STREET, NEWARK 5, N. J. DEPT. EW-361

TERMS: 25% deposit must accompany all orders, balance COD. Orders under $5: add $1 handling charge plus postage. Orders over $5: plus postage. Approx. 8 tubes per 1 lb. Subject to prior sale. No COD's outside continental USA.

105B, are available for 50 cents each from the company's tube distributors or from the Division direct.

FOREIGN PRODUCTION DATA

The Business and Defense Services Administration of the U.S. Department of Commerce has issued a 40-page booklet entitled "Electron Tubes and Semiconductors" which surveys the market for these components in ten countries.

Included in this survey are Australia, Canada, Japan, Netherlands, New Zealand, Spain, Taiwan, Turkey, Union of South Africa, and West Germany.

Copies of this book are available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. or at Field Offices of the Department of Commerce. Price is 30 cents a copy.

GOVERNMENT PUBLICATIONS

The U.S. Department of Commerce, 350 Fifth Ave., New York 1, New York has announced the availability of four new publications of interest to those in the electronics industry.

The new Air Force-sponsored "RADC Reliability Notebook" is available for $4.00; the "Micro-Module Production Program" latest quarterly report is $3.00; "Research on New High-Temperature Semiconducting Materials" is priced at $3.00 a copy; while the report "Investigation of Physical Properties of Semiconductors" is $1.50.

Any or all of these publications may be ordered from the Department at the above address. Full payment must accompany the order.

INDUSTRIAL PHOTOTUBES

CBS Electronics has issued a new 4-page bulletin entitled "Phototubes in Industry" which describes high-vacuum as well as gas phototubes, photomultiplier tubes, photocells, and photoresistive cells.

Typical applications are shown for photoresistive cells combined with transistors. The effects of temperature, excessive illumination, and other environmental conditions are described.

Copies of Bulletin PA-220 are available through the company's tube distributors or from the Information Services of the firm at 100 Endicott Street, Danvers, Mass.

SOLAR CELL HANDBOOK

International Rectifier Corporation, El Segundo, California has just published a 100-page handbook covering solar cells and photocells.

Containing over 75 practical light-operated circuits, projects, and demonstrations of both selenium photocells and silicon solar cells, this book also includes chapters on basic photovoltaic theory, nomenclature, radiation theory, photocell performance characteristics, power supplies, photometers, relays, photoelectric camera control, and infrared and ultraviolet photocell applications.

Copies of this new publication may be obtained by sending $2.00 (check or money order) to "Photocell Handbook" at the company address, 1521 E. Grand Ave., El Segundo, California. -30-

SSB DINNER SET

THE SSB Amateur Radio Assn. will sponsor the Tenth Annual SSB Dinner and Hamfest on Tuesday, March 21st, at the Hotel Statler-Hilton, New York City.

Equipment displays open at 10 a.m. and the dinner starts at 7:30 p.m. William B. Williams, noted radio personality, is MC. Tickets purchased in advance are $10 each, $11 at the door.

Send checks for reservations to SSBARA, c/o Mike Le Vine, WA2BLH, 33 Allen Road, Rockville Centre, Long Island, N.Y. -30-

TRANSISTORIZED METRONOME

By A. V. J. MARTIN

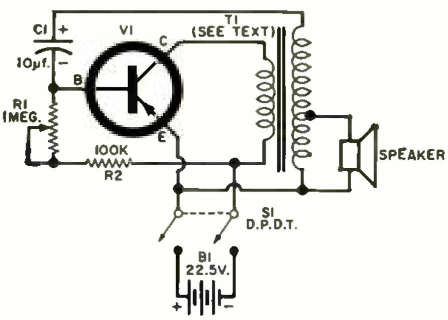
THIS small device is very convenient for musical timing purposes. It uses few parts and practically any readily available transistor will work. The volume it provides is ample for musical applications.

Basically, the circuit is a relaxation oscillator with collector-to-base coupling for feedback. The relaxation frequency is controlled by the RC time-constant. With the values indicated, it varies from 0.5 to 3.3 cps. approximately, according to the setting of the potentiometer.

A tap on the coupling transformer feeds a 2-inch PM speaker. The whole device fits into a standard 2" x 2" x 2" box. Total current is 3 ma. so that an ordinary battery will provide long service.

The coupling transformer may be practically any interstage type. The tap on the secondary should be adapted to the loudspeaker impedance for maximum volume, but is not at all critical. In fact, the loudspeaker could be connected directly across the low-impedance primary winding of the transformer, if desired. -30-

This simple transistorized unit will provide beats from 0.5 to 3.3 cps, using control pot.



V1: 2N188-2N191-CK882-2N34-2N64-2N104-2N106-2N207 2N133-2N263-2N175-ETC.

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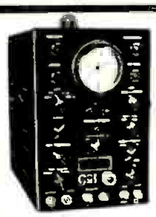
TS-100AP 'SCOPE

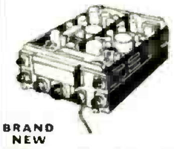


(WORTH $750) OUR LOW PRICE **$29.50**

Can be used with linear sweep or general purpose test scope. Cables included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.
BRAND NEW $59.50

FAMOUS BC-645 TRANSCEIVER

15 Tubes 435 to 500 MC



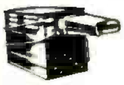
BRAND NEW

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

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

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

LORAN R-65/APN-9 RECEIVER & INDICATOR



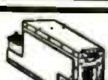
Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. Exc. used.
Value $1200.00. Our Price **$79.50**
Used, less tubes, crystal and visor, but with 3HP1 C.R. tube $29.50
28 Volt Inverter Power Supply, New .... P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

LORAN APN-4

FINE QUALITY NAVIGATIONAL EQUIPMENT

Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes. Exc. used **$49.50**
Receiver-Indicator as above, BRAND NEW **$88.50**
28V Inverter Power Supply. New .... P.U.R.
Shock Mount for above $2.95
We carry a complete line of spare parts for above.

ARC-5/R28 RECEIVER



2-meter Superhet. 100 to 156 Mc in 4 crystal channels. Complete with 10 Tubes. BRAND NEW **$24.45**
110V AC Power Sup. Kit for above $9.75

ARC-5/T-23 TRANSMITTER

100-150 Mc Includes 2—832A, 2—1625 Tubes. BRAND NEW **$21.50**
SPECIAL OFFER! Limited quantity ARC-5/T23 xmitters. Excellent Used, less tubes $5.95
MD-7 MODULATOR for T-23, complete with 4 tubes. LIKE NEW **$9.95**

ARC-5 MARINE RECEIVER-TRANSMITTER

Navy Type Comm. Receiver 1.5 to 3 Mc BRAND NEW with 6 tubes **$16.95**
Navy Type Comm. Transmitter 2.1-3 Mc BRAND NEW with 4 tubes and Xtal **$12.45**
MODULATOR for above, new with tubes $5.95

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 Mc	10.45	12.45
BC-455	Receiver 6-9 Mc	11.50	13.95

110 Volt AC Power Supply Kit, for all 274-N and ARC-5 Receivers. Complete with metal case. Instructions **$7.95**
Factory wired, tested, ready to operate ... $11.50

SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only **49c**

BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal. BRAND NEW **$8.95**
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal. BRAND NEW **$9.75**
BC-459 TRANSMITTER—7-9.1 Mc. complete with all tubes and crystal **$13.95**
T19 TRANSMITTER 3-4mc complete with all tubes and crystal. Exc. used **$9.95**
BC 696 TRANSMITTER 3-4 mc complete with all tubes and crystal. Exc. used **$9.95**
BC-456 Modulator .... USED 3.45 NEW 5.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

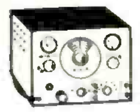
WILLARD 6-VOLT MIDGET STORAGE BATTERY

3 Amp. Hour. BRAND NEW. 3⅝" x 1-13/16" x 2⅜". Uses Standard Electrolyte .... Only $2.95

2 VOLT BATTERY "PACKAGE"

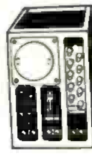
1—2V. 20 Amp. Hr. Willard Storage Battery. Model #20-2. 3" x 4" x 5½" high $2.79
1—2V. 7 prong Synchronous Plug-in Vibrator 1.49
1—Quart Bottle Electrolyte (for 2 cells) 1.45
ALL BRAND NEW! Combination Price **$5.45**

TS-16/APN TEST SET



For aligning and calibration of radio altimeters. May be used to check calibration of count or circuits and modulator sweep freq. and bandwidth of transmitter. Audio-oscillator range: 340 to 7250 cycles. 13/14 V.DC input. Complete with tubes, connecting cables, instruction summary. BRAND NEW ... **$9.95**

BC-603 FM RECEIVER



20 TO 27.9 MC.
Excellent Used **$14.95**
BRAND NEW $18.95

10-channel, pushbutton or continuous tuning. Complete with speaker, squelch, and ten tubes: 3-6AC7, 1-6J5, 2-12SG7, 1-6H6, 1-6V6, 2-6SL7.
EXTRA SET OF 10 TUBES FOR ABOVE brand new in original boxes $3.95
FT-237 Mounting Base for BC-603 Brand New **$5.95**
12 or 24V Dynamotor for Above. Exc. Used $4.25 .... Brand New **$5.50**
BC-683 FM Receiver, 27 to 38.9 Mc. Complete with all tubes. Like New **$33.33**
BC-604 TRANSMITTER—Companion unit for BC-603 Rcvr above. With all tubes. BRAND NEW $6.95
We carry a complete line of spare parts for above.

SPECIAL! BC-603 FM RCVR CONVERTED FOR ANY FREQ.—30 TO 50 MC.

BRAND NEW! Checked out, perfect working condition, ready for operation. Specify Frequency desired (between 30-50 Mc) when ordering. **$27.50**

AC POWER SUPPLY FOR BC603, 683
Interchangeable, replaces dynamotor. Has On-Off Switch. NO RCVR. CHANGES NEEDED. Provides 220 VDC @ 80 Ma. 24VAC @ 2 Amps $9.25
Complete 240-page Technical Manual for BC-603, 604 .... $3.15

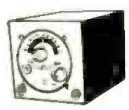
BC-605 INTERPHONE AMPLIFIER for above. BRAND NEW .... Each $4.95

AN APR-4 RECEIVER only. 38 to 4000 Mc in 5 tuning unit ranges. High precision laboratory instrument used to monitor or indicate frequency of any signals within its range. Includes wide and narrow band IF strip selected from panel. Outputs provided for attachments to pulse analyzer, panadapter, etc. Input 115 V 60 cy. LIKE NEW **$69.50**
Tuning Units: TN16, TN17, TN18 .... each $39.50
TN19 .... each $89.50

RECEIVER SPECIALS!

BC-312 MOBILE RECEIVER 6 Bands, 1500 Kc to 18 Mc. With Tubes and 14V Dynamotor. Exc. Used **$69.50**
BC-342 RECEIVER 1.5 to 18 Mc. AC only. Exc. Used $69.50
BC-348 SUPERHET Receiver 200 to 500 Kc and 1.5 to 1800 Mc. Voice, tone, CW. Self-contained dynamotor for 24 VDC. Like NEW $69.50

BC1206-C BEACON RECEIVER



195 to 420 Kc. made by Setchel - Carlson. Works on 24-28 volts DC. 135 Kc. IF. Complete with 5 tubes. Size 4" x 4" x 6". Wt. 4 lbs. BRAND NEW ... **$9.99**
Brand New, less tubes ... $5.95
USED, with tubes 5.95
USED, less tubes 2.95

SCR-522 2-METER RIG!

Terrific buy! VHF Transmitter-receiver, 100-156 Mc, 4 channels, Xtal-controlled. Amplitude modulated voice. They're going fast! Excellent condition.
SCR-522 Transmitter-Receiver, complete with all 18 tubes, top rack and metal case.
COMBINATION. Exc. Used **$29.50**

DYNAMOTOR ASSEMBLY

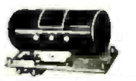
Very fine unit, made by Collins Radio. Consists of TWO Dynamotors mounted on filter base.

	INPUT	OUTPUT
Dynamotor #1	12VDC @ 3.8A	220VDC @ 100 Ma.
Dynamotor #2	12VDC @ 9.9A	400VDC @ 180 Ma.

BRAND NEW, in original packing. shpg wt 29 lbs.
OUR LOW PRICE **$7.95**

MOBILE-MARINE DYNAMOTOR

Model DM35



Input 12V DC. Output: 625 V DC @ 225 Ma. for press-to-talk intermittent operation. Shpg. wt. 14 lbs.
OUR LOW PRICE, BRAND NEW **$8.95**

OTHER DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-25	12V 2.2A	250V .050A		$4.50
DA-1A	28V 1.6A	230V .100A		3.25
DM-28	28V	224V .07A	2.75	4.75
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A 28V 7A	575V .16A 540V .25A	1.95	3.75
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-53A	28V 1.4A	220V .080A	3.75	5.45
DM-64A	12V 5.1A	275V .150A		7.95
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

BD-77 DYNAMOTOR Input 14V @ 39A. Output 1000V @ .350A with starting solenoid, Filter Box and Mounting Base .... Like New $14.95

SCHEMATIC DIAGRAMS For any equipment on this page, each ... **65c**

Please include 25% Deposit with order—Balance C.O.D. or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change

G & G RADIO SUPPLY CO.

Telephone: CO 7-4605
51 Vesey St., New York 7, N. Y.
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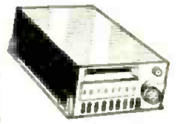
ARC-3 RECEIVER!



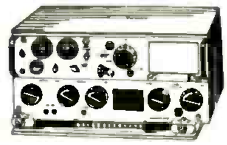
Complete with All Tubes Exc. Used **$16.95**
Like NEW $21.50
Used $14.95
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 pre-selected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.

ARC-3 TRANSMITTER

Companion unit for above, tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used .... Only **$16.95**
Like new condition $22.50

AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc
$48.50



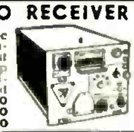
Complete with Tubes
Famous Collins Autotune Aircraft Transmitter, AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90%, class "B." A Real "HOT" Ham buy at our low price! Orig. cost $1800. Exc. Used **$48.50**
0-16 Low Freq. Osc. Coil for ART-13 .... 7.95
24V Dynamotor for ART-13 .... 11.95
Same as above less meter 39.50
We carry a complete line of spare parts for above.

POWER SUPPLY for BC-620, 659, available for 6, 12 or 24 Volts DC. Specify $8.95

BC-659 TRANSMITTER & RECEIVER

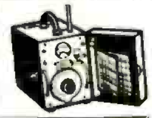
27 to 38.9 Mc. F.M. Two preselected channels crystal controlled. 5 watts. Complete with speaker, tubes. Used **$10.95**
Less tubes, used $5.95

NAVY AIRCRAFT RADIO RECEIVER



ARB/CRV 46151—190 to 9050 Kc in 4 bands. 6 Tube Superhet communications receiver, with local and remote tuning, band change. Sharp and broad tuning. AVC, CW. Illuminated dial. Complete with tubes and dynamotor. BRAND NEW $34.50
Like New $26.50
Power Supply 110 V. AC. Wired $8.50

BC-906 FREQ. METER—SPECIAL



Cavity type, 145 to 235 Mc. BRAND NEW, complete with antenna. Manual included.
OUR LOW PRICE **$10.88**

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$27.50**

MICROPHONES

Model	Description	Excellent Used	BRAND NEW
T-17	Carbon Hand Mike		$5.45
T-30	Carbon Throat Mike	$ .34	.74
T-45	Army and Navy Lip Mike		1.25
TS-9	Handset		3.88
TS-11	Handset		3.95
TS-13	Handset		4.25
RS-38	Navy Type		4.75

HEADPHONES

Model	Description	Excellent Used	BRAND NEW
HS-23	High Impedance	$2.19	$4.49
HS-33	Low Impedance	2.69	4.59
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16/U	High Imp. (2 units)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS. BRAND NEW. PER PAIR $3.25
CD-307A Cords, with PL55 plug and JK26 Jack .... .99
Earphone Cushions for above—pair .... .50

EE-8 ARMY FIELD PHONES. Excellent condition checked out, perfect working order, complete with all parts less battery. Each $12.95

TG-34A CODE KEYER

Self-contained automatic unit, reproduces code practice signals recorded on paper tape. By use of built-in speaker, provides code-practice signals to one or more persons at speeds from 5 to 25 WPM.
BRAND NEW **$22.50**
Checked out, exc. used $18.95
Single Reels of Tape. Each ... $1.85

5-TUBE AMPLIFIER

Made by Pioneer Instrument Co. Uses 2—6SN7 1—6X5, 2—6H6 tubes.
BRAND NEW .... VERY SPECIAL **$2.49**

STANDARD TUBES

Removed from Brand New Gov't Equipment

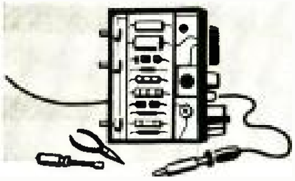
RECEIVING					
6AG5	.35	12SG7	.75	807	.95
12AT7	.45	6J5	.65	813	6.95
6AK5	.40	6H6	.55	814	2.25
6C4	.25	6SL7	.85	815	2.15
6AL5	.38	12A6	.45	826	.44
6AC7	.55	SPECIAL PURP.		1625	.29
6J6	.32	2C39	3.50	4X-150	5.95
6V6	.65	3E29	4.25	6072	2.50
				1P25A	7.95

234-258 MC RECEIVER

AN/ARR-2

BRAND NEW 11-tube UHF Tunable Receiver with schematic. Only a few at this low price!
Complete with tubes **$8.88**

Send Name, Address on Post Card for FREE BULLETIN of Wonderful Surplus Buys!



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TV Tuners—Rebuilt or Exchanged $9.95 complete—all types—fast, guaranteed service. Send tuner with all parts to: L. A. Tuner Exchange, 4611 West Jefferson Blvd., Los Angeles 16, California.

TUBES—TV, Radio, Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality, Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics Corp., 512 Broadway, New York 12N, N. Y.

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BALANCE Your Stereo From Across The Room—How it sounds where you sit—that's what counts! Remote volume and balance control works with any system using separate preamplifier and power amplifier or any tape deck with cathode follower outputs. Small control (5 x 3 x 2 inches) can be placed as far as 30 feet away. $26.95 in walnut or mahagony housing. $19.95 in metal. Sun Radio Service, 320 Chestnut Street, Kearny, New Jersey WY 1-0564.

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