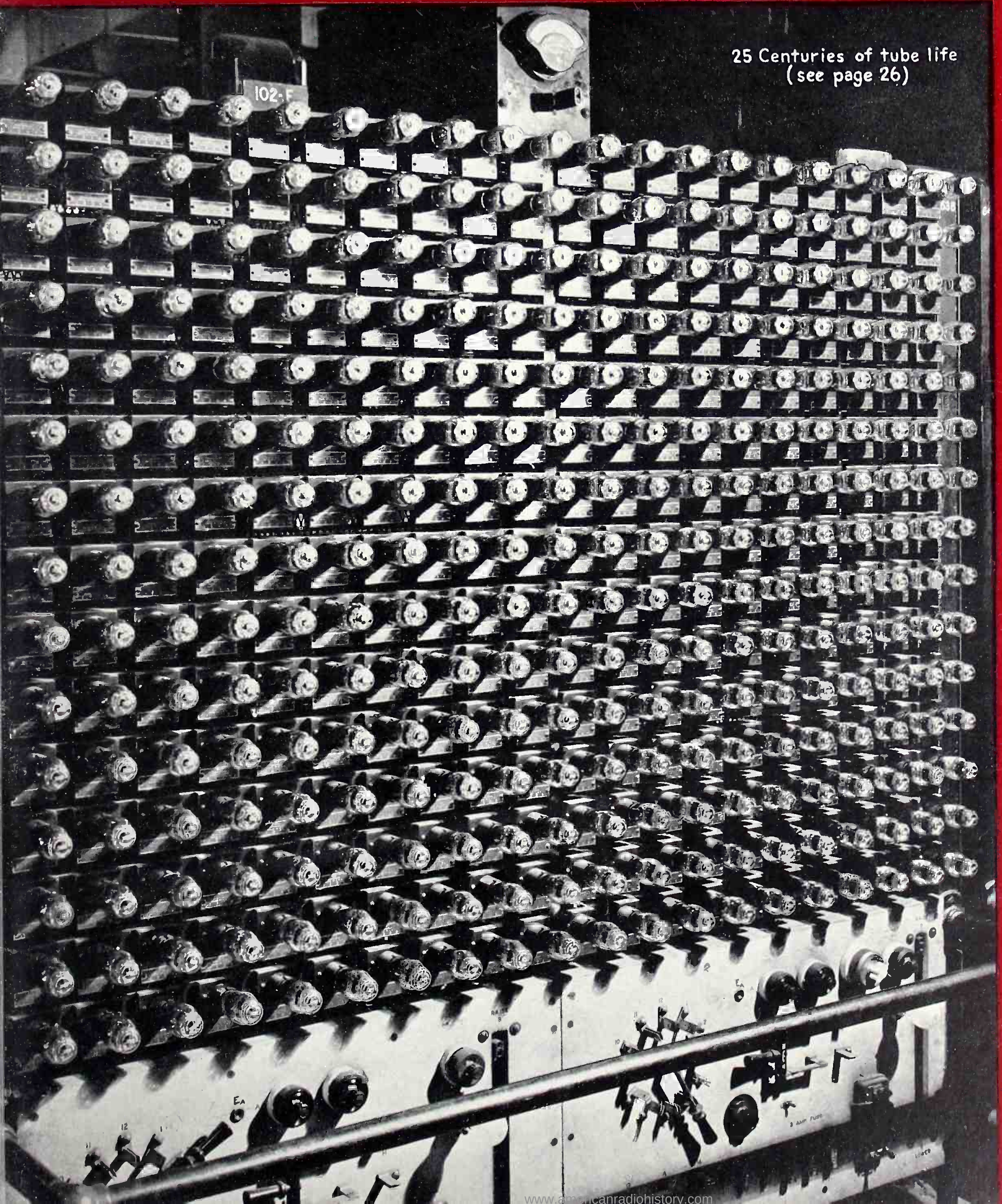
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



25 Centuries of tube life
(see page 26)

NOVEMBER
1939

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The 300 Western Electric Type 102F repeater tubes are destined to spend their useful lives in telephone repeater stations as voltage amplifiers in voice frequency long distance circuits. The heater rating is one-half ampere at 2.1 volts and the rated plate current is 0.7 ma dc

40 CM WAVES IN AVIATION **12**

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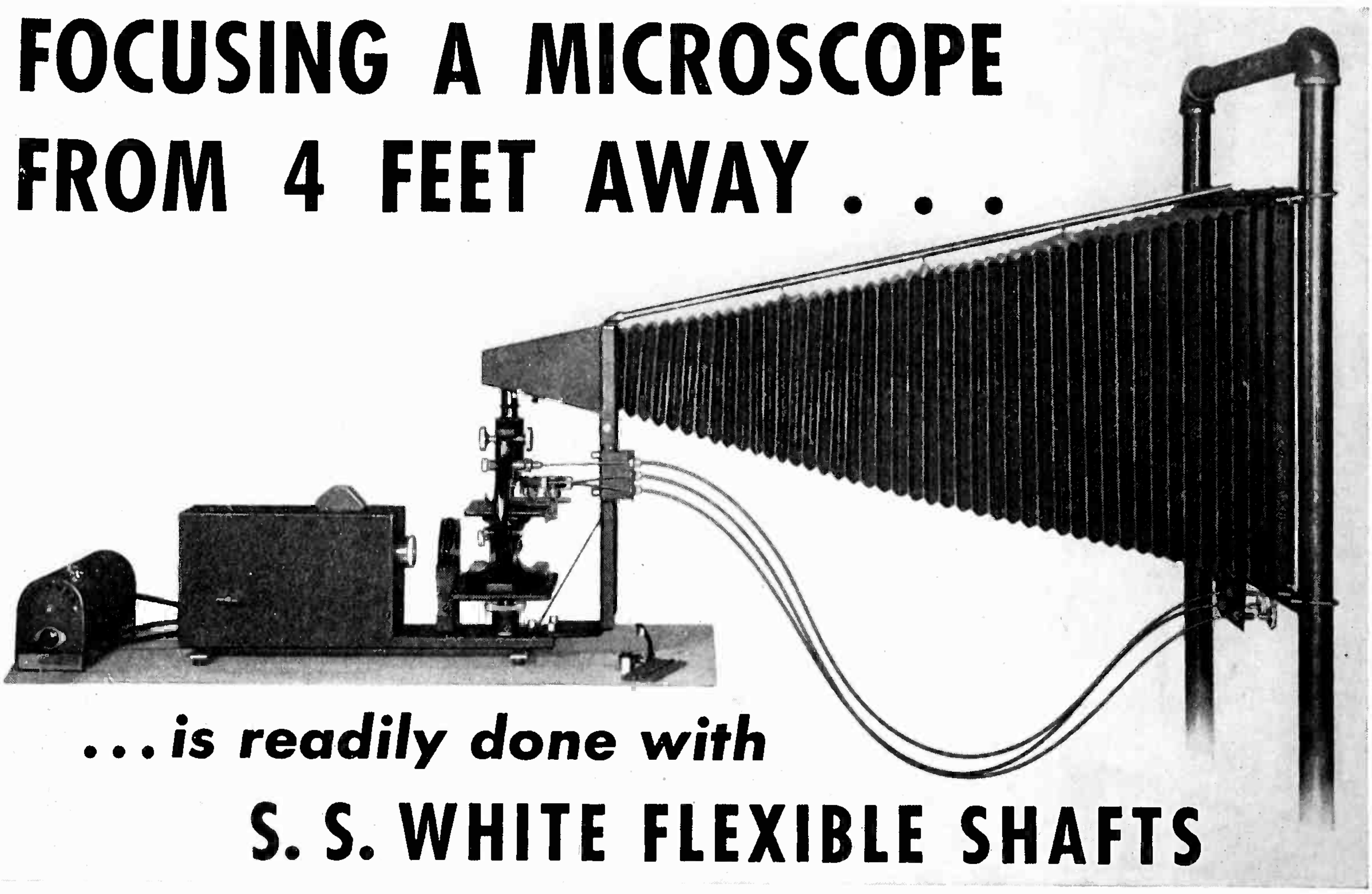
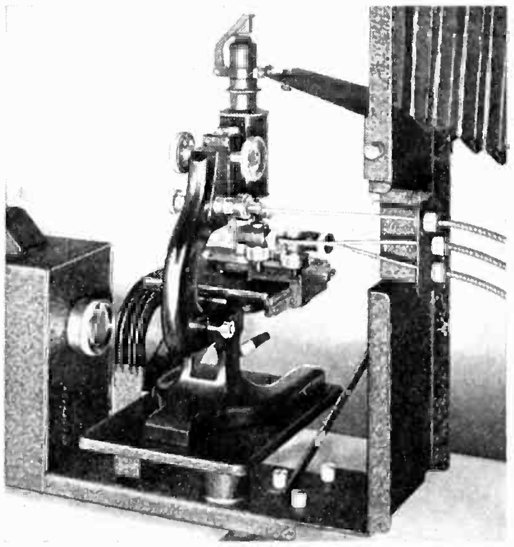
DEPARTMENTS

FOCUSING A MICROSCOPE FROM 4 FEET AWAY . . .



. . . is readily done with

S. S. WHITE FLEXIBLE SHAFTS



The M.S.A. MICROPROJECTOR is used in dust determinations. By projecting an enlarged image of the microscope's field on a ruled translucent screen, it greatly simplifies and speeds up the accurate counting and size-estimation of dust particles in collected impinger samples. It is made by the Spencer Lens Co. and distributed exclusively by Mine Safety Appliances Co., Pittsburgh, Pa.

In this M.S.A. MICROPROJECTOR, three S. S. WHITE Flexible Shafts serve as the means for focusing the microscope from a distance of approximately four feet. And the satisfactory functioning of the shafts for this purpose proves their suitability for instruments and other applications requiring close, and even delicate, adjustment from a remote point.

Consideration of the illustrations also makes clear how flexible shafts reduce the problem of remote adjustments to simplest terms.

The particular shafts used are of the type developed by S. S. WHITE for remote control, with special characteristics which satisfy the requirements.

On request, we will be glad to send you printed matter giving details about these remote control shafts and their application. Write for it.

Anytime you have a mechanical remote control problem let our engineers help you work it out . . . No obligation.

S. S. WHITE

The S. S. White Dental Mfg. Co.
INDUSTRIAL DIVISION
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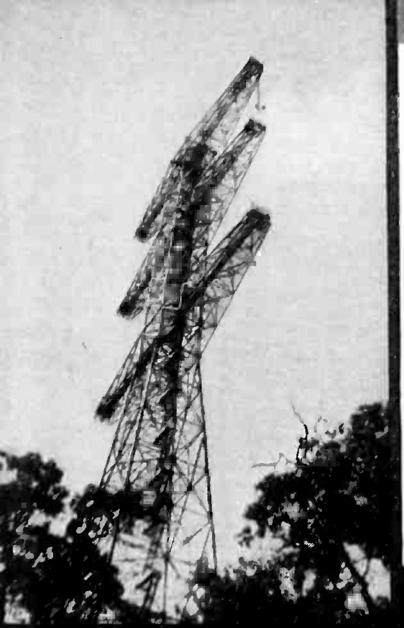
FREQUENCY MODULATION

(ARMSTRONG SYSTEM)

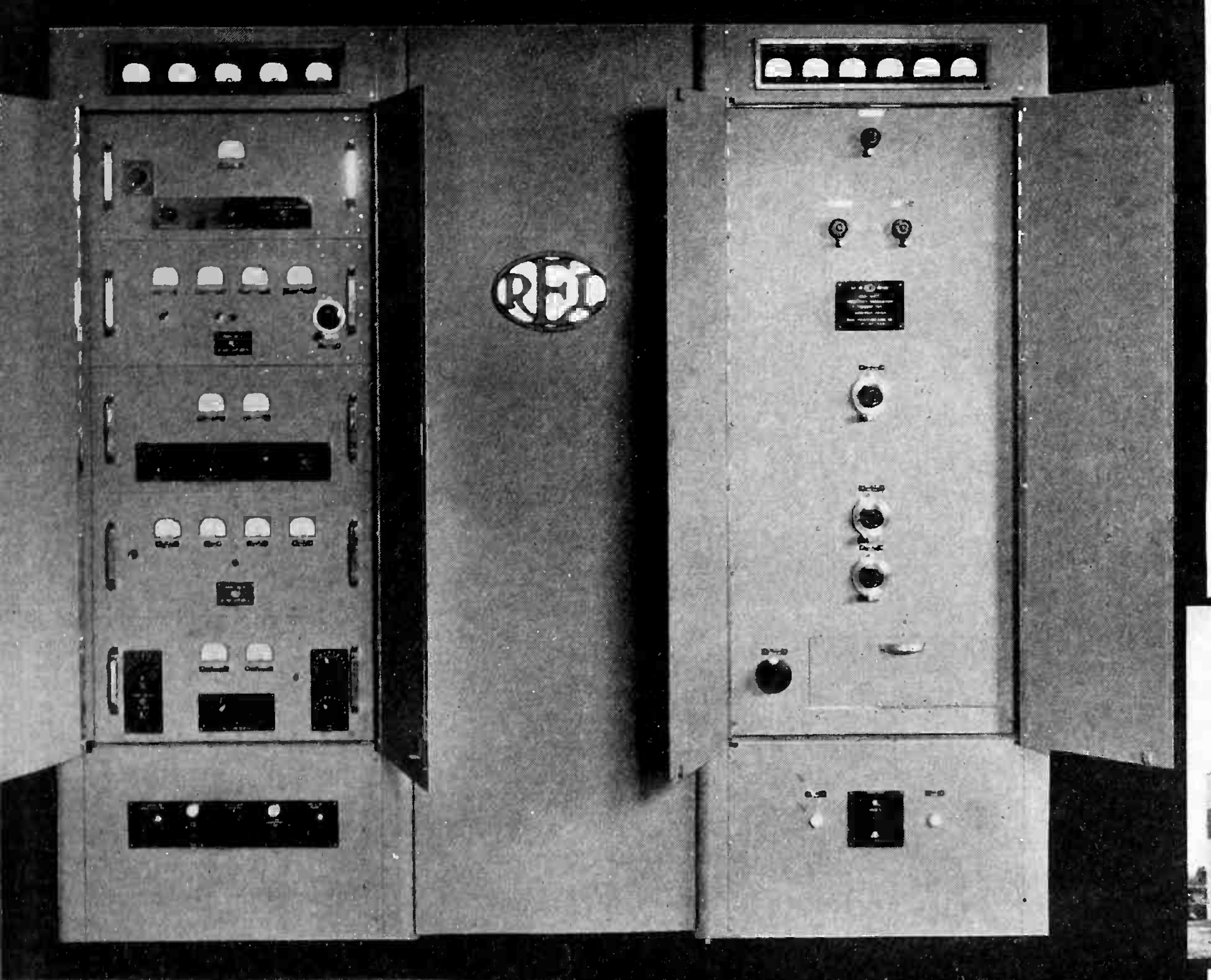


W2XMN, Alpine, N. J., Major E. H. Armstrong's original 40-Kw, Frequency Modulation Transmitter Tower . . . Metropolitan New York's newest landmark.

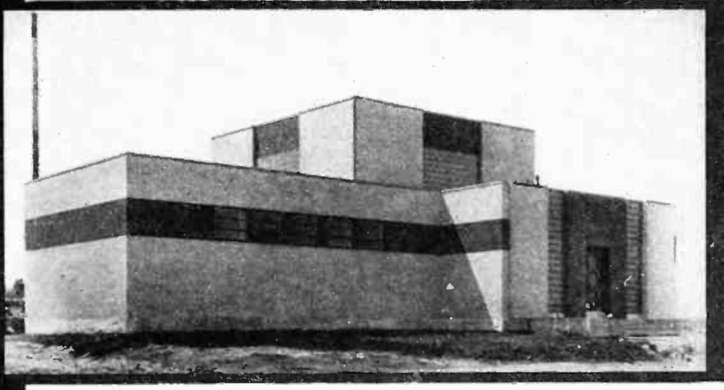
REL

1-2-5-50 Kw

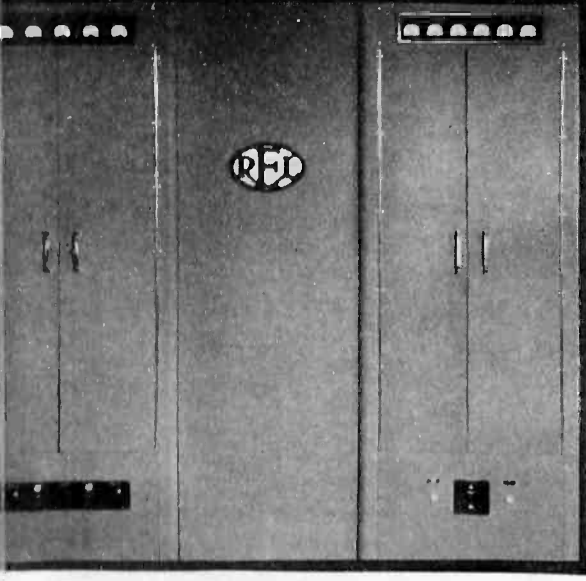
FREQUENCY
MODULATION
TRANSMITTERS



REL 1-2-5 Kw models Frequency Modulation Transmitters, showing attractive arrangement of control, panels, etc.



W1XOJ, Yankee Network's 2,000 Watt mountain-top Frequency Modulation Station at Paxton, Mass. REL now installing 50,000 Watts.



ame REL Frequency Modulation Transmitter as above, with doors closed.

Radio Engineering Laboratories, Inc. are the builders of Frequency Modulation Transmitters (Armstrong System). As pioneers in the field of "high-signal-to-noise-ratio" radio transmission, we have already equipped the following stations with REL Frequency Modulation Transmitters, where they are now in regular use:

STATION	LOCATION	OWNED BY
W2XMN	Alpine, N.J.	Major E. H. Armstrong
W2XCR	Yonkers, N.Y.	C. R. Runyon, Jr.
W1XOJ	Paxton, Mass.	Yankee Network
WEOD	Boston, Mass.	Yankee Network
W3XO	Washington, D.C.	Jansky & Bailey

In addition, we are at present building REL Frequency Modulation Transmitters for the following well-known stations:

WHAM	Rochester, N.Y.	Stromberg-Carlson Telephone Mfg. Co.
WTMJ	Milwaukee, Wisc.	The Journal
WHEC	Rochester, N.Y.	WHEC, Inc.
WQXR	New York, N.Y.	J. V. L. Hogan

Within the next 6 months, pending final approval by the F.C.C., approximately a dozen other of the nation's leading broadcasters are also planning to use REL Frequency Modulation Transmitters (Armstrong System), ranging up to 50 Kw.

REL

RADIO ENGINEERING LABORATORIES, INC.

35-54 36th STREET
Phone RAvenswood 8-2340
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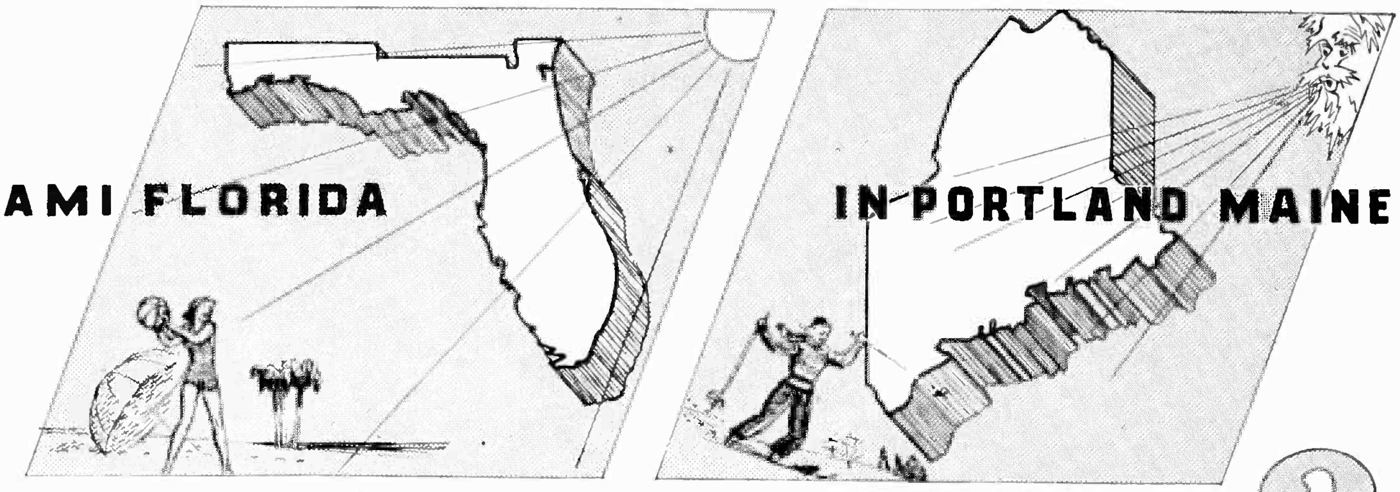
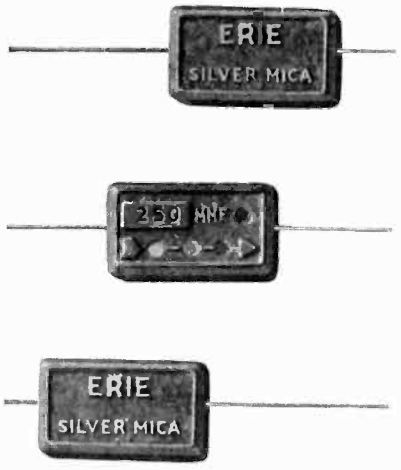
Push the button —



— there's your station (MAYBE?)

HEAT, COLD, AND HUMIDITY CAN EASILY CHANGE TUNING CAPACITY, UNLESS DEPENDABLE

SILVER-MICA CONDENSERS ARE USED



Erie Type K Silver Micas are made in capacities from 15 MMF to 500 MMF. Other Erie Silver Micas are available up to 2500 MMF. See these condensers and other Erie Resistor products at the Rochester I.R.E. meeting.

YOU CAN'T change the weather when heat, cold or humidity play havoc with your automatic tuning, but you can protect your receivers against capacity change in condensers by using dependable, Erie Silver Micas.

Repeated tests have shown that after 100 hours in 100% relative humidity at 104° F. maximum capacity change is less than .05%. But even more astonishing is the low average capacity change of ±0.113% after being subject to 5 complete cycles of 5 hours at —30° F. and 15 hours at 180°F.

You will agree that any condenser that is affected so little by these extreme conditions will not throw any automatic tuning system out of adjustment due to weather conditions encountered either in shipping or in actual use.

We will be glad to send you complete test data on these molded Type K Silver Mica Condensers.

ERIE RESISTOR CORPORATION, *Erie, Pa.*

TORONTO, CANADA • LONDON, ENGLAND • PARIS, FRANCE-J.E.CANETTI CO.

MANUFACTURERS OF RESISTORS • CONDENSERS • MOLDED PLASTICS

LAPP GAS-FILLED CONDENSERS

LAPP TOWER FOOTING INSULATORS

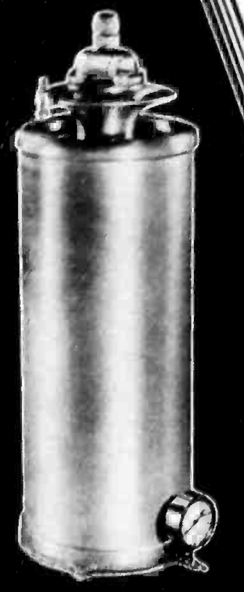
LAPP GUY STRAIN INSULATORS

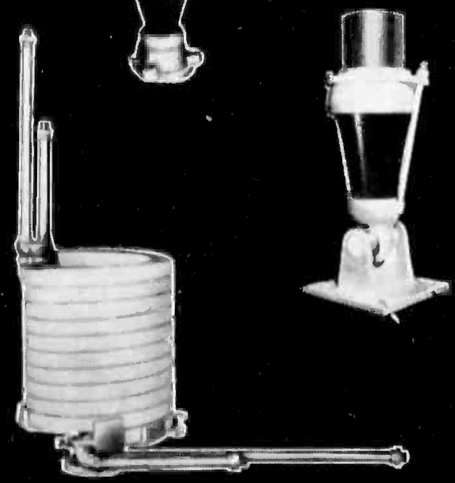
LAPP PORCELAIN WATER COILS

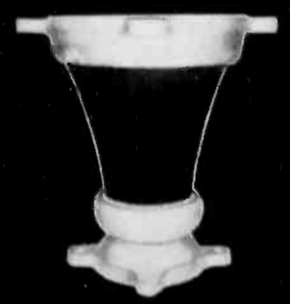
CHECK LIST

FOR RADIO ENGINEERS

CONTEMPLATING PURCHASE OF NEW TRANSMITTER EQUIPMENT







Dedicated to the cause of more efficient, trouble-free radio transmission, these Lapp specialties should be on the check list of every engineer contemplating installation of new transmitter equipment or modernization of present equipment. "Insulated by Lapp" is a phrase synonymous with operating security in radio transmission and in electrical power transmission the world over.

☐ **LAPP GAS-FILLED CONDENSERS**

New, superior design and rigid mechanical construction in the Lapp Condenser results in genuinely trouble-free service. Maximum capacity for given external dimensions. Practically zero loss. No change in capacitance with change in temperature. Puncture-proof. Wide range of sizes for practically every transmission requirement.

☐ **LAPP TOWER FOOTING INSULATORS**

Sectionalizing types for insulation of existing structures. Push-pull types for self-supporting radiators. Base insulators for guyed radiators up to 1000-foot height. All these base insulators utilize the Lapp patented curved-side compression cone for maximum mechanical strength.

☐ **LAPP GUY INSULATORS**

Mast guy insulators are available in a range of sizes suitable for supporting structures up to and including 1000 feet high and 500 KW duty, for break-up duty and primary installation. Construction with the Lapp compression cone assures that porcelain be loaded only in compression.

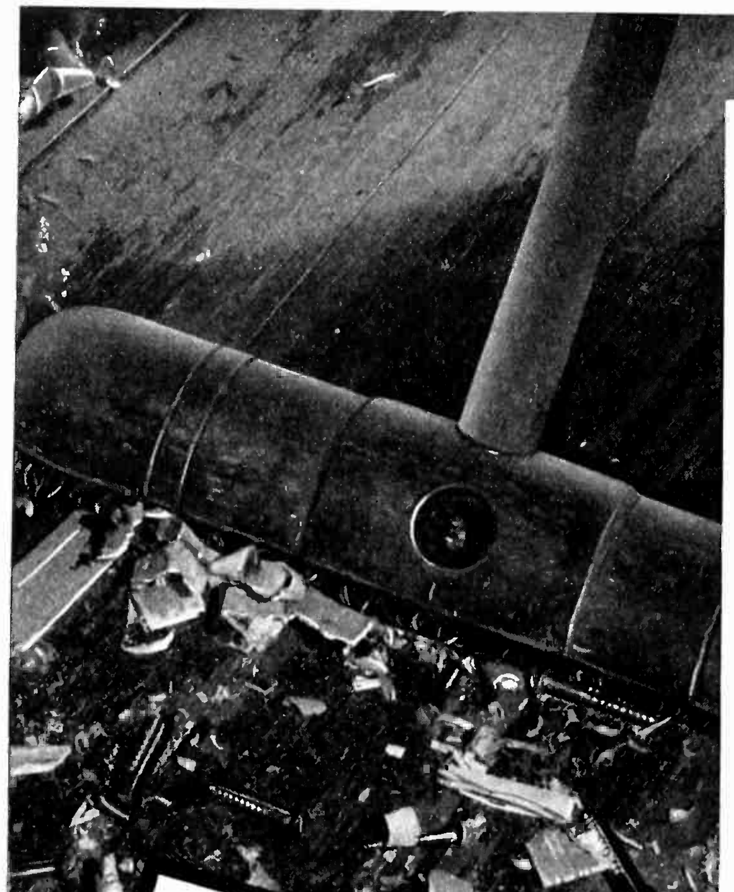
☐ **LAPP PORCELAIN WATER COILS**

The famous Lapp Water Coil for transmitter tube cooling, the coil that eliminated sludging in the water system. Because water used with the Lapp coil remains pure and at high resistance, tube life is increased and expense and inconvenience of changing water and replacing hose and fittings is eliminated. Alternate cooling system can be worked out with Lapp porcelain pipe, pieces and fittings of which are available for practically any requirement.

Complete descriptive literature is available on all these Lapp specialties for radio transmission. Write today.

LAPP

INSULATOR CO., INC., LE ROY, N. Y., U. S. A.



Here's where SCREW COSTS *mount up* *. . . and where PHILLIPS screws* CUT THEM DOWN

AVERAGE 50% LESS ASSEMBLY TIME

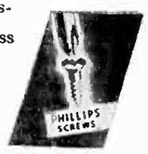
The patented Phillips recessed head means that *every screw is used.* Phillips Screws cling to the driver—none fumbled, even with one hand steadying the work. Phillips Screws are self-centering—none driven crooked. Phillips Screws fit the driver snugly—no reaming action to throw up burrs.

Shape, taper and depth of the genuine Phillips recess were determined after thousands of tests. The recess utilizes the driver's maximum turning power without sacrifice of strength in the screw head . . . without danger of shearing the metal.

So, give your assemblies the benefit of this fastening method that so many thousands of manufacturers have adopted. And give yourself the benefit of profits that Phillips Screws will earn on your production line.

Write for facts about further advantages—elimination of spoilage, tighter assemblies, improved appearance, etc. Address one of the firms listed below.

This Booklet will help your plant to cut fastening costs and improve assemblies. Address one of the firms below for free copy.

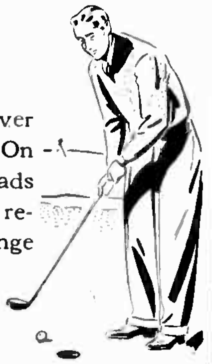


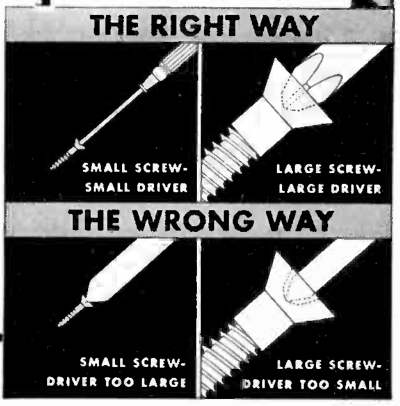
The rubbish barrel takes care of any savings a manufacturer thinks he is making by buying *slotted* screws instead of *Phillips* Recessed Head Screws.

Screws dropped on the floor . . . screws that drive crookedly and get their threads spoiled . . . screws that burr easily or split at the head . . . *these* are the *expensive* screws. You save *their* cost by buying Phillips.

YOU WOULDN'T PLAY EVERY SHOT WITH ONE DRIVER

For efficient driving, contact between recess and driver should extend as far as possible from the screw's axis. On the other hand, too big a driver means stripping threads or tearing fibre structure of wood or metal. Thus it requires four driver sizes to drive properly the entire range of recessed head screws. Two sizes of Phillips Drivers handle diameters No. 5 through No. 16 or approximately 85% of all screws driven.





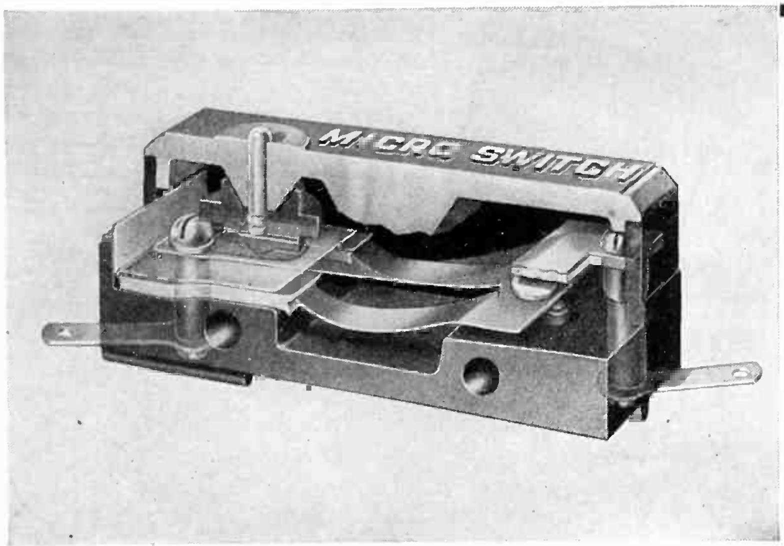
PHILLIPS *recessed head screws*

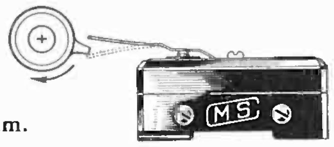
MACHINE SCREWS **SHEET METAL SCREWS** **WOOD SCREWS** **STOVE BOLTS**

U. S. Patents on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338.
Other Domestic and Foreign Patents Allowed and Pending.

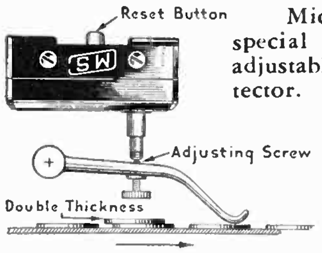
American Screw Co., Licensor, Providence, R. I.
Chandler Products Company, Euclid, Ohio
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corporation, New Britain, Conn.
The Lamson & Sessions Co., Cleveland, Ohio
National Screw & Mfg. Co., Cleveland, Ohio
Parker-Kalon Corporation, New York, N. Y.
Pheoll Manufacturing Company, Chicago, Illinois
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Lock Washer Co., Chicago, Ill.

IT COSTS LESS TO USE PHILLIPS SCREWS

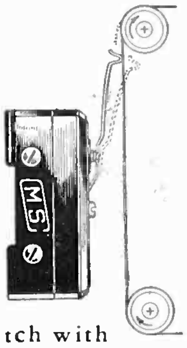




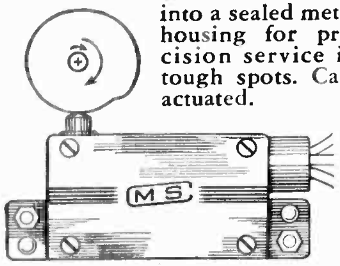
Micro Switch with snap spring actuator operated by cam.



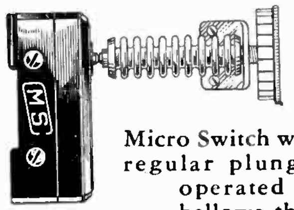
Micro Switch with special plunger as an adjustable thickness detector.



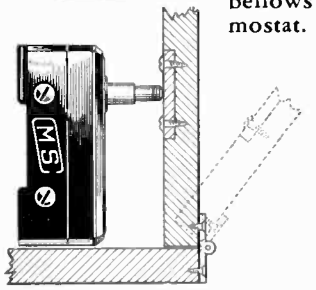
Micro Switch with snap spring actuator used as a break indicator.



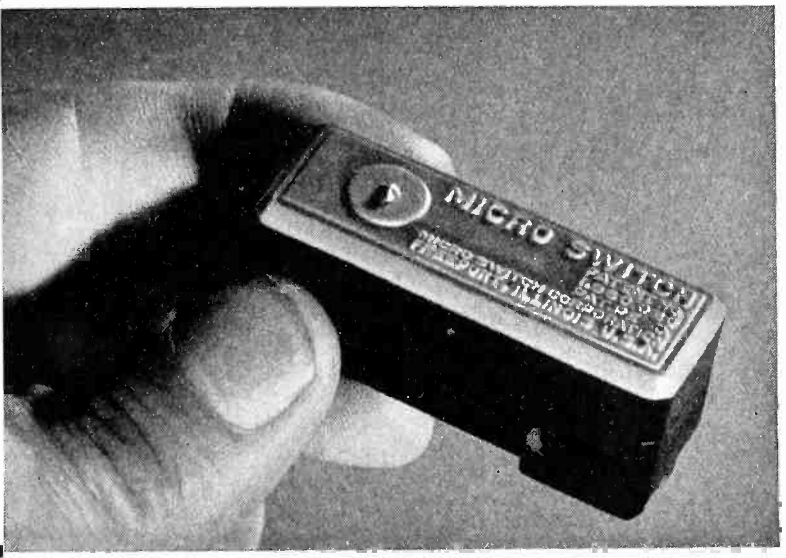
Micro Switch built into a sealed metal housing for precision service in tough spots. Cam actuated.



Micro Switch with regular plunger operated by bellows thermostat.



Micro Switch with plunger used as a door switch.



MICRO MS SWITCH

If you use time, temperature, pressure, weight, relay, or solenoid controlled devices or fractional H. P. motors in the manufacture of your product, you can apply the Micro Switch to advantage. It is now used on products in this partial list of classifications.

CONTROLS

Air Conditioning__Blower and Draft__Boiler__Cycle Circuit__Damper Regulators __Electric Furnace__Magnetic__Pressure__Test__ Gate Control__Relays__Signals__Interlocks__

INSTRUMENTS

Flow Meters__Fuel Indicators__Fuel Tank Level Testers __Humidistats__Electrometers__RPM Indicators__ Tickers__X-Ray Timing Devices__

THERMOSTATIC DEVICES

Incubators__Brooders__Indicating__Industrial__Oven __Room__

MACHINES & MACHINE TOOLS

Coin Operated__Automatic Hobbing__Honing__Hydraulic Presses__Automatic Gauging__Bottling__Counting and measuring__Cutting __Die Sinking__Drilling__ Tapping__Lathes__Automatic Screw__Milling__ Riveting__Packaging__ Rubber Working__Printing __Textile__Welding__

SAFETY DEVICES

Burglar Alarms__Recorders __Oil Burners__Stop Light Systems__Traffic Signals__ Transformer Protection__

MISCELLANEOUS

AnnunciatorSystems__Counting Devices__Direction Indicators__Daters and Printers __Flashers__Cameras__Oil Regulators__Phonographs __ScalePivots__Scale Weight Printer__Steaming Devices __Animated Displays__

A compact, sensitive, light weight snap action switch that is only 1$^{15}/_{16}$″ long, $^{7}/_{8}$″ high and $^{3}/_{4}$″ deep, and weighs only 1 ounce—operates precisely on small energy, small movement and small force at speeds as high as 600 times a minute. . . . It is rugged, resists vibration, needs no leveling, endures millions of operations. . . . It has a conservative rating of 10 amperes at 125 volts A.C.; 5 amperes, at 250 volts A.C.; 3 amperes, 460 volts A.C.; 2 amperes, 600 volts A.C.; and is adaptable to loads of ½ H. P., 115 to 460 volts; 1200 watts, 115 to 600 volts. It is listed by the Underwriters' Laboratories and the Hydro-Electric Power Commission of Ontario. . . . If your problem involves any of the operating factors; or your product is similar to those listed on the left, we will be pleased to work with you.

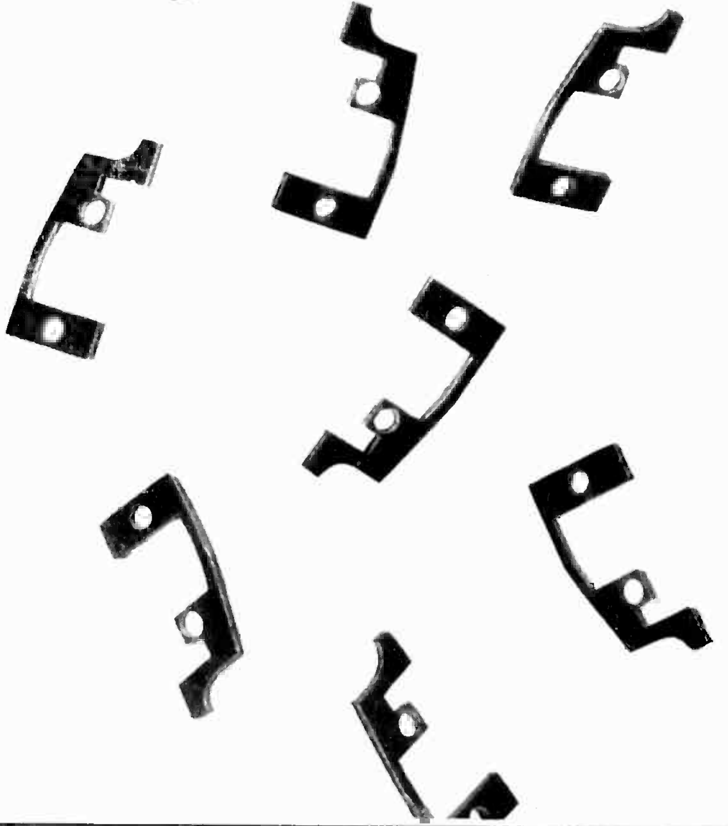
MICRO MS SWITCH

MANUFACTURED IN FREEPORT, ILLINOIS BY

MICRO SWITCH CORPORATION

New York Chicago Boston

INTRICATE SHAPES PUNCHED COLD *from* FORMICA



THERE have been great improvements in the workability of laminated material of recent years as exemplified by Formica Grade XPND-33 from which intricate shapes can be punched cold up to 5/64 inch thickness with a clean edge and a minimum of surface cracking between the holes. Simple shapes may be punched cold up to 1/8 inch thickness.

The workability of the sheet is combined with good insulating qualities. Faster production and lower costs are made possible on many jobs by this grade.

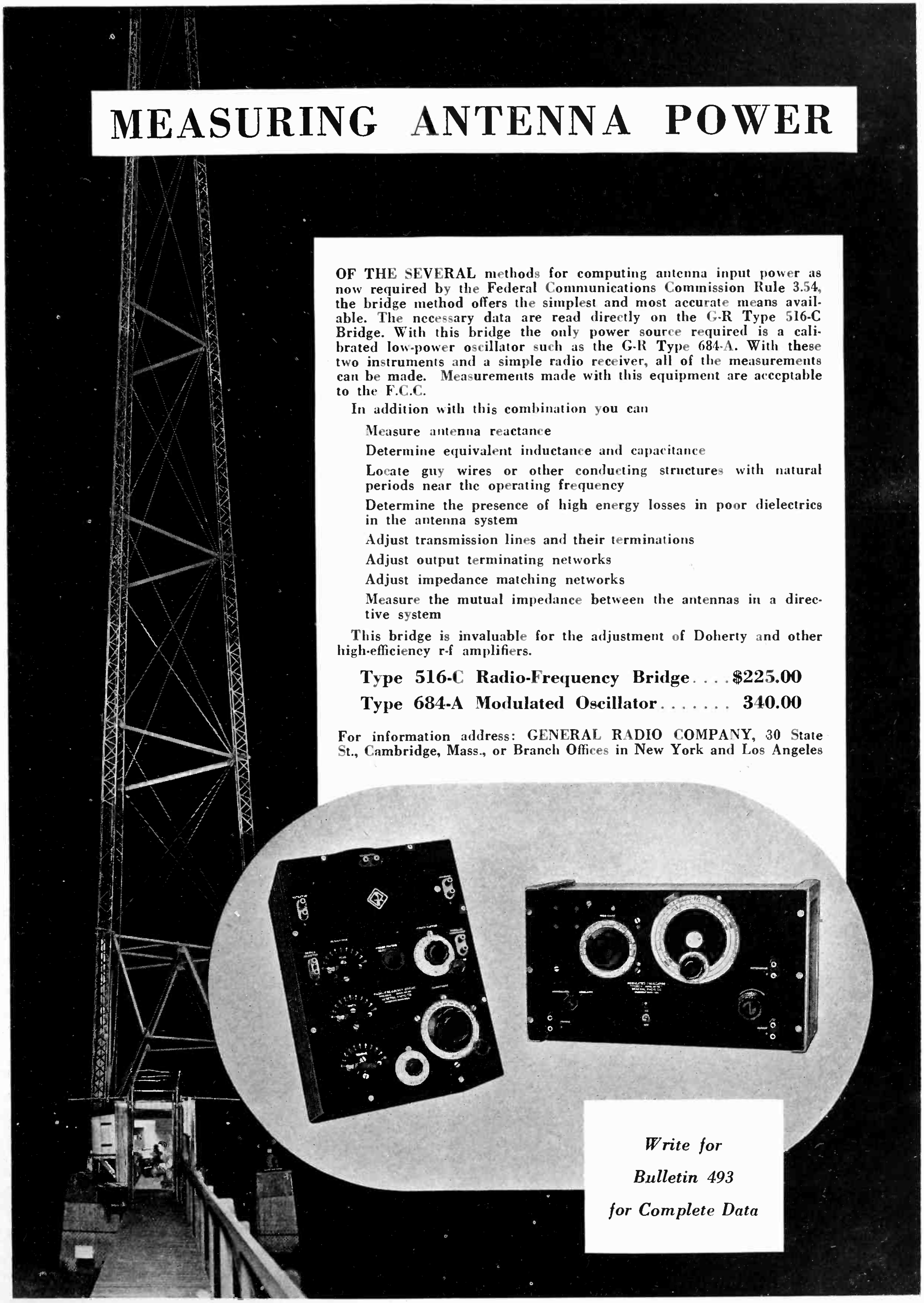
IF YOU ARE HAVING TROUBLE WITH PUNCHING STOCK, ASK FOR SAMPLES OF THIS NEW PRODUCT.

THE FORMICA INSULATION COMPANY
4658 Spring Grove Ave., Cincinnati, O.

FORMICA

Physical Properties of Grade XPND-33 in the 1/16 inch thickness

Flexural Strength	18,500 lbs. per sq. in.
Water absorption (3"x1"x1/16") 24 hrs.	3.9%
Rockwell Hardness (1¼" ball, 100 kilogram load)	73-75
Dielectric strength, short time test	650 volts per mil
Power factor at 1,000 kilocycles	.039
Dielectric constant	6.05



MEASURING ANTENNA POWER

OF THE SEVERAL methods for computing antenna input power as now required by the Federal Communications Commission Rule 3.54, the bridge method offers the simplest and most accurate means available. The necessary data are read directly on the G-R Type 516-C Bridge. With this bridge the only power source required is a calibrated low-power oscillator such as the G-R Type 684-A. With these two instruments and a simple radio receiver, all of the measurements can be made. Measurements made with this equipment are acceptable to the F.C.C.

In addition with this combination you can

Measure antenna reactance

Determine equivalent inductance and capacitance

Locate guy wires or other conducting structures with natural periods near the operating frequency

Determine the presence of high energy losses in poor dielectrics in the antenna system

Adjust transmission lines and their terminations

Adjust output terminating networks

Adjust impedance matching networks

Measure the mutual impedance between the antennas in a directive system

This bridge is invaluable for the adjustment of Doherty and other high-efficiency r-f amplifiers.

Type 516-C Radio-Frequency Bridge $225.00

Type 684-A Modulated Oscillator 340.00

For information address: GENERAL RADIO COMPANY, 30 State St., Cambridge, Mass., or Branch Offices in New York and Los Angeles

Write for
Bulletin 493
for Complete Data

At the New York World's Fair . . .

P. R. MALLORY & CO. Inc.

MALLORY

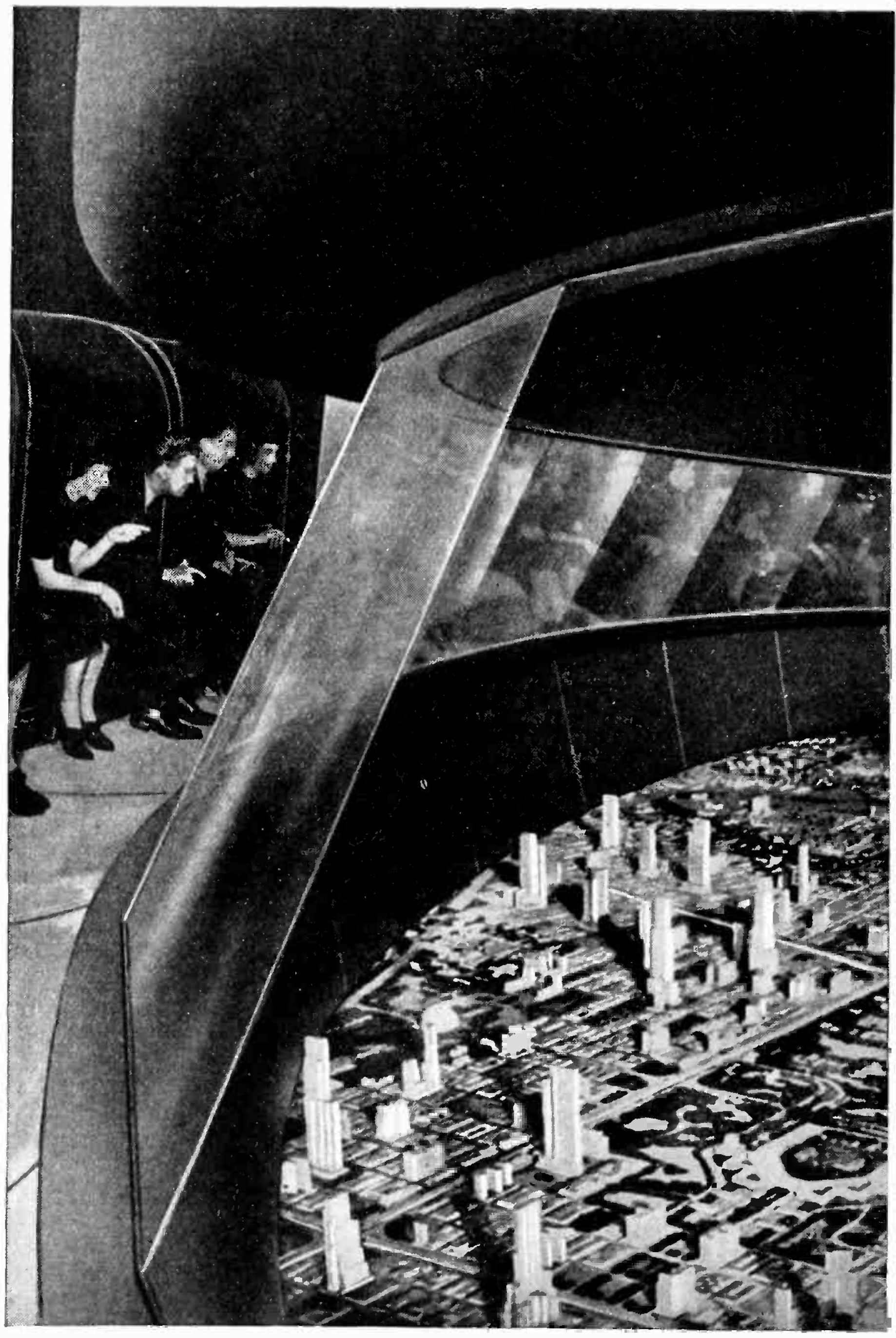
*FP (Fabricated Plate)

TRADE MARK REG. U. S. PAT. OFF.

CAPACITORS

help you HEAR as well as see the General Motors Exhibit

*NOT etched construction



In the great General Motors Exhibit "Highways and Horizons", the sightseers glide along in their comfortable chairs for a third of a mile seeing the world of 1960 unfold before their eyes. Viewing 35,000 square feet of the largest scale model ever constructed is dramatic enough. But that isn't all! The visitors hear about the marvels of the future as well as see them.

Automatic speakers at each chair tell the story of the passing panorama. To accomplish this modern marvel, the gigantic Western Electric sound reproducing system delivers 147 different descriptive talks simultaneously.

In selecting the parts for the speech amplifiers it is significant that Mallory FP Capacitors were chosen.

10 to 1 capacity ratio . . . assured chemical purity and freedom from corrosion . . . low R.F. Impedance . . . surge proof construction . . . these are just a few of the revolutionary features of FP Capacitors. Millions are in use. Millions more already scheduled.

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CROSS TALK

► **BLOOD AND THUNDER** . . . How many times have you been caught up in the excitement of a news commentator's voice who thought he had something hot to tell—only to find the item in the next morning's paper hidden away in some corner, of no real importance! This was going on before the war, and evidently is a style into which certain commentators throw themselves in order to let the listener believe something good has come in over the wire.

No one blames a commentator for trying to make his stuff sound important but the "now I am going to hand you a hot one" style does not wear well unless there is really some warmth in the news.

Mr. Swing's rapid rise into a major place among the nightly commentators may come, partly at least, from the fact that he does not seem all out of breath with the importance of his comments.

► **T.E.I.A.** . . . In 1936 students of an extension course in television in Hollywood formed the Hollywood Television Society. Now the Society enlarges the scope of its activities by forming a national organization whose aims "will be the same as the I.R.E.'s are for radio." This will be known as the Television Engineers' Institute of America; George H. Seward is the moving spirit; and national headquarters are to be at 763 Gower Street, Hollywood. Members are welcome and applications may be obtained by applying to Mr. Seward.

► **SERVICE** . . . Opportunity to enlist and to serve in the United States Coast Guard is made possible at the moment by the fact that this branch of the Government is to greatly increase its force of enlisted men. Especially wanted are radiomen. Ex-radiomen having served previously in the Navy or Coast Guard may be advanced immediately to radioman, third class. The requirements for enlistment for apprentice seamen are: unmarried men, age 18 to 24 inclusive, height five feet six inches to six feet four inches, minimum weight 122 pounds, grammar school education. Apply the nearest Coast Guard office.

► **NO FIGHT** . . . On October 2 announcement by RCA and Farnsworth that an interchange of patent agreements had taken place, put an end to much speculation as to what would ultimately happen between these two large holders of television patents when the time came to put television on the map. By these agreements each party received the right to use the inventions of the other in the fields of television and in other fields of their respective businesses. Neither Corporation acquired any right to grant sub-licenses to third parties under the patents of the other Corporation.

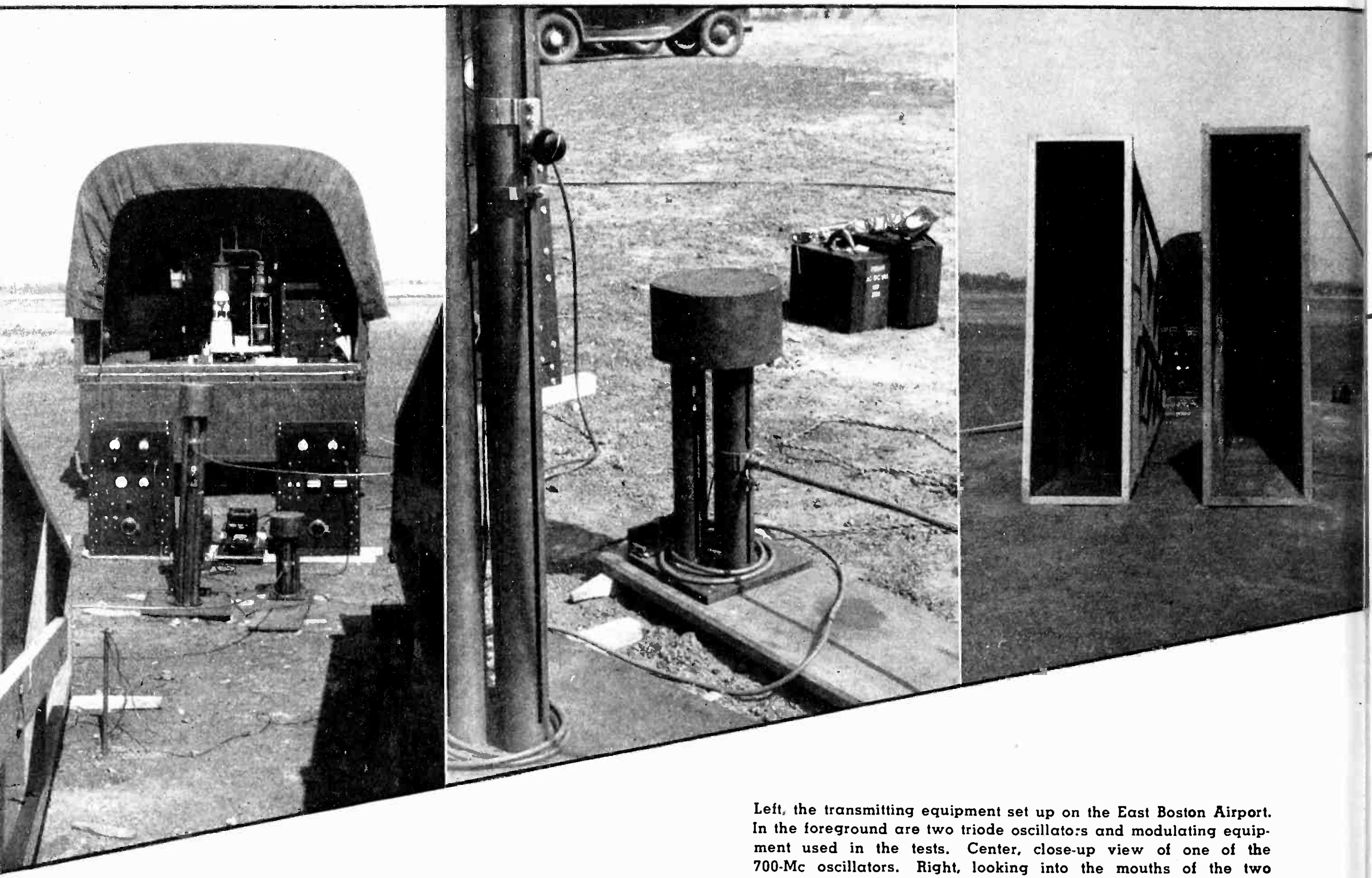
Incidentally, much interesting information on the patent policies of RCA will be found in a publication of the RCA Institutes Press, a brochure by Otto S. Shairer, Vice-president of RCA. It tells of the early history of the Corporation, and of its cross licensing agreements with GE, Westinghouse, AT&T, etc., and of the manner in which these agreements have changed with time. It relates something of the manner in which RCA acquires its patents, or rights to use other's patents, how it pays inventors for those patents it purchases, of why it prefers to buy outright rather than to pay royalties, and gives data on the royalties which RCA's competitors pay it for the use of its patents. This amounts to about 3⅝ per cent on the manufacturing licensee's selling price of complete receivers sold for domestic use, about 1.8 per cent of the manufacturer's price for sets to be sold abroad, 5 per cent of the manufacturer's price for radio tubes for domestic use and 2½ per cent for tubes for export.

It is interesting to note that several hundred licenses have been granted for the nominal sum of one dollar to radio broadcast stations which acquired their apparatus from unlicensed sources.

In this brochure there is a list of patents not yet expired which enter into the design and construction of radio receivers and tubes.

► **INVENTION** . . . An advertisement of a new automobile antenna states that this new aerial is the only one that "is grounded in two places." This reminds us of an antenna we once had. It fell down and got covered up with wet leaves. It did not work very well, which was disappointing, because we thought we might have something new. We burned the leaves and hung the wire up on insulators and finally grounded the near end of the wire through a coil tightly coupled to one of the coils in the set. This worked much better than the grounded antenna. (Advertisement really meant that the shield was grounded in two points. Why can't they write these ads, correctly?)

► **CREDIT** . . . Through an unfortunate oversight the photograph used as cover of the September cover was not credited to its photographer, Mr. Richard Wurts of Wurts Brothers, New York City. Not only is Dick Wurts a good photographer, but he is a good fellow to boot, and your editors had every intention of pointing out the fact that he was responsible for the cover photo.



Left, the transmitting equipment set up on the East Boston Airport. In the foreground are two triode oscillators and modulating equipment used in the tests. Center, close-up view of one of the 700-Mc oscillators. Right, looking into the mouths of the two horn radiators which set up the overlapping horizontal signal patterns

RECENT progress in the field of the ultra-ultra high frequencies, above 500 Mc, has consisted principally in the development of more efficient generators, more sensitive detectors. Behind the scenes, however, several organizations have been working toward the application of the very short waves to the problems of aerial navigation and guidance. One of the outstanding examples of this work is the collaboration between the Civil Aeronautics Authority and the Massachusetts Institute of Technology on a system of instrument landing which employs 40 centimeter waves* and which makes use of nearly all of the modern developments in the field of microwave research. The system is the solution of a problem proposed by a C.A.A. engineer, Irving Metcalf, and developed in practical form by the electrical engineering department staff of M. I. T. under Professor E. L. Bowles. The apparatus was recently demonstrated in experimental form to C.A.A. officials at the East Boston Airport.

Beams from Horn Radiators

The transmitting equipment operates on a frequency of approximately 700 Mc. At such high frequencies, beams may be formed by radiating the energy from horn structures of convenient dimensions. Two such horns were used in the demonstration, each fed by a separate transmitter. The horns are wooden structures, about 26 feet deep, and 10 by 2½ feet at the mouth. They are lined with copper sheeting. At the end of each horn is a rectangular box which closes the throat. Inside the box is a quarter-wave antenna which protrudes into the box directly from a coaxial transmission line. The length of the antenna is about 10 cms, (roughly 4 inches). The 700-Mc energy radiated from the antenna is conveyed down the horn to its mouth, and there it spreads out in a flat fan-like pattern, whose width is at right angles to the long dimension of the mouth of the horn and parallel to the ground. (This relationship obeys the rule for diffraction effects, namely that the diffraction pattern spreads widest at right angles to the long dimension of the slit). Consequently the horn generates a flat nearly horizontal beam of signal, inclined at a slight angle

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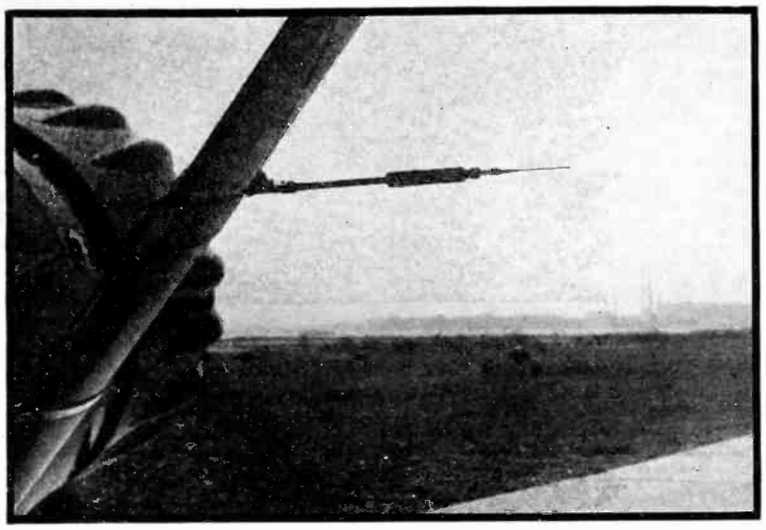
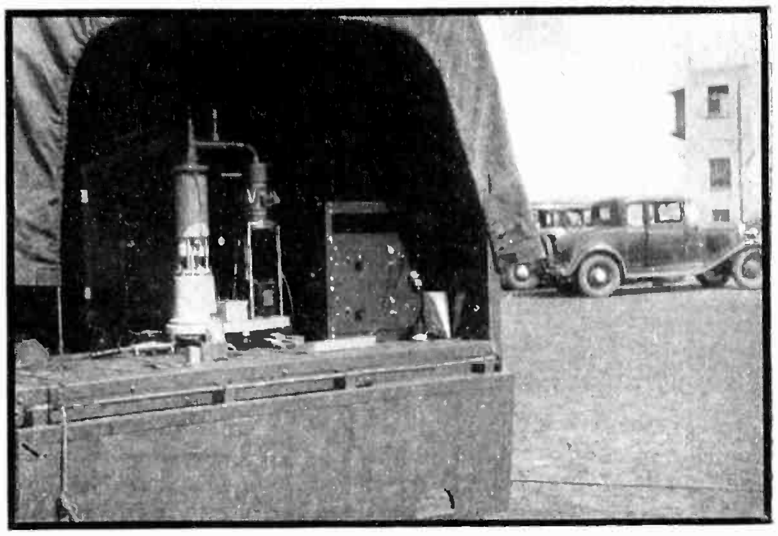
* A preliminary report of this work was carried in the January, 1939 issue of *Electronics*, pages 12-14. The demonstration was reported from the aeronautical point of view in the November, 1939, issue of *Aviation*.

40-CM Waves for Aviation

Tests at M.I.T. reveal practical apparatus for generating a 40-cm "hillside" of signal for blind landing of airplanes. Horn radiators and a receiver having 15-microvolt sensitivity show practicability of 700-Mc communication



Similar in appearance to a hypodermic needle, this "coaxial" antenna is mounted on the wing strut of the plane. The antenna proper is the quarter-wave (4-inch) length of wire protruding from the coaxial line



The klystron oscillator, mounted in a truck complete with high voltage power supply and vacuum system, is capable of power in excess of 100 watts at 40 cms. This is one of the first applications of the new "beam-group" tubes to radio communication

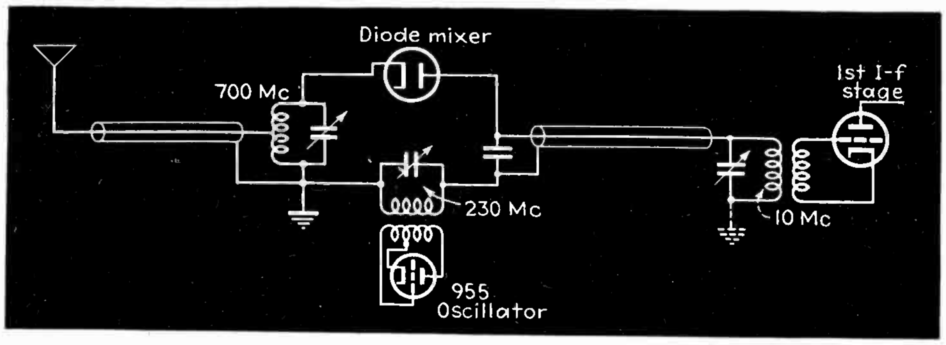
to the airport surface. Two horns are used, each fed with signals of the same frequency, one modulated at 150 cps, the other at 90 cps. The horns are set up so that the central axis of one makes an angle of 5 degrees to the earth's surface, the other an angle of 10 degrees. The fan-like beams from the two horns overlap in a region which extends from about 3 degrees to 7 degrees. The overlap region constitutes a "hillside" of signal down which the plane glides to the airport surface. In the plane, the receiver tells the pilot when both signals (90 cps and 150 cps modulations) are received. When both are received at equal strength the glide angle is 7.5 degrees, which is somewhat steep for most aircraft, hence the receiver is set to indicate the proper position when the upper beam is received somewhat stronger than the lower, producing a normal glide angle of from 3 to 4 degrees.

The arrangement just described gives so-called "vertical guidance", that is, it guides the plane in the up-down direction. Similar guidance in the horizontal or left-right direction is also necessary. In the demonstration the horizontal guidance was provided by a conventional long-wave runway localizer transmitter, designed and operated by engineers of the Washington Institute of Technology. When the C.A.A.-M.I.T. system is completed, the horizontal guidance may be set-up by 40-cm waves in the same fashion as the vertical guidance.

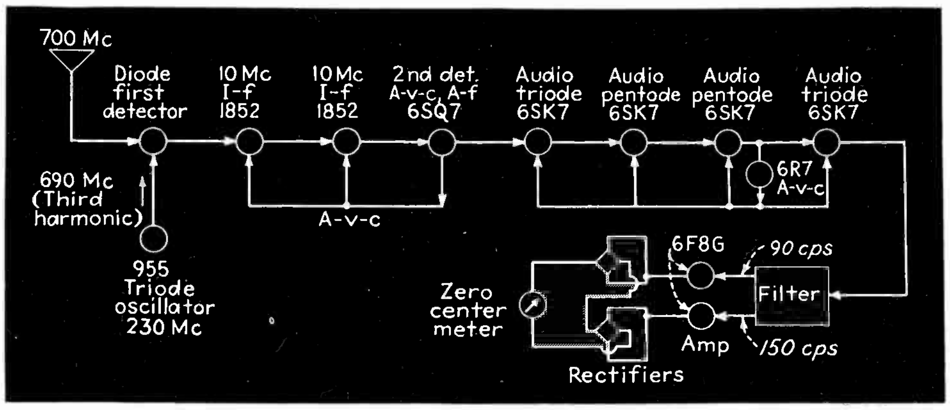
The 700-Mc Generators

The horn structures just described are highly directional (in the plane of the fan pattern) and hence conserve the energy fed to them from the transmitter proper. For this reason, very small amounts of transmitter power will suffice, so long as the receiver in the plane has adequate sensitivity. Two possibilities arise: a transmitter of several hundred watts power may be used with an insensitive receiver, or a few watts of transmitter power may be used with an elaborate receiver. The low-power arrangement was used at the demonstration, although the high-power method has been tested with success.

The generation of hundreds of watts of power at 700 Mc has been possible only since the advent of the beam-type of cathode-ray generator. One of the "klystron" generators originated at Stanford University was available for the purpose, and was set up in operating condition on the airport, mounted in a truck complete with high voltage power supply and a continuous vacuum-pumping system. With less than 100 watts output, in previous tests, adequate signal strength was received in the plane at a distance of more than 25 miles, which constitutes a record for microwave transmissions. In the demonstration, however, it was more convenient to use lower power, and to rely on the high sensitivity of the receiver. Accordingly, two conventional triode oscillators were used, one for each horn radiator. The oscillators employed the Western Electric type 316A door-knob tubes in coaxial-line tuned circuits, and were fed with about 25 watts of power, one modulated at 90 cps, the other at 150 cps. The output of the oscillators was in the neighborhood of one watt at 700 Mc (43 cms), but even this small power was adequate to produce a strong signal at distances greater than five miles. Since the glide path to the airport surface is usually less than five miles long, the performance was satisfactory, despite the very low power of the transmitters.



The diode first-detector circuit in the superheterodyne receiver. Circuits tuned to the signal frequency, the oscillator frequency and the intermediate frequency are connected in series with the diode, which develops the third harmonic of the oscillator output and mixes it with the signal, simultaneously



Tube line-up of the receiver. Two 700-Mc signals, modulated at 90 and 150 cps respectively, are amplified several hundred thousand times before separation in a filter and applied to the indicating meter

The 15-Microvolt Microwave Receiver

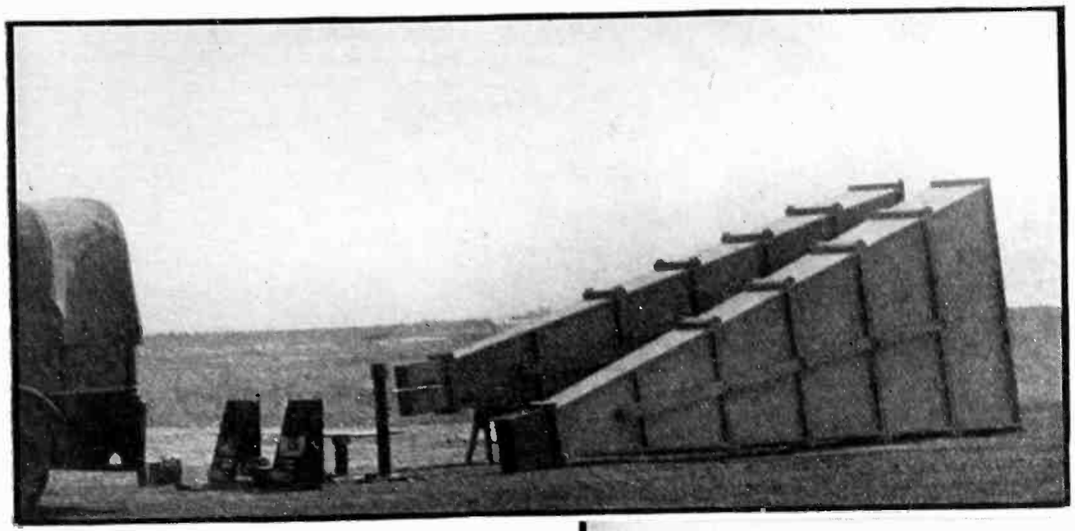
From the standpoint of radio engineering, the most significant development in the project (save possibly the use of horn radiators) is the 40-cm receiver. This receiver displays the phenomenal sensitivity of 15 microvolts input for full output (off-scale swing on the indicating meter). The tube lineup is shown in the accompanying figure. The antenna is of the coaxial variety developed by the Bell Labs. It is fixed to one of the wing struts. The coaxial lead-in connects to the input circuit. The first detector is a diode tube, a W. E. development type. This tube serves two functions. In the first place it develops the third harmonic of the oscillator output, and in the second place it mixes this third harmonic with the input signal, producing a 10-Mc intermediate frequency. The dual aspect of the diode action is illustrated in the accompanying diagram. Three tuned circuits are connected in series with the diode, as shown. The first is tuned to 700 Mc, the input frequency. The second is tuned to 230 Mc, the oscillator frequency, and the third is tuned to 10 Mc, the intermediate frequency. At other than these resonant frequencies, the tuned circuits are essentially short circuits, so it is possible to consider the action of each circuit as though it were the only element in the series with the diode. Hence the diode produces a 690 Mc frequency as the third harmonic of the oscillator voltage, mixes it with the 700 Mc input, and derives the 10 Mc i-f voltage, simultaneously.

The oscillator proper, which employs a 955 acorn triode, is a specially-designed coaxial tuned circuit similar to those developed by Peterson. The tuned circuit is in the form of a high-Q resonator, which encloses the tube, and which is so proportioned as to produce a highly stabilized output.

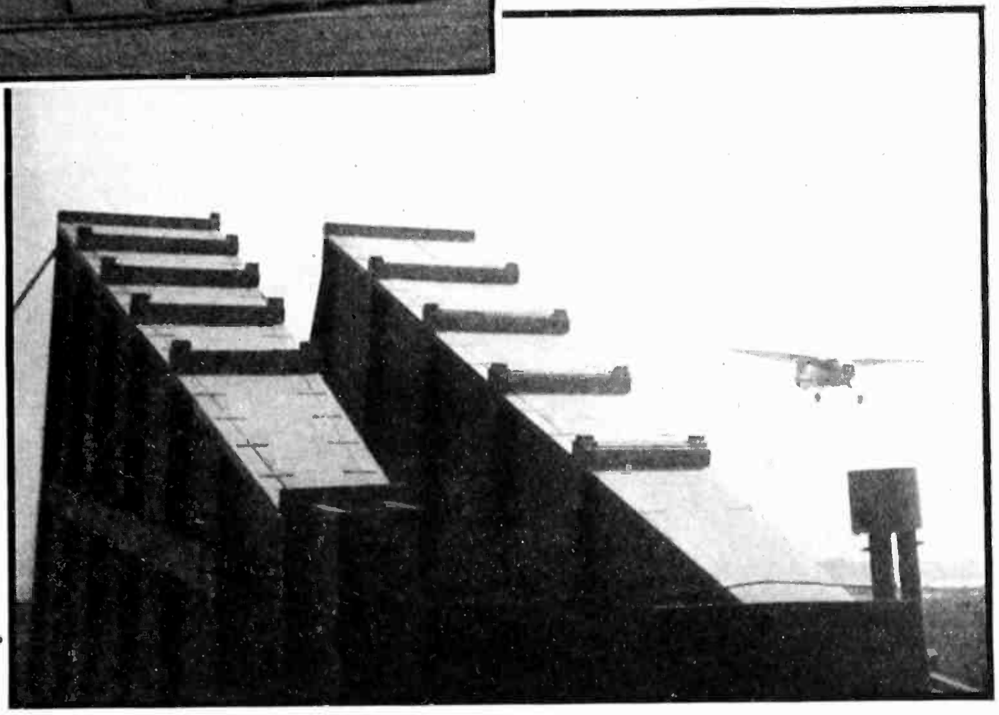
The i-f output of the first detector is amplified in two 1852 i-f stages, which pass a band several hundred kilocycles wide, but which develop a gain of several thousand times overall. The second detector is a diode element in a 6SQ7 diode-triode tube. Then follows the triode section of the same tube as an a-f amplifier. A-v-c voltage is developed and applied to the 1852 tubes. The audio output of the 6SQ7 is then fed to an elaborate a-v-c controlled audio amplifier employing four 6SK7 tubes, the first and last triodes, the others as pentodes.

The output of the third 6SK7 feeds a 6R7 which acts as an a-v-c diode and amplifier. A-v-c voltage is applied to all four 6SK7's, with the result that the output is substantially constant (within about 20 per cent) with audio frequency inputs ranging from one millivolt to three volts. The gain in this amplifier is very great, of the order of 100,000 times. The problem of motor-boating and noise has been solved by the use of resistance-capacitance band-pass couplings between stages, which pass components from 50 to 400 cycles, thus including the 90-cps and 150-cps modulations which are of importance, but discriminating against noise, and inhibiting low-frequency oscillations.

The output of the final 6SK7 amplifier leads to a filter which separates the 90 cps signal from the



Above, the two horns viewed from the side. The axis of one horn extends at an angle of 5 degrees to the airport surface, the other at 10 degrees. The overlap region between the flat horizontal signal radiated from them constitutes the signal followed in landing the plane



Below, the test plane making an approach to the field, following the indications of the landing instruments. The horns are situated to one side of the landing path. The signal regions radiated are inclined to and nearly parallel to the airport surface

150 cps. Each of these components is amplified individually in the sections of a 6F8G double triode, and applied to two copper oxide bridge-type rectifiers. The connection between opposed outputs of the two bridges is made to a zero-center microammeter which thereby is made to indicate the relative strength of the 90- and 150-cps components. The gain of the 90 cps channel may be varied in the 6F8G stage relative to that in the 150 cps channel. This allows a zero-center indication to be obtained with varying ratios of 90 cps to 150 cps modulation, which in turn corresponds to positions in the upper and lower portions of the overlap region between the two fan patterns. By adjusting the relative gain of the two channels, the glide angle may be adjusted to suit the landing characteristics of different types of planes.

Observations During Test Flights

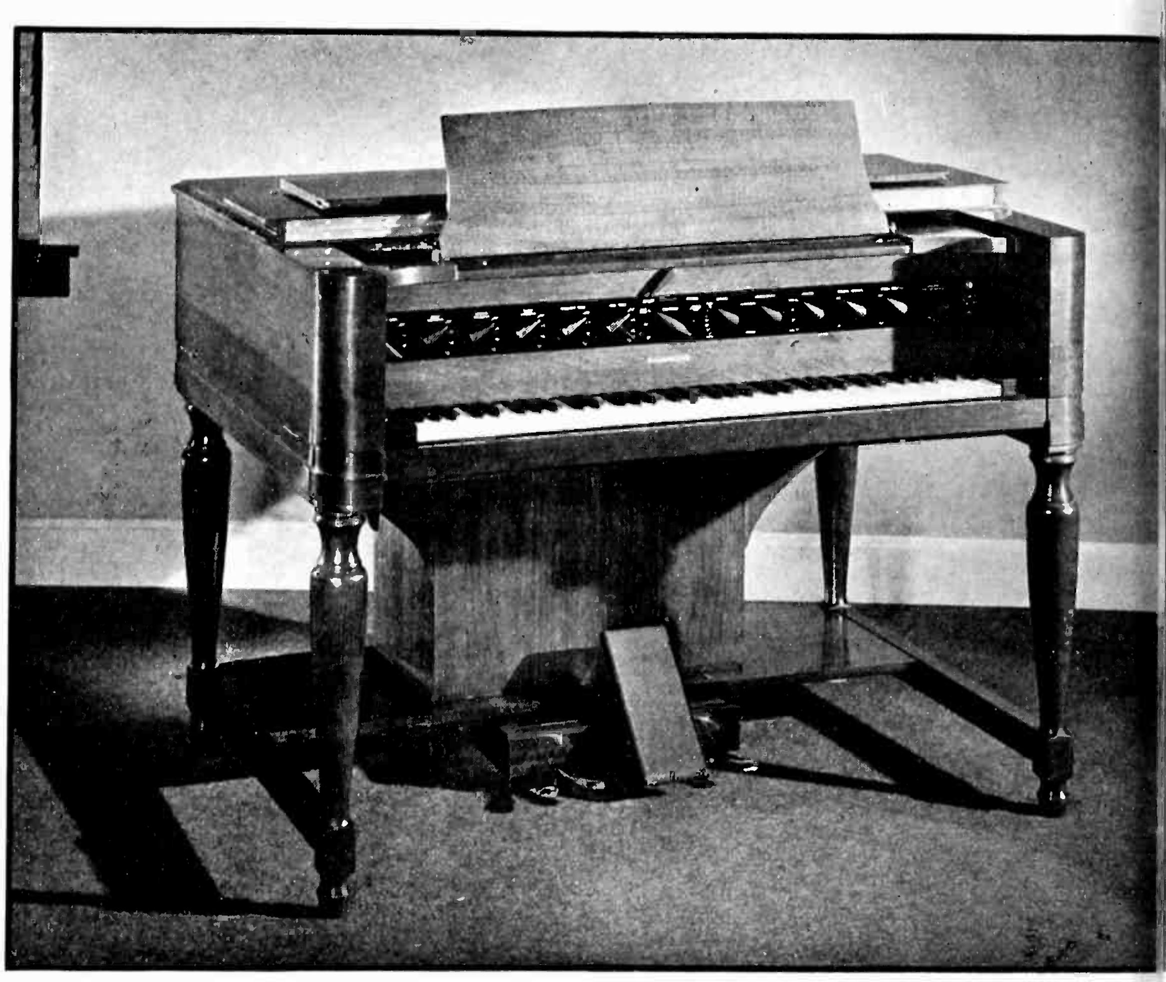
In the test flights, the pilot flew about five miles from the airport, and picked up the glide path at an altitude of about 900 feet. By keeping the two cross pointers on the indicating instrument (one for the vertical guidance, the other for the horizontal), he guided the plane to the airport surface, but did not land because of a high crosswind which would have made landing difficult. Throughout the descent, the rate of climb meter and the airspeed indicator remained fixed in position, indicating that the plane was following a straight line to the ground. The straight-line aspect of the system is an important distinction from that of the conventional longer-wave instrument-landing systems, which follow a more or less curved contour of constant signal strength. The straight line path of the new system makes a definite point of contact with the ground, so that the plane reached its lowest altitude over a region no more than 50 feet in diameter.

The indications of the system were also made to appear on a cathode-ray tube, on whose face three spots appeared. The spots were formed by a commutating system, and were so controlled that they indicated not only the position of the plane relative to the glide path but also the tilt of the planes wings, and its azimuthal position. The latter indications were derived electrically from the gyro compass and artificial horizon instruments in the plane, in the manner described in the reference previously cited. The three luminescent spots have the appearance of fixed spots on the ground, and hence allow the pilot to judge almost instinctively his position relative to the airport at all times during the descent.

Since the horns determine the shape of the pattern, the glide path is not changed by variations on the airport surface, such as would be caused by a snowfall. The signal regions extend a considerable distance to the left and right of the horn openings, hence it is quite feasible to place the horns to one side of the glide path, and thus remove them from the airport surface. The photograph above shows the plane approaching the field on the landing beam, and the relative positions of the path and the horns.—D.G.F.

THE NOVACHORD

By FREDERIC D. MERRILL, JR.



FURTHER evidence that the art of electronics is occupying an increasingly important role in the field of instruments for creating music directly is presented in the recently introduced Hammond Novachord.

To duplicate even partially its musical effects from conventional non-electronic instruments would require many of the tonal resources of a church pipe organ, piano, orchestra brasses, woodwinds, harp, and bowed strings. Although not intended to duplicate any existing musical instrument, the Novachord, shown in Fig. 1, accomplishes all this with a single simple keyboard playing technique and occupies as little space as a 4½-foot square.

Vacuum tube oscillators for producing musical tones have been suggested many times[1], but the problems of frequency drifting, timbre variety and proper amplitude-time starting and decaying characteristics to simulate organ or percussive qualities for a keyboard chordal instrument have necessitated the use of many tubes in a tremendous complexity of circuits. Consequently the design of a practical commercial model of small size and low cost that could be made in mass production represents an outstanding achievement in electronics engineering.

Principle of Operation

The present device[2] contains 163 vacuum tubes, most of which are arranged within the easily accessible shielded compartments of the main chassis for generation and control of the alternating current. This chassis is shown in Fig. 2. There are no strings, hammers, reeds, or organ pipes in the generator system, in fact no moving parts except the vibrator pendulums.

The twelve top octave frequencies are generated by separate constant frequency audio oscillators operating continuously. There are no other oscillator tubes because all the lower frequencies are separated by octave intervals and furnished by novel frequency halvers, called dividers. Individual tone keying and determination of amplitude-time characteristics are performed in the control tube sections where the way in which the grid bias value varies from the instant of keying is the important factor. With the exception of the top octave that needs no frequency dividers, there are two tubes, *i.e.* the divider and control tubes, associated with each of the 72 playing keys. Timbre regulation is accomplished both at the input to the 72 individual non-linear amplifier control tubes and also at common output multiple resonant circuits.

The Oscillator Units

The oscillator circuit for a single tempered frequency is shown in Fig. 4 and it is noted that the iso-

Fig. 1—Left, by the use of vacuum tube oscillators, the Novachord produces a wide variety of musical tones

Fig. 2—Above, a total of 163 tubes is used to generate and control the alternating currents which produce the tones

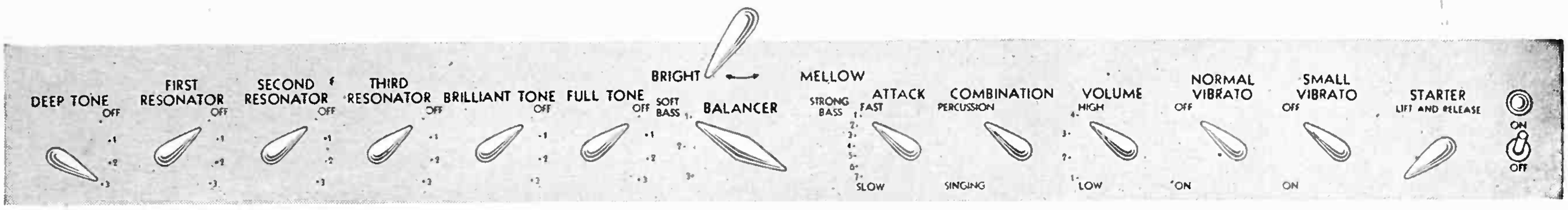


Fig. 3—Control board of the Novachord. By manipulation of the various controls, music similar to that of the pipe organ, piano, orchestra brasses, woodwinds and plucked and bowed strings may be produced

lation of feedback capacity resistance RC by a second triode section resembles a modified relaxation oscillator. The tuning coil L_1 is of special high Q construction to improve the frequency stability.

The output of the first triode is essentially sinusoidal in waveshape, one of the alternations having its peak lopped off somewhat. The second triode section gives an extremely rich harmonic output because the grid is operated nearly at cut-off[3]. Two separated output points are used for isolation and also to be able to place a higher amplitude signal on the following divider tube.

As long as the various tube operating voltages have the same ratios, the frequency remains constant over a wide range in their actual magnitudes. This is realized in practice by the simple expedient of a common voltage divider so that line voltage changes as much as 80 to 130 result in no perceptible beat with another instrument on 110 volts. Naturally then the exact frequency of supply line is also unimportant in affecting the oscillator frequency.

Tuning

Rough tuning is originally set by the condenser C_1 and fine tuning carried out by turning a knurled knob in one of the oscillator compartments to move in and out of the coil a single lamination and vary the permeability. Once an instrument has been installed the tuning remains satisfactory for many months except when the chassis receives severe shipping shocks or after long aging of tubes. Normally the original factory tuning makes an additional tuning at installation unnecessary. Unlike other frequency generating systems such as the conventional piano with strings or a single oscillator tube per tone, the octave tuning never gets out because of the frequency halving units controlled by the master oscillators. Therefore, obviously, only the temperament as set by the twelve controlling oscillators need be adjusted.

The instrument is normally set at *A* 440 cycles per second at the factory but should it be necessary to retune to say *A* 444 then this can be accomplished in six minutes by the musician himself. First the *A* frequency is set according to that desired by the orchestra conductor. Then a jumper lead couples two control tube grids in second octave from top. Each oscillator is tuned by a clear zero beat formed by pure fourths and fifths, with the slight expansion of 4th and contraction of 5th for tempering the scale furnished by a single small fixed condenser bridging across the grid coil of the oscillator being adjusted. The closure error, or sum of all the errors from setting the individual oscillator frequencies is checked by beating the final *E* against the *A* starting point. If this beat rate is slow enough to be counted, then the temperament is accurately adjusted.

Vibrato

The use of twelve master oscillators permits a frequency variation constituting a vibrato rather than the customary volume variation tremulant and since it is rare that two adjoining keys will be depressed simultaneously the number of vibrato units at the oscillators may be cut down to but six, one for each two consecutive generators.

These vibratos are set at slightly different rates so that the phase differences are constantly changing to produce a rich choir effect. The actual unit consists of reeds equipped with contacts to switch small condensers in and out of the tuned circuits. A compensating switch with correcting condenser maintains the mean frequency constant regardless of whether the vibrato rate is fast, slow or not in use at all.

There are twelve distinct frequency dividing systems corresponding to the twelve chromatic tones of the octave; that is, one system provides all but one of the C octave tones, another all but one of the C# octave tones, etc. Within a given system there may be as many as five frequency halving units with a single pentode 6W7G to each unit. A given system consists of a series of these vacuum tubes connected together in cascade fashion and supplied at the input by one of the master oscillators. The outputs of each divider unit are also rich in harmonics. It is re-emphasized that these tubes are not oscillators for if the input signal is removed, then no output signal remains. Each tube acts as a non-linear amplifier.

The typical divider circuit illustrated in Fig. 5 merely passes plate current pulses for every other positive grid voltage alternation.

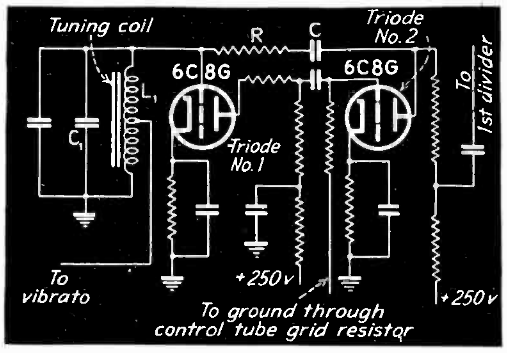


Fig. 4—Oscillator circuit for a single tempered frequency. L_1 is of high-Q construction to increase frequency stability

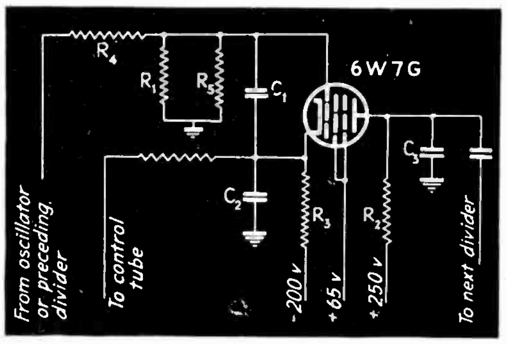


Fig. 5—Typical frequency divider circuit. Every other grid voltage pulse permits a passage of plate current

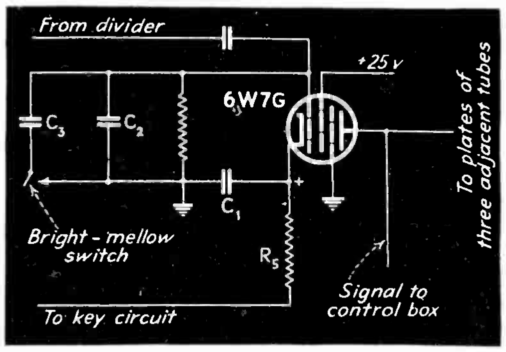


Fig. 6—Control tube circuit in which is generated a voltage rich in harmonics and which controls the brillance of the tone

The arrangement resembles a self biased, cascade connected resistance coupled amplifier except for the circuit constants and the two additional condensers C_1 and C_3. Owing to the self biasing of the tube, the cathode floats at a direct current potential with respect to ground so that the voltage between cathode and grid will be the cut-off voltage of the tube. Hence the direct current through the tube is practically fixed, almost entirely independent of the input signal and extremely small in average value.

One can thus consider the operation taking place at a point so close to cut-off that completely non-linear operation results. Naturally if the grid voltage goes only a minute degree positive with respect to cathode voltage, a sudden large surge of current will take place. On the other hand any further increase of bias can only serve to reduce an already small plate current. Only alternate positive excursions of the grid are effective in producing plate current pulses because of the inter-dependence of the grid to cathode potential owing to the condenser C_1, and the influence of C_2 in discharging owing to the rapid flow of cathode current to finally produce cut-off. The grid becomes sufficiently negative to prevent the following signal cycle from pulsing the plate but by the time the second input signal cycle arrives the grid potential has diminished enough to allow another short duration plate current pulse.

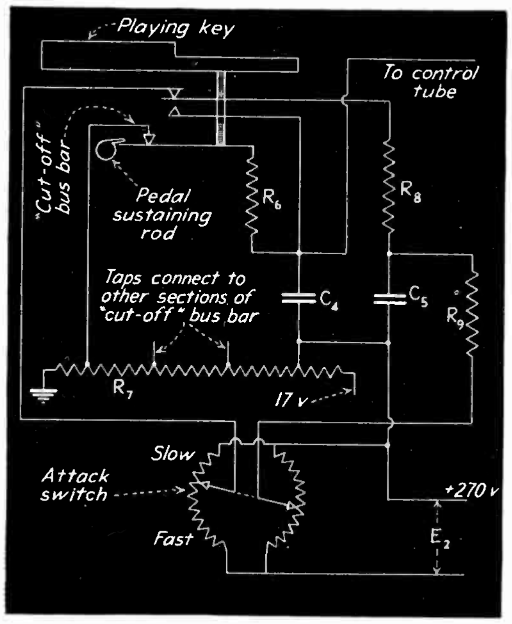


Fig. 7—This keying arrangement provides slow, medium and fast attack. Means for sustained tones is also provided

While both waveforms across C_3 and C_2 are sawtooths, that at C_3 has the greater amplitude and slope and is therefore more effective in driving the next frequency halving unit.

It is interesting to note that an increase of the R_1 R_5 combination beyond the 1 to 3 megohm range may result in frequency being divided by three or a larger integer than the desired two. Below one megohm the output frequency may be the same as the input.

Envelope Control Tube and Circuit

The onset and decay of the musical tone are just as important as the harmonic content, for if the timbre is kept constant and only the amplitude-time characteristics altered, one may, for one example, pass through the surprising range of musical effects of a plucked string (guitar), a struck string (piano), a bowed string (violin) and even an organ tone. A rectangular beginning and ending envelope heard in an acoustically dead room is generally tiresome when used for an appreciable time and certainly unlike any familiar non-electronic instrument. Consequently it is desirable to have the envelope different from that given by sudden switching of a loudspeaker to a continuously operating alternating current generator.

For each key of the Novachord there is one control tube that allows not only wide latitude in the choice of envelope, but also the timbre. Even were the input to the control tube grid substantially sinusoidal, the output would still possess many harmonics because the grid bias is normally at cut-off so that only the positive peaks of signal voltage continuously applied are effective in producing plate current pulses[3]. With playing key in up position the grid is so negative that no plate current results even though there is signal voltage on the grid. The electrostatic field of the grid is effectively blocked from affecting the plate by virtue of the intervening shield of the pentode.

Under normal conditions the input signal voltage to grid is sawtoothed so that the control tube acting as a non-linear distorting tube furnishes an extremely rich harmonic output. In the control tube circuit shown in Fig. 6 the use of C_2 alone gives a sufficiently brilliant string tone. The addition of C_3 serves to diminish the sharpness of

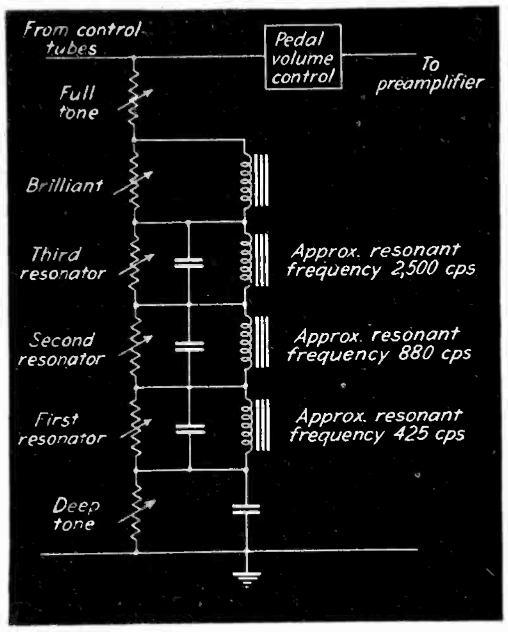


Fig. 8—The importance of the various parts of the musical tone range is controlled by the circuit shown here

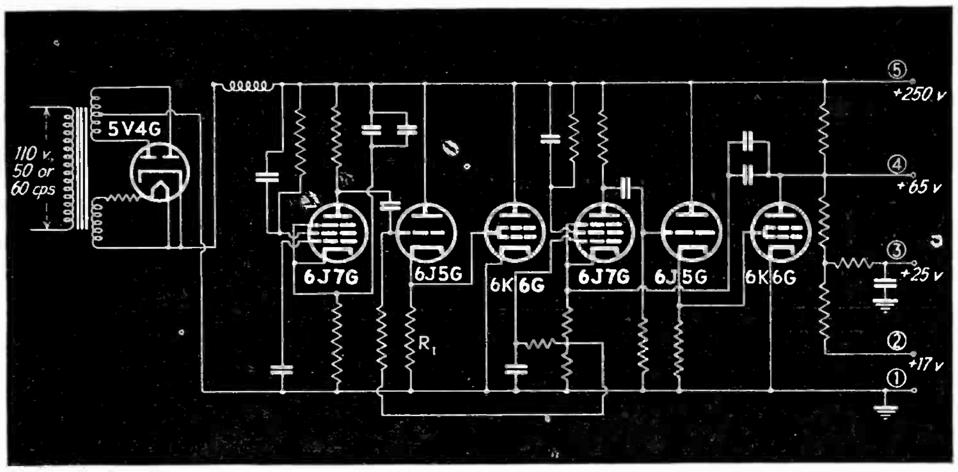


Fig. 9—The power pack which supplies 250 volts uses vacuum tubes for filtering in place of the condensers usually used for this purpose

the positive signal voltage alternation so that a more mellow timbre of weaker upper harmonics results. This "bright"-"mellow" switch is uni-controlled for the entire 72 tones, although the circuit arrangement is slightly different for the highest octave and none is used in the 18 bass control tubes.

The keying arrangement for the control tube circuit is given in Fig. 7 and permits both slow, medium, or fast attack as well as the sustaining of the tones through a foot pedal similar in effect to the piano pedal used to remove string dampers.

A brief explanation of the functioning is as follows. For organ effects the attack switch may be placed at "slow" so that condenser C_5 has very little charge when playing key is up, owing to R_8 being of much less resistance than R_9. When the key is depressed C_5 charges up slowly through R_9 and in turn the increase of negative potential carried over to C_4 through R_8, results in slowly diminishing the positive cathode potential, so that positive signal peaks are effective in producing very brief plate current pulses of increasing amplitude. The transient charging over, the plate current pulses continue constant in amplitude as long as the key remains depressed, since E_2 provides a fixed bias value less than cut-off. If the key is now allowed to rise, E_2 no longer passes bias potential along to C_4 and on the contrary C_5 is nearly discharged by R_8 and C_4 quickly returns to normal cut-off potential because of the shorting R_6. An organesque tone decay results. But should the sustaining pedal be depressed before the key is released, then C_4 does not dissipate its charge across R_6 but instead much more slowly through the tube itself.

For the case of the fast attack, C_5 starts off with a large charge when the key is up, rapidly losing it across R_9, and C_4 R_8 combination. This results in only a momentary application of grid bias less than cut-off.

An intermediate setting of the attack switch permits envelopes between those of a plucked string and a bowed string, the piano being one such example.

Examples of amplitude-time curves for various settings of the attack control switch and with key held down are given in Fig. 10. #1 corresponds to a plucked string, rapidly damped tone while the extreme #7 represents a slow bowed string attack.

The generator system for the Novachord does not permit control over the amplitude of the individual harmonics since the output from a single source, the control tube, is already rich in overtones. When it is remembered that many orchestral instruments are limited in pitch range and the timbre characterized by a group of adjacent harmonics being especially prominent, the electrical counterpart is provided by adding one or more inductive-capacity circuit elements tuned to different frequencies as shown in Fig. 8.

The "Full Tone" section alone will provide equal loudness for all the keys. The "Brilliant" portion accentuates the upper harmonics and thus the treble while the bass is weakened; the "Deep Tone" accomplishes the reverse. In this way the timbre and tone volume between bass and treble is balanced without any sudden discontinuities.

The keyboard range of fundamental frequencies to be reproduced is from 43.7 cycles per second to 2637 cycles per second, a full six octaves. It is noted that the resonant frequency of the third tuned circuit is approximately 2500 cycles per second, just at this upper keyboard limit. Obviously harmonics of the fundamentals extend far beyond the 2637 value.

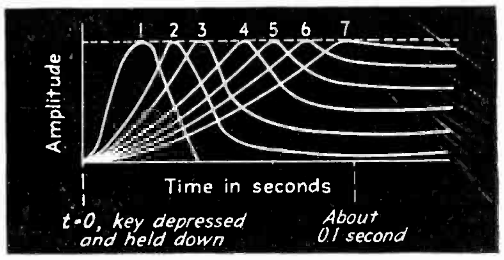


Fig. 10—Amplitude-time curves for attack switch positions

If one of the resonator circuits has its largest resistance setting and all other resistances are set at zero, then a given band of harmonics will be particularly emphasized. A setting of some resistance at the "Full Tone" will allow part of the regular output from control tubes to pass through unaltered as well as diminish the accentuation of a particular resonant frequency range by that resonator.

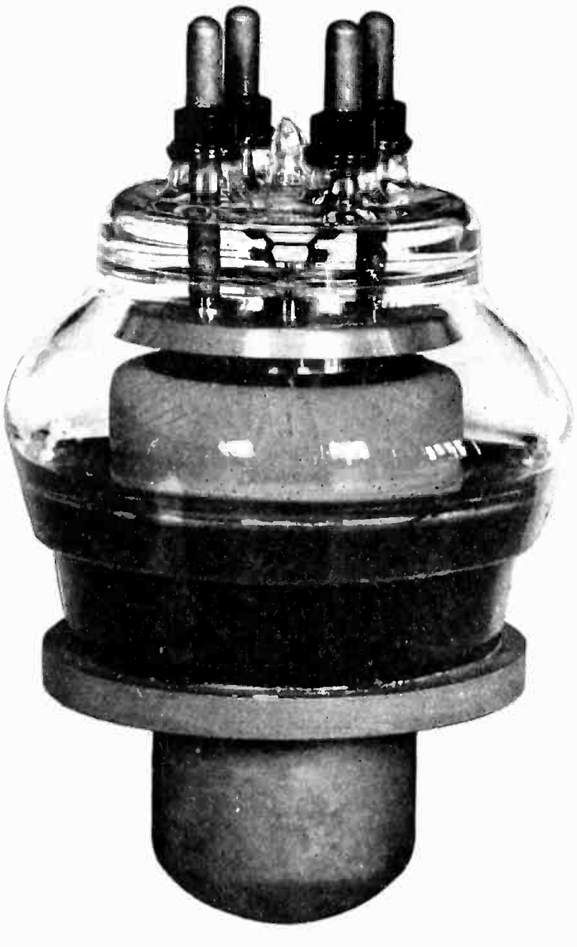
Although the keys are not touch responsive as the ordinary piano is, this is partly compensated for by the attack switch being set at position #3 or #4 to allow the tone volume from the longer held keys to

(*Continued on Page* 92)

FREQUENCY MODULATED TRANSMITTERS

Twenty-five broadcast stations are making active preparations to go on the air with frequency-modulated transmitters in the near future—and the list is growing. The equipment used, now commercially available, is here reviewed

FREQUENCY modulation has changed its status almost overnight in the minds of broadcast engineers. A few months ago, the system was discussed as an interesting and highly successful method of high fidelity broadcasting which might eventually cause a revolution in the radio industry. Then, suddenly, the interest took on a warmer tone. Now many broadcast engineers are actively considering the system as an operating reality. At the present writing there are about 25 broadcast stations who either have a frequency-modulated station in operation, have received a construction permit, or have applied for a permit, and the list is growing at the rate of two or three stations a week. There is a strong temptation to state that an avalanche of activity in frequency-modulation is now gathering momentum, and indeed every indication points to it. But predictions in the radio industry have a habit of backfiring, so we will content ourselves with a review of the facts as they exist. This review is designed especially for the broadcast engineers and operators who may now be considering applying for a f-m license and who want to know what commercial f-m transmitting equipment is in operation, how much it costs.

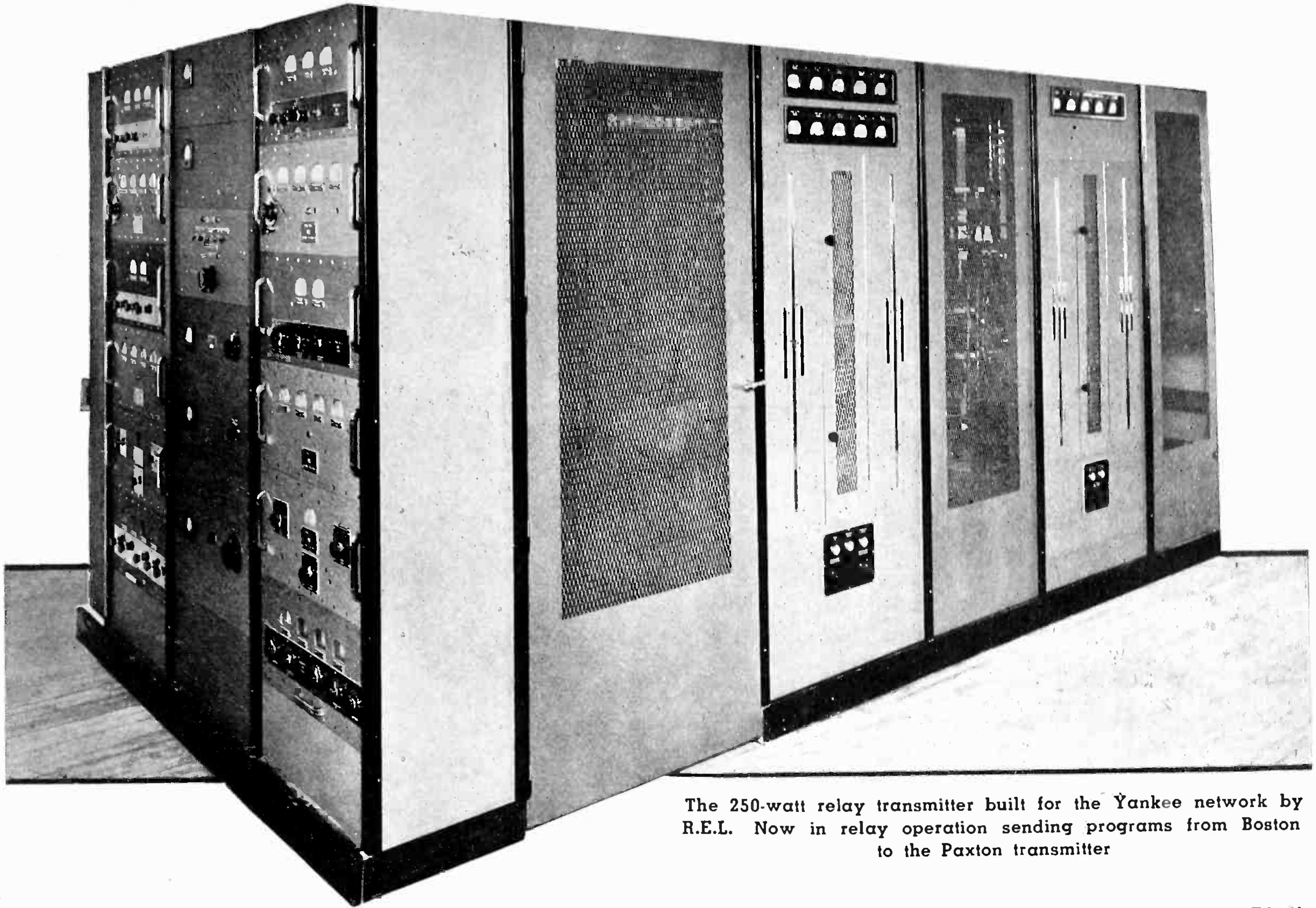


The G. E. "king's crown" tube, type GL-880, developed originally for television, now a part of G.E. f-m transmitters of over 3 kw power

As a preliminary, we can review the status of stations in operation, those in construction and those whose applications are pending. The outstanding transmitter is W2XMN, the 40 kilowatt set owned and operated by Major E. H. Armstrong at Alpine, N. J. This station is now on regular schedule with 30 kw output (40 kw occasionally) from 4 to 11 pm, except Saturdays and Sundays, with the regular programs originating from WQXR and WABC.

In power it will shortly be eclipsed by the Yankee Network Installation, W1XOJ, at Paxton, near Worcester, Massachusetts. At present this station is operating at 2 kw output, broadcasting all the regular programs of the Yankee Network on 43 Mc. Soon a 50-kw amplifier will be added to bring this installation up to its full authorized power. John Shephard, Jr. of the Yankee network has also applied for two *commercial* licenses, one for 5000 watts atop Mount Washington (altitude 6300 feet), and one for 50 kilowatts at Alpine, N. J. These non-experimental applications have not yet been acted upon, but they show the way the wind is blowing. Mr. Shephard, in his applications, states that the period of experimentation with frequency modulation is past, and the time for commercial service has come.

Experimental transmitters now in operation include 1000 watts in Washington (W3XO) operated by Jansky and Bailey. Another consulting firm, McNary and Chambers, are preparing to experiment with the system. Dr. Doolittle, owner of WDRC in Hartford, Conn. has a frequency-modulated station in operation atop the Meriden mountain. The ex-amateur W2AG (now experimental W2XCR), in Yonkers, N. Y., is on the air occasionally, usually as an adjunct to W2XMN in Alpine. A construction permit has been granted



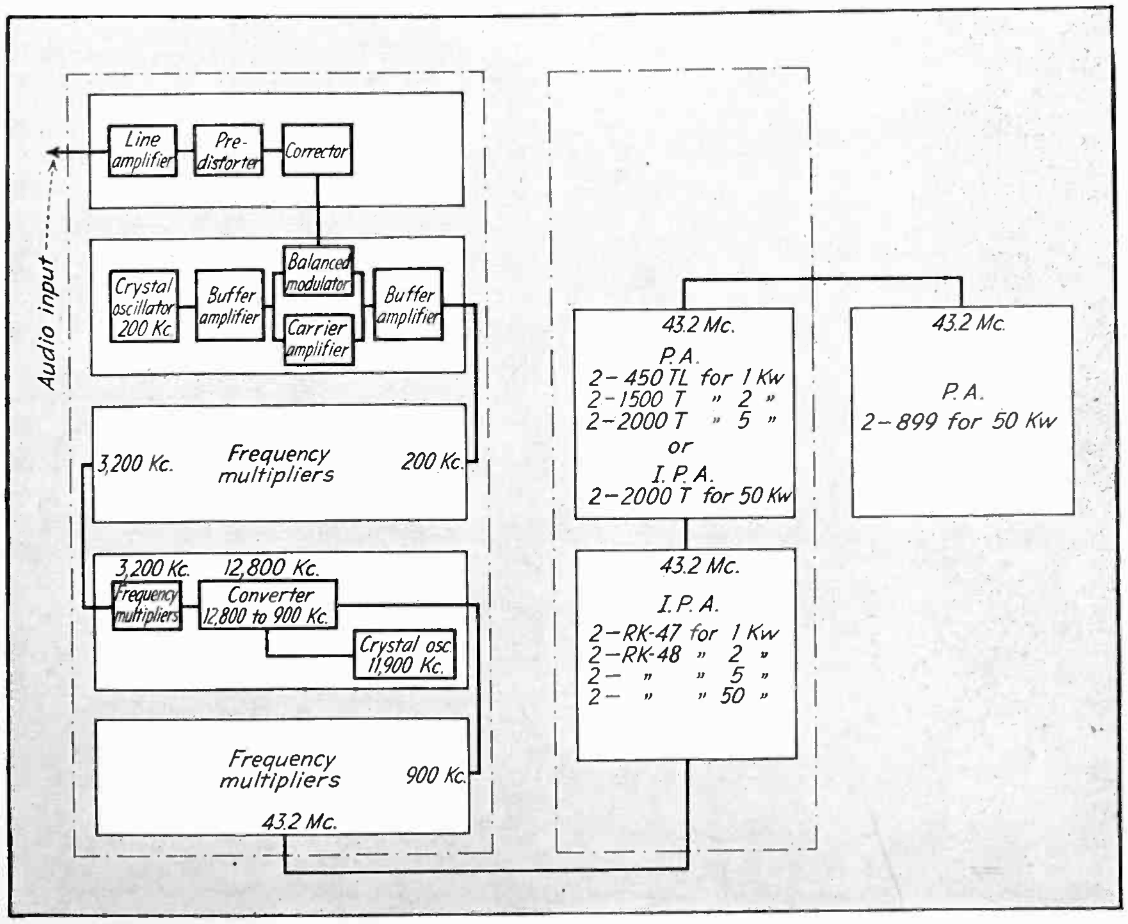
The 250-watt relay transmitter built for the Yankee network by R.E.L. Now in relay operation sending programs from Boston to the Paxton transmitter

to Stromberg-Carlson in Rochester (their 2-kw transmitter will be ready for demonstration to the engineers at the Rochester Fall Meeting, November 13–16). Other c-p applications granted are for WTMJ, Milwaukee, WHEC, Rochester, both 2 kw; WQXR, New York, 1 kw; for the Bell Telephone Laboratories, for the National Broadcasting Company, for the Mutual Broadcasting System (WOR). It was recently announced that the Columbia Broadcasting System has applied for a 50-kw authorization for New York City. WTIC in Hartford, WEBC in Duluth, Minn., WTAG in Worcester and WGAN in Portland, Maine, have permits for construction granted. WFBL, WHDH, and WHIO have applications on file. A Westinghouse station in Springfield, Mass., is in regular operation. Zenith, Chicago, has applied for a 5-kw permit. Before these words can be printed, it is safe to assume that five or ten more applications will be in.

The F-M station most truly representative of the latest practice, from the broadcast engineer's viewpoint, is the transmitter at Paxton, Mass. operated regularly by the Yankee Network. While less powerful, at present, than Major Armstrong's transmitter, it is newer equipment and most significant, it was purchased by an established broadcaster under very much the same conditions which face the rest of the industry.

The Paxton installation makes use of two F-M transmitters. The first is the relay transmitter at Boston, which shoots the programs directionally over the 45-mile path to the Paxton transmitter. The relay equipment has 250 watts power and operates on a center frequency of 133 Mc. The complete relay system is flat, so far as the audio system goes from 30 to 15,000 cps within 1.0 db, and the noise at all times is –65 to –70 db, Distortion at maximum modulation at the low frequencies is measured under one per cent. The claim of the engineering is that this relay system does a better job than a wire line could possibly do, and at considerably less expense. The relay transmitter has two complete modulators, with a change-over switch between them. In the event of failure the switch may be flipped from one modulator to the other in less

Block diagram of the Armstrong circuit as applied in the R.E.L. equipments from 1 kw to 50 kw output. The 50-kw version is scheduled for early installation at Paxton, Mass.



than a second's time. Thus far in the several months since the station went on the air, this change from one modulator to the other has never been required, but has been carried out to permit checking and maintenance of both units. The transmitting antenna at the Boston end is 4-bays of three elements each, (reflector, radiator, director) horizontally polarized. The receiving antenna is a double V, one V above the other, with reflectors spaced 0.1 wavelength behind each. The length of each leg of the V is about 10 wavelengths. The efficiency of the directive system is such that the final amplifier of the transmitter may be disconnected without observable decrease in the signal-to-noise ratio. Likewise a failure of the V receiving antenna does not interrupt the service.

The transmitting equipment at Paxton is very similar to that of the relay transmitter, so far as the modulating equipment is concerned, but the r-f stages operate at 43 Mc, and the final power output is now 2 kw. The audio input (applied at 0 db) is first put through the predistorter and corrector amplifiers, which employ receiving type tubes. This function is carried out in the uppermost panel of the modulator rack, and takes a total of seven tubes. The audio is then applied to the balanced modulator in the second panel which applies the audio to the output of the 200 kc crystal and buffer stage in such a way that the phase of the output of the modulator shifts by a maximum phase angle of 30 degrees, at the audio frequency rate. Thereafter, this signal with its varying phase shift is multiplied in frequency a total of approximately 3000 times. This seems like a tremendous amount of frequency-multiplication, and judged by ordinary standards it is a very large amount. Nevertheless a multiplication of 1000 times is carried out in but three panels, all of which employ receiving tubes, except the last which employs 807 beam power tubes. In the Paxton transmitter, the 807's operate at one third the carrier frequency but in later models of the same equipment, the full carrier frequency is attained in the 807 stage. In the Paxton transmitter, the modulator output, at one third the final frequency, is fed first to a pair of 807's then a pair of RK-48's and then to a power tripler stage, which produces the carrier frequency in a pair of 1500T tubes and gives a two or three times power gain at the same time. The final amplifier is also a pair of 1500T's. The antenna is a 4-bay turnstile mounted on the top of Mount Asnebumskit, at a total elevation of about 1400 feet above sea level. Signals from this station are received regularly at New York, over a distance of roughly 150 miles. In Boston, at a distance of 45 miles, the signals are so strong as to provide a better service, hour by hour, than that offered by the local Boston stations. When the 50 kw amplifier is added, it is expected that an equally excellent signal will be available in New York, although at present the New York reception does not constitute a regular high fidelity service because of occasional fading and an inadequate signal-to-noise ratio.

Commercially Available Transmitters

At present three names are associated with the development and manufacture of frequency-modulated transmitters. Westinghouse is building a form of frequency modulated transmitter for their own stations W1XFN at Springfield and W1XKA at Boston and Pittsburgh. It is anticipated that possibly at a later date, Westinghouse may offer commercial equipment for sale.

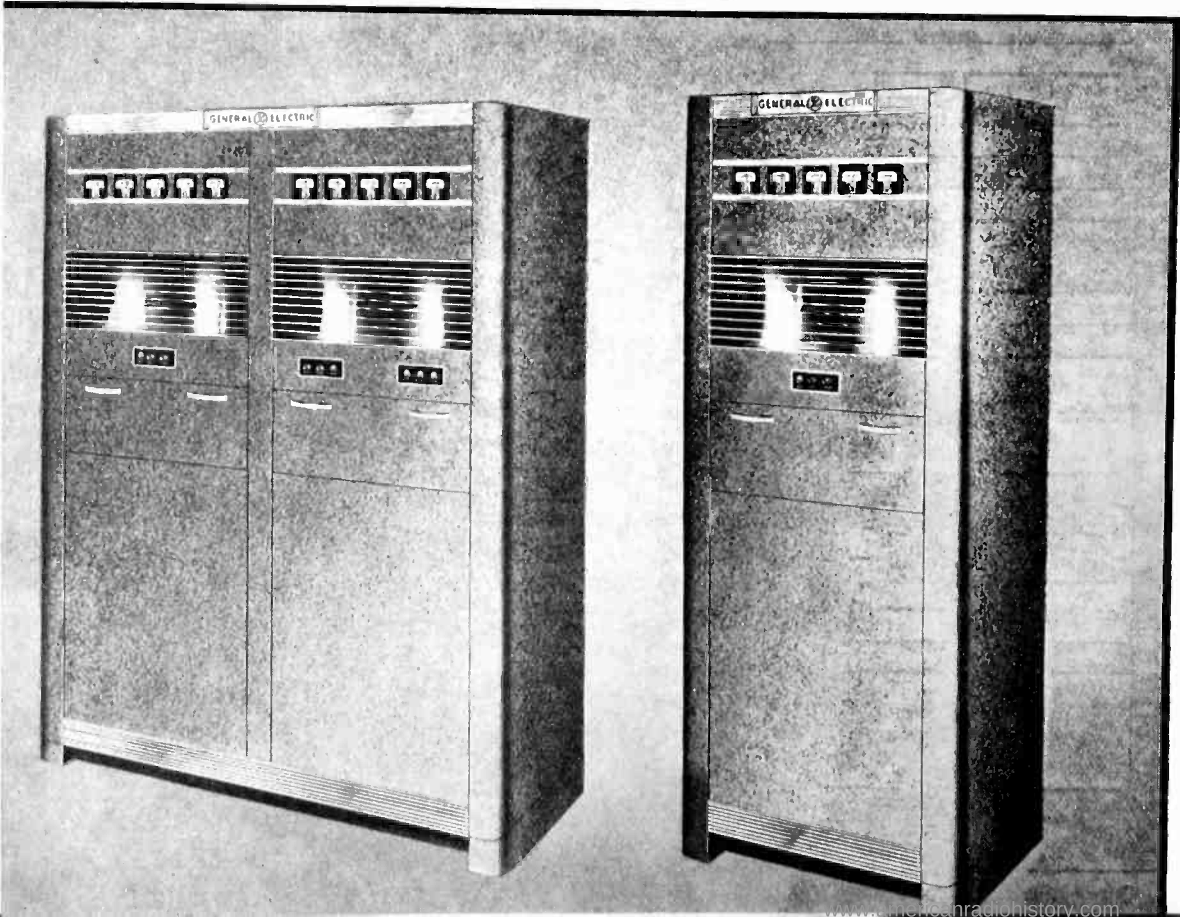
The General Electric Company, which has been cooperating with Major Armstrong in F-M developments for several years, offers a series of five transmitters. The smallest, 250 watts output, is complete in itself but is intended also for use as a driver stage for higher powers. Designs have been completed for 1-, 3-, 10- and 50-kw frequency-modulated amplifiers. Descriptive specification for all these units are now available.

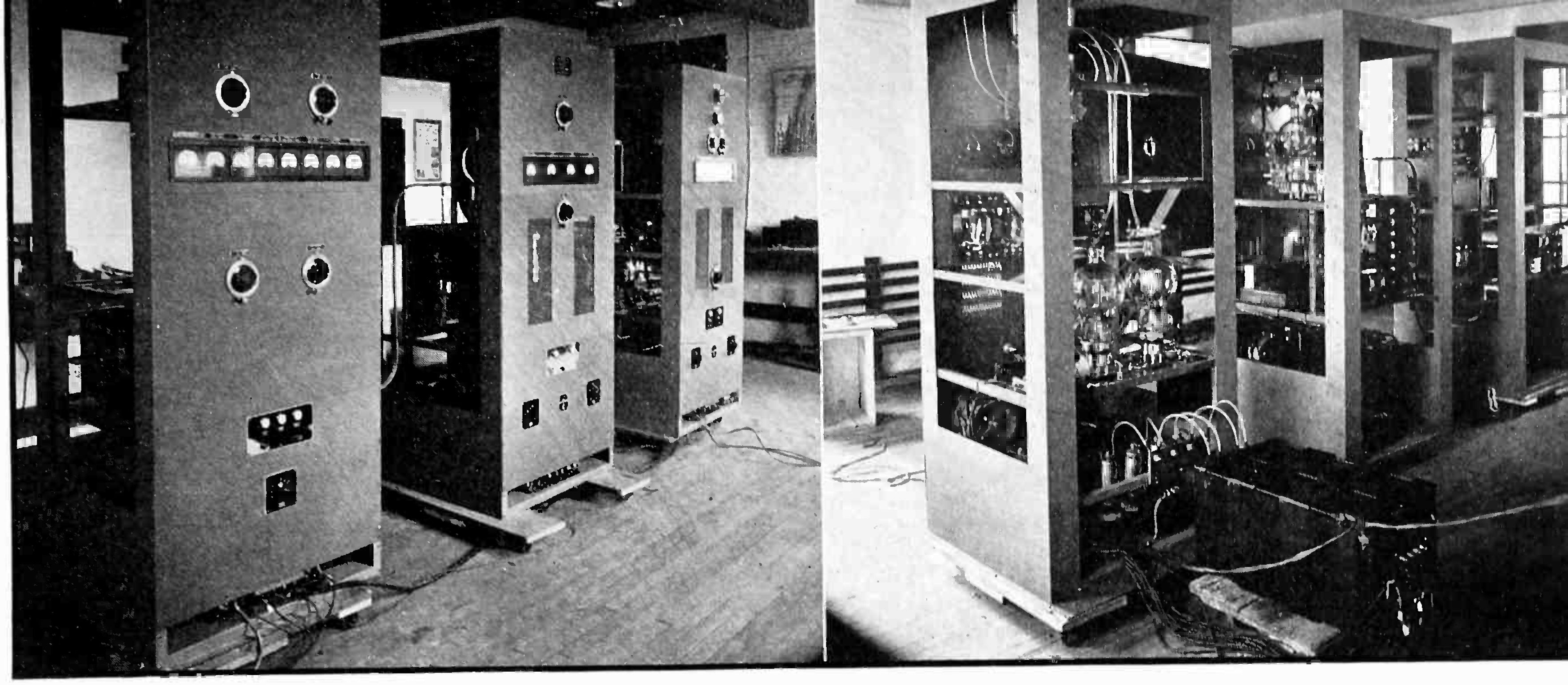
The G. E. transmitters differ somewhat from the Armstrong method of obtaining frequency modulation in that they employ the so-called "Crosby" circuit. A single crystal is used as the frequency determining source. Feedback is used for stabilization, and reactance-tube modulation is used, which results in a material reduction in the number of tubes required in the modulator. Engineering reports indicate that high fidelity, low distortion characterize the new transmitters, and that their operation is simple, economical and reliable.

In the power amplifiers of 3 kw power and higher, the new 880 "king's crown" tube is used. This tube was originally designed for television service, and proved to have many advantages in u-h-f service. It is a water-cooled triode with a reëntrant anode shell which reduces the electrode length without reducing the cooling surface.

General Electric is now building a high power F-M station near the site of their television transmitter on the Helderberg mountains near Schenectady. The relay channel for the television sound is also operated

Two General Electric transmitters. On the right is the 250-watt modulator-exciter which can act as a low-power transmitter, or, as shown at left, as an exciter for a 1-kw amplifier





The 2-kw Yankee Network equipment now operating regularly from Paxton, near Worcester, Mass., as it appeared when on test in the R.E.L. plant. The addition of a 50-kw class-C amplifier will shortly increase the power to 50 kw

on a low-power directional F-M system.

The third name in the commercial picture is the Radio Engineering Laboratories in Long Island City, N. Y. This concern built the modulator and all the amplifier stages, except the final, for Major Armstrong's Alpine station, and they are also responsible for the relay and main transmitters at the Paxton location.

The R.E.L. line includes the basic modulator with 10 watts output at carrier frequency (this power output is not intended for actual transmissions, although the modulator is in itself a complete low-power F-M transmitter). The amplifiers available are of 1-, 2-, 3-, 5- and 50-kw rated output.

The stage line-up for the R.E.L. transmitters is shown in the accompanying block diagram. The modulator is quite similar to that described above (the Paxton transmitter) but the output, instead of being at one-third the carrier frequency, is at the carrier frequency itself. The final stage in the modulator is a pair of 807 beam power tubes, all other tubes in the set-up being receiving type tubes.

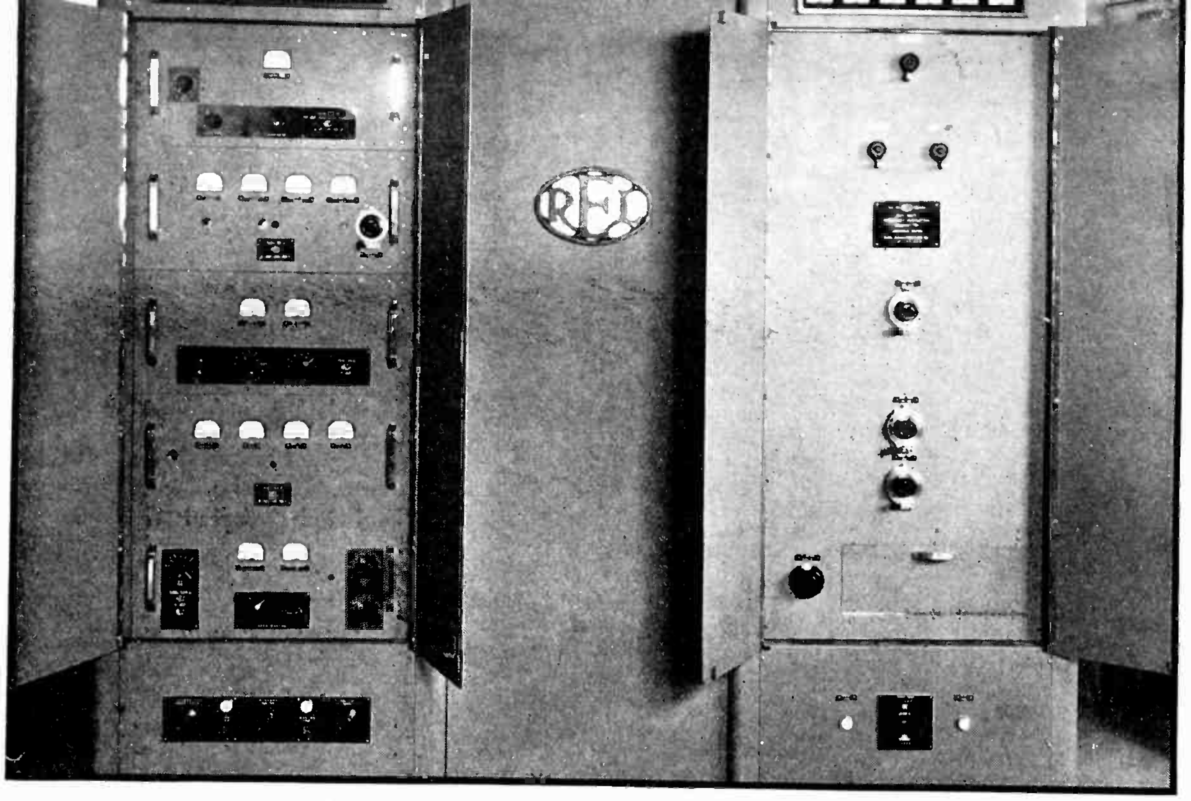
The power amplifiers for 1-kw service make use of a pair of RK-47 tubes in class C "telegraph" service which drive a pair of 450TL tubes in the output stage. The power supply for this transmitter is included in the cabinet with the amplifiers. The 2-, 3-kw outfits make use of a pair of RK-48's in the driver stage, and a pair of 1500T's in the final out-put. The 5-kw final uses 2000T's. The main difference for the various powers is in the power supply. The 50-kw amplifier employs a pair of 899 tubes (formerly called AW-200 tubes) which are of the conventional water-cooled variety, having a conventional anode shell but adapted to u-h-f service. These tubes form the final stage of the Alpine transmitter.

Several of the operating characteristics of these transmitters are of interest. All the small receiving tubes in the modulator unit are operated at 180 volts, whereas the maximum tube ratings are 250 volts or more. The 807 output stage of the modulator operates at 350 volts (maximum tube rating of 600 volts), Hence the tube economy is high, and failures are so rare that they can be readily circumvented by periodic checking. The total frequency multiplication in the modulator unit is of the order of 3000 times (from 200 kc to about 43 Mc with one intermediate frequency conversion downward). The final amplifiers, in the 1-, 2-, 3-, and 5-kw equipment, have plate efficiencies of the order of 60 to 70 per cent. The total frequency swing for 100 per cent modulation is about 150 kc, 75 kc each side of the center frequency.

Power and Price

Most of the present FCC authorizations for F-M service call for power of one or two kilowatts, with a few permits and one or two applications for 50 kw. The prices of transmitter, complete with power supply, tubes and crystal controls, but no site, building, antenna or installation are roughly $8000 to $10,000 for a 1-kw transmitter to $65,000 to $85,000 for a 50-kw equipment, with intermediate powers in rough proportion. For the low power equipment (below 1 kw) the principal item of cost is for the modulator, but at high power, the cost is taken up almost entirely with the high power tubes, circuits and power supplies. Corresponding prices for amplitude modulation equipment of 50-kw carrier power for the b-c band are roughly 25 to 35 per cent higher. Thus far no one has built a 50-kw a-m transmitter for the u-h-f bands, but its cost would certainly be very much more.

One of the interesting aspects of the power problem is the ease with which power may be increased or decreased when special conditions arise. One such condition is the forming of ice on antennas and feeders. In the high and exposed locations where F-M transmitters are usually located, the icing conditions may be very severe. Feeder systems which have been trimmed up to eliminate standing waves under normal conditions may show a considerable increase in the standing wave amplitude when ice begins to form. In that case the power of the transmitter may be reduced temporarily to whatever level is necessary to protect the feeder and antenna from the voltage peaks set up by the standing waves. Power reduction in a-m equipment involves reducing the modulator level simultaneously with the r-f level, but in



R.E.L. 2-kw transmitter, similar in appearance to the 1-kw and 5-kw outfits. The modulator at the left develops the carrier frequency at 10 watts, while two class-C stages at the right feed the antenna

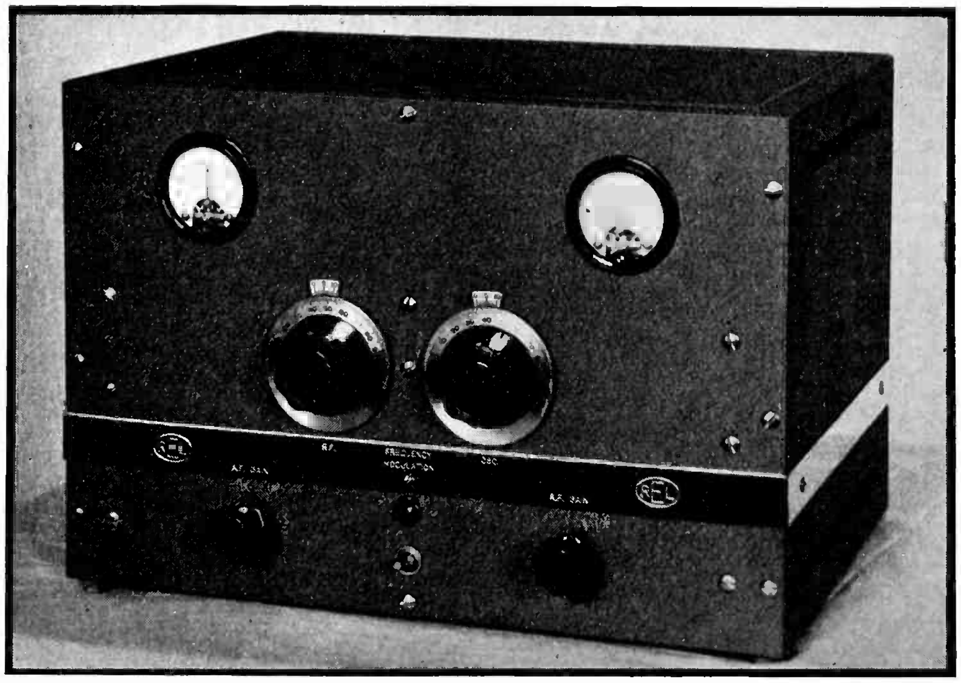
f-m it is only necessary to reduce the plate voltage on the final r-f amplifier. Such reduction of power does temporarily reduce the quality of the transmissions at the fringes of the service area, but the effect on the bulk of the audience will go entirely unnoticed until conditions permit the power to be raised to its normal level. This simple adjustment of plate voltage is characteristic of the ease with which the class C amplifiers may be controlled, and is indicative also of the reliability and simplicity of class C operation. Broadcast operators in general (unless they happen to be hams with straight telegraph equipment of high power) are not familiar with the day-in day-out workability of the constant-level class C amplifier since this mode of operation has no use in a-m practice.

Raising the power is similarly simple. Tubes and power supplies will take plenty of load when not subjected to peaks of power, so that air-cooled tubes can be used, even at 40 Mc, for power levels up to 10 kw. But of even greater significance from the long-range point of view is the ease with which higher power stages can be added to existing equipment. Both manufacturers now offering commercial equipment have so designed their units that additional amplifiers may be added with a minimum of changes, and with practically no detriment to the appearance of the equipment. Thus many of the present f-m broadcasters have bought 2 or 3-kw transmitters, even though their construction permit calls only for 1 kw, in anticipation of operating the equipment at 1 kw output until conditions warrant higher power and the permit to use it is obtained. A 2 kw final amplifier makes an excellent driver for a 50 kw stage, if the latter should be added at a later date. Thus the present investment in equipment is not lost in the event that higher power becomes the rule on the F-M channels.

Monitoring equipment is available for use with each of the transmitters described above. A typical unit made by R.E.L. is a 10-tube receiver which tunes through the range from 40 to 44 Mc, and which has a pair of 6V6 beam power tubes in the audio output.

Receivers intended for the home, while not of direct concern to the broadcast engineer, are of general interest to all those of the radio fraternity who may desire to check the new system for themselves. Besides the R.E.L. monitor model which sells for $120 (speaker column $75), the General Electric and Stromberg-Carlson lines for 1940 contain receivers of several types. A G.E. 8-tube table model receiver for a price of about $60, contains circuits for F-M only, has an intermediate value of sensitivity, and adequate, but not elaborate audio equipment (five watts output). A similar "F-M only" receiver is available also in a console. The most elaborate receiver is a 13-tube outfit providing reception on both f-m and a-m with 20 watts audio output.

The Stromberg-Carlson line includes a table model for about $60 which includes F-M only, which is equipped with a high-frequency tweeter speaker. The low-frequency output is fed to the phonograph input jack of any standard broadcast receiver. This receiver comes close to being a "frequency-modulation attachment" despite the fact that it is a complete receiver. Two more elaborate models containing a-m as well as f-m circuits are also available in the Stromberg-Carlson line. One is a medium-priced console model, the other a more elaborate console with an acoustic labyrinth.
—D.G.F.



10-tube f-m monitor receiver furnished by R.E.L. for general service in conjunction with their transmitters. The r-f sensitivity is 10 microvolts

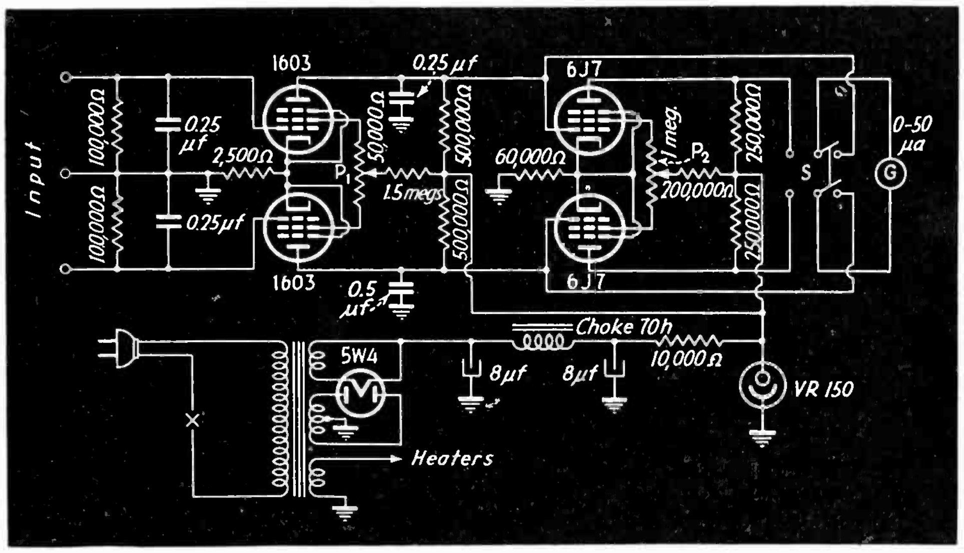
A Direct Reading Vacuum Tube Millivoltmeter

Investigation in the field of bio-electronics has led to the development of the instrument described herein whose stability is of a high order and which with few changes may be adapted to other applications involving the measurement of small voltages

By WALTER LYONS and RICHARD E. HELLER

Michael Reese and Chicago Memorial Hospitals, Chicago

THE greatly increased interest in recent years in the measurement of electric potentials in biological systems has resulted in the development by the authors of a direct current vacuum tube millivoltmeter which is stable, sensitive, portable and of moderate cost. It is of interest to the electronics engineers because of its applications to other branches of endeavor. For instance, by making minor changes in the circuit, it may be used as the direct current amplifier in oscillographic studies.



Circuit diagram of the vacuum tube millivoltmeter. The push-pull circuit arrangement contributes to the stability of the instrument

Such studies as those mentioned in the bibliography have involved the use of rather cumbersome equipment which is expensive and not readily adaptable to measurements of potentials developed in the human body. The instrument used is of the vacuum tube potentiometer type, a stable and delicate instrument for measuring minute voltages. In the past, vacuum tube voltmeters of such sensitivity have been unstable because of the difficulty of establishing a constant zero base line. This difficulty is due to two major factors: (1) Variations in the degree of amplification due to changes within the elements of the circuit i.e., tubes and resistors, and (2) variations in the supply voltages. Therefore the design of an instrument which approximates the potentiometer in stability and sensitivity involves the development of a stable circuit and of a nearly constant power supply. Buchtal and Nielsen (see bibliography) have designed a stable amplifier, but of limited range and powered with a large number of dry cell batteries. This instrument uses many stages, each one of low amplification and each stage is individually shielded.

The diagram shows the circuit of the direct reading vacuum tube volt meter designed especially for the measurement of bio-potentials and which will operate from a 110-volt a-c power line. As may be seen readily from a cursory examination of the disposition of the circuit elements, the inherent stability is of a high order. This is due to the push-pull circuit which is used. Electrodes are connected to the input grids of two pentode amplifiers. The output circuits of these tubes produce potential changes across their respective loads 180 degrees out of phase, one from the other. Hence, any plate supply voltage variation will be nullified very nearly, since both plates will follow the voltage change to nearly the same degree and thus have little effect upon the recording instrument. In addition, the amplification of pentode valves varies insignificantly with plate supply potentials. However, the amplification changes markedly with a variation in screen supply voltage. This undesirable characteristic is removed by the push-pull arrangement since both screen grids, varying with a changing supply voltage, will produce amplified signals in their respective plate circuits in phase. Therefore, no deflection on the galvanometer which is connected from plate to plate will occur if both tubes produce the same degree of amplification.

Variations in the a-c line voltage cause filament current fluctuations which, if of considerable magnitude, will cause slow oscillations of the recording device. This oscillatory motion is ordinarily very slow due to the thermal inertia of the cathode emitter of the modern heater type of tube. However, if it is objectionable, it may be eliminated by drawing the filament current from a separate 6.5 volt compensated trans-

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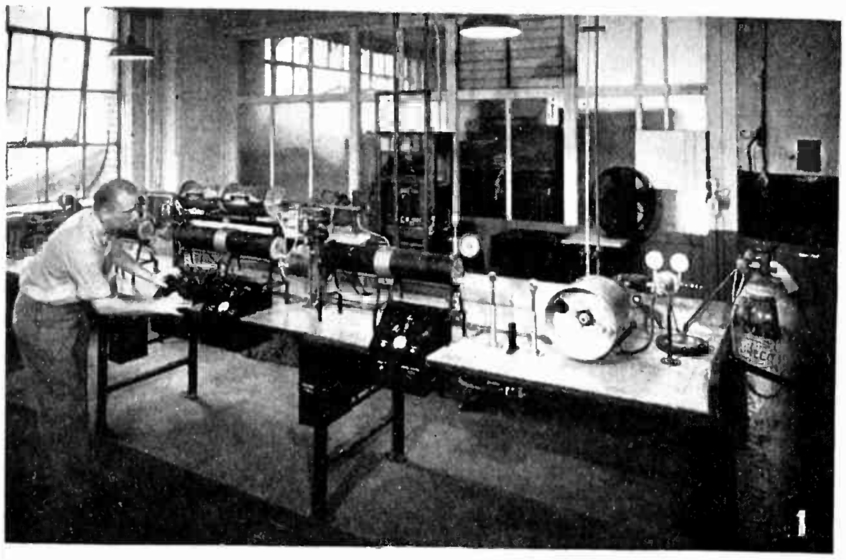
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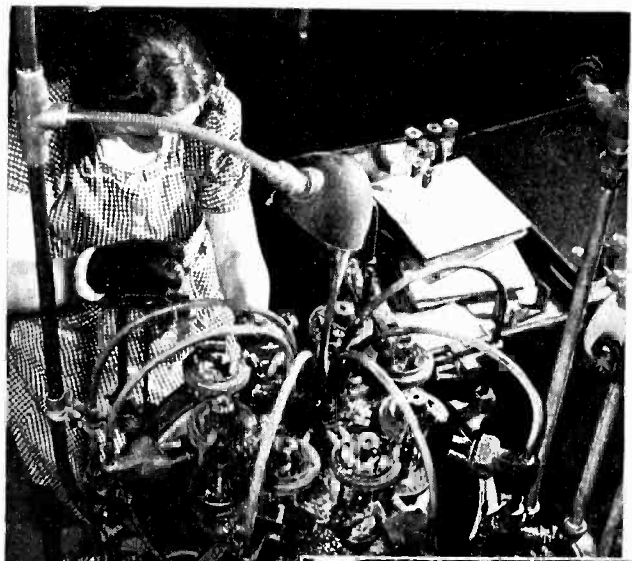
TUBE LIFE: 75,000 HOURS

The new Western Electric type 102F triode repeater tube has a life expectancy of eight and one-half years, continuous operation. Careful manufacture and conservative operation contribute to this phenomenal length of service, perhaps the longest life of any commercial electronic device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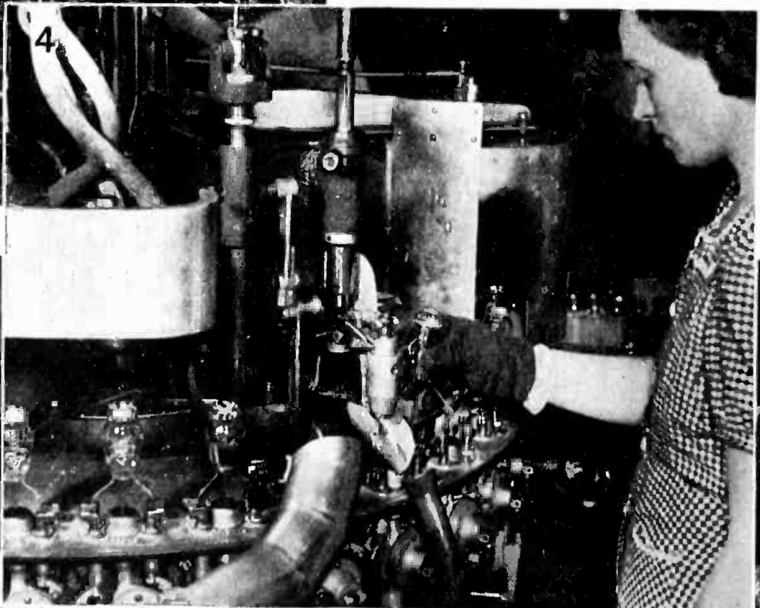
1. The filament coating machine at the Western Electric tube shop. Exact control of this process is necessary to insure long tube life. The filament operates at 2.1 volts, 0.5 ampere
2. Each operator is a master of the entire tube mounting process, rather than of a single operation as is customary in commercial receiving tube manufacture. Here filament, grid, and plate are assembled and welded
3. The tube mount is sealed in to the envelope, a separate operation from the exhaust process. In contrast, sealing-in and exhausting are carried out in one machine in high-speed production of receiver tubes
4. The exhaust machine was designed by Western Electric engineers especially for the purpose. Careful and prolonged bombarding and outgassing eliminate gas which would reduce the tube life
5. The tube base is little different from that of the repeater tubes placed in service twenty years ago. Special alloy tips on the pins require a nice soldering technique
6. Testing for filament activity, filament voltage, impedance, plate current, and grid insulation is performed on each tube, followed by elaborate spot-testing of sample tubes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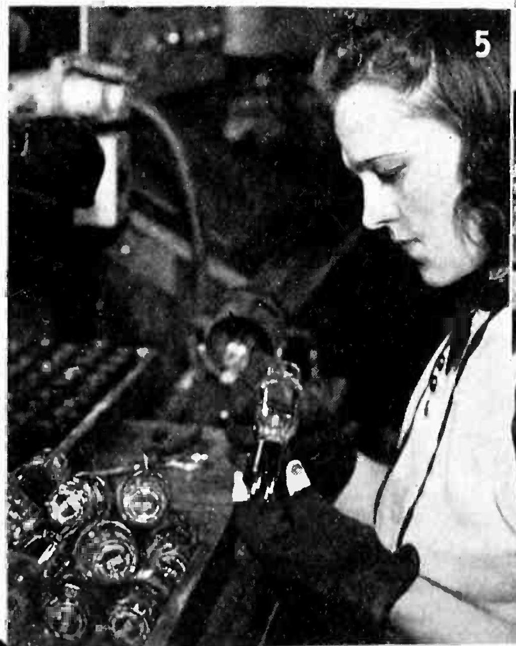
THE COVER: The tubes are aged for 16 hours. The cover shows 300 tubes on the aging rack. If placed in service consecutively, the life of the tubes in this rack would extend back to the founding of Rome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MINIATURE BATTERY TUBES

The great success of the battery portable set has prompted improved methods looking toward lighter sets and lower battery drain. Four small and efficient tubes, a converter, r-f pentode, diode-pentode, and output pentode, are now available for use at 45 volts B supply

By **KENNETH G. BUCKLIN**

RCA Mfg. Co., Harrison, N. J.

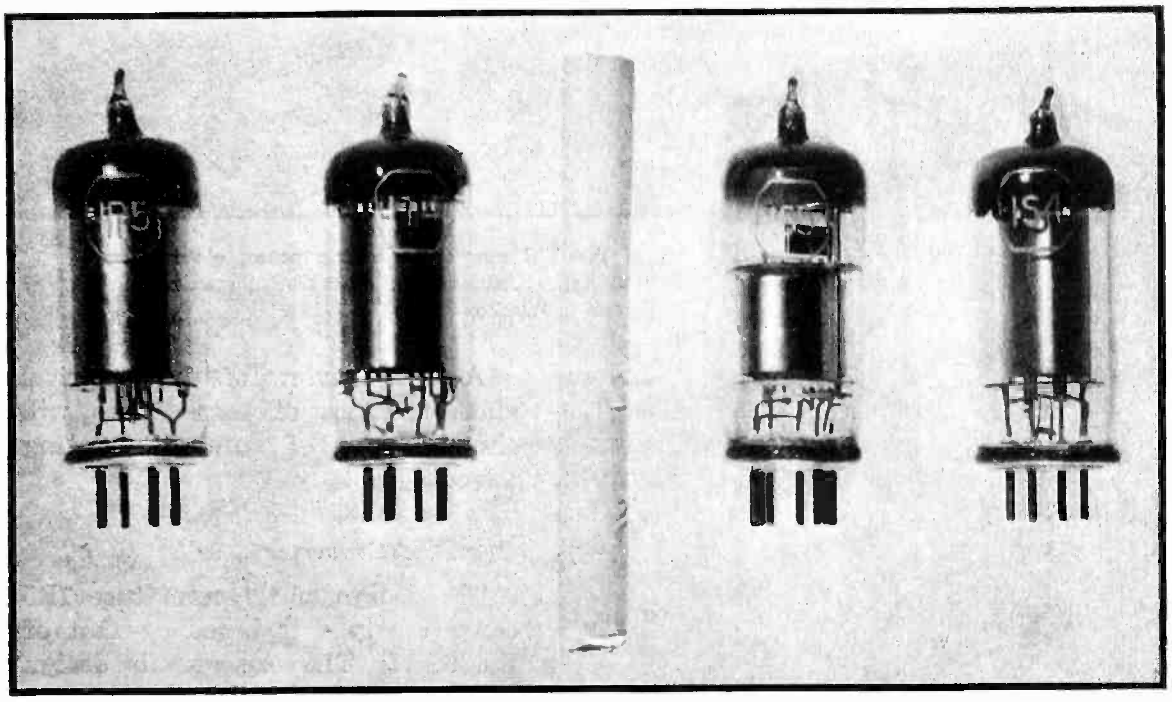


Fig. 1—The four new tubes reproduced life size in comparison with a cigarette. The lead wires serve as base pins

BECAUSE of the popularity of midget receivers, there has been during the last few years a gradual reduction in tube size. However, it is in portable sets that small tubes appear to have particular advantage. The advent of the 1.4-volt battery tubes has made it possible to produce portable sets which are both efficient and economical in operation. With the intention of making possible further reduction in the weight and size of these receivers the RCA Mfg. Co. has developed four "miniature" tubes very small in size and highly efficient in operation with a 45-volt B supply.

These new tubes include a converter, radio-frequency pentode, diode audio-frequency pentode and power output pentode, and provide a complete complement for receiver design. This article describes the physical characteristics of these tubes and briefly covers the electrical features of each type.

A requisite for the success of new tubes intended for radio use is that their cost must not be out of line with comparable tubes already available. A curve of cost versus tube size shows that tube cost drops appreciably with decrease in bulb size from ST-16 (2-inch diameter) or ST-14 to the T-9 (1⅛ inch diameter) bulb in widespread use today. This decrease is due largely to more economical use of material. If, however, a further reduction in tube size requires closer spacings between electrodes, assembly difficulties caused by increased trouble with shorts and by greater percentage variation in alignment during processing will increase tube cost faster than material economies reduce it. The acorn tube because of its special ultra high-frequency requirements is an example of reduction in size leading to an inherently costly design. For this reason it cannot be expected to enjoy widespread use in conventional radio receivers.

The design of the new miniature tubes has been chosen to retain most of the economical manufacturing advantages of conventional tubes and at the same time to make possible tubes occupying a minimum of space.

A comparison of volume discloses that a tube of the new design occupies only about one-fifth as much space as the smallest conventional type, represented by the GT line. Figure 1 shows the miniature tubes, their size indicated by a cigarette. The diameter is slightly under three quarters of an inch and the overall length is less than 2⅛ inches. No base is used, but instead 0.040″ wires from the seal serve as pin connections to the socket. The stem, as shown in Fig. 2, is similar to the button stem which has been used in metal tubes for some years. The seven leads are arranged in a circle, with an eighth lead omitted to provide for base orientation. A feature of this button type of seal is that it requires only about ⅛″ space from the top of the base pins to the electrode leads inside the tube. The leads within the tube are reduced in diameter, to facilitate forming them by machine for proper connection to the tube electrodes. The exhaust tube is located at the top of the bulb. All of the types are of the single-ended construction; i.e., no top cap connection is used.

The grid and plate structures are identical in length to those of conventional 1.4-volt battery tubes. As a result, the same span of filament is available to provide comparable emission area. The reduction in

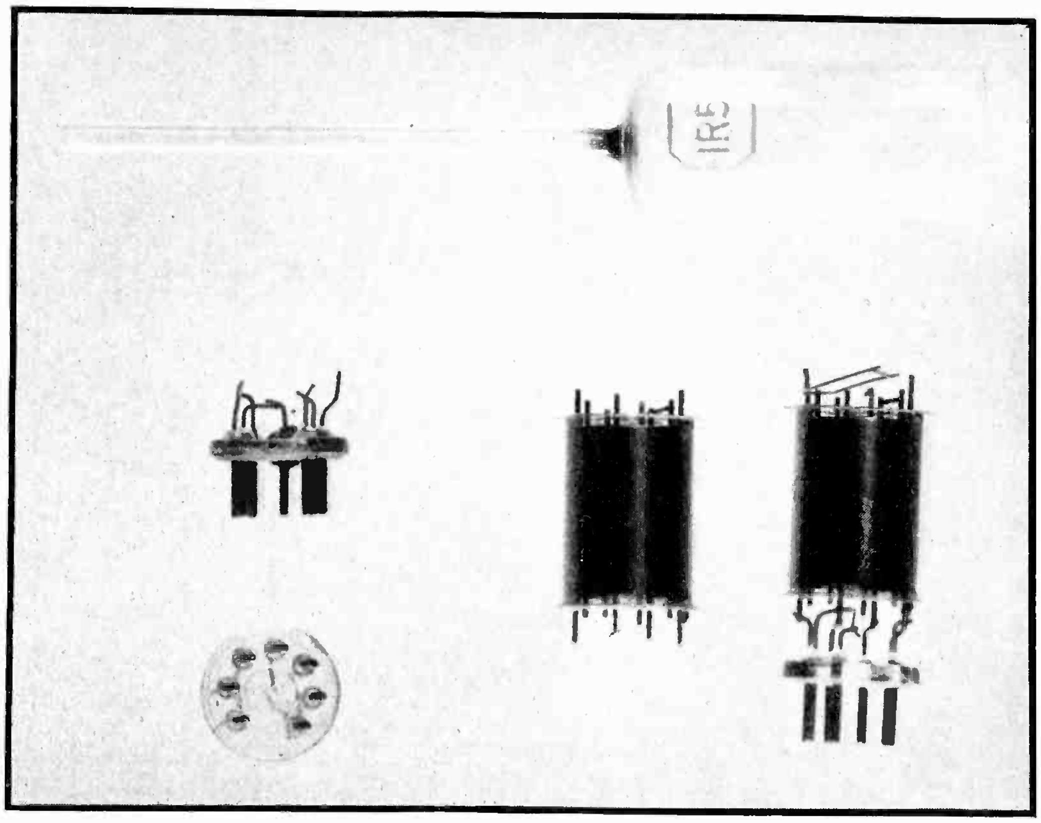


Fig. 2—Component parts of the 1R5 converter: button press, elements and completely assembled mount. Minimum use of material results in lowered production costs

tube length, therefore, is due entirely to the compact method employed to make connections from the electrodes to the socket terminals. Since the filament length is unchanged, the spacing from filament to control grid can be maintained the same as that of conventional types and, as a result, the same efficiencies of operation can be obtained. In general, the grids have conventional dimensions. The plates, however, occupy considerably less space, and therefore make possible the large reduction in bulb diameter.

These new tubes use the pins on each side of the missing eighth pin for their filament connections. The negative filament, pin No. 1, has tied to it suppressor grids and whatever shielding is incorporated in the tubes. Pin No. 1, therefore, is intended to be the ground connection. Pin No. 7 goes to the positive filament.

For portable radios reduction of the space and weight of the plate supply battery is important. To make this reduction practical, the miniature tubes have been designed especially for efficient operation at 45 volts. They may, of course, be operated at higher voltage with a corresponding improvement in performance, but their performance at 45 volts far exceeds that obtainable with conventional types. With the exception of the output tube, which contains two filaments in parallel, the new tubes have a filament rating of 50 milliamperes at 1.4 volts.

A brief review of the electrical characteristics of these tubes will show some of their operating advantages.

Type 1R5 Converter

The design of the miniature 1R5 converter type is based on that of the 6SA7. The use of this design principle provides much better performance at low plate voltage than any conventional pentagrid converter designed for the same low voltage. The 1R5 has a remote cut-off voltage of —9 volts and an improved oscillator transconductance of 1200 micromhos. At 45 volts, it is superior in performance to hitherto available battery type converters operated at 90 volts. This improved performance is obtained with a 50 milliampere filament and no increase in B-battery drain. The high oscillator transconductance is of especial value for short-wave reception.

Type 1T4 R-F Pentode

Internal shielding is incorporated in the 1T4 so that a bulb shield is not required. The grid-to-plate capacitance is less than .01 μμf when the tube is used with a shielded socket. The 1T4 has a remote cut-off characteristic to provide optimum performance with automatic volume control if desired for this stage. The cut-off value matches that of the converter. The transconductance at zero bias is 650 micromhos with a plate current of 1.9 milliamperes.

Type 1S5 Diode Pentode

Consideration was given to the design of a diode triode, but the higher gain which can be obtained from a pentode at low B-supply voltage was an important advantage. The 1S5 will give about three times as much amplification as can be obtained with a triode designed to give ample output voltage for the grid of the power tube at the end of life point of 45-volt battery. Electron coupling and capacitance coupling between the diode and pentode sections have been kept at a minimum.

Type 1S4 Power Output Pentode

Although the other tubes are intended for operation at zero bias, a bias is necessary for satisfactory operation of a power output pentode. Since the bias required subtracts from the available plate supply voltage, every volt used on the grid is important when the supply is limited to 45 volts. At the same time the plate current must be kept low for good battery life. These requirements call for a tube of high efficiency and good power sensitivity. The 1S4, when operating on self-bias at a bias equivalent to —4 volts, gives a power output of 50 milliwatts, with only 3.5 milliamperes plate current.

Typical Receiver Performance

The following table shows the gains which have been obtained in a typical four tube receiver with a plate supply of 45 volts, at a total drain of 7.5 milliamperes.

Tube Number	Tube Type	Gain per Stage
1R5	Converter	25
1T4	I-f amplifier	60
1S5	A-f amplifier	35
1S4	Power amplifier	50 mw at 10% distortion

To enumerate the possible applications of the miniature battery tubes would require too much space in this article. Many, such as hearing aids, meteorological work, portable sets for policemen, firemen, as well as general public will occur to the reader. With expansion of these applications, many of the component parts of the receivers will undoubtedly be reduced in size to take full advantage of the small dimensions of the miniature tubes.

High Frequency Pre-Emphasis

Reduction of noise and distortion result when the high audio frequencies are emphasized at the transmitter and correspondingly attenuated at the receiver. Results of recent NBC tests which led to the adoption of pre-emphasis as standard for television sound

By **J. L. HATHAWAY**

Development Laboratory,
National Broadcasting Company

BACKGROUND noise has been and will continue to be a major problem in radio broadcasting since it determines the service limits on all transmitters. High power, high modulation, volume compression, circuit polarization, special antennas and receivers have all been developed to push noise down. Frequency modulation also has been found useful in combating noise, especially when the received interference voltage is somewhat below that of the desired signal voltage.

A system is now coming into use whereby substantial reduction of background noise is achieved with little complication, by the simple expedient of pre-emphasizing the high audio frequencies at the transmitter and compensating in the receiver. This is applicable to both amplitude and frequency modulation and involves such minor differences from the normal present day system and yet offers such definite advantages that it should be fully and carefully considered for use, wherever possible, especially in sound broadcasting on ultra high frequencies. A standard for such pre-emphasized transmitting and receiving has been adopted for television sound by the RMA. The system also appears to have some advantage in the standard broadcast band and may even be useful in video transmission. Electrical transcriptions utilizing this system have been found vastly superior to the conventional. Pre-emphasis methods have been adopted

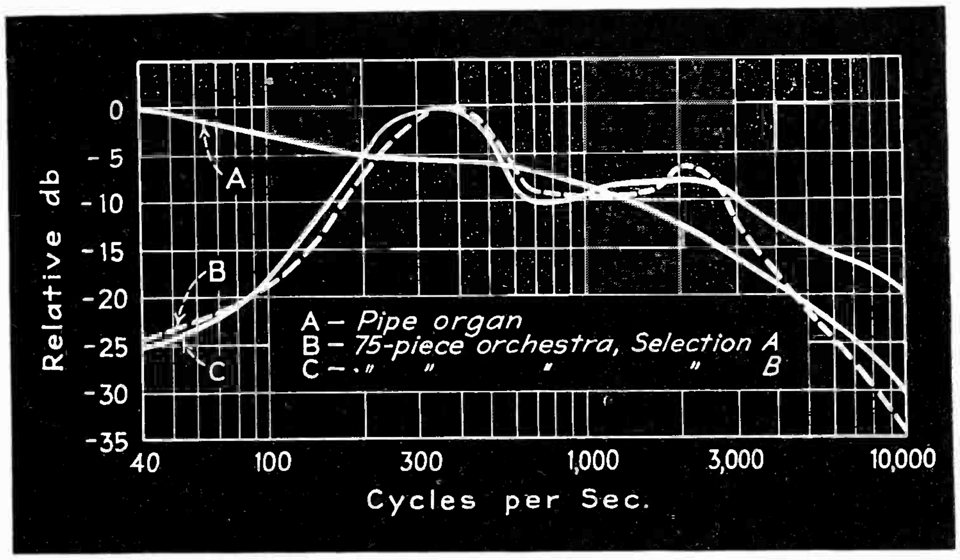


Fig. 1—Peak energy per increment of frequency measured in typical programs involving a pipe organ and a 75-piece orchestra

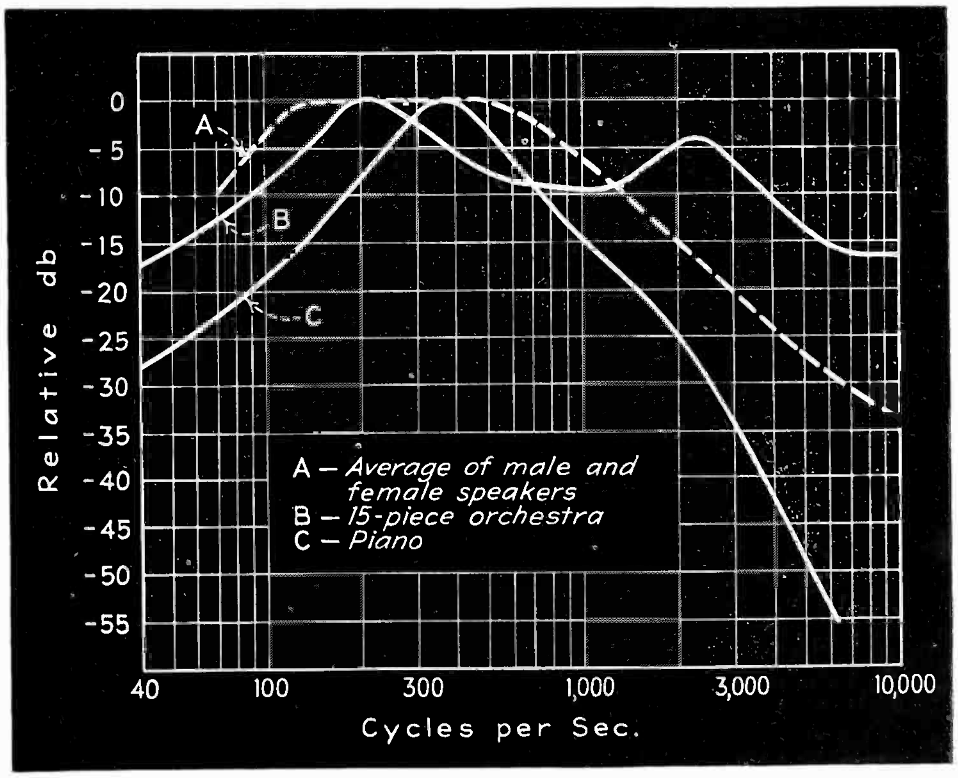


Fig. 2—Energy-frequency relationships displayed by male and female speakers, a small orchestra, and a piano. All except the orchestra show a pronounced decrease in energy at high frequencies

in the newly-developed RCA-NBC Orthacoustic transcriptions.

Previous Tests

Advantages in reduction of noise level and distortion by means of pre-emphasis were demonstrated in the National Broadcasting Laboratory in 1931 but because of apparatus difficulties and the narrow frequency band employed, 4500 cps, results were partially masked. At that time also, engineering philosophy was that each component of a circuit should be flat, even though some benefit could be derived by other means. This was probably justifiable, since a general chaos might have resulted without standardization by the industry. However, distinct advantages in noise level and harmonic distortion reduction were found.

By 1938 it was felt that compensations might be safely applied to transmitters and in March of that year another investigation of the possibilities of high frequency pre-emphasis at the transmitter was conducted with particular reference to the standard broadcast band with its 10-kc channels. One of the major portions of this investigation dealt with the problem of adjacent channel interference. Because of the favorable findings a moderate amount of high frequency pre-emphasis was introduced and used with complete satisfaction in the WEAF and WJZ transmitters.

Practicability of High Frequency Pre-emphasis

Pre-emphasis of high frequency energy in the transmitter is possible because of the relatively low peak energy existing at these frequencies. Ordinarily most programs carry maximum peak energy in the frequency range between 150 and 400 cps with very little above 2000 cps. Typical curves showing relative peak amplitudes per frequency increment are shown in Figs. 1 and 2. These represent relative peaks reached for 0.5 per cent of the time of average selections, and indicate that high frequencies may usually be pre-emphasized greatly without appreciably increasing the program peak amplitude. Tests were conducted in the National Broadcasting Company Laboratory, covering a total observation time of more than 100 hours to determine what degree of high frequency peaking could be tolerated without creating an excessive increase of peak amplitude on a given circuit with a fixed low frequency level. It was found that a peaking curve similar to that of "Position 3" of Fig. 3 seldom caused any increase of peak amplitude, as judged by an oscilloscope. The only musical programs showing a definite increase of peak amplitude with this high frequency accentuation were orchestras having instruments of extreme high frequency energy, such as cymbals, snare drums, harmonicas, gourds, piccolos, etc. When peak amplitudes definitely did show an increase with peaking, the amount of increase was not more than about 4 db. This was checked a great number of times and it seems reasonable to assume that not more than 1 part in 100 of our musical program time would produce appreciable increase of peak level, with the pre-emphasis indicated in Fig. 3. Curve "Position 2" was almost the same in this respect, except that due to the rise starting at about 500 cps, there was often a peak increase of about one db.

On normal speech or singing, the high frequency pre-emphasis does not appreciably alter the peak amplitudes of the program. However, an increase of peak amplitude was noted on certain voices wherein the sibilants were inherently unnatural. The voices creating this condition sounded peculiar with normal present day transmission and even more so with pre-emphasized high frequency transmission unless approximately 3 db less low-frequency gain were used in the circuit. This so-called "spitting S" is objectionable in ordinary broadcasting and it is hoped that its cause may be definitely corrected in the near future.

Since high frequency pre-emphasis of normal radio programs does not lead to an appreciable increase of peak level on the transmitter, it is axiomatic that receiver background noise may be reduced by compensating the receiver, that is by reducing its high frequency response permitting the receiver to discriminate against the high frequency components of both program and noise.

It is sometimes pre-supposed that high frequency overloading caused by pre-emphasis will give increased

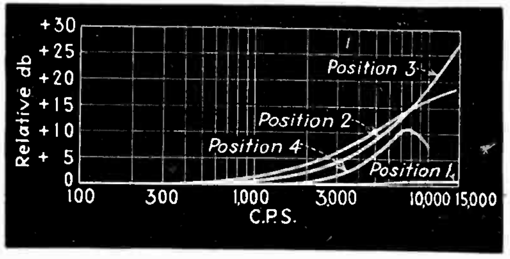


Fig. 3—Below, Filter characteristics employed at the transmitter to ascertain the effects of different amounts of pre-emphasis

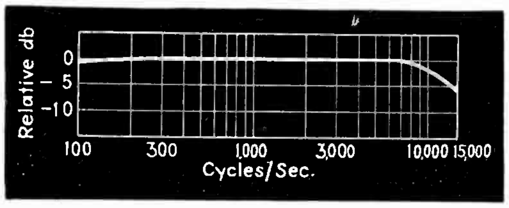


Fig. 4—Bottom, Overall response characteristic, transmitter through receiver

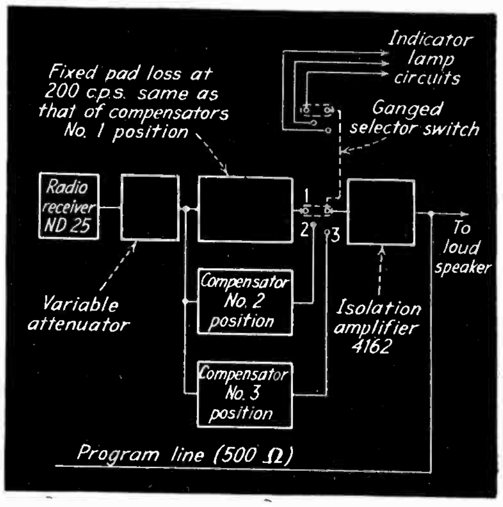


Fig. 5—Top right, circuit arrangement for switching compensators in listening tests, with lamps to indicate filter characteristic in use

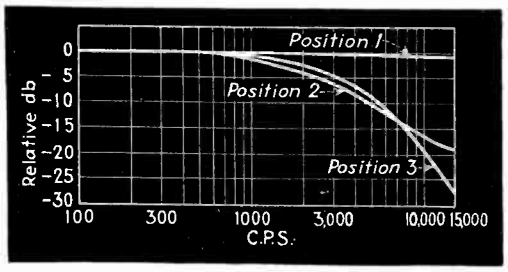


Fig. 6—Restoring characteristics of the filters used in the receiver, corresponding to the curves shown in Fig. 3

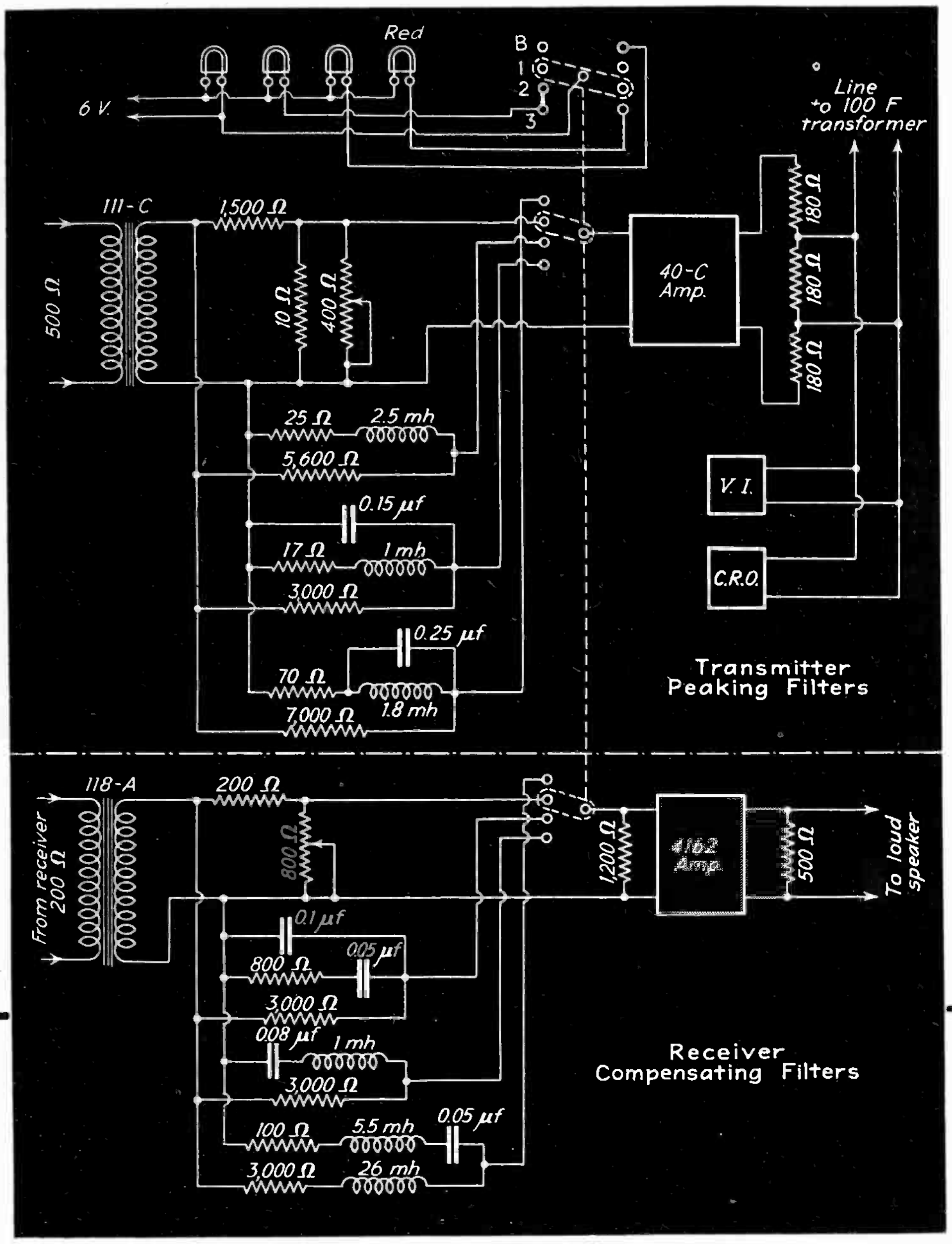


Fig. 7—Details of transmitter and receiver circuit arrangement. The various filter elements are shown, corresponding to the curves in Figs. 3 and 6

harmonic distortion. Tests, however, indicate just the reverse. Since the high frequencies are accentuated in the circuit prior to the introduction of distortion and are cut down after it, they are generally reduced even though cross-modulation products may be increased. The reduction of high order high frequency harmonics actually reduces the crackling type of distortion which is so objectional to the listener.

Possible Difficulties

The system of pre-emphasizing high frequencies at the transmitter and compensating within the receiver may lead to certain minor difficulties, but these should be readily solved. They include (1) the possible necessity of reducing by 2 or 3 db the low frequency level to the transmitter, (2) the possible design difficulties within the transmitter in order to obtain high modulation percentages at the high frequencies, (3) the possibilities of wide sideband interference created by occasional high frequency over-modulation, (4) the possibility of interference with video signals created by audio high frequency over-modulation in the television receiver first detector, and (5) the possibility of improper level control caused by high frequency peaks actuating the limiter, unless the limiter control were arranged to operate at a higher level on pre-emphasized frequencies.

Pre-emphasis of Highs on Ultra-High Frequencies

The most recent investigation in the National Broadcasting Company laboratory of pre-emphasis of high frequencies at the transmitter was in February 1939 and was primarily directed to the ultra-high frequency spectrum with particular attention to the associated sound channels of television.

It was assumed that television receivers should reproduce sound as naturally as possible. Although some persons hear tones above 15,000 cps, it has been indicated that for most persons a 12,000 cps upper limit is sufficient for essentially perfect realism. This investigation, therefore, related to the provision of optimum reproduction of audio frequencies up to a limit of 12,000 to 15,000 cps.

Demonstration

A verbal report of the results of the investigation was tendered to a RMA Sub-committee on High Frequency Pre-distortion. The test apparatus was made available to the committee members and demonstrations were given of noise and distortion reduction. The results were so obviously beneficial that a decision was reached by the committee to propose adoption of high frequency pre-emphasis on television sound channels.

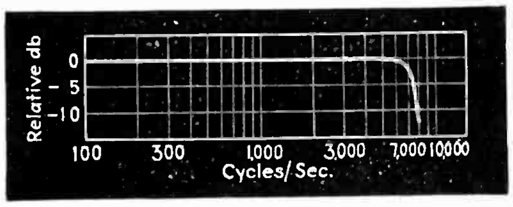


Fig. 8—Response curve of 7500-cps low-pass filter

Further tests were made following these demonstrations, results all indicating the value of the proposed system. A sequence of tests was set up to demonstrate the system, an RCA 100F transmitter being used in conjunction with a special NBC ND-25 receiver. Thermal noise in the receiver was generated by utilizing the signal at low level, whereas the impulse type of noise was generated by a sparking buzzer. The overall characteristic of the system through the loudspeaker, Fig. 4, was constant for all of the three test conditions, except that related to narrow channel transmission. The sequence of four tests used to demonstrate the system is given in the following outline together with the correlated results of the listening groups. These consisted of more than twenty-five competent listeners.

Test No. 1: Apparent Noise Reduction

Details: Background noise reduction effected by receiver compensation was measured for individual ear characteristics by supplying constant level, constant quality program to a loud speaker and injecting noise voltage into the program, as shown in Fig. 5. The noise voltage was derived from a high fidelity radio receiver, and was in the form of hiss or impulse type as desired. High frequency compensation was then applied to the noise voltage, as shown on the curves of Fig. 6. Simultaneously with this the noise voltage was raised by an amount such that its interfering effect in the background of the program, although differing in character, remained essentially unchanged in level as judged by the listeners.

Results: Both hiss and impulse types of noise, contrary to theory, seemed to be reduced by similar amounts. This amounted to about 3 to 4 db for high level background noise and 10 to 12 db for low level noise. The reason for so little improvement on high level noise is explainable in that this noise was actually tending to mask the program. It is well known that low frequencies are especially effective in such masking, therefore, the reduction of high frequency noise components gave only minor benefit.

Test No. 2: Audible Distortion Comparison

Details: High frequencies were pre-emphasized in the transmitter by means of filters according to the curves of Fig. 3, with apparatus as shown in Fig. 7. The receiver filters exactly compensated for the corresponding pre-emphasis and the overall characteristic on all three switch positions is shown in Fig. 4. Program level to the transmitter was exactly the same at 200 cps on all positions, and was adjusted so that slight distortion occurred, over 100 per cent modulation, with flat transmission and reception. Switching between position 1, 2 and 3 then permitted comparison of the audible distortion with and without pre-emphasis. Peak levels were indicated on a cathode ray oscilloscope connected across the input to the transmitter.

Results: Results were essentially the same for orchestra, organ, piano and most voices, the distortion on the pre-emphasis system being less audible than on the conventional flat system. Approximately 2 db higher level to the transmitter was required on the pre-emphasis system to obtain the same audible distortion as the conventional system. The only exception to this was on certain voices having unnatural sibilants or "spitting S's".

Test No. 3: Overall Comparison of Noise and Distortion

Details: Circuits were arranged as in test No. 2. A weak signal was supplied to the radio receiver and normal level fed to the transmitter so that over-modulation occasionally occurred. Switching between positions 1, 2 or 3 then gave an overall demonstration of differences in reception between conventional and pre-emphasized transmission.

Results: With high level background noise the distortion was noticeably reduced. The noise masking effect was almost unchanged (about 3 db improvement with pre-emphasis) but the noise was much less disagreeable. With low level background noise, the distortion was noticeably reduced and background noise diminished 10 to 12 db.

Test No. 4: Overall Comparison on 7500 cps Band

Details: Circuits were arranged as in tests No. 2 and 3 except that a sharp 7500-cps cut-off filter was used in the loudspeaker circuit. The filter characteristic is shown in Fig. 8. The same comparisons were then made as in test No. 3 except that pre-emphasis and corresponding compensation were used as designated by "Position 4" in Fig. 3. It should be noted that this position 4 compensation produces a frequency characteristic similar to present day "high fidelity" broadcast receivers. Pre-emphasis is alternately added to and removed from the transmitter to show the improvement in standard broadcasting quality and noise reduction effected by even this small amount of pre-emphasis.

Results: Same as in test No. 3, but with less improvement, as only about 6 db reduction of low level noise was obtained. Less distortion existed than with conventional system.

Pre-emphasis Curve

Various degrees of pre-emphasis were considered and tested, but that finally standardized by the RMA seems entirely satisfactory. There was little or no difference between several similar curves tested, although it should be noted that excessive amounts of pre-emphasis accentuated peak amplitudes too great a percentage of the time, whereas insufficient pre-emphasis did not permit full advantage of the system. The standardized curve is similar to "Position 2 of Fig. 3" and may be specified as high-frequency pre-emphasis characterized by the impedance characteristic of a 2 element series inductive-resistive network with a time constant of 100 microseconds.

Conclusion

There are no apparent reasons why high frequency pre-emphasis at the transmitter and corresponding compensation at the receiver will not lead to a very appreciable improvement in overall program reproduction especially on ultra-high frequency transmission. This improvement consists of a slight decrease of audible distortion together with a great reduction of noise level. Although impulse type noise should theoretically be reduced more than hiss type, there seems to be little audible difference. For a system reproducing up to 12,000 cps, high level background noises fall by at least 2 db, whereas low level background noises are diminished by 10 or 12 db. This indicates that excellent reception may be obtained with the proposed pre-emphasis system at a distance which would require, for the same excellence of reception, a transmitter of about 10 times as much power with the conventional system.

The Empire State television sound channel has operated with high frequency pre-emphasis since March, 1939. Results have been most satisfactory and many favorable reports have been received on the excellence of studio sound quality as well as the freedom of background noise on the compensated television receivers.

Modern Vacuum Practice in Electronics

The entire electronics industry is dependent upon the electron tube which in turn is dependent upon the production of high vacuum. In this article the author discusses modern vacuum technique and the application of recently developed synthetic organic compounds to diffusion pumps

By **RICHARD S. MORSE**

Distillation Products, Inc.

THE production of high vacuum appears to be one of the fundamental problems inherent to the manufacture of almost every electronic device. The actual final pressures required may vary from a fraction of a millimeter for a neon sign to less than 10^{-8} mm in the case of a high voltage cathode ray tube.

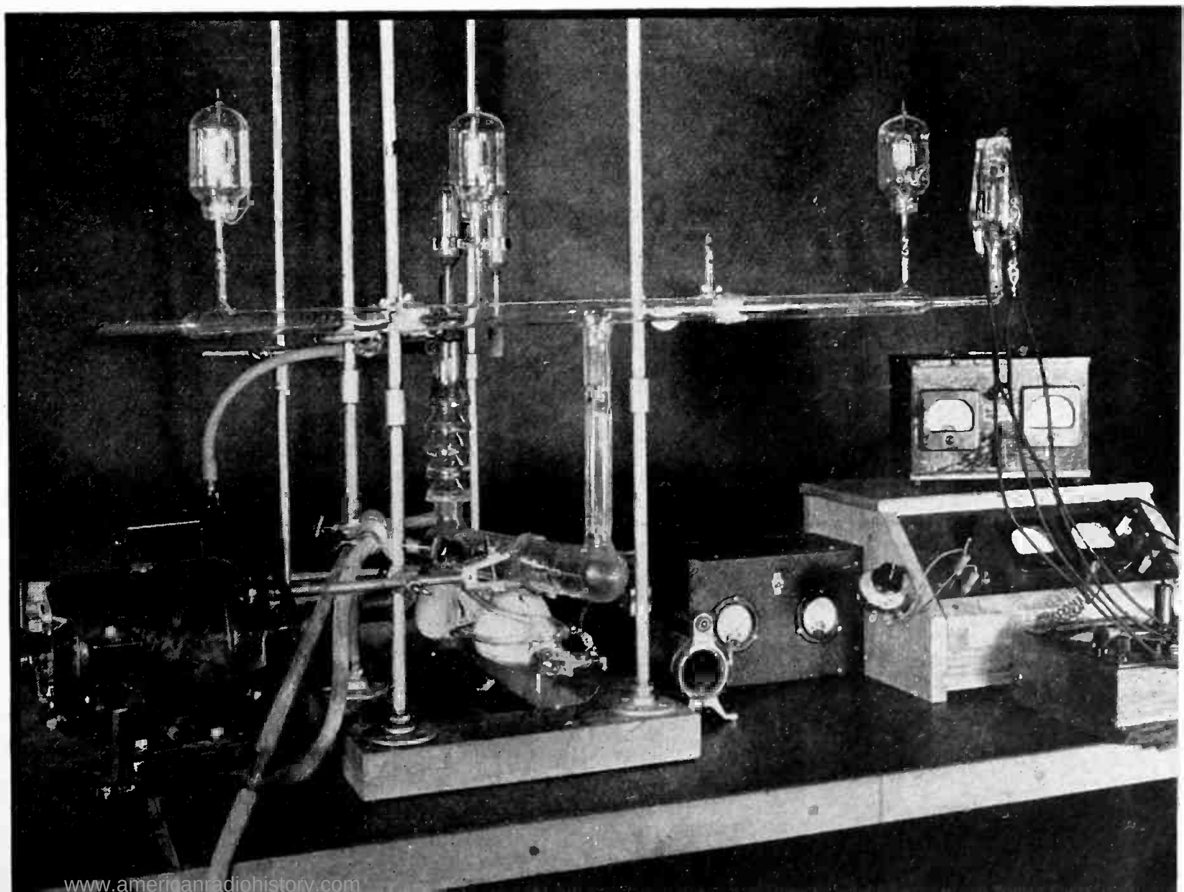
Mercury diffusion pumps developed by Gaede[1], Langmuir[2], and others[3] have for many years been standard equipment for the commercial exhaustion of x-ray, cathode-ray, and radio tubes, photo-electric cells, etc. Because of the relatively high vapor pressure of mercury at room temperatures, *i.e.*, approximately 10^{-3} mm, and the tendency of a mercury vapor to remain supersaturated, pumps of this type can generally be employed only with the aid of cold traps employing refrigerants such as liquid air or solid carbon dioxide. In addition to the expense and inconvenience of providing such refrigerants, the more common traps materially reduce the available pumping speed, generally by a factor of from 4 to 10. Although mercury has the advantage of being an inexpensive and stable material, it is subject to contamination and the vapor tends to wander. For optimum performance, mercury pumps and attendant pipe lines may require frequent cleaning.

Burch[4] advanced the art a significant step by suggesting the use of low vapor pressure fractions of hydrocarbon oils as a substitute for mercury. These fluids, commercially known as Apiezon oils, permit the attainment of relatively low pressures, less than 10^{-6} mm, without a cold trap of any type. Although with such oils a considerably lower fore pressure is required than with the older mercury pumps, units charged with the Apiezon oils soon found limited usefulness abroad in the broadcasting industry where they provided the vacuum for demountable transmitting tubes. However, in spite of their high pumping efficiency as compared with mercury, these materials have not found wide application in the commercial field in the United States. This is probably due to three causes, the most significant being that pumps of a type capable of bringing out their best features were not available. Hydrocarbon fluids also tend to crack, breaking down into higher vapor pressure components, particularly if air is admitted when the pump is hot.

In 1930, Hickman and Sanford[5] suggested replacing the hydrocarbon oils with highly purified synthetic organic compounds such as esters of phthalic acid and in particular butyl phthalate.

More recently the development of compounds of much lower vapor pressure[6] have rendered n-butyl phthalate obsolete except in cases where the lowest pressures are not of primary importance. By employing some of the newest esters such as Octoil and Octoil-S it is possible to obtain pressures at room temperature which are as low or lower than those made possible with the best mercury pumps employing liquid air traps.

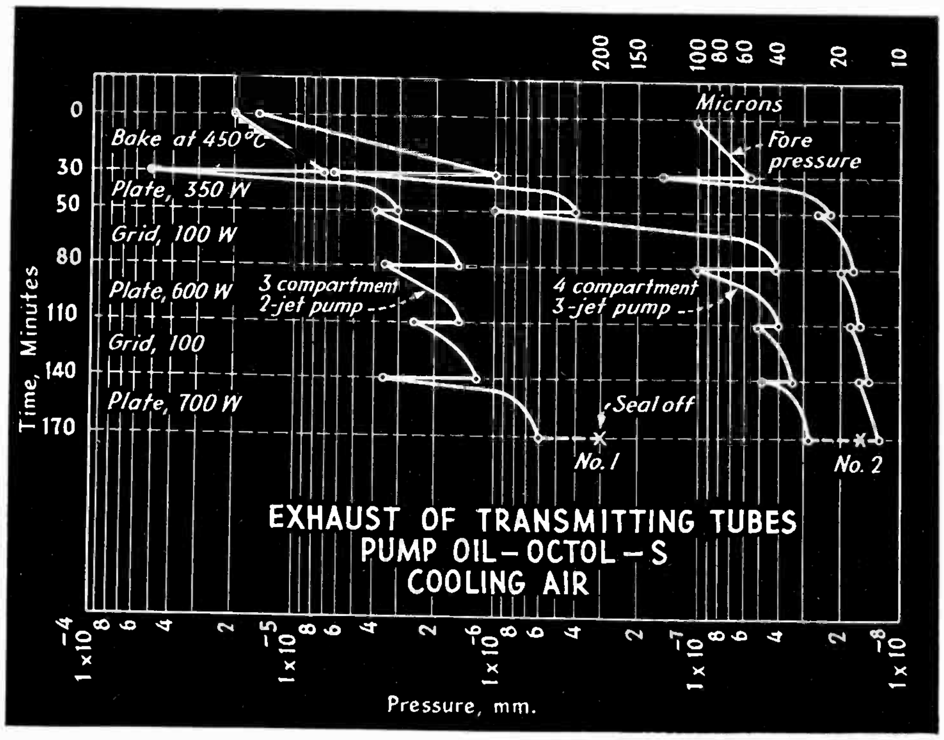
In operating any type of diffusion pump regardless of whether one employs mercury, hydrocarbons, or synthetic oils, the question



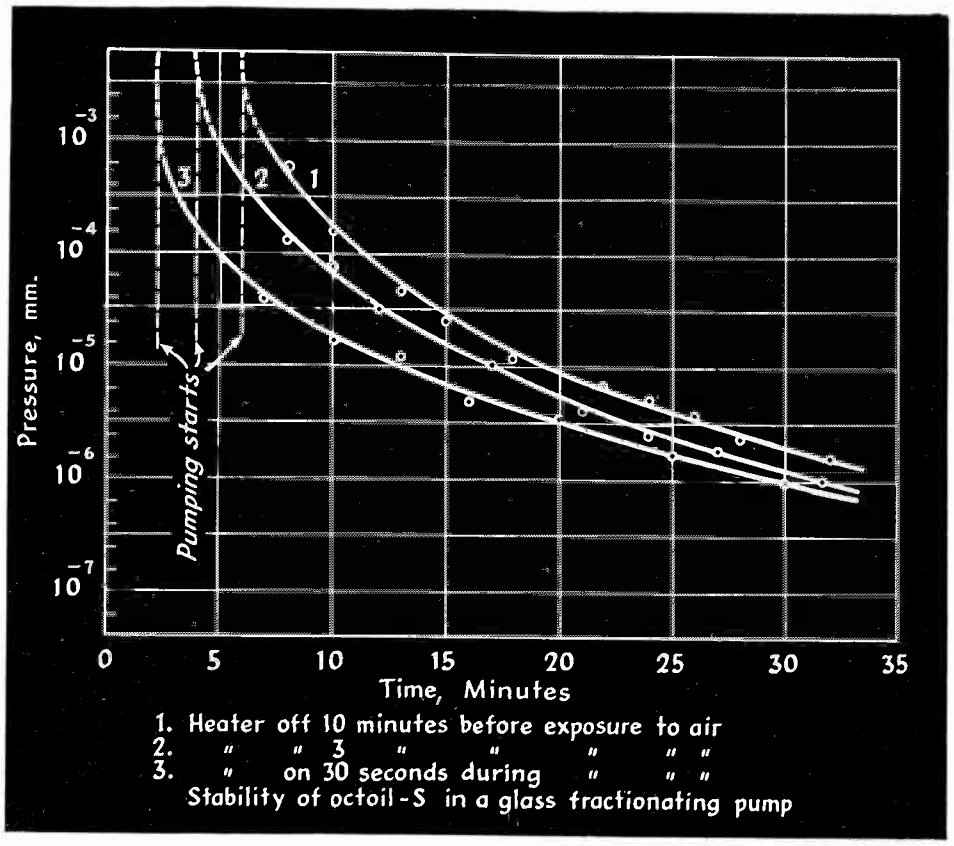
Experimental vacuum system to exhaust transmitting tubes without the aid of a cold trap

of contamination of the fluid is of prime importance. Gaede[7] has shown that the lowest pressure attainable with a vapor pump corresponds to the vapor pressure of the working liquid. It must also be remembered that this pressure may depend upon contaminating materials even though present in minute quantities.

Hickman[8] has investigated this general problem and has demonstrated that through the use of fractionating pumps the lowest pressures commensurate with the pumping fluid are assured at all times even though reactive and relatively high vapor pressure materials are being handled by the system. These findings have been confirmed by others[9], and the term "Fractionating pump"[10] has come into use for any type of diffusion pump in which the pumping fluid is continuously purified during operation, the volatile constituents being rejected or segregated at the fore pressure end of the system and only the lowest vapor pressure materials being allowed to reach the high vacuum jets.



Exhaust curves of medium power transmitting tubes illustrating the difference between a two jet pump with air cooling and a three jet pump with ice cooling



Curves showing the ability of the synthetic organic ester pump fluid. Octoil-S, to withstand exposure to the atmosphere while hot

Exhaustion of Transmitting Tubes

In spite of the extremely low pressures which have been consistently obtained with fractionating oil pumps by many scientific workers equipment of this type has only recently been used for commercial purposes. In order to demonstrate the effectiveness of this newly developed apparatus, several types of standard transmitting tubes have been evacuated according to schedules generally used with mercury pumps employing liquid air traps.

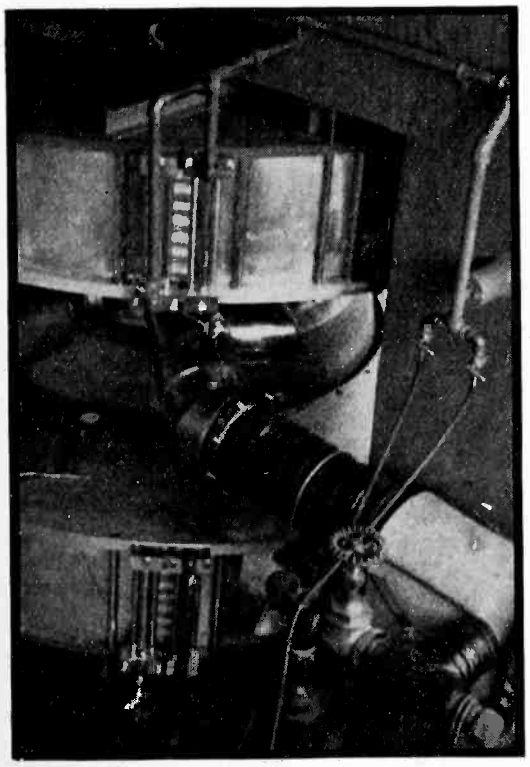
A typical arrangement of work of this type is shown on page 33. The diffusion pump is a 3-compartment, 2-jet all-glass fractionating unit and as can be seen, direct connection is made to the manifold without the usual high impedance trap or cold sink.

During the exhaust schedules of various types of transmitting tubes, continuous pressure readings were made on the manifold with an ionization tube (Western Electric Type D79512). The fore pressure was also measured with the aid of a Pirani type gauge. Typical results are shown in the upper diagram, the schedules as given approximating those employed by several manufacturers of medium power transmitting tubes.

Curve No. 1 is representative of an exhaust procedure followed with the 2-jet pump as illustrated. A rise in pressure was, of course, noted each time that bombardment of one of the electrodes took place. Because of the relatively high capacity of the pump employed and the fact that no trap with its corresponding high impedance was placed between the manifold and the high vacuum jet, the pressure was reduced very rapidly after each evolution of gas. Problems of ionization during the early stages in the tube were, therefore, practically eliminated.

In an effort to obtain the lowest possible pressures additional tubes of several types were evacuated with a 4-compartment, 3-jet fractionating pump and the connecting tube between the manifold and the pump maintained at 0°C with ice. Typical results of this work are shown by Curve No. 2 and it can be seen that the final pressure attainable was of the order of $1.5x10^{-8}$ mm.

Although usually the speed of exhaustion is limited by the diameter and length of the seal-off tube, in many cases considerably higher pumping speeds could well be used on the exhaust manifold itself. The more commonly employed mercury pumps rarely have speeds in excess of one to three liters per second at 10^{-4} mm. Assuming, therefore, a trap efficiency of 20 per cent, the available pumping speeds may well be below 0.2–0.6 liters per second.



Metal oil diffusion pump exhausting the cyclotron without the aid of a cold trap at M.I.T.

The 4-compartment, 3-jet and 3-compartment, 2-jet pumps used during these tests have speeds of 15 liters per second and 12 liters per second respectively for all pressures below 10^{-4} mm. This capacity is adequate to handle several large tubes and it has been demonstrated that one such pump is capable of simultaneously exhausting ten nine-inch cathode-ray tubes.

Data is also given for the fore pressures normally encountered under average conditions. As can be seen, these readings offer an excellent indication as to the operation of the pump and the pressure in the system under exhaust.

These do not represent the best, or by any means the shortest, procedures which might be employed, as the tests were conducted merely to obtain a direct comparison between tubes exhausted with mercury pumps and those evacuated with the simple setup as shown using only air cooling.

Commercial tubes made according to both of the above procedures have been submitted to life test and gas current measured under recommended operating conditions. In all cases, the final products were found to be as good or better than tubes made with mercury pumps employing liquid air.

Stability of Pumping Fluid

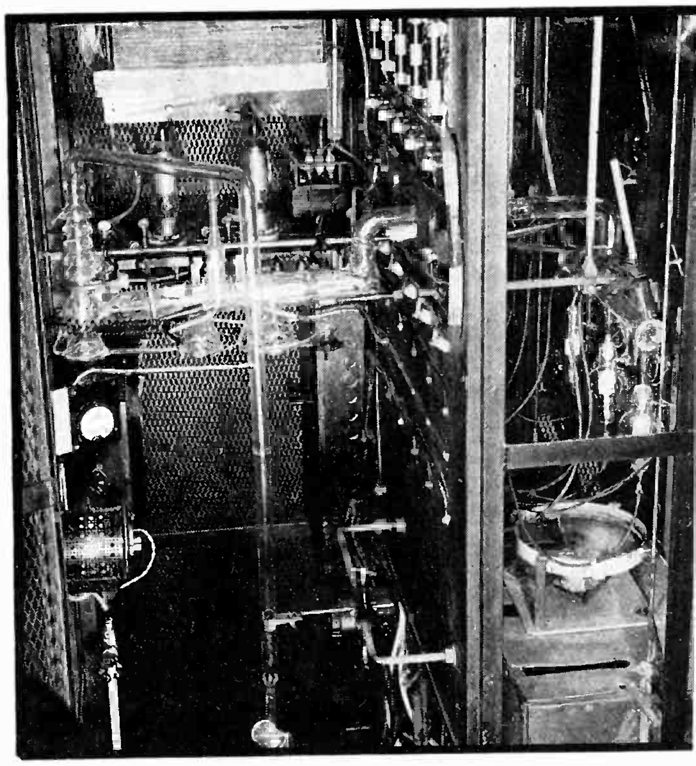
For commercial applications of oil pumps the question of decomposition of the pumping fluid under adverse operating conditions must be considered. In employing the pumps for production work, there is always the possibility of exposing the fluid to atmospheric pressure because of breakage of a tube under exhaust, mishandling, etc. In order to demonstrate the stability of the newer low vapor pressure fluids, particularly Octoil and Octoil-S, a series of tests were made with the 4-compartment, 3-jet all glass fractionating pump.

After the pump was operated for several hours, a study was made of the effect of exposing the hot oil to atmospheric pressure. The results of tests of this type are shown on page 34 and it can be seen that even when the heaters, which are immersed directly in the oil, were operating and the pump was exposed to atmospheric pressure for thirty seconds the same ultimate vacuum was attained. As a matter of fact, with this particular condition lower pressures were reached for any given time after pumping action began. In this case the fluid was sufficiently hot to permit pumping action during the initial stages of exhaust although decomposition was detected by a rise in fore pressure.

These tests indicate that these pure organic esters, which have been selected from a large number of less suitable compounds, represent a very real advance in pump fluids. Although with all fluids decomposition may take place under conditions of high temperature and pressure, the products coming from the new esters are more volatile than the esters themselves and are easily removed by the fore pump. The compound remaining in the pump is a relatively pure substance essentially the same as the original oil except for the development of a slight color under adverse conditions.

Advantages

Providing sufficiently low fore pressures can be maintained at all times oil pumps may, in almost all cases, be advantageously substituted for mercury units in order to produce economically the lowest pressures. It is also interesting to note that the capacity of any mechanical pump may be effectively increased many times in the lower pressure regions through the aid of so-called "oil boosters." Units of this type operate against high fore pressures, *i. e.* greater than 0.5 mm and yet they can be designed with capacities of hundreds or even thousands of liters per second. If, for example, a booster is operated with a fore pressure of 0.5 mm and the system under



Three-stage glass fractionating pump used to exhaust Raytheon getterless transmitting tubes

exhaustion is at $5x10^{-4}$ mm, the combination of mechanical pump and booster permits an equivalent pumping speed of 1000 times that of the mechanical pump alone.

In considering the use of fractionating oil diffusion pumps the following factors are of interest:

A. Use of Cold Traps. Because of the extremely low vapor pressures of the newer organic fluids oil pumps may be operated without the aid of cold traps of any type. Pumping speeds are thus not impaired, the inconvenience of maintaining liquid air or solid carbon dioxide is eliminated and considerable saving can usually be effected.

B. Speed. Because of the higher pumping efficiency and the unique types of design which may be used with oil pumps, extremely high pumping speed may be obtained. In general, these are many times that of common mercury pumps.

C. Cooling. Because of the low vapor pressure materials which are employed with the newer oil pumps, those of glass construction operate very satisfactorily with air cooling. The larger metal units generally require water but the heat to be dissipated for a given speed is relatively low.

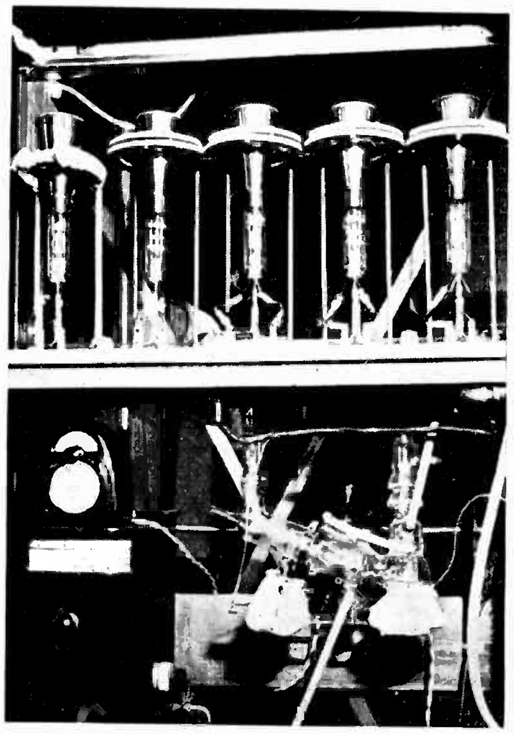
Other Applications

Although it has been demonstrated that fractionating oil pumps are particularly useful for the economical exhaustion of "getterless" transmitting tubes, there are many other electronic devices with which they may well be employed.

In spite of the many advances which have been made by the electronics industry in recent years, an improvement in vacuum technique appears to be peculiarly lacking. Exhaust schedules employed by different organizations in some cases differ from twenty minutes to four hours for the same type of tube. Obviously in the latter case, a substantial reduction in the manufacturing cost could be achieved by more appropriate design of exhaustion equipment and proper adherence to the fundamentals of high vacuum technology.

Television and cathode ray tubes. In the exhaustion of both cathode ray and, in general, all types of "image" tubes, the highest possible vacuum is generally desirable. Because of the relatively large volumes involved, the problems of outgasing must be more seriously considered and relatively high pumping speeds are desirable. Glass fractionating pumps are now being used for work of this type and pressures are being consistently reported which are as low or lower than those attainable with the best mercury pumps employing liquid air traps.

Receiving tubes. In the manufacture of receiving tubes with automatic machines, it is questionable whether extremely low pressures are necessary or in some cases even desirable. Because of the small exhaust ports, extremely high exhaust speeds are quite impossible. Providing that adequate fore pressures can be maintained, there appears to be some justification for replacing the generally employed mercury pumps with metal oil boosters in order to make somewhat lower pressures possible and obtain savings in both water and power consumption.



Glass fractionating pump used in the exhaustion of commercial television picture tubes

It is interesting to contemplate the possibility of attaching a high capacity oil pump to a large volume, this in turn being maintained at a pressure of perhaps 10^{-5} mm. Connections could then be made from this volume to various ports on the machine and the large number of mercury units which are generally employed would be eliminated. In this way, extremely high effective pumping speed would always be available at each exhaust position. The question of breakage with subsequent loss of vacuum at any exhaust position could be adequately taken care of with the aid of properly designed automatic check valves.

X-ray tubes. The problems of exhaust with both the x-ray and cathode-ray tubes are quite similar, although in the former case somewhat higher pressures may be tolerated. Through the use of even the smallest glass oil pumps adequate pumping speed and sufficiently low pressures may be attained.

Neon signs, etc. In the exhaustion of neon and other types of gas discharge tubes, extremely low pressures are rarely required. Nevertheless relatively small oil pumps are being used by many manufacturers because of the ease with which they permit the rapid exhaustion down to pressures of 10^{-8} or below. Here again, particularly with the present interest in large size fluorescent tubing, higher pumping speeds are of interest.

Continuously evacuated systems. At the present time there is considerable interest both in this country and abroad in the development of high power demountable transmitting and x-ray tubes. Although high pumping speeds are not generally required, reliability of operation is of utmost importance and the questions of maintainance and operating cost must be considered. Although the design of proper baffle arrangements to prevent back streaming of the oil vapor should receive serious consideration, through the use of fractionating oil pumps, cold traps may be eliminated and assurance given that the lowest possible pressures will be maintained at all times even over long periods of operation.

References

(1) Gaede, *Ann. de. Physik*, 46, 357-392 (1915); *Z. fur tech Physik*, 4, 337 (1923).

(2) Langmuir, *G. E. Rev.*, 1060 (1916); *J. Frank. Inst.*, 182, 719 (1916).

(3) Dushman, *J. Frank Inst.*, 211, 689-750 (1931); Williams, *Phys. Rev.*, 7, 583 (1916); Molthan, *Z. fur tech Physik*, 7, 377, 452 (1926); Crawford, *Phys. Rev.*, 10, 557 (1917).

(4) Burch, *Nature*, 122, 729 (1928); *Proc. Royal Soc. London*, 123, 271 (1929).

(5) Hickman - Sanford, *R.S.I.*, 2, 140 (1930); U. S. Patent No. 1,857,508.

(6) U. S. Patent 2,147,479; U. S. Patent 2,147,488; Kipp, *Phys. Rev.*, 9, 311 (1917); Baker, *Phys. Rev.*, 10, 6422 (1917); Volmer, *Ber. Deut. Chem. Gess*, 52, 804 (1919); 804 (er.Phys.RBak ev.,648804(1919); Ebert, *Z. of Phys.* 19, 3, 206 (1923).

(7) Gaede, *Ann. de. Physik*, 46, 357 (1915).

(8) Hickman, *J. Frank. Inst.*, 221, 215-235 (1936).

(9) Lockenwitz, *RSI*, 8, 322-323 (Sept. 1937); Malter and Marcuvitz, *RSI*, 9, 92-95 (March 1938).

(10) U. S. Patents 2,080,421; U. S. Patent 2,150,676; U. S. Patent 2,153,189.

A Central Antenna System

A means by which receivers located in buildings in congested areas may be supplied with high quality signals from a single antenna. The signals are amplified at the antenna and fed through a transmission line to the individual receivers

By D. J. FRUIN, *Hilversum, Holland*

THE increased interest in high quality reception calls for wideband transmission and wideband receivers. This again brings forward the question of signal-to-noise ratio. The simplest and probably easiest improvement in the signal-to-noise ratio is obtained by the use of a high receiving antenna with a shielded lead-in cable.

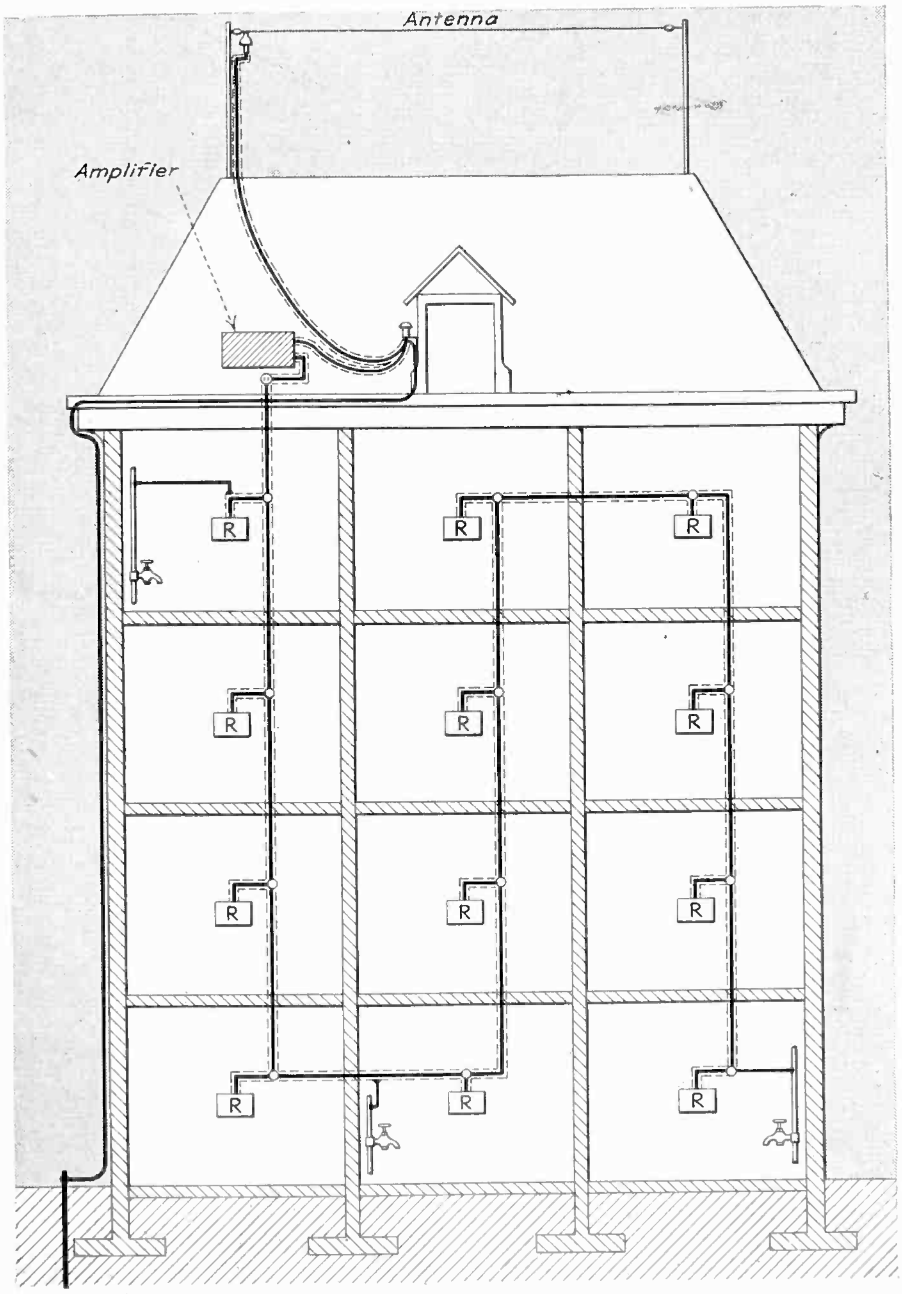
In the larger cities, where the signal-to-noise ratio is poor on account of man-made static, the erection of high antennas for individual receivers is particularly difficult in the majority of cases. The larger buildings for instance, offer no possibilities for high individual antennas for all receivers and in many cases indoor antennas with a poor signal-to noise ratio are used.

A solution can be found by erecting one central antenna on a building and by feeding the individual receivers in the building from it. An attempt to put this idea into practice shows a number of complications however. The main points are: (1) Some receivers will be at a remote distance from the antenna so that a simple lead-in wire will suffer too much loss and moreover, will pick up noise, (2) a number of receivers in parallel will have a total impedance which is too low to match the antenna-impedance, (3) the power available from the antenna will be insufficient for a large group of receivers and (4) interaction between receivers is likely.

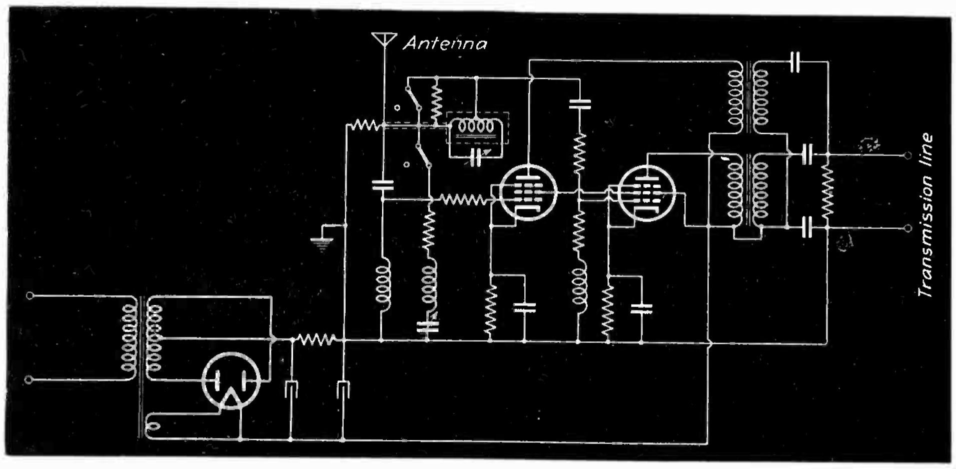
These difficulties can be overcome in the following ways:

1. The power from the antenna can be conveyed to remote points by means of a transmission line, with small losses and noise pick-up. A transmission line can be designed having such characteristics that a wide band of frequencies can be passed with small losses. As short-wave reception should be possible, the frequency-band which has to be passed is very wide indeed. All frequencies from the long-wave broadcast band up to some 15 Mc should be passed. This can be done by means of a transmission line having a low impedance and terminated at the far end by a resistance equal to the characteristic impedance of the line.

2. A large group of receivers can be connected in parallel to such a line as the impedance of the line



The input impedance of each receiver should be high compared to the impedance of the transmission line. The low impedance transmission line is terminated with a resistance equal to the characteristic impedance of the line



In order to cover the frequency range from 150 kc to 15 Mc, there are two amplifier sections, one to cover the upper portion of the range and the other to cover the lower portion

can be much lower than the impedance of the receivers. All receivers must have input impedances which are high compared with the line impedance or the transmission line characteristics will be upset. A resistance of a certain minimum value can be connected in series with each receiver. This resistance also prevents short-circuit of the line in the case of an accidental short-circuit in one of the receivers. The impedance of the line can be matched to the impedance of the antenna by means of impedance-matching transformers.

3. As the impedance of the line is low a considerable step-down ratio must be used. This brings the available voltage on the line down to a very low value. This can be overcome by the use of an amplifier. The amplifier must have a flat response over the broadcast-frequency band. As the short-wave band should be included, this means a flat response over a frequency band from 150 kc up to 15 Mc. The line can be connected to the amplifier by means of impedance-matching transformers and the amplifier should be able to furnish the power required for all receivers together plus line losses.

4. Interaction between receivers can be overcome by the series resistance in each receiver.

The Philips Antennaphil System

The general lay-out of a practical system is shown on page 37. One antenna is used and is connected to the amplifier by a shielded lead-in cable. The amplifier should be mounted as near the antenna as is practicable, to shorten the lead-in cable. The transmission line from the amplifier is run through the building and tapped in all rooms. It is not allowed to make side-taps on the line, as these side-lines will upset the impedance match. So the transmission line is run from one room to the other throughout the building and in every room an outlet is mounted on the wall. In the series resistance and a blocking-condensor are incorporated in the outlet. The condensor prevents the line voltage from coming into the line or into the receivers and the resistor prevents short-circuit of the line or excessive power-drain from a defective receiver. The last outlet at the end of the line also contains the terminating resistance. The value of the resistance is 64 ohms which is the characteristic impedance of the line.

The line consists of an inner conductor, surrounded by a special insulating low-loss material. Around this insulation is a copper braid which acts as a screen and provides a ground for the receivers. The shield is grounded at several points in the building. The shield is covered with a protective cover.

The Amplifier

The amplifier has several interesting features. The circuit diagram is shown above. A rather flat response is required over a frequency band from 150 kc up to 15 Mc. It has not been found possible to design an amplifier with such characteristics in one stage. So the frequency band to be covered is split into two sections. One section covers the high-frequency band and the other section covers the broadcast bands. The amplifier actually consists of two one-stage amplifiers in parallel and the antenna is connected to both amplifiers. Each stage has an output transformer which matches it to the line and as one amplifier covers only part of the frequency band, the transformer has to be designed for only that part of the frequency band. Since some power is required, power tubes are used. The amplifier will furnish the antenna power for 50 receivers plus line losses. Tubes of very high mutual conductance such as the 1852 or 1853 are used so that sufficient gain is obtained with only one stage. The use of high-mu tubes renders the amplifiers liable to self-oscillation at some frequencies which can be prevented by the use of damping resistances. The tubes used have characteristics of which a large portion is a straight line. This is important since a bent characteristic will cause cross-modulation. Cross-modulation may occur however on powerful local transmitters and cause excessive grid-swing. To prevent this, two wave-traps have been incorporated into the amplifier. One for the long-wave and the other for the short-wave broadcast band. They may be tuned or switched out of the circuit.

Performance

The voltage gain of the amplifier, comparing the input voltage and the output voltage at the line near the amplifier measured under rather poor conditions, is as follows:

200 kc	voltage	gain	1.4
600 kc	”	”	1.0
1200 kc	”	”	1.0
8000 kc	”	”	0.5

The voltage gain found by comparing the input voltage to the amplifier with the output voltage measured at the far end of the transmission line is:

200 kc	voltage	gain	1.2
600 kc	”	”	0.8
1200 kc	”	”	0.8
8000 kc	”	”	0.2

A transmission line of 400 meters was used. If practical, two lines with a total length of 500 meters can be connected in parallel to the amplifier. If this length is insufficient, two antennas, two amplifiers and two transmission lines should be used. If short-wave reception is not required, a transmission line of 2000 meters may be used on a single antenna and amplifier.

Transient Amplifier Analysis

By **ERIC A. WALKER**
Tufts College Engineering School

IN calculating the gain of an amplifier stage, defined as the ratio of the voltage on the second stage to the voltage on the first stage, no reference is usually made to the shapes of the two voltage waves for it is tacitly assumed that both are sinusoidal. In fact, if the plate resistance R_p and the amplification factor μ are assumed to be constant, no distortion is accounted for and the output must have the same shape as the sinusoidal input voltage.

The solution is not so simple if the input voltage is a complex wave for the various harmonics are amplified disproportionally and the shape of the input and output voltages are quite different. For instance, an instantaneous pulse of voltage, such as is required in some television circuits, may become quite distorted. There are two methods by which the shape as well as the magnitude may be determined.

To illustrate the first method, suppose that the input signal is the periodic pulse shown in Fig. 1. Let us further suppose that this pulse recurs 13,230 times each second, and that it is one microsecond wide. The Fourier series of this wave is found to be:

$$f(x) = \frac{E\,b}{2\pi} + \sum_{n=1}^{n=\infty} \frac{E}{\pi n^2} (1 - \cos nb) \sin (2\pi\, nft)$$
$$+ \sum_{n=1}^{n=\infty} \frac{E}{\pi n^2} (\sin nb) \cos (2\pi\, nft)$$

where $f = 13{,}230$; E is the height of the pulse, n is the number of the harmonic to be found, and b is the duration of the pulse.

If one begins to substitute values of n in the above equation it is soon evident that many terms will be required before their effect on the resultant wave becomes negligible, or before the series begins to approximate the square-topped pulse. Then to find out how much each harmonic is amplified it is necessary to extend the gain-frequency curves much further than is usually done.

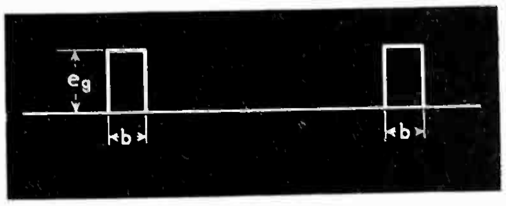


Fig. 1—Periodic pulse on which analysis is based

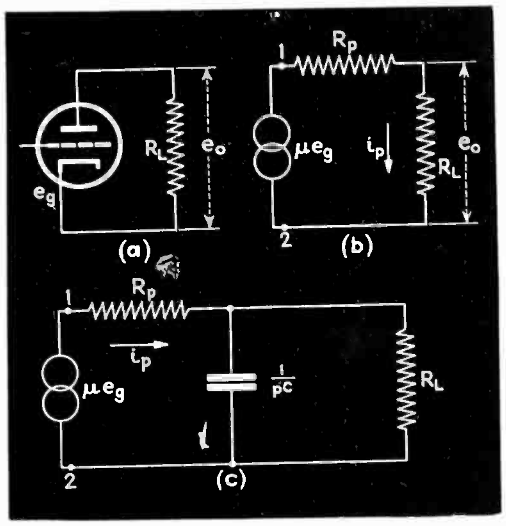


Fig. 2—Actual, equivalent and operational circuits for high frequency response

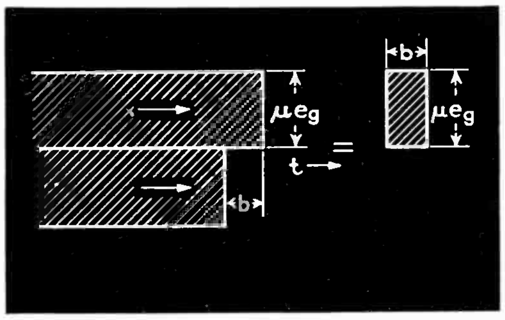


Fig. 3—Derivation of pulse from two unit voltages

A simpler method of finding both the shape and the magnitude of an amplified pulse requires the use of simple operational methods. The solution is usually in three steps:

(1) Determine the operational impedance of the circuit.

(2) Find the operational expression for the driving function, in this particular case the voltage pulse.

(3) Find the solution in a table of operators or by any other method necessary or available. The methods of the operational calculus are found in many text books.⁽¹, ²⁾ Only the necessary steps will be given here.

To find the operational impedance of a circuit the circuit is redrawn replacing the inductances with impedances equal to pL and replacing the capacitances with impedances equal to $\frac{1}{pC}$. Then the input impedance is found in the ordinary manner. The entire process will be carried through for several circuits.

Figure 2a shows a circuit consisting of a tube and a resistance load. Figure 2b shows the equivalent circuit neglecting all inductance and capacitance. The impedance is:

$$Z_{12} = R_p + R_L \qquad (1)$$

Figure 3 shows the method by which the voltage function is put into the equation. The pulse can be considered as made up of two voltages (often called Heaviside unit functions) $+\mu e_g$ and —μe_g, the second applied at a time b later than the first. This method can be used for periodic functions if the two or more transients which are caused by the pulse have decayed to negligible values before the next pulse is impressed.

If one first impresses the positive unit pulse on the impedance Z_{12} one gets:

$$e_o = \frac{+\pi\, e_g R_L}{R_p + R_L} 1 \qquad (2)$$

The solution is obviously a continuous, positive voltage. Add to this a solution with —μe_o as the driving voltage, lagging in time by b and the amplified pulse is obtained.

Figure 2c is the same circuit including a shunt capacitance C. In this circuit

$$Z_{12} = \frac{R_p + R_L + p\,R_p R_L C}{1 + p\,R_L C} \qquad (3)$$

and

$$e_o = \frac{\mu\, e_g}{R_p C} \left[\frac{1}{p + \frac{R_p + R_L}{R_p R_L C}} \right] \qquad (4)$$

The solution is:

$$e_o = \frac{\mu\, e_g R_L}{R_p + R_L} \left[1 - \epsilon^{-\left(\frac{R_p + R_L}{R_p R_L C}\right) t} \right] \qquad (5)$$

This equation shows that the maximum amplification which can be attained is $\frac{\mu R_L}{R_p + R_L}$. Add to this a

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⁽¹⁾Operational Circuit Analysis (a book). V. Bush. John Wiley & Sons, N. Y.

⁽²⁾Heavisides Operational Calculus (a book). E. J. Berg. McGraw-Hill Book Co., N. Y.

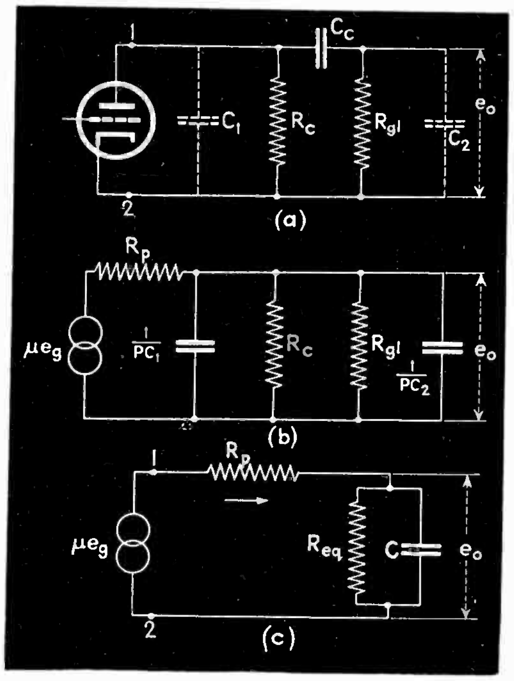
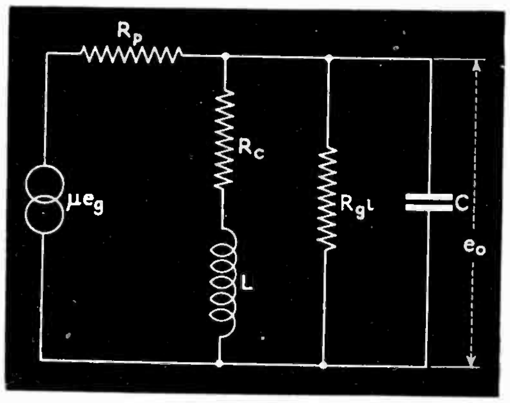


Fig. 4—Actual and equivalent circuits for low frequency response

Fig. 5—Right, pulse (crosshatched) and response of amplifier. The response is the superposition of the two portions a and b corresponding to positive and negative voltages

Fig. 6—Compensated amplifier circuit for wide-band response



solution lagging in time by b and with a negative sign and the resulting pulse is obtained.

Many circuits include a coupling capacitor as is shown in Fig. 4a. If an attempt is made to solve the complete circuit as shown an equation with four roots is obtained. Its solution is laborious. Much information can be obtained by studying two simpler circuits. These are the case where C_c is so large it can be neglected and the case where the stray capacitances C_1 and C_2 are so small they can be neglected.

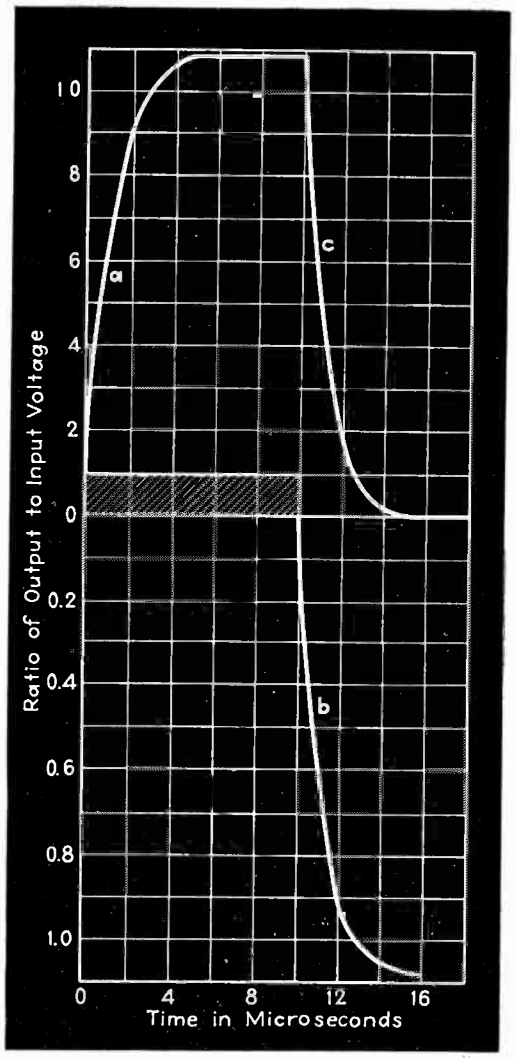
Figure 4b shows the circuit of 4a with C_c replaced by a short circuit. This circuit yields exactly the same equation as the circuit of Figure 2c if the C and the R_L of Equation (5) are replaced by:

$$C = C_1 + C_2 \qquad\qquad R_L = \frac{R_c\, R_{gl}}{R_c + R_{gl}}$$

as is shown in Figure 4c.
Equation (5) then becomes:

$$e_o = \frac{\mu\, e_g\, R_c\, R_{gl}}{R_p\, R_c + R_p\, R_{gl} + R_c\, R_{gl}}$$

$$\left[1 - \epsilon^{-\left(\frac{R_p R_c + R_p R_{gl} + R_c R_{gl}}{C\, R_p\, R_c\, R_{gl}}\right)t}\right] \quad (6)$$



If one uses a Type 954 tube and assumes the following values: $\mu = 1100$; $C_1 + C_2 = 11\mu\mu$fds; $R_c = 10^4$ ohms and $R_{gl} = 10^6$ ohms and $R_p = 10^6$ ohms, this equation becomes:

$$e_o = 10.78\, e_g \left[1 - \epsilon^{-0.903 \times 10^7 t}\right] \quad (6a)$$

Some idea of the effect of the coupling capacitor which has been neglected can be obtained by considering C_1 and C_2 as sufficiently small so that they can be ignored in a trial solution. Then:

$$e_o = \frac{\mu\, e_g\, R_c\, R_{gl}\, C_c\, p}{p\, C_c\,[(R_c + R_{gl})\,(R_p + R_c) - R_c^2] + R_p + R_c} \quad (7)$$

$$e_o = \frac{\mu\, e_g\, R_c\, R_{gl}}{R_p\, R_c + R_p\, R_{gl} + R_c\, R_{gl}} \left[\frac{p}{p + a}\right] \quad (7a)$$

where

$$a = \frac{R_p + R_c}{C_c\,(R_p\, R_c + R_p\, R_{gl} + R_c\, R_{gl})}$$

The solution then is:

$$e_o = \frac{\mu\, e_g\, R_c\, R_{gl}}{R_p\, R_c + R_p\, R_{gl} + R_c\, R_{gl}}$$

$$\left[\epsilon^{-\left(\frac{R_p + R_c}{C_c\,(R_p R_c + R_p R_{gl} + R_c R_{gl})}\right)t}\right] \quad (8)$$

The decrement factor, found by evaluating a for this circuit is 9.9. The effect of this term is negligible for the micro-second pulse which we have been considering and therefore this capacitance can be safely neglected.

A common circuit is one in which inductive compensation is used as is shown in Fig. 6. A solution of this circuit is given by:

$$e_o = \mu\, e_g \left[\frac{R_c\, R_{gl}}{R_T} + \frac{1}{2b\, R_p\, LC} \left(\frac{R_c - L\,(a + b)}{b + a}\,\epsilon^{-(a+b)t} + \frac{R_c - L\,(a - b)}{b - a}\,\epsilon^{-(a-b)t}\right)\right] \quad (9)$$

where

$$R_T = R_p\, R_{gl} + R_c\, R_{gl} + R_p\, R_c$$

$$a = \frac{R_c}{2\,L} + \frac{1}{2\,R_p\,C} + \frac{1}{2\,R_{gl}\,C}$$

$$b = \sqrt{\frac{1}{4}\left(\frac{R_c}{L} + \frac{1}{R_p C} + \frac{1}{R_{gl} C}\right)^2 - \frac{1}{LC}\left(1 + \frac{R_c}{R_p} + \frac{R_c}{R_{gl}}\right)}$$

The two decrement factors $a + b$ and $a - b$ may be real or complex depending on the values of the constants. If they are complex the circuit will oscillate. For the critical case a value of L can be chosen which will make the constant b equal to zero. Because b also appears in the denominator of the equation this makes the transient theoretically infinite in magnitude but of very short duration. If one recalls that μ and R_p are constants only as long as the path of operation is on a linear portion of the tube characteristics it is evident that the output voltage peaks will not actually become infinite. There are two values of inductance which will make the constant b equal to zero. For the above circuit they are $L = 11.165$ and $L = 0.272 \times 10^{-3}$ henries.

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A Vector Conversion Chart

By Elliot L. Gruenberg
Henry Shoiket
Harry Sussman
Ingvar Jensen

IN radio engineering it is frequently necessary to convert from the polar form of coordinates to the rectangular and vice versa. These conversions arise frequently in designing networks and analyzing their action, since the impedances involved are often given in rectangular form (as resistance and reactance) whereas the current-voltage relation of the impedance depends on the polar form (the absolute magnitude of the impedance and its phase angle). A simple means of performing such conversions, to very nearly the same degree of accuracy as offered by a ten-inch slide rule, is given in the accompanying chart. The use of the chart is best illustrated by the following examples:

EXAMPLE 1. TO CONVERT FROM THE RECTANGULAR TO THE POLAR FORM

Given: 3.00 + j4.00. Locate the smaller component 3.00 on the S scale and the larger component 4.00 on the L scale. Connect by a straight line. Read the vector angle 53.1° at the intersection of this line with the LS scale, reading on the SMALL + jLARGE side of the scale. Locate the same angle 53.1° on the MS scale and connect by a straight line with the 3.00 previously located on the S scale. Read the magnitude of the vector 5.00 at the intersection of this line with the M scale. Hence: 3.00 + j4.00 =5.00 / 53.1°. Were one given 4.00 + j3.00, the LARGE + jSMALL angle scales would be read, giving 5.00/ 36.9°.

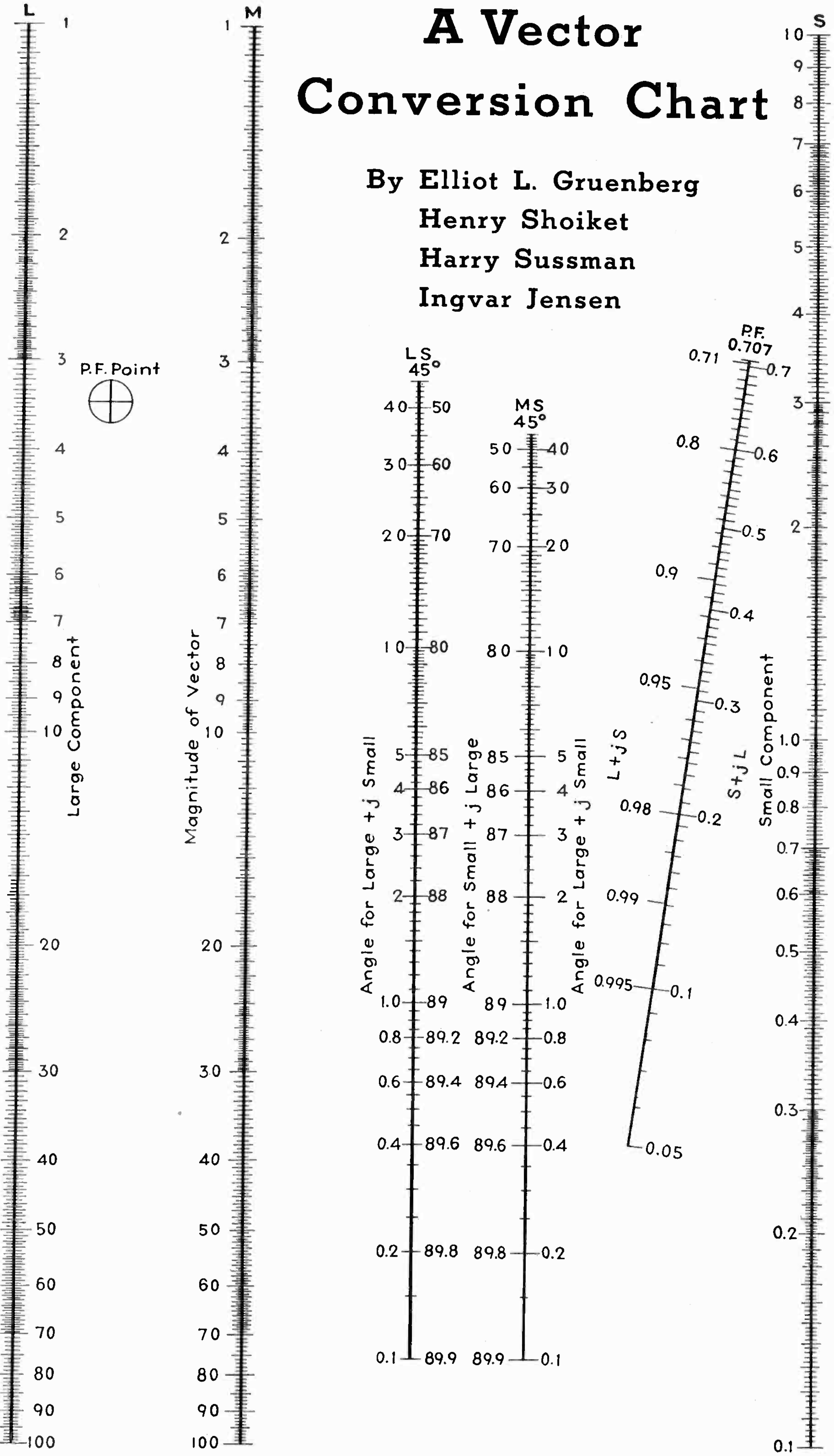
EXAMPLE 2. TO CONVERT FROM THE POLAR TO THE RECTANGULAR FORM

Given: 13.0/ 22.6°. The method is the inverse of example 1. Locate the vector magnitude 13.0 on the M scale and the vector angle 22.6° on the MS scale. Connect by a straight line. Read the smaller component 5.00 at the intersection of the line with the S scale. Locate the vector angle 22.6° on the LS scale and connect by a straight line with the smaller component 5.00 just found on the S scale. The intersection of this line with the L scale gives the larger component 12.0. The side of the angle scales on which the angle is read determines form of the result, namely, LARGE + jSMALL. Hence: 13.0/ 22.6° = 12.0 + j5.00.

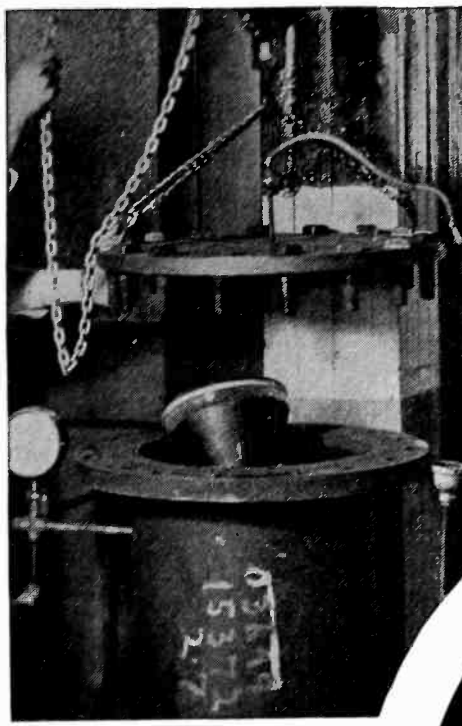
EXAMPLE 3. TO CONVERT FROM ANGLES TO COSINES AND POWER FACTORS

Given: 24.5°. Locate the angle on the LS scale. Connect by a straight line with the PF point. The intersection of the line with the PF scale gives the cosine, 0.910, or the power factor, 91.0 per cent. Always read PF and LS scales on corresponding sides.

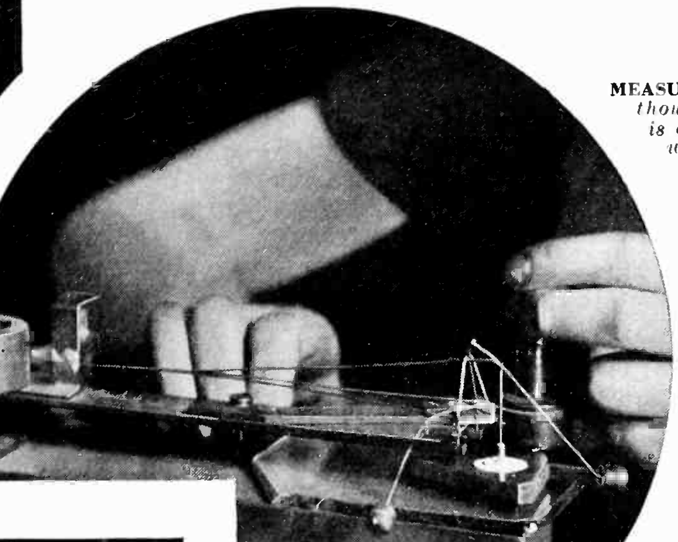
EXAMPLE 4. The components and vector magnitude may be divided or multiplied by a common factor, multiples of 10 in particular. Thus for 90 + j137 set 9.0 + j13.7 and multiply resultant by 10. Angle and power factor remain unchanged.



HYGRADE SYLVANIA picks NICKEL for TELEVISION TUBES



DESTRUCTION TEST: *In this tank tubes are tested to destruction. The one shown is a type 12AP4/-1803. The large tubes are normally subjected to 70 pounds pressure, which is the limit. The smaller tubes have been left in the tank over night at pressures running as high as 75 pounds without breaking. This determines the factor of safety.*

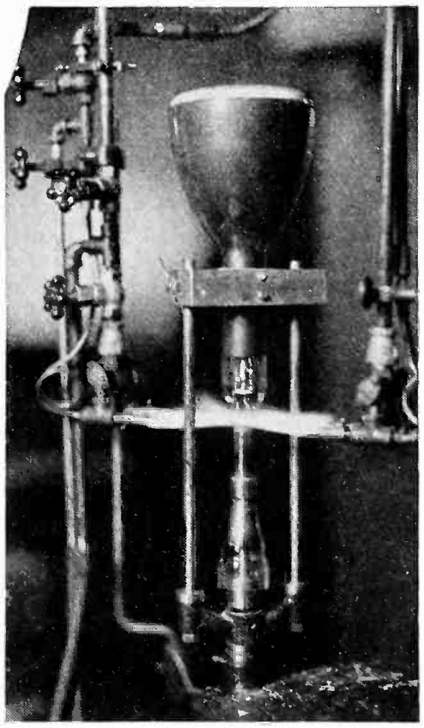


MEASURING CATHODE HEIGHT: *This machine, though not quite as accurate as the original, is a copy of a piece of research equipment which will measure the distance as short as 1/400 second growth of beard. Maintaining the accuracy of delicate metal parts is one of the important reasons for using Nickel and Nickel base alloys in television.*

* * *

SEALING: *(Below) Sealing in a type 5AP4/1805 tube—note 8 lead wafer header. Important to the tube maker is Nickel's ability to withstand heat.*

ACCURATE ALIGNMENT: *(Left) Mounting a type 5BP4/1802 gun on to the wafer type header. A special jig is required for accurate assembly and alignment so that when the tube is operating, only a tiny, perfectly round spot will fall on the screen, the sharpness of the pin point spot being the prime factor determining the clarity of the picture definition. Maintaining this accuracy is an important junction of Nickel, performed by its lasting strength.*



Experience with this metal in radio tube production has demonstrated its many advantages

Long known as a big producer of quality radio tubes is Hygrade Sylvania Corp., of Emporium, Pa. Like other leading makers, Hygrade for years has used Nickel.

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That Nickel, so long the choice for radio tubes, is now widely used in television, points to one conclusion: That it is an excellent material for electronic applications in general.

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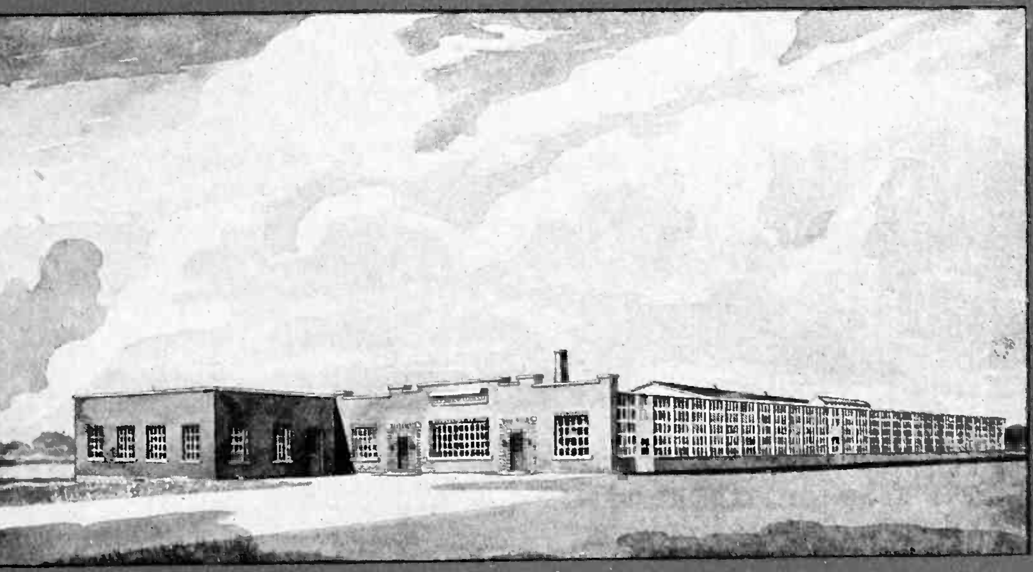

The darker shaded portion of the above sketch shows the latest addition to "Our Factory in the Fields". Into this structure we will move offices and laboratory and convert the vacated space into larger manufacturing quarters for our one and only product — Fine Small Tubing.

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New Books

The Decline of Mechanism in Modern Physics

By A. d'Abro. *D. Van Nostrand Co., Inc., New York, 1939. 982 pages, 61 illustrations. Price, $10.00.*

THE PRACTICING ENGINEER in electronics today may find very little use for the advanced findings of the research physicist, just as the electrical engineers of 1910 found little of value in the then new discoveries in thermionic and photoelectric emission. But many electronic engineers have found it worthwhile to keep up with advances in physics because the most significant findings have appeared in the atomic and sub-atomic domain. A more practical reason lies in the fact that it takes (judging from past experience) only 15 years for the academic discoveries of physics to become the practical realities of engineering.

But keeping up with modern physics has not grown easier in recent years, because the physicists have found it necessary to adopt a very specialized mathematical approach and to think in terms of concepts which seem far removed from the hard facts of experience. In his latest book, Mr. d'Abro has recognized this fact and has written a treatise intended to explain and make plausible these new concepts without resorting to involved mathematical demonstrations. To do so without taking great liberties with the rigour of the subject is a difficult job, but Mr. d'Abro has succeeded, to the same degree in fact (though in a very different way) as has K. K. Darrow in his reviews of contemporary physics.

The book is a large one, and its price proportionately great. This fact may deter many from buying it who prefer to reserve major expenditures for books to be used frequently for reference. The Decline of Mechanism is not a reference work, but it is a masterpiece of simple exposition of an abstruse subject. For those who wish to be conducted in not-to-hurried fashion from the familiar concepts of Newton, Huygens, and the classic physicists to the bizarre ideas of de Brogile and Heisenberg, this book is certainly well worth the price.

The book has no fewer than 41 chapters, divided into three parts: I, General Considerations (the scientific method, the basic of cause-and-effect theories, including one interesting chapter on "The Psychological Differences Among Physicists"); II, Physical Theories of the Classical Period (mathematical formulation, gravity, undulatory theory of light, thermodynamics and kinetic gas theory); and The Quantum Theory (Planck's original work, the Bohr atom, de Broglie's Wave Mechanics, Heisenbergs Uncertainty principles, Schrodinger's mechanics and radiation theory, matrix concepts, Dirac's theory of the electron, new statistical methods, etc.). Throughout, the mathematics employed should give no difficulty to an engineering graduate. The author has a lot say, and he has taken plenty of space in which to say it, but he says it well. —D.G.F.

• • •

Principles and Practice of Radio Servicing

By H. J. Hicks, *Radio Instructor, Hadley Vocational School, St. Louis. McGraw-Hill Book Co., New York, 1939, 305 pages. Price, $3.00.*

THE SERVICING BRANCH of the industry is well served by this book. The problem of servicing radio receivers and allied equipment is approached from both the theoretical and practical viewpoints. The author states in the preface that the fundamental principles are carefully explained and then the application of these principles to various components of radio receivers is discussed. In addition, the more complicated problems are covered in some detail and definite instructions are given.

The first two chapters are devoted to the fundamentals of magnetism, electricity and radio. In Chapter III are discussed radio tubes, their operation and application to the basic circuits. R-f amplifiers, a-f amplifiers, power supplies and detectors are treated in separate chapters. The various control circuits such as volume and tone controls, loud-speakers, antennas and the elimination of static are covered in considerable detail. The design and use of test equipment including the set analyzer, Wheatstone bridge, a-f and r-f oscillators, vacuum-tube volt meter, etc. are described. There is also included a chapter on public address systems with a discussion of microphones, circuits, installation and operation. The last chapter is entitled "The Business Side of Radio Servicing" and endeavors to get across to the reader the idea of how to best use the knowledge gained in reading the previous chapters. Incidentally, any one in business would do well to read this chapter because the ideas presented are by no means limited to the field of radio servicing. An appendix is included which contains much frequently referred to information and a list of twenty-nine helpful books and magazines.

This book is well worth its cost and the time of studying to any service man who is interested in consistently doing a first-class service job. It is also valuable to the person who desires an elementary treatment of the theory of radio and the practical application of that theory.—C.W.

• • •

Electron Optics

By the Research Staff of Electric and Musical Industries, Ltd., compiled and written by Otto Klemperer. Cambridge University Press, The Macmillan Company, New York. Paper bound, 117 pages. Price $1.75.

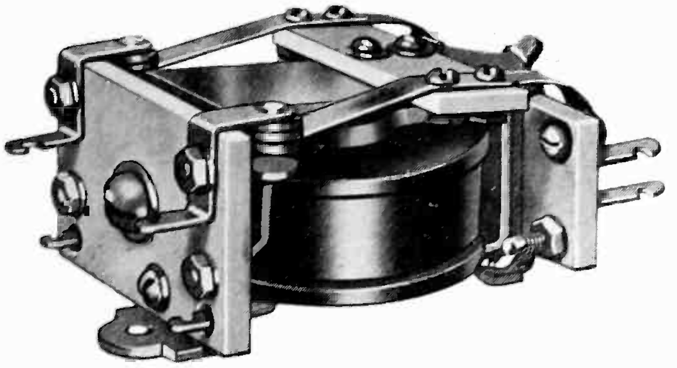
THIS SHORT BOOK is one of the series of "Cambridge Physical Tracts" which so ably review the progress of modern physics. It has been written for the advanced physics student and the research worker, but does not presuppose any but a general knowledge of physical theory. In particular it is not assumed that the reader has specialized in the geometrical optics of light. However, the text is not "elementary," since it is necessary to follow the usual calculus demonstrations, including one or two of the vector calculus variety. The chapters include an introduction, discussions of cardinal points of lense and of field plotting, descriptions of electrostatic and magnetostatic lenses and their aberrations, followed by a review of practical applications. The concluding chapter describes the uses of fields having radial symmetry (as against the axial symmetry of conventional "ray" electron optics) taking the beam power tube as an important example. The book is recommended as a concise introduction to the subject, written in a manner understandable to those who have had a good course in college physics.—D.G.F.

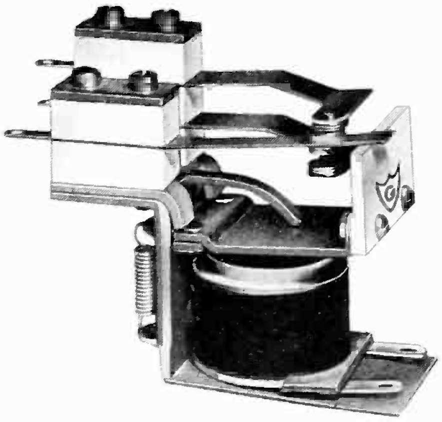
• • •

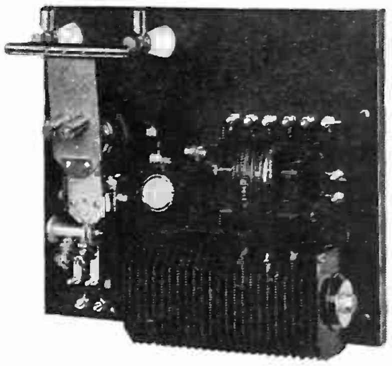
Neon Tube Practice
Second Edition

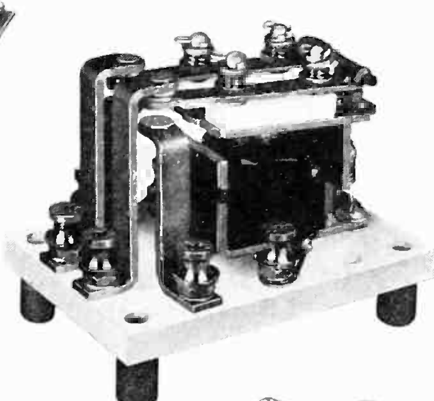
By W. L. Schallreuter, Ph. D. *Chemical Publishing Co., New York, 1939. 255 pages, 28 figures, 30 plates. Price, $4.25.*

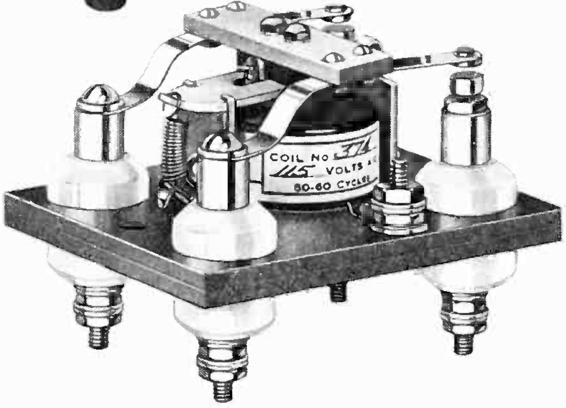
THIS SECOND EDITION has been enlarged and detailed treatment has been accorded two developments which have assumed increased importance since the first edition: the hot cathode and the fluorescent tube. The book, although written and printed in Great Britain, is generally applicable to American practice. The treatment is simple, since the book is intended for technicians who manufacture, install, and maintain neon signs. The more advanced reader will find of interest the data on special effects (such as "wriggle tubes" in which the gas discharge path maintains a continuous motion) and on vacuum practice.—D.G.F.











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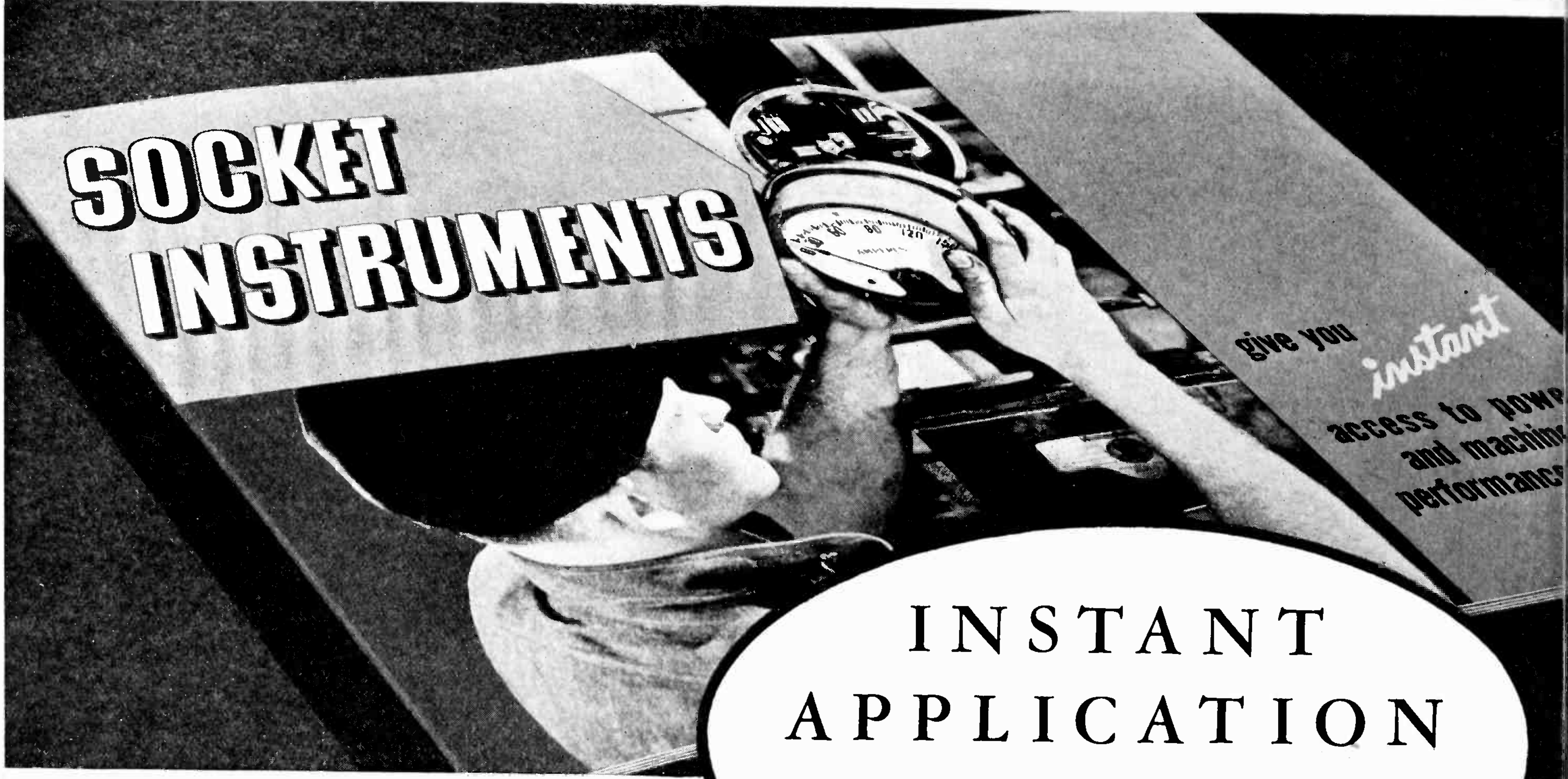
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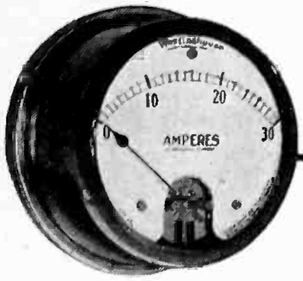

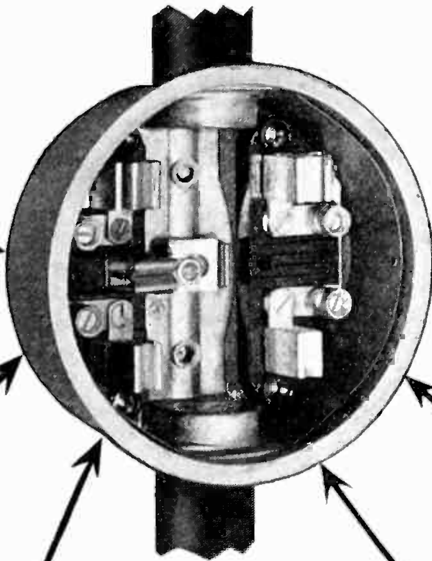

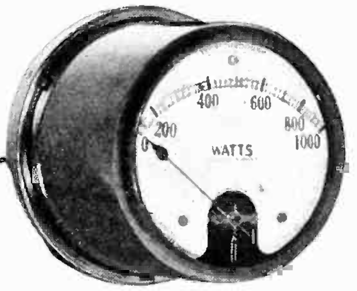

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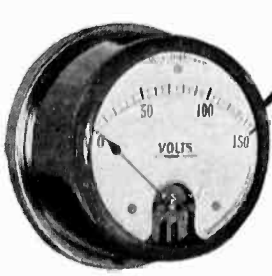

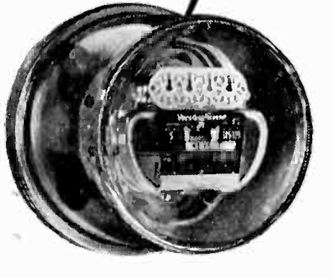

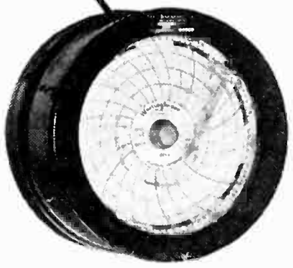

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TUBES AT WORK

A SIMPLE high-quality beat oscillator, the problem of measuring dosage in s-w therapy, measuring thin films by capacitance, and testing coils with r-f—this month's crop of tube applications

A Modern Beat Oscillator

By

C. W. Caldwell and C. W. Harrison

Purdue University *Lehigh University*

The design of beat frequency oscillators has passed through many stages from the elaborate 10-tube to the simplest 1-tube signal generator. The simplified oscillator is limited in application due to its poor wave form while the elaborate oscillator is limited by its expense. The details of an oscillator that can be used for almost every purpose, with very high standards of performance, are described in this paper. This oscillator has the following desirable features:

(1) Simplicity of design
(2) Constant output voltage
(3) No elaborate shielding required
(4) Multiple range of voltage and impedance output
(5) No locking-in tendencies
(6) Excellent waveform
(7) Appreciable output at one cycle per second
(8) Band spread which offers a full scale to 1000 cycles variation, plus or minus that of the set frequency
(9) Inexpensive to construct.

The high frequency oscillators which beat together to give the difference frequency play a large part in the design of the signal generator. A small percentage change in the frequency of one oscillator will affect the output or audio signal directly, unless the other high frequency oscillator should vary an equal amount in the same direction. This condition calls for two principal characteristics: an inherently stable, electron-coupled oscillator and symmetry in the physical layout with respect to internal heat and to the electrical symmetry of the oscillator inductances.

Another element used to stabilize the oscillators electrically is a highly capacitive L-C circuit. The additional capacitance, which may be either a mica dielectric or an air dielectric condenser, is of value for another reason, that is, the fact that a trimmer condenser on the fixed frequency oscillator will not produce a large percentage change in capacity of the resonate L-C circuit. The band-spread feature of this beat frequency oscillator depends upon the trimmer condenser. It varies the frequency of the "fixed frequency" oscillator from 169 to 170 kc which gives a change in the audio output of 1000 cycles regardless of the difference frequency already produced.

The trimmer condenser is distinctly an economic advantage because it saves the expense of a tapered variable condenser on the variable oscillator. The output of the fixed frequency oscillator is fed into a resonant circuit which filters out the harmonics and gives a sine wave output over the 169 to 170 kc range. The resonant circuit is necessary to prevent superfluous beat notes that would otherwise be produced.

The variable frequency oscillator is quite similar to that of the fixed frequency oscillator, the principal difference being that in place of the trimmer condenser a 500 μμf variable condenser is used. The inductance coils of the oscillators may be designed for the audio frequency range desired, the only limitation being that both oscillator inductances must be identical, physically and electrically. To obtain good waveform the fixed frequency oscillator signal is strong and of constant output while the variable oscillator signal is rather weak. This results in favorable waveform as well as constant voltage output over the entire frequency range. The tubes used in the oscillator are metal, hence the only shielding necessary is that directly over the oscillator inductances.

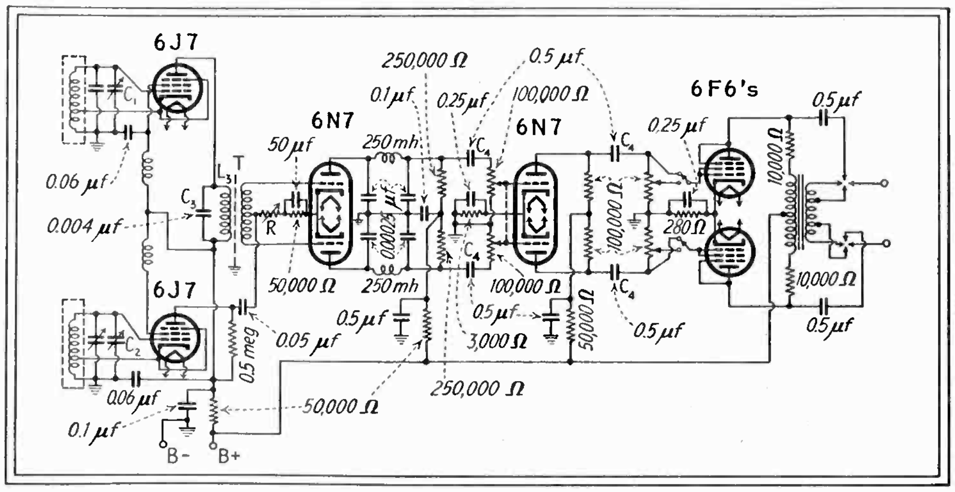

Fig. 1—Complete circuit diagram of a stable and simple beat oscillator

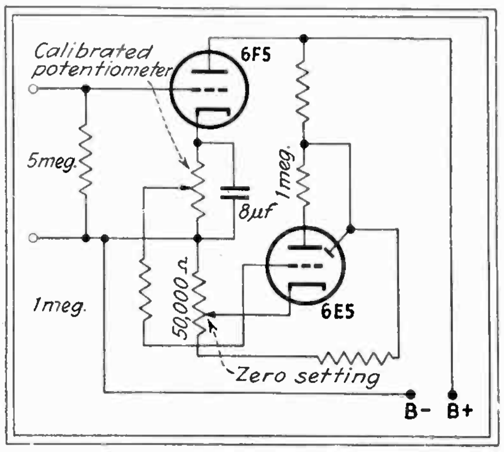

Fig. 2—Tuning indicator circuit

The transformer (T) is an intermediate-frequency, three-winding type whose adjustment is not critical as long as the primary resonates at 169 to 170 kc. Balanced detection is especially adaptable because there is no tendency to lock-in at low audio frequencies. This detector affords an appreciable output, approximately one volt at intermediate frequencies. The plate resistance of the detector is used as the terminating input resistance in the filter design and the filter is terminated into the plate load resistors. The coupling condensers, C_4, are 0.5 μf each, and even though they offer a high resistance at low frequencies, five volts may be obtained at one cycle with an infinite terminating impedance.

The filter design is of the usual π-section type, and is necessarily in both halves of the audio amplifier. When this filter is properly designed and terminated it will remove all radio frequency and will help to suppress superfluous beat notes. Some designers find it necessary to include two sections but this is not necessary if the design and terminating resistors are correct.[1]

A dual volume control is necessary because of the push-pull, class A arrangement of the audio amplifier. This volume control is in the input of the first amplifier stage. The output of this amplifier may complete the oscillator as 10 or more volts may be obtained

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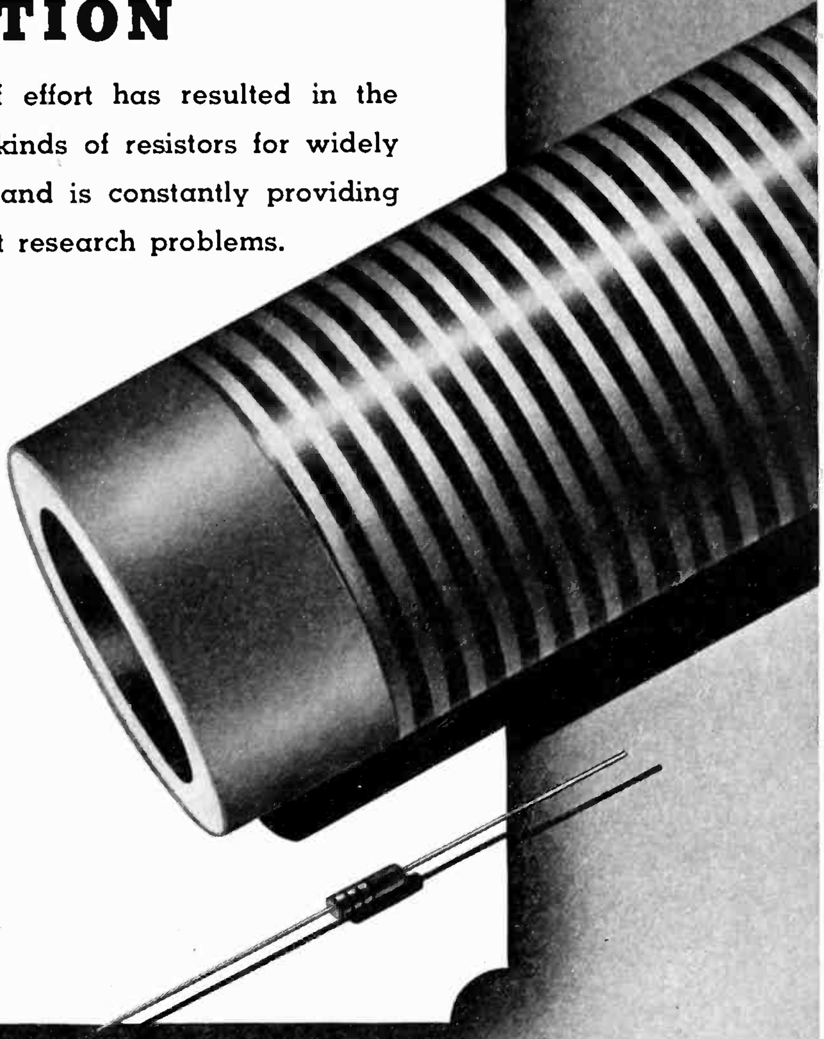
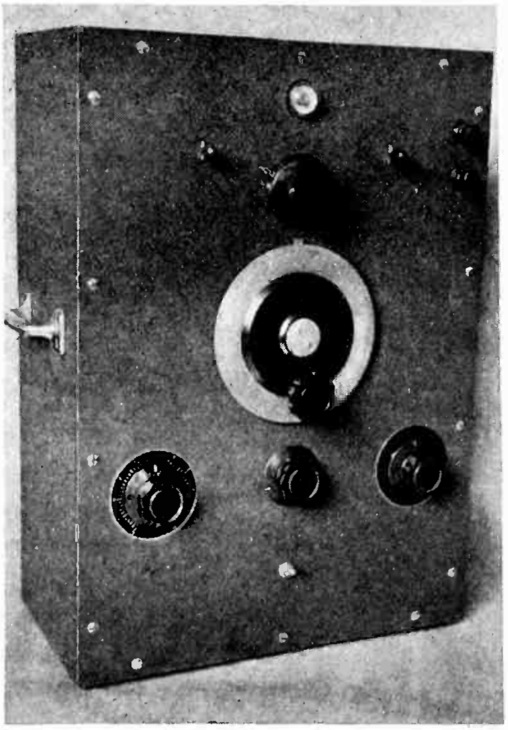
[1] F. E. Terman, "Measurements of Radio Engineering," McGraw-Hill Book Co., 1935, pp. 298–303.



between 100 and 12,000 cps. This would complete the 4-tube (working) beat frequency oscillator which has all the performance characteristics excluding automatic volume control, found in most commercial beat frequency oscillators.

The last stage was added purely to make the beat-frequency-oscillator more versatile. It offers a higher voltage output and a choice of impedances. The 6F6 is normally used as a pentode but its distortion proved to be relatively high; hence, it was connected as a triode. The resistors in the 6F6 plate load provides an impedance at low frequencies. The double pole triple throw switch provides an adequate method for changing output impedances.



View of completed oscillator

In place of automatic volume control, a simple vacuum tube voltmeter assures a constant output independent of frequency. The vacuum tube voltmeter used is a simple cathode-ray indicator, shown in Fig. 2.[2] The output is adjusted to the desired level by the calibrated control on the vacuum tube voltmeter and the eye is closed by the volume control on the beat frequency oscillator. Adjustment is normally required only over the low frequency range.

---

[2] Conner, "The Vacuum Tube Voltmeter as a Service Tool," Bulletin.

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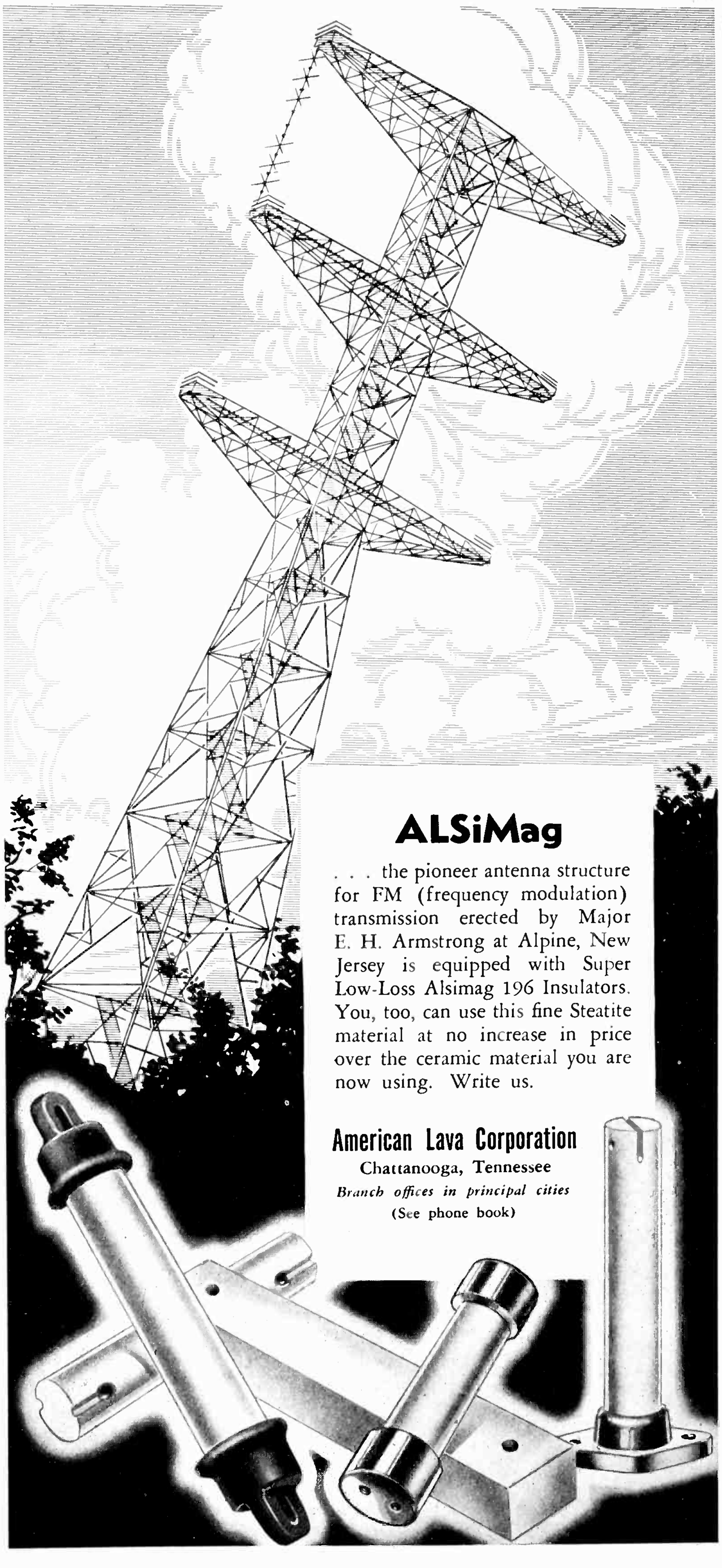
Dosimetry In Short Wave Therapy

By Eugene J. Mittelmann,
E. E., Ph. D.

Short wave therapy is now in common use all over the world as a very successful branch of physical therapy.



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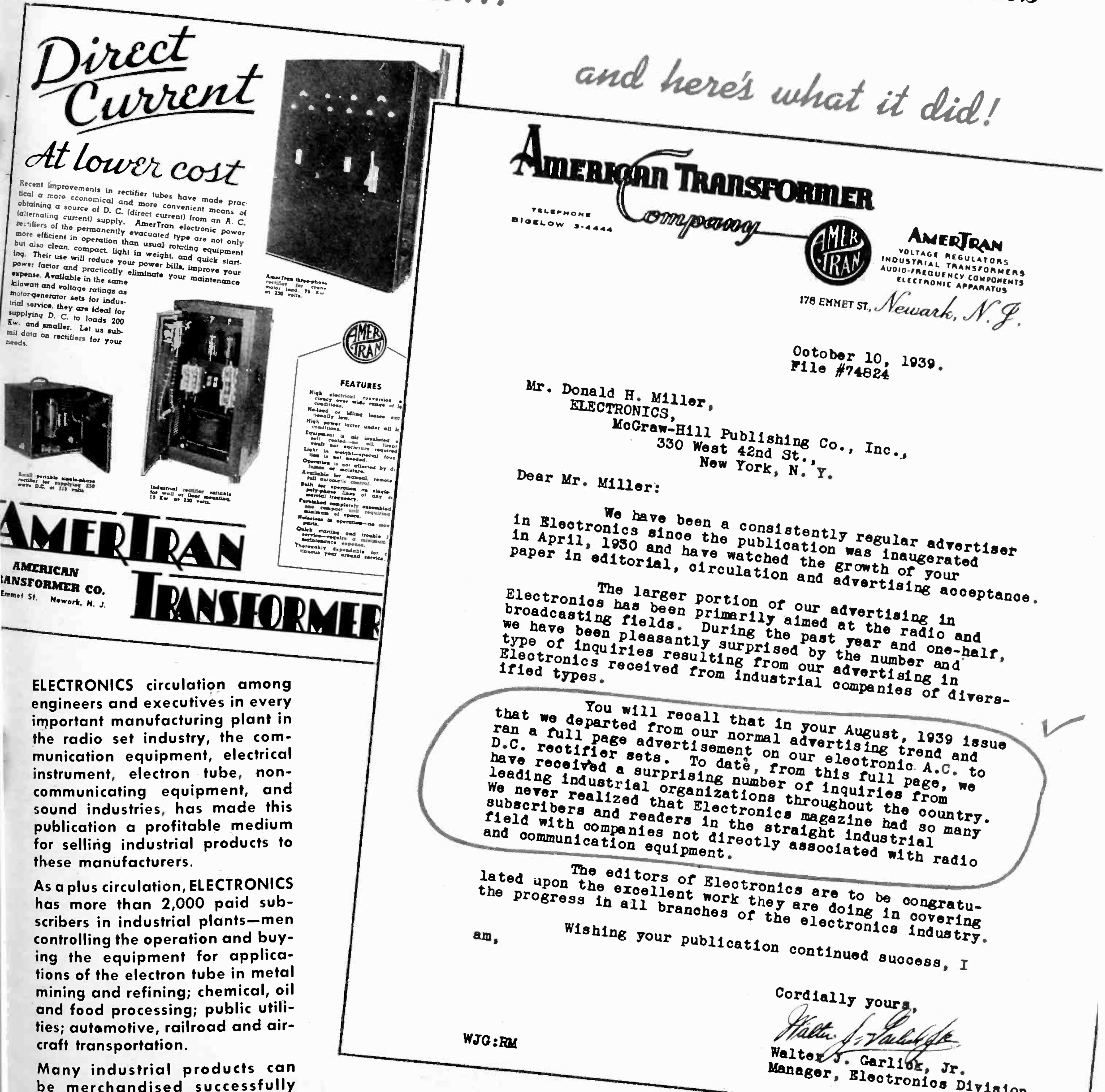

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178 EMMET ST., *Newark, N. J.*

October 10, 1939.
File #74824

Mr. Donald H. Miller,
ELECTRONICS,
McGraw-Hill Publishing Co., Inc.,
330 West 42nd St.,
New York, N. Y.

Dear Mr. Miller:

We have been a consistently regular advertiser in Electronics since the publication was inaugerated in April, 1930 and have watched the growth of your paper in editorial, circulation and advertising acceptance.

The larger portion of our advertising in Electronics has been primarily aimed at the radio and broadcasting fields. During the past year and one-half, we have been pleasantly surprised by the number and type of inquiries resulting from our advertising in Electronics received from industrial companies of diversified types.

You will recall that in your August, 1939 issue that we departed from our normal advertising trend and ran a full page advertisement on our electronic A.C. to D.C. rectifier sets. To date, from this full page, we have received a surprising number of inquiries from leading industrial organizations throughout the country. We never realized that Electronics magazine had so many subscribers and readers in the straight industrial field with companies not directly associated with radio and communication equipment.

The editors of Electronics are to be congratulated upon the excellent work they are doing in covering the progress in all branches of the electronics industry.

Wishing your publication continued success, I am,

Cordially yours,

Walter J. Garlick Jr

WJG:RM

Walter J. Garlick, Jr.
Manager, Electronics Division

ELECTRONICS circulation among engineers and executives in every important manufacturing plant in the radio set industry, the communication equipment, electrical instrument, electron tube, non-communicating equipment, and sound industries, has made this publication a profitable medium for selling industrial products to these manufacturers.

As a plus circulation, ELECTRONICS has more than 2,000 paid subscribers in industrial plants—men controlling the operation and buying the equipment for applications of the electron tube in metal mining and refining; chemical, oil and food processing; public utilities; automotive, railroad and aircraft transportation.

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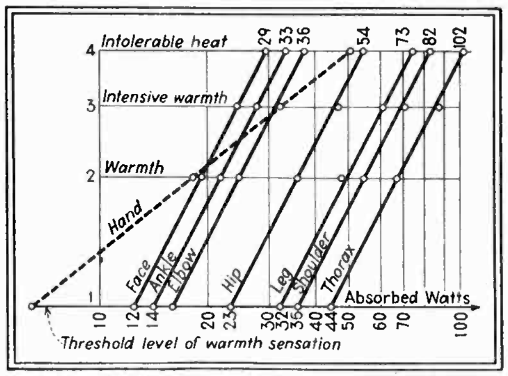
electronics

A McGraw-Hill Publication
330 West 42nd Street, New York, N. Y.

Unfortunately one of the most important problems of the new therapy remained unsolved for many years. When a body is introduced between the electrodes of a short wave therapy machine, heat is created in the interior of the body due to the dielectric losses in the object under treatment. It is of the utmost importance from the point of view of duplicating a certain treatment under similar conditions to know the exact amount of energy absorption in the body. The number of calories developed in the interior of the body is proportionate to the amount of the energy absorption. The total power delivered by a short wave therapy machine is divided into two components.



Heat impression vs. absorbed power

One part is radiated in the air space due to the radiation losses, the magnitude of which will depend on the distance and area of the electrodes. The other component is absorbed by the dielectric losses of the object introduced between the electrodes. This power is of interest to the physician. The technical problem is to measure this magnitude alone, i.e., a certain fraction of a given total power. To make the problem more complicated, both the total power and the fraction to be measured are widely varied due to the different techniques of electrode application during the treatment.

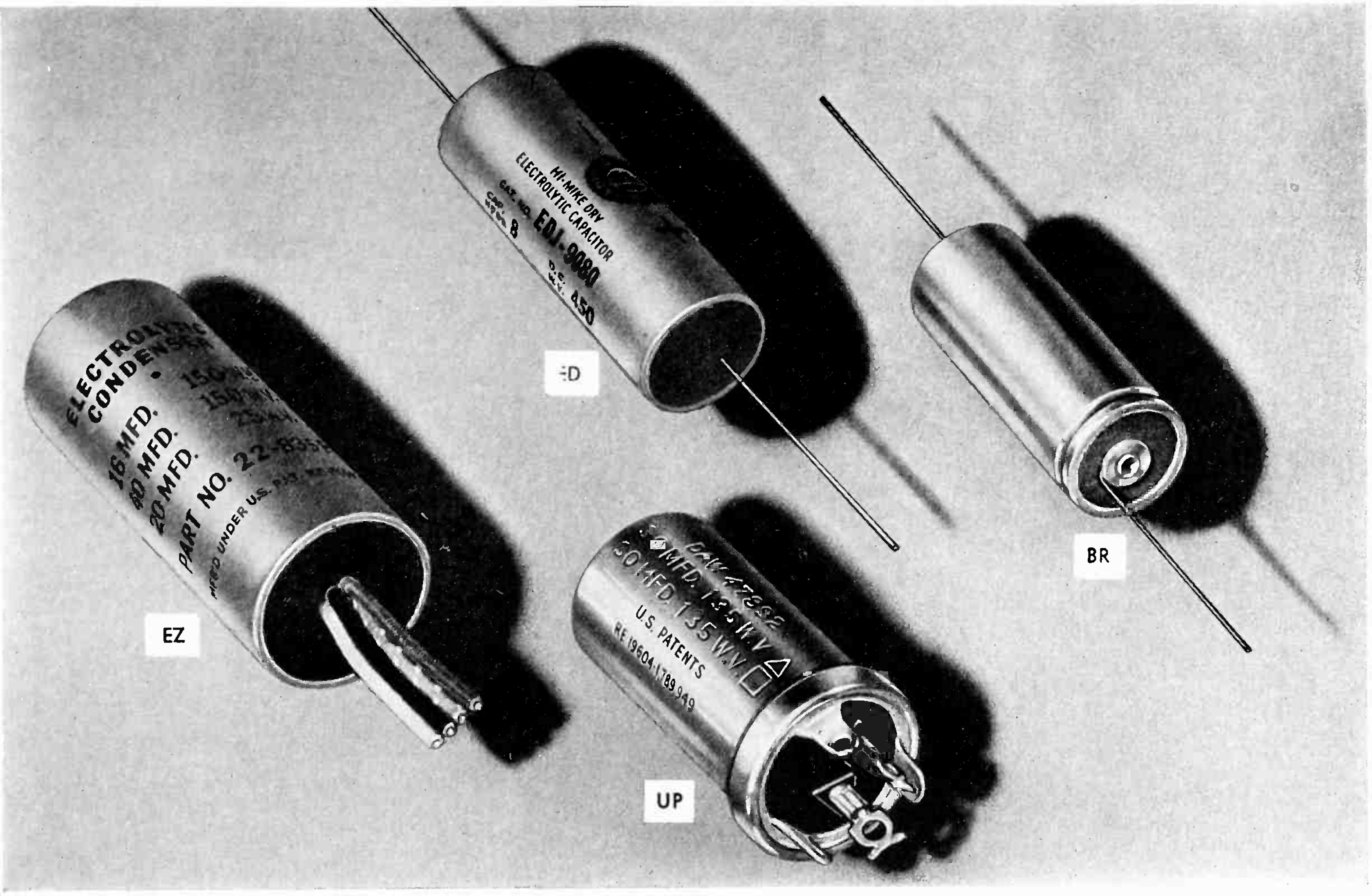
Considering this basic problem, if dosimetry is to satisfy all demands which can reasonably be placed upon it, the following are the minimum conditions which must be fulfilled:

(1) The measurement must be direct reading and register the actual high frequency power absorbed by the patient and only that energy alone.

(2) The measurement must be available during the treatment in a manner permitting reading a scale ranging from zero to maximum. The instrument must follow and indicate every variation in energy absorbed by the object under treatment. Only such a method of measurement which facilitates constant control of treatment meets with the essential demands.

(3) The method must have no influence on the usual medical technic; in other words, measurement should be possible irrespective of the size or position (air distance) of the electrodes and for all objects under treatment.

The principle on which the instrument developed by the author[1] is based may be explained in the following



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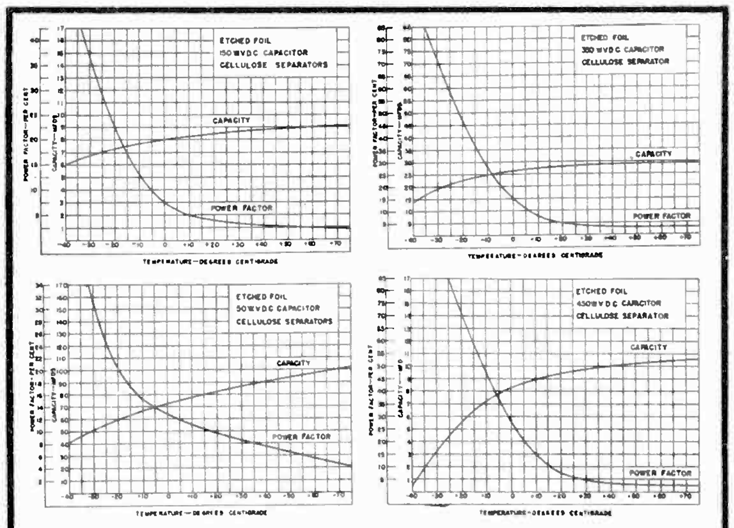
*C-D type UP Electro-Chemically Etched Foil Capacitors have been found most suitable for use in automobile radio receivers by a majority of manufacturers



The above curves show the effect of variations in ambient temperature on capacity and power-factor values of etched foil units.

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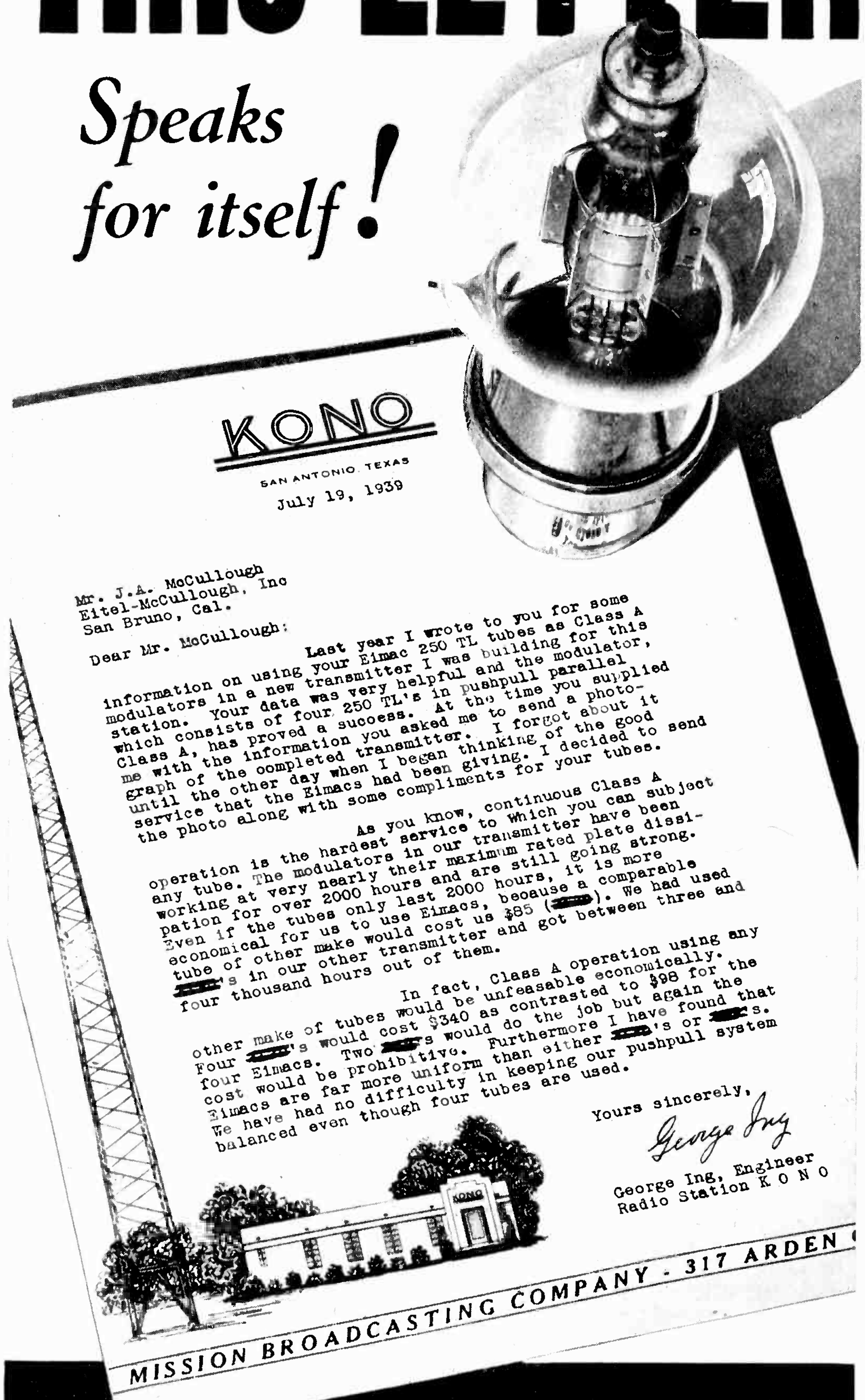


KONO
SAN ANTONIO TEXAS

July 19, 1939

Mr. J.A. McCullough
Eitel-McCullough, Inc
San Bruno, Cal.

Dear Mr. McCullough:

Last year I wrote to you for some information on using your Eimac 250 TL tubes as Class A modulators in a new transmitter I was building for this station. Your data was very helpful and the modulator, which consists of four 250 TL's in pushpull parallel Class A, has proved a success. At the time you supplied me with the information you asked me to send a photograph of the completed transmitter. I forgot about it until the other day when I began thinking of the good service that the Eimacs had been giving. I decided to send the photo along with some compliments for your tubes.

As you know, continuous Class A operation is the hardest service to which you can subject any tube. The modulators in our transmitter have been working at very nearly their maximum rated plate dissipation for over 2000 hours and are still going strong. Even if the tubes only last 2000 hours, it is more economical for us to use Eimacs, because a comparable tube of other make would cost us $85 ([redacted]). We had used [redacted]'s in our other transmitter and got between three and four thousand hours out of them.

In fact, Class A operation using any other make of tubes would be unfeasable economically. Four [redacted]'s would cost $340 as contrasted to $98 for the four Eimacs. Two [redacted]'s would do the job but again the cost would be prohibitive. Furthermore I have found that Eimacs are far more uniform than either [redacted]'s or [redacted]s. We have had no difficulty in keeping our pushpull system balanced even though four tubes are used.

Yours sincerely,

George Ing

George Ing, Engineer
Radio Station K O N O

MISSION BROADCASTING COMPANY - 317 ARDEN

figures. In Fig. 1 L and C denote the total secondary inductance and capacity of the patient circuit. The object O is introduced between the electrodes E. This actual circuit may be reproduced by the electrically equivalent circuit of Fig. 2 in which C represents all circuit capacity. The total losses of the circuit are given by the parallel resistances R_1 and R_2. R_1 represents the equivalent total loss resistance of the circuit due to the radiation losses and the loss of the unloaded circuit itself. R_2 is the equivalent parallel resistance introduced in the circuit by introducing the object between the electrodes. The magnitude of the resistance R_2 will depend on the coupling capacities between the electrodes and the object corresponding to the distance chosen.

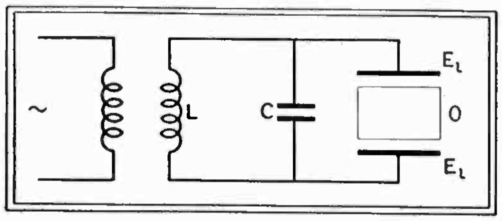


Fig. 1—Basic therapy circuit

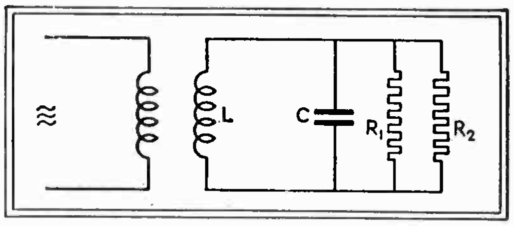


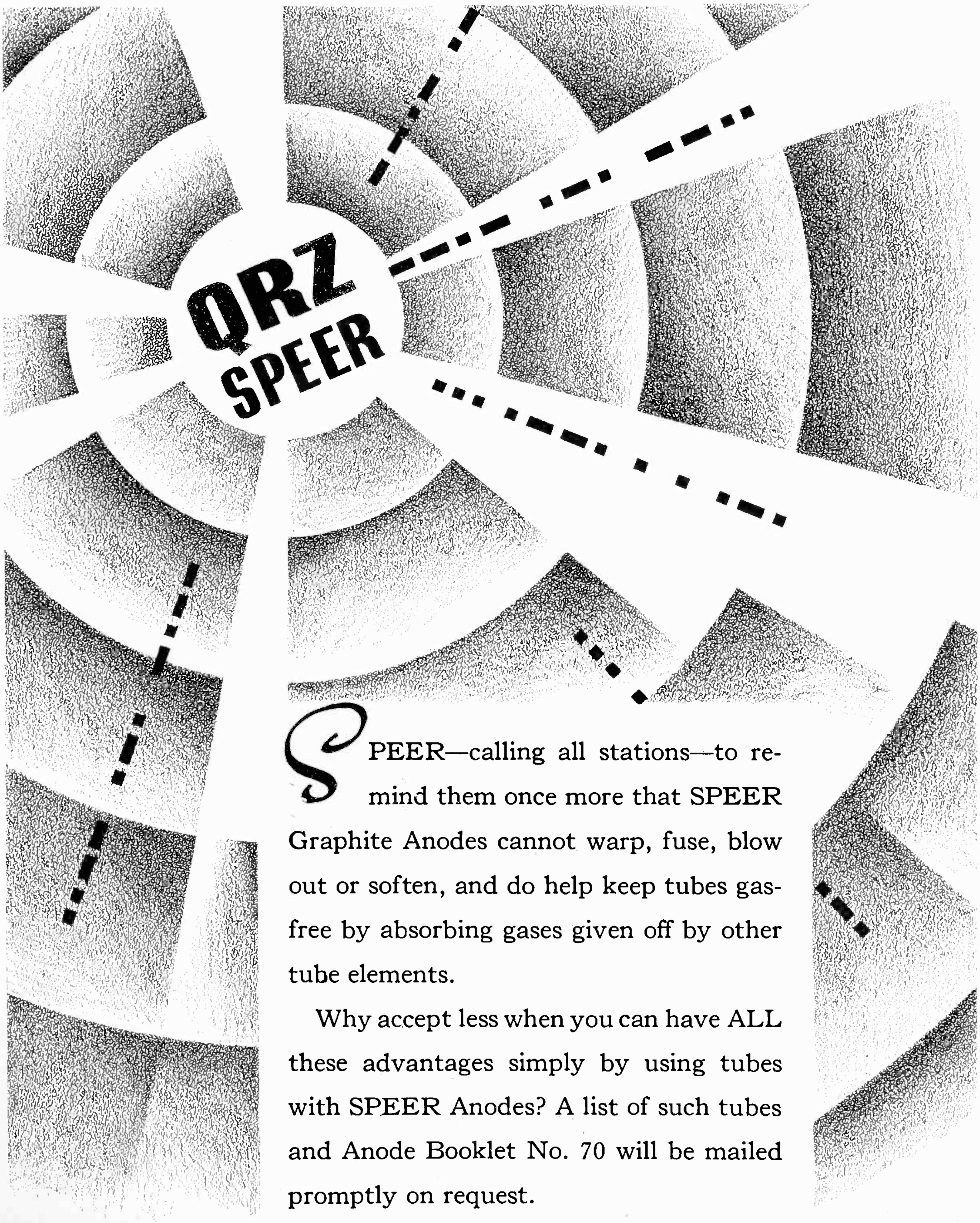
Fig. 2—Equivalent circuit with resistance load

Considering Figs. 1 and 2, the only way to measure the power absorbed by the patient under treatment is by first determining the "equivalent patient resistance." This may be done in a very simple way. Let's assume, that the circuit in Fig. 2 is excited by a constant primary voltage. In this case the resonant voltage across the terminals of the circuit will be proportional to the magnitude of the equivalent parallel resistance, which represents the total losses of the circuit. Let us denote by e_1 the resonance voltage when no object is introduced between the electrodes and all losses are represented by the parallel resistance R_1. Then $R_1 = k\ e_1$. After introduction of the patient between the electrodes the resistance R_2 is switched in parallel to resistance R_1 and the resonance voltage e_2 will be proportional to the resultant resistance of both R_1 and R_2.

$$\frac{R_1\ R_2}{R_1+R_2} = k\ e_2 \ldots\ldots\ldots (1)$$

From (Eq. 1) we get

$$R_2 = R_1 \frac{e_2}{e_1 - e_2} \ldots\ldots\ldots (2)$$


QRZ
SPEER

It may be proven that the resistance R_1 which represents the total losses of a given short wave therapy machine with no objects between the electrodes, is with great accuracy independent of the position of the electrodes, if the distance of the unloaded electrodes does not go beyond a certain lower limit, which practically never will be reached under working conditions. Considering this and the assumption that we maintain the exciting primary voltage and the resonant voltage e_1 constant, the resistance R_2 is given as a pure function of the resonant voltage e_2.

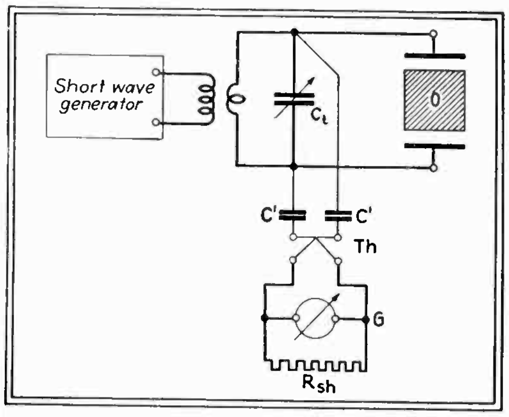


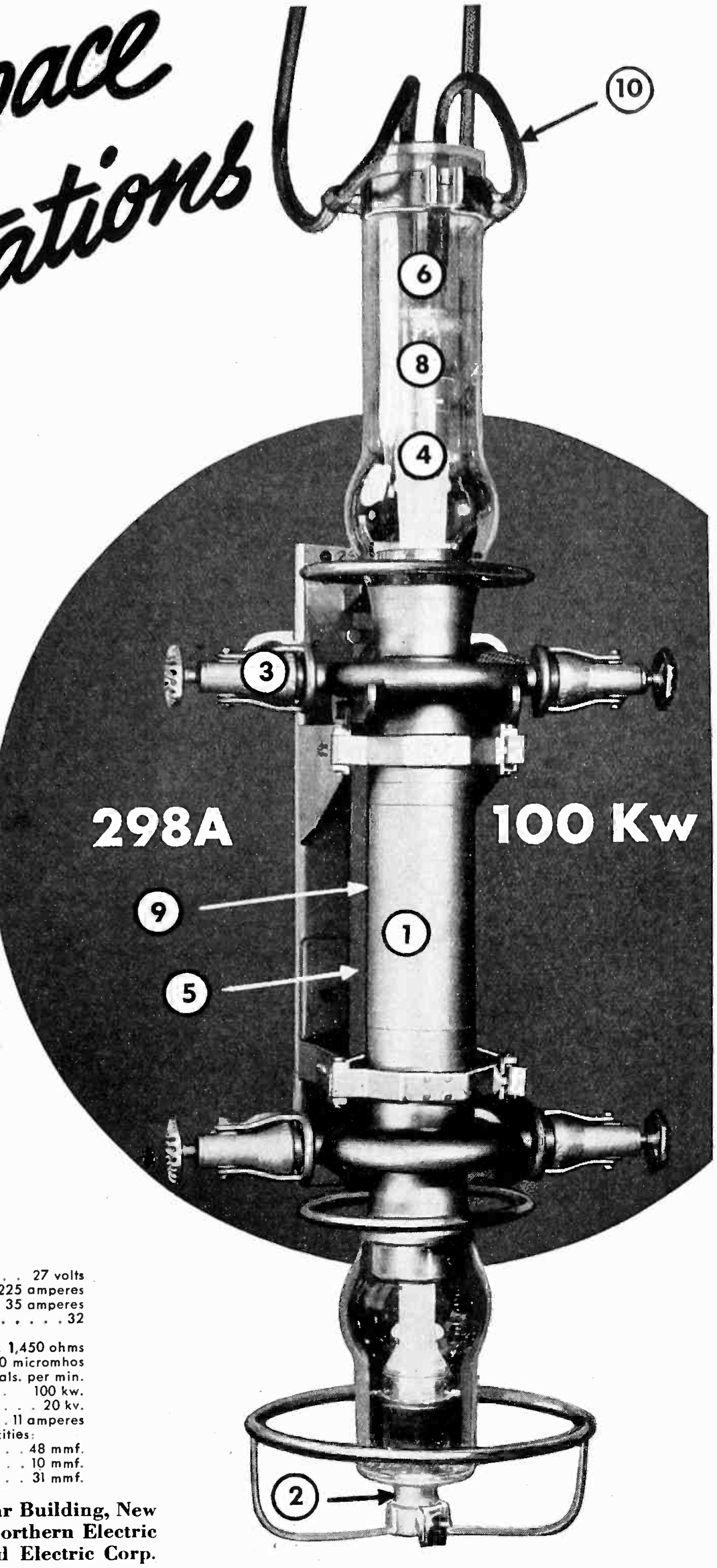
Fig. 3—Measuring circuit to check output power

Since the equivalent patient resistance is known, it is only necessary to measure the voltage E across the circuit under working conditions, to obtain the absorbed power as given by the equation

$$P = E^2 \frac{1}{R_2} \text{..........} (4)$$

The schematic diagram of the circuit indicating the power absorption in the body by a direct reading on a linear scale is given in Fig. 3. The voltage E across the circuit is measured by a thermocouple Th which is coupled by small condensers C' to the circuit. The thermocouple produces a current in the galvanometer G proportional to the square of the voltage E. As the deflection of the galvanometer is proportional to the current flowing through the moving coil and to the sensitivity of the system, the instrument will read values proportional to the absorbed power, if we adjust the sensitivity of the meter so that it will be proportional to the reciprocal of the equivalent parallel resistance R_2. This is carried out in the simplest way by shunting the meter by a calibrated resistance R_{sh}. The dial of this resistance is calibrated in such a manner that when setting the dial to the corresponding reading as indicated by the resonant voltage e_2 the correct sensitivity is obtained to convert the galvanometer into a direct reading wattmeter. The average accuracy of the instrument is about 3-5 per cent, regardless of the position and size of the electrodes.

Setting the pace in 50Kw stations



WHAT USERS SAY: — Owners of 50kw transmitters are enthusiastic about the performance they're getting from Western Electric 100 kilowatt tubes. They'll tell you that 298A's give the greatest value per kilowatt of output of any tubes now in service! Here's why:

1. Brazed copper water jacket is a permanent part of the tube.
2. Heavy copper grid lead-in and support allows safe operation at higher frequencies than are possible with other tubes of comparable ratings.
3. Double-ended construction, along with new tube mounting, facilitates quick changes.
4. Jeweled expansion bearings give long mechanical life.
5. Grid made of tantalum laterals welded to six heavy conducting supports.
6. Copper to glass seals used for all lead-ins permit operation without cooling air streams.
7. Exact filament voltages supplied for the rated emission in tube booklet to encourage maximum tube economy.
8. Filament tension spring located in the coolest portion of the tube.
9. Extra large, pure tungsten filament assures long burnout life and low tube hour costs.
10. Flexible filament leads.

Ratings

Nominal Filament Voltage	27 volts
Average Filament Current	225 amperes
Average Filament Emission	35 amperes
Amplification Factor	32
Average Plate Resistance at 18,000 v. and —250 v. bias	1,450 ohms
Transconductance	22,000 micromhos
Normal Water Cooling Flow	35 gals. per min.
Maximum Plate Dissipation	100 kw.
Maximum Plate Voltage	20 kv.
Maximum Plate Current	11 amperes
Approximate Inter-Electrode Capacities:	
Plate to Grid	48 mmf.
Plate to Filament	10 mmf.
Grid to Filament	31 mmf.

DISTRIBUTORS: Graybar Electric Company, Graybar Building, New York, New York. *In Canada and Newfoundland:* Northern Electric Co., Ltd. *In other countries:* International Standard Electric Corp.

Western Electric

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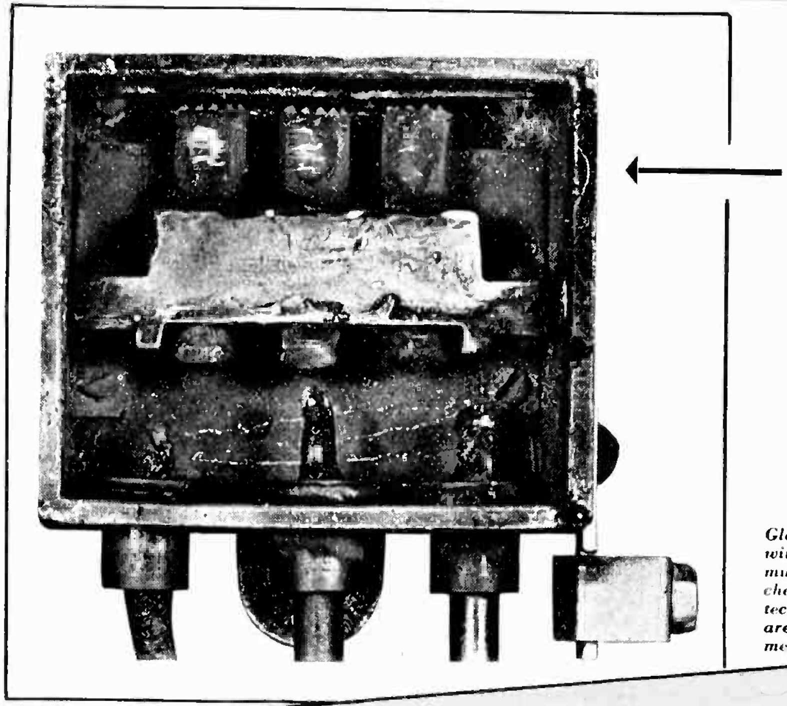
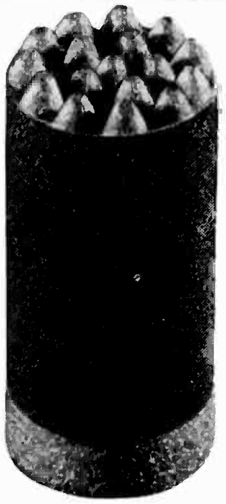




Some results of a long series of measurements are reproduced as they were carried out with the described instrument as shown on page 54.[2]

BIBLIOGRAPHY:

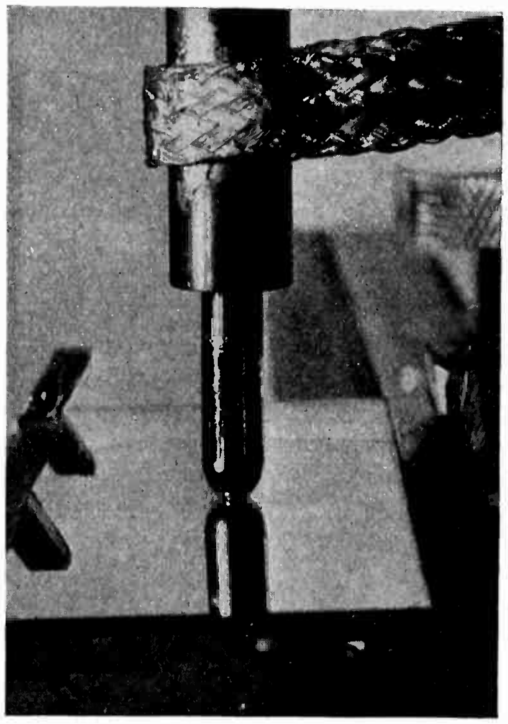
[1] Mittelmann, E. Dosimetry in short wave therapy, *Archives of Physical Therapy*, Chicago. Vol. XVIII, 1937, pp. 613–699. Mittelmann, E.: Die Messung der Hochfrequenzleistung bei Kurzwellentherapiesendern; *Elektrotechnik und Maschinenbau*, Vol. LV. 1937, copy 38.

[2] Mittelmann, E. and Kobak, D. Dosage measurement in short wave Diathermy, *Archives of Physical Therapy*, Chicago. Vol. XIX, 1938, pp. 725–736.

• • •

Investigating Insulation Value of Molecular Films

INVESTIGATING the properties of films of molecular thickness has revealed the fact that ordinary materials may possess unusual dielectric properties in such thin sections. One fact revealed by this work, now being carried out in the General Electric Research Laboratories, has shown that such organic compounds as barium stearate have unsuspected dielectric strength, and dielectric constant.



Film thickness gauge using mercury electrodes

Since the capacitance displayed by two plates depends inversely on the thickness of dielectric between them, it follows that very high capacity is associated with molecular films. In order to obtain capacitances for measurement which have values within the usual ranges of measuring equipment, it is necessary to use a very small area of film. Actually the area in typical cases is only 0.003 square inch. A mercury point electrode is used to establish contact with the film over this small area. By measuring the capacitance between the electrode and the base plate, it is possible to calculate the thickness of the layer within an accuracy of two

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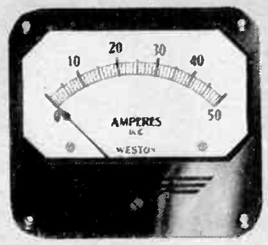

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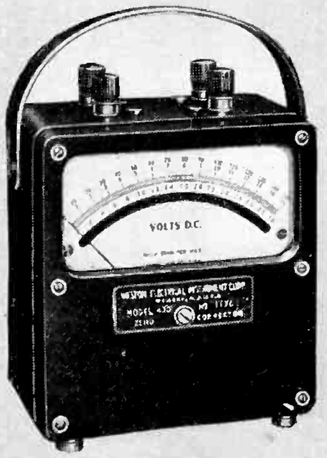

WESTON Maintenance Instruments . . . compact, rugged, inexpensive. Large, easily read scales facilitate maintenance testing.

WESTON Multi-purpose Instruments . . . ideal for use in assembly and inspection . . . available as volt-ohmmeters . . . volt-ohm-milliammeters . . . and other combinations.

Correct use of dependable instruments eliminates work interruptions . . . costly maintenance . . . in the busy shop

With sudden demand straining production facilities, the methods used for "getting by" in leaner days quickly break down . . . invariably turn into expensive bottlenecks.

★ **Costly work interruptions and equipment repairs** are the penalties of infrequent or inadequate testing of motor driven equipment.

★ **Costly rejects and impaired product quality** are the price of inadequate testing along the electrical assembly and inspection lines.

★ **Excessive service costs and customer dissatisfaction** result when inadequate instruments are "built-in."

Right now is the time to check your instrumentation . . . make sure it is adequate for today's needs and any sudden impact which may come. Call in the WESTON instrument specialist in your vicinity. His counsel on instrument selection and use will make for greater simplicity in assembly, lower service costs, and enable you to maintain your equipment at the highest availability and efficiency. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

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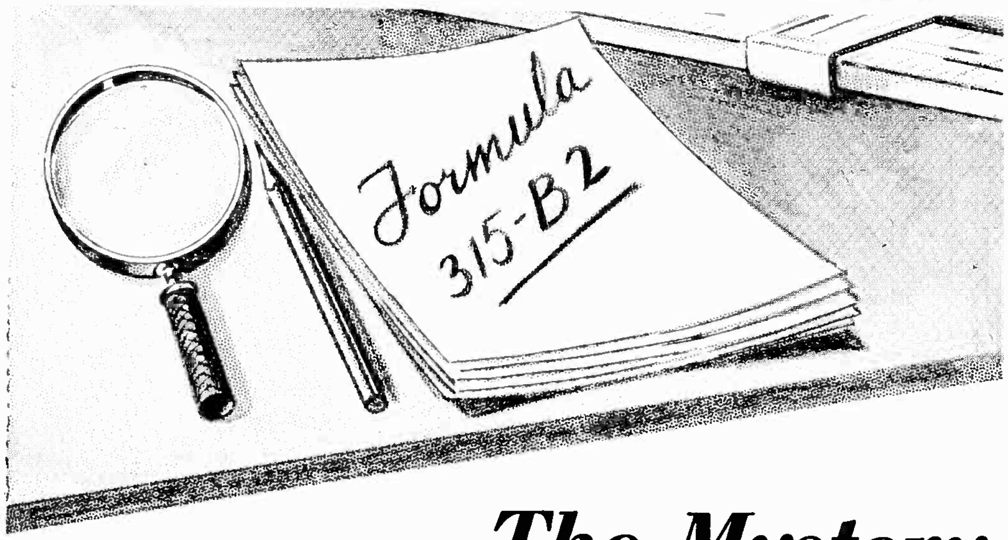

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DILECTO
A laminated plastic, commonly known as phenol fibre, made in sheets, rods and tubes or fabricated parts to specifications. Has high electrical insulation properties, great resistance to water, practically unaffected by oil or mild acids. It is a strong, tough material with a wide application for use in connection with modern electrical appliances.

DIAMOND VULCANIZED FIBRE
A tough, economical, insulating material made in standard sheets, rods and tubes. Can be readily fabricated or formed. A material of countless applications.

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A thermo-plastic, non-hygroscopic insulating material made in standard sheets, rods and tubes. It is strong and tough, has good electrical insulating properties and is readily fabricated.

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A phenolic molded fabric base material of exceptional mechanical strength yet extremely light in weight. Can be molded to any desired shape and contour to replace intricate metal and insulation assemblies. Write for CELORON Bulletin.

molecules. At present the investigations are in the realm of pure science, although such useful application as the recently announced "glareless" glass have already resulted from it.

• • •

Oscillator used for Coil Testing

A NEW COIL TESTER which makes use of a high frequency oscillator to develop high voltage between the turns of a coil to be tested has been developed in the General Electric research laboratories. A standard vacuum-tube oscillator, fed from a rectifier power supply from 110 volts a-c source is used to excite a laminated iron core, made of special high frequency material. On either side of the winding small detector coils are mounted and connected in a v-t voltmeter bridge circuit. The voltages induced in the detector coils are balanced, normally, and the v-t voltmeter reads zero. However, if the excited unit succeeds in breaking down the insulation in the coil under test, the flux through the nearest detector coil is reduced, the bridge balance disturbed, and the v-t voltmeter indicates. The whole unit is mounted in a steel case fitted with interlocks, and an observation window is provided for inspecting the coils during test. Several hundred coils per hour may be tested with the equipment.

• • •

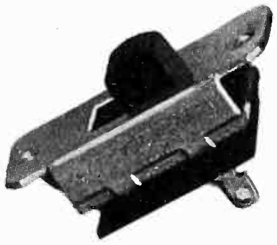
COORDINATING FIRE PREVENTION

Fire Chiefs from various parts of the nation gathered at local amateur stations to participate in an organized attempt to co-ordinate fire prevention activities via radio. Amateur operators in Colorado, California, Missouri, Texas and one station in Peru had local fire executives on hand. Above, William H. Gardner, Chief of Kansas City Underwriters Fire Patrol is answering questions put to him by the Denver fire chief, in the station of James Blair

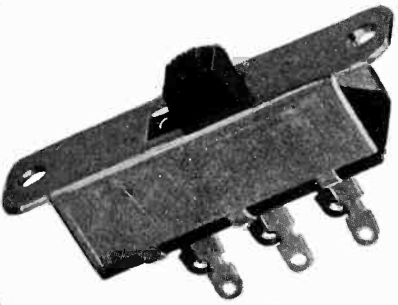
Here are the New STACKPOLE SLIDE SWITCHES

TYPE SS 1A

TYPE SS 1



TYPE SS 3



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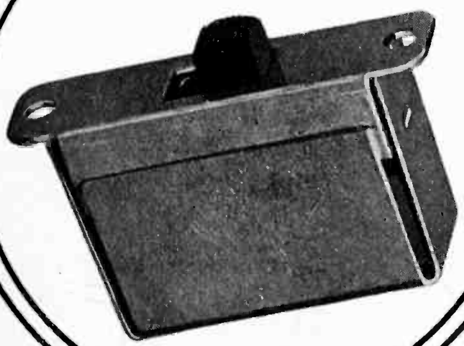

All illustrations are actual size.

● Engineers concerned with design problems where low cost and space savings are factors will find that these compact inexpensive switches fit in exactly with their plans. The four types illustrated here have innumberable applications for handling small power circuits.

TYPE SS-1 is a single pole throw switch with Underwriters' Approval for .75 amp. 125 volts. May also be supplied with three terminals as a single pole double throw switch which is not approved by the Underwriters'. This is known as Type SS-2. These types suggest the following uses:

Two-position tone control; Sensitivity control; Change-over switch for AC-DC sets; Line switch for small sets; Small motor control; Tap switch for power transformer; Dome light switch for automobiles; Defroster motor switch; Heater-blower switch for automobile use; High-low speed switch for small motors; Battery drain control switch for battery sets; Pilot light switch for battery sets. TYPE SS-1A is identical with SS-1 except it has a snap-on shield approved by the Underwriters' as a terminal enclosure.

TYPE SS-3 is a double pole double throw switch which suggests itself for the following uses:

Change-over switch for battery-110 volt sets; Band change switch; Phono-radio switch; and many other uses. May be supplied as a double pole single throw switch known as Type SS-4.

TYPE SS-3A is identical with SS-3 except has a snap-on terminal enclosure.

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VOLUME CONTROLS • **TONE CONTROLS**

TUBES . . .

a new department

NEWS of recently issued tube types, their characteristics and special fields of use, including a month-by-month registry of new tube types compiled by the R.M.A. Data Bureau

Graphic Aid for the Design of Degenerative Amplifiers

SINCE THE USE of feedback amplifiers has become rather widespread, an engineer may occasionally wish to know quickly and easily what performance to expect from a particular amplifying system when it is degenerated. We are indebted to Hygrade Sylvania Corp., Emporium, Pa. for the following graphic aid in determining the performance of degenerative amplifiers.

It can be shown that if:

A = the voltage amplification of a system in the absence of feed back

K = that fraction of the output voltage which is fed back

A' = the voltage amplification in the presence of feedback

Then $A' = \dfrac{A}{1 + KA}$

When the sign of K is positive then the feedback voltage is in phase-opposition to the signal voltage.

Also it can be shown that if:

D = the distortion of the system in absence of feedback

K = same as above

D' = the distortion in the presence of feedback

Then $D' = \dfrac{D}{1 + KD}$

It is thus seen that gain and distortion in the presence of feedback are similarly related respectively to gain and distortion in its absence. Thus a graph, in which the normal amplification of a system is taken as abscissa and the ordinates represent amplication with feedback, can likewise and simultaneously represent the distortion content of the system in the absence of feedback as abscissa and the distortion content with feedback as ordinates.

Figure 1 is a family of calculated curves of just such a graph, wherein K is made to vary from 0.01 to 0.95 (or from 1 per cent to 95 per cent) of the output voltage of the system. The area to the left of the 45 degree line ($K = 0$) represents a state of regeneration or oscillation, while that to the right represents a condition of degeneration. It will be immediately obvious that each of the curves is asymptotic to some value. This results because of the increased value of the "Feedback Factor", KA, which is a product of the normal amplifier gain and the fraction of the output voltage which is fed back. Otherwise stated (for the case of degeneration), it is because the actual signal voltage is the comparatively small difference between two large out-of-phase voltages. Furthermore, it follows that a given per cent of feedback has a very much larger effect upon the gain of a high-gain amplifying system than upon one of low gain.

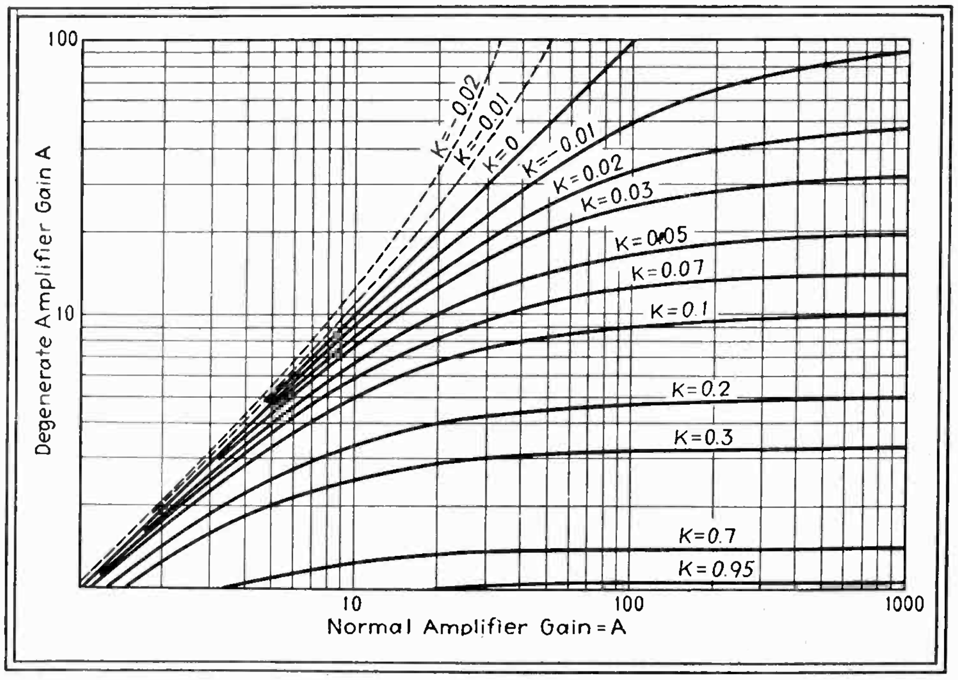


Fig. 1—Effect of degeneration on amplifier gain. K represents the percentage of the output which is fed back to the input of the system

For power considerations, since the power into any load equals the square of the voltage developed across its resistive component divided by that resistance value, it follows that the power of a degenerated system is related to its undegenerated power level by the expression $(A'/A)^2$ provided the loads are equal and resistive.

In an experimental set-up to provide illustrative data on degenerated amplifiers which would show their asymptotic gain properties, two resistance coupled stages were set up and adjusted with the aid of an oscillograph to operate over straight dynamic characteristic curves. Suitable switching allowed a selected per cent of degeneration over either one or two stages. Tabulated below are the measured gains of this set-up:

Normal Voltage Gain	Per Cent Degenerated	Degenerated Voltage Gain
13	11.5	5.2
700	12	8.2

An inspection of the family of curves will demonstrate at once the effect upon a high gain system of even a small amount of common-impedance coupling between stages, resulting in seriously impaired amplification and, in case of in-phase coupling, a condition of instability. The importance of eliminating such coupling elements is thus immediately evident.

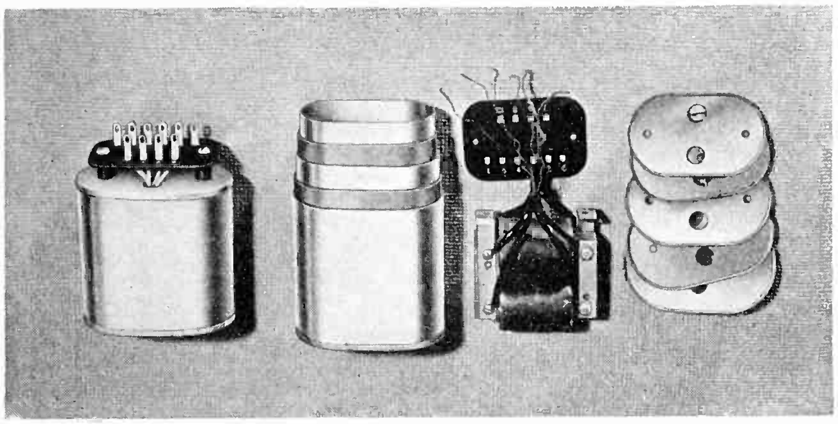
• • •

Ratings Increased for RCA Transmitting Tubes

AN ENTIRELY NEW system of ratings for air-cooled transmitting tubes has been announced by RCA Manufacturing Company, Inc., of Harrison, N. J. Instead of one set of maximum ratings for each tube type, two sets of maximum ratings are given. These ratings are designated "Continuous Commercial Service" (CCS) and "Intermittent Commercial & Amateur Service" (ICAS).

Coming — after 2 years of intensive research

AMER TRAN

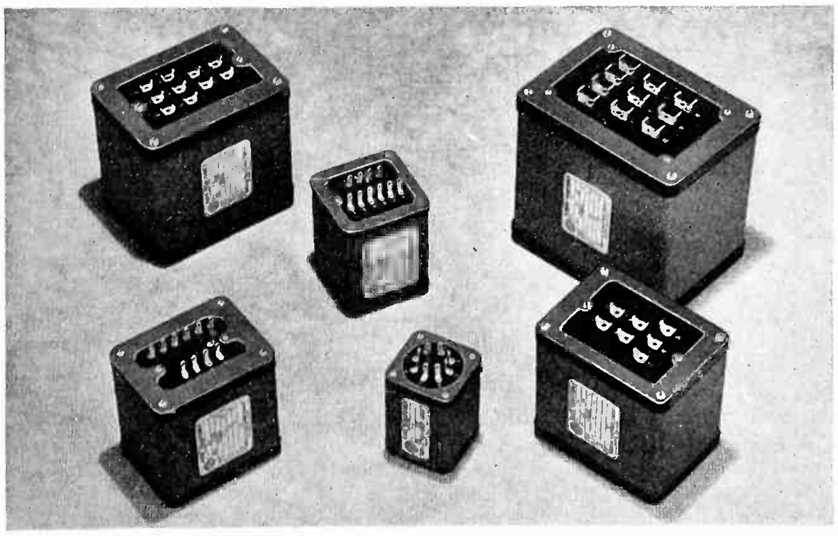


- AmerTran's new laminated, bimetallic shield offers the most effective electromagnetic shielding thus far developed for audio-frequency transformers and reactors. It comprises five telescoping shields and covers of steel alloy and copper which completely surround the core-and-coil assembly inside the regular case.

A New and Greatly Improved Line

Soon a new and greatly improved line of AmerTran transformer and reactor components for service in electronic circuits will be made available to users of precision equipment. Two years of intensive research work have been completed, standard designs have been thoroughly tested, manufacturing tools have been requisitioned, and now, actual production of standard units is being planned.

New AmerTran electronic components, Types PR and PS, will offer equipment of distinctly higher quality than standard transformers previously available. Ratings will be listed for every usual requirement and all units will be mounted in reversible cases and symmetrical design. Audio types will be supplied either with or without AmerTran's new laminated, bimetallic, electromagnetic shield. Similar equipment in special ratings will also be manufactured to order.



- AmerTran transformers and reactors, Types PR and PS, of all ratings will be mounted in similar symmetrical cases of the reversible type which permit the assembly of neatly balanced apparatus in a thoroughly professional manner with either exposed or concealed wiring.

Be one of the first to receive complete details of this new line which represents an improvement on AmerTran's famous "DeLuxe" and "Precision" components. Send in your name for a descriptive bulletin with prices which will be mailed as soon as it is received from the printer.

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TRANSFORMERS

The CCS ratings are essentially the same as the former maximum ratings. The ICAS ratings, however, are considerably higher, permit the use of much greater power input, and provide a relatively large increase in useful power output. For example, the a-f power output of two 809s in class B is 100 watts at the old maximum plate-voltage rating of 750 volts. At the new ICAS rating of 1000 volts, the power output is 145 watts, an increase of 45 per cent. In plate-modulated telephony service, the r-f output of the 809 is 38 watts with the CCS ratings and 55 watts with the new ICAS ratings, also an increase of about 45 per cent. Complete operating data, including both CCS and ICAS ratings, have been prepared for types 802, 804, 806, 807, 809, 810 and 814, as well as for the new 811, 812, and 828, and can be obtained on request.

The new system provides transmitting-tube ratings which recognize the diversified design requirements of modern transmitter applications. For example, there are numerous applications where the design factors of minimum size, light weight, low initial cost, and maximum power output are far more important than extremely long tube life. In such cases, the set designer may very properly decide that a small tube operated with ICAS ratings better meets his requirements than a larger tube operated with CCS ratings.

It is self-evident, of course, that the harder a tube is worked the shorter will be its useful life. Although no rule can be set up which will accurately predict the life performance of an individual tube under specified operating conditions, it is practical to make an estimate of tube life on the basis of average results from a large number of tubes. In average amateur service, a tube operated at the higher ratings can normally be expected to give about 50 per cent of the life obtainable with CCS ratings.

It has been estimated that an active amateur does not have his carrier on the air more than 300 hours per year. Therefore, a tube lasting 1000 to 1500 hours when used with CCS ratings would give him at least 3½ to 5 years of service. The amateur, because he is usually most interested in low initial cost and maximum power output, may consequently decide that the ICAS ratings are better suited for his purpose.

The engineer designing a broadcast transmitter has quite a different problem. A broadcast station may operate tubes on an average of 18 hours a day. Tube failures are expensive both in themselves and in advertising revenue lost because of interrupted programs. Consequently, since reliability is his main concern, he should operate tubes at the CCS ratings or perhaps even lower. Only in this way can he obtain the long tube life required for continuous commercial services.

In view of the fact that the ICAS ratings are considerably higher than the former maximum ratings, an ex-

★ ★

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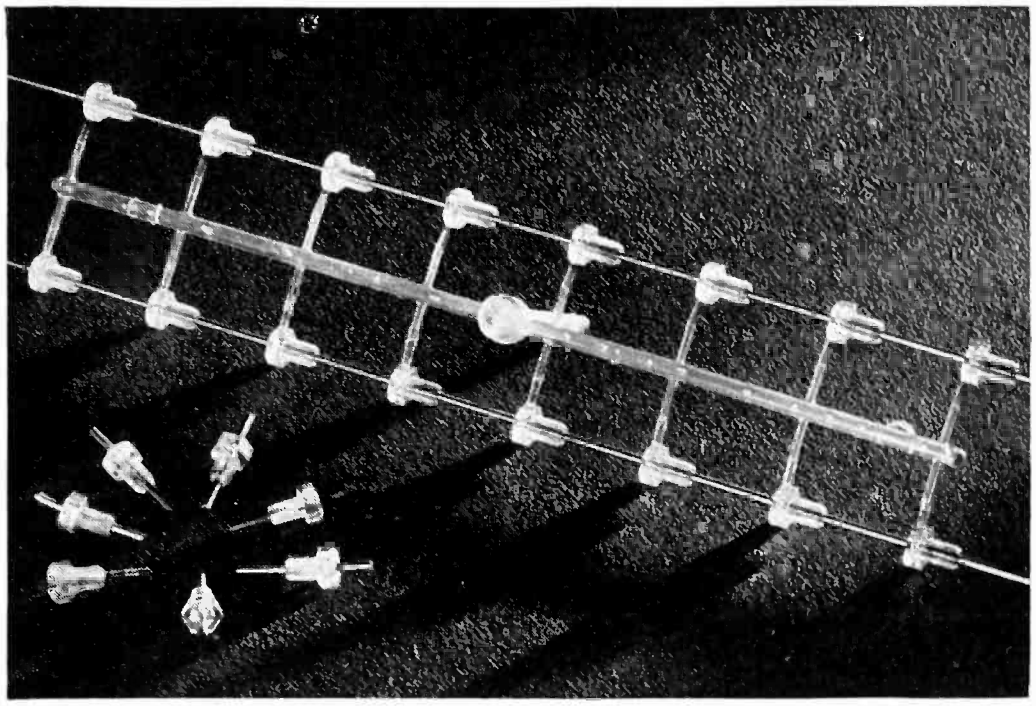
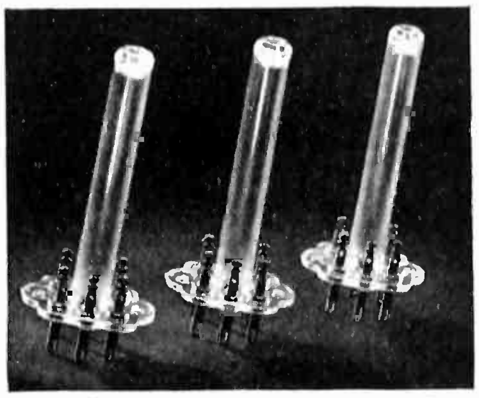
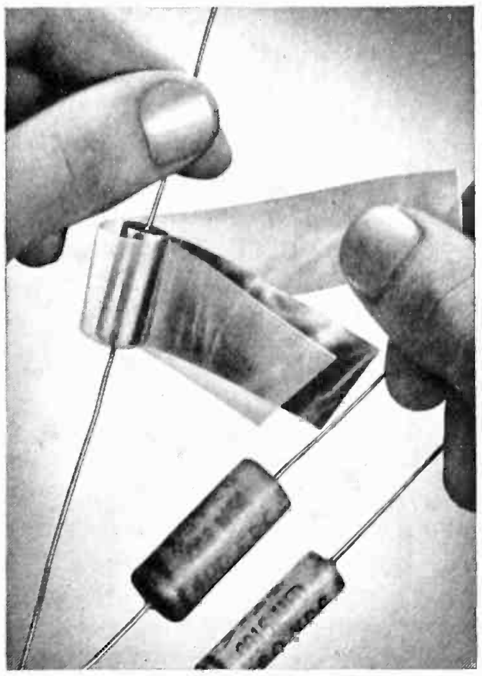
with Bakelite Polystyrene Plastics



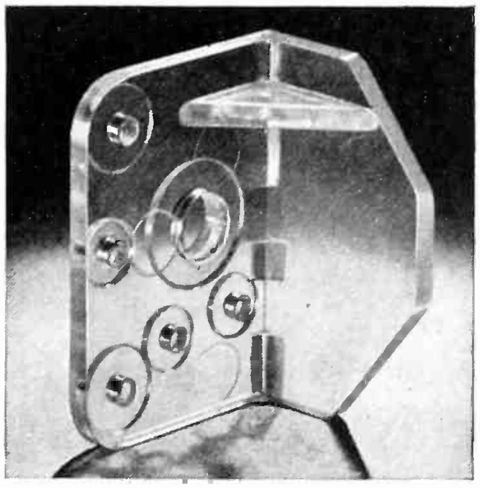
Lead-through bushings for National Co., Inc. ultra-high-frequency receivers molded from Bakelite Polystyrene by the Thomas Mason Co., Inc.



Bakelite Polystyrene coil forms are used on all RCA Victor Television Receivers. Molded by Erie Resistor Corporation.



Bakelite Polystyrene Film provides new high efficiency in radio capacitors. Supplied in water-white or purple-black tint.



Radio socket bracket of Bakelite Polystyrene used in National Co. ultra-high-frequency receivers. The Thomas Mason Co., Inc., molder.

WITH a power factor and dielectric constant superior to any other organic plastic material, Bakelite Polystyrene offers vast new possibilities for the improvement of high frequency circuits!

Radio and television parts of accurate dimensions may be completely formed from this low-loss dielectric through a comparatively simple molding process. Capacitors and splices may be built for minimum loss and maximum efficiency with Bakelite Polystyrene Film—a new sheet form in which this material also is available.

Bakelite Polystyrene offers a power factor of less than .0002, and a dielectric constant of 2.60 at frequencies from 60 to 1,000,000 cycles. Its stable electrical properties and exceptional moisture resistance provide dielectric characteristics that remain constant even at varying temperatures.

Investigate the important implications of Bakelite Polystyrene plastics for your high-frequency apparatus and equipment. Enlist the cooperation of our Research and Development Laboratories on specific problems. Write for detailed Reference Bulletin 13 describing Bakelite Polystyrene plastics.

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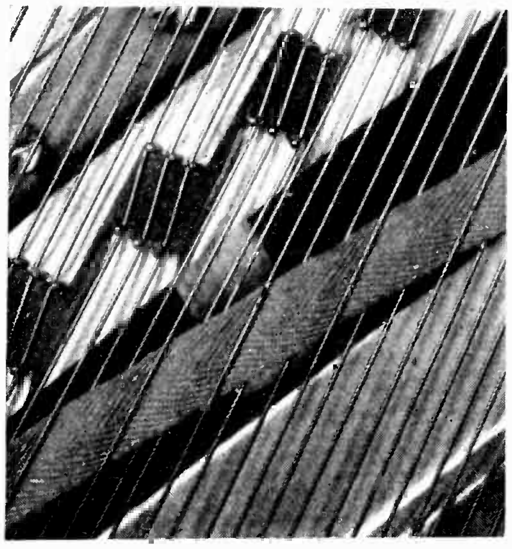
PLASTICS HEADQUARTERS



dag
COLLOIDAL GRAPHITE
and its part in
MUSIC

"Plywood board painted on the outside with 'Aquadag' serves to shield the back of the (electrical) piano" reports F. D. Merrill, Jr. in the May 1939 issue of "Electronics" - - "All the inside cabinet surfaces of the piano must be made electrically conductive by painting with a colloidal graphite solution".

This convenient means of obtaining electrostatic shielding also extends to other musical instruments such as electrical violins, guitars, and organs.

The homogeneous and tenacious graphite films formed with "dag" dispersions are not only easy to apply but their conductivity is readily varied by simple alteration of graphite content. Write for Technical Bulletin 270 giving details.

The above statements should not be considered as recommending the use of colloidal graphite in violation of any valid patents which may exist.

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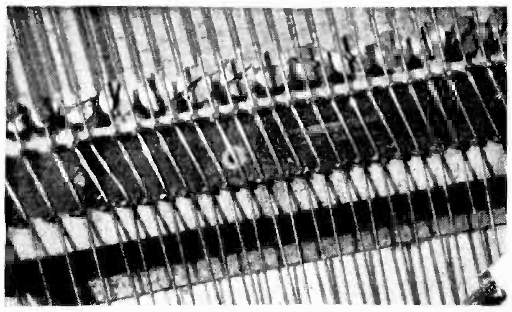


planation of the basis on which these new ratings are established is desirable. The old method of rating transmitting tubes has been based on the assumption that tubes would always be used under the most severe operating conditions possible for each class of service. Although it was recognized that this method was not representative of actual operating conditions, it did provide a very large factor of safety. In recent years, rapid progress in tube design, tube manufacture, transmitter design, and operating technique has made it practical to refine the method of rating transmitting tubes so that it more closely represents actual operating requirements.

For example, in class C telegraph service, the old ratings were set up on the basis of continuous key-down operation. In practice, however, all class C stages which are keyed are not under load when the key is up, as it is during spacing intervals. The average load on the tube is, of course, much less than it is under steady key-down conditions.

In class C plate-modulated telephony service, the old ratings were based on steady, 100 per cent, sine-wave modulation. Under this condition, the total plate input (dc and ac) is 1.5 times the unmodulated d-c plate input. In practice, a broadcast transmitter (for example) modulates its carrier on the average only 25 to 30 per cent. Under these conditions, the average plate power input is only 5 per cent higher than the unmodulated d-c plate input.

Similarly, the old class B a-f amplifier ratings were based on steady, full-signal operating conditions with a sine-wave signal. Actually, the average signal is much smaller than the maximum value and the average d-c plate current and power input varies continuously between no-signal and full-signal values. In addition, it is well known that speech signals place a much lighter load on the class B amplifier than signals having sinusoidal waveform.

It is apparent from the foregoing considerations that increased transmitting-tube ratings are practical for many applications. The new ICAS ratings, together with the CCS ratings, make it possible for the radio amateur and the radio engineer to choose the operating conditions best suited for the job at hand.

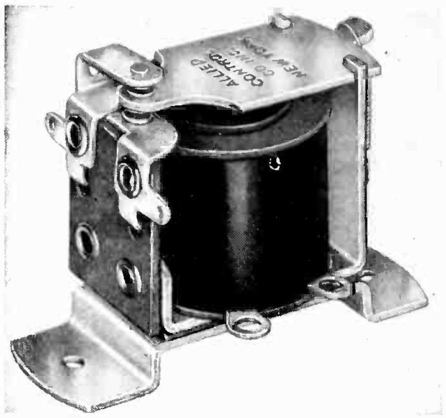
Tube Registry

Tube Types Registered by R.M.A. Data Bureau During July, August and September 1939

Type 117Z6 (GT)

Prototype 117Z6 (G)

FULL wave rectifier-doubler; heater type; (T-9) glass envelope, seated



ALLIED RELAYS:

Type P.C.1—2500 Ohms—layer wound coil —condenser paper between layers—adequately impregnated—yoke, armature and pole piece made of Armco Iron—over-all dimensions 2 5/16" long, 1½" high, 1⅛" wide—designed for plate circuit of vacuum tubes.

Type P.C.2—Similar to above except coils available up to 5000 ohms.

Type P.C.3—6 volts AC; Type P.C.4—110 volts AC; Type P.C.6—6 volts DC; Type P.C.7—12 volts DC.

Also Type D relays for police, aircraft, and industrial uses.

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Because of quantity production, these relays are sold at extremely attractive prices.

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Belmont Radio Corp.
Majestic Radio & Tel. Corp.
Motorola
Crosley
General Electric Co.
Western Electric Co.
Detrola Radio Corp.
Colonial Radio Corp.
Sparks-Withington Co.
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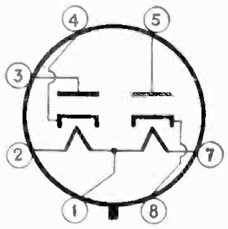
height 2¾ inches (max); 7 pin, small metal shell wafer base.

e_h = 117 v
e_{ac} = 117 v (max)
i_{dc} = 60 ma (max)
i_h = .075 amps
Basing 7—AR

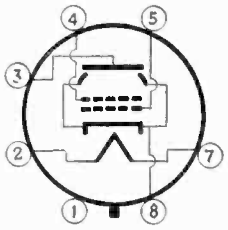


Type 6V6 (GT)

Prototype 6V6 (G)

Beam Power Amplifier; heater type; (T-9) glass envelope; seated height 2¾ inches (max) 7 pin octal base, metal shell.

e_h = 6.3 v
i_h = .45 amps
e_b = 250 v
e_c = −12.5 v
i_p = 45 ma
G_m = 4100 μmhos
R_l = 5000 ohms
PO = 4.25 watts (8%)
Basing 7-AC



Type 7J7 (GL)

Triode-Hexode converter, remote cut-off; heater type; (T-9) glass envelope-base; seated height 2¼ inches; 8 pin loktal base.

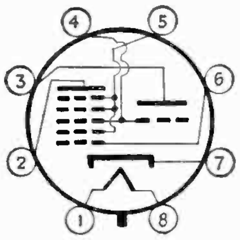
e_h = 7.0 v
i_h = .32 amps

TRIODE

e_p = 150 v
e_g = −3 v
i_p = 7.5 ma
G_m = 1350 μmhos
R_p = 10400 ohms

HEXODE

e_b = 250 v
e_c = −3 v
G_c = 310 μmhos
R_p = 1.5 megohms
$C_{if\ output}$ = 7.5 μμf
$C_{rf\ input}$ = 5.5 μμf
Basing 8—AR

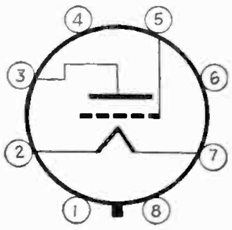


Type 1G4 (GT)

Prototype 1G4 (G)

Triode; filament type; (T-9) glass envelope; seated height 2¾ inches (max) intermediate shell 7 pin octal base.

e_f = 1.4 v
i_f = .05 amps
e_p = 90 v
e_g = −6 v
i_p = 2.3 ma
μ = 8.8
R_p = 11660 ohms
Basing 5—S

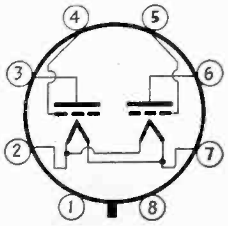


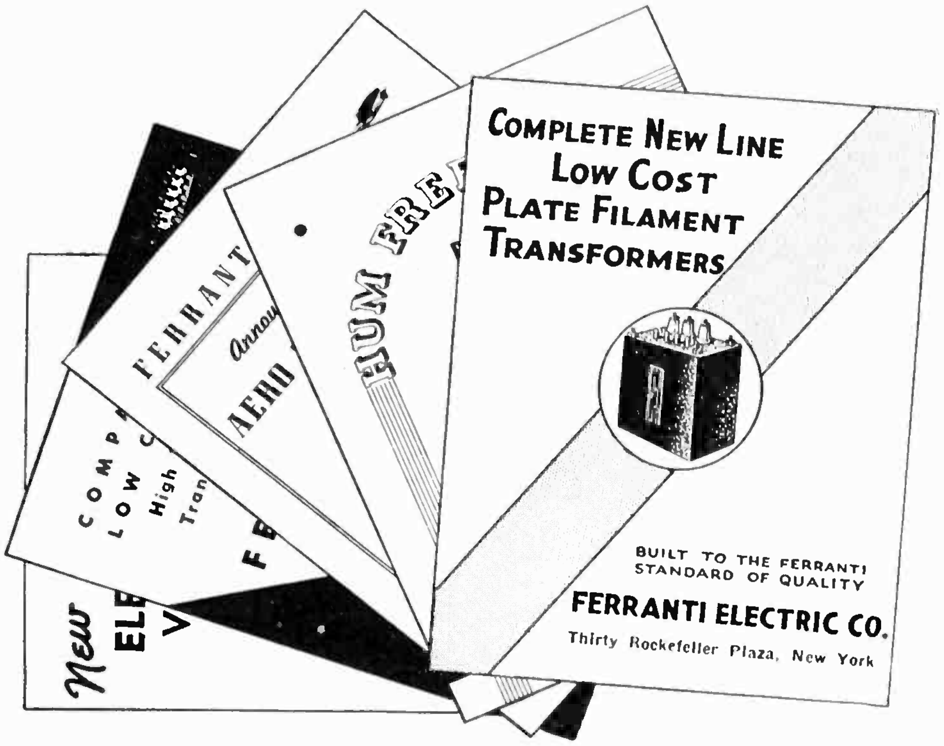
Type 1G6 (GT)

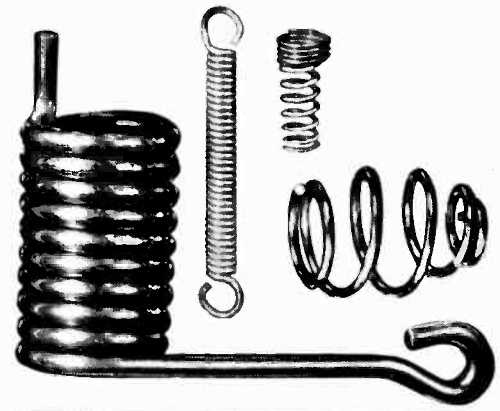
Prototype 1G6 (G)

Double triode, Class B; filament type; (T-9) glass envelope; seated height 2¾ inches; intermediate shell, 8 pin octal base.

e_c = 1.4 v
i_f = .10 amps
e_p = 90 volts
e_g = 0 v
i_p = (2 to 14 mamps)
R_l = 12000 ohms
PO = .675 watts (5%)
Basing 7—AB



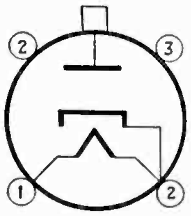




Type 2X2/879

HALF-WAVE rectifier, filament type; (ST-12) glass envelope, seated height 4 1/32 inches (max) small 4 pin base.

e_h = 2.5 v
i_h = 1.75 amps
e_{ac} = 4500 v (design max)
i_{dc} = 7.6 ma (design max)
e_{pi} = 12,500 v (design max)
i_{peak} = 100 ma
Basing 4—AB



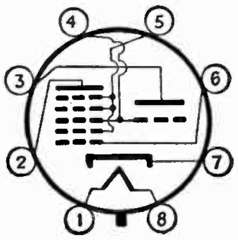
Type 7D7 (GL)

FOREIGN service, triode-hexode converter, remote cutoff; heater type; (T-9) glass envelope-base; seated height 2-⅝ inches (max) internal shield; 8 pin loktal base.

e_h = 7.0 v
i_h = .48 amps

HEXODE
e_b = 250 v
e_c = −3 v
G_c 275 μmhos
Rg = 1.5 megohms

TRIODE
e_p = 150 v
e_g = −3 v
i_p = 3.5 mamps
μ = 32
G_m = 1900 ohms
R_p = 16800 ohms
$C_{if\ output}$ = 8.0 $\mu\mu$f
$C_{rf\ input}$ = 5.5 $\mu\mu$f
Basing 8—AR



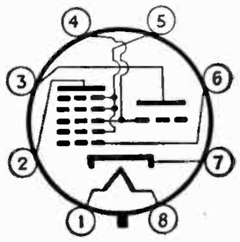
Type 21A7 (GL)

FOREIGN service, triode-hexode converter, remote cutoff; heater type (T-9) glass envelope-base; seated height 2⅝ inches (max) internal shield; 8 pin loktal base.

e_h = 21.0 v
i_h = .16 amps

HEXODE
e_b = 250 v
e_c = −3 v
G_c = 275 μmhos
R_p = 1.5 megohms

TRIODE
e_p = 150 v
e_g = −3 v
i_p = 3.5 ma
μ = 32
G_m = 1900 μmhos
R_p = 16800 ohms
$C_{if\ output}$ = 8.0 $\mu\mu$f
$C_{rf\ input}$ = 5.5 $\mu\mu$f
Basing 8—AR

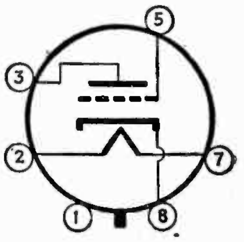


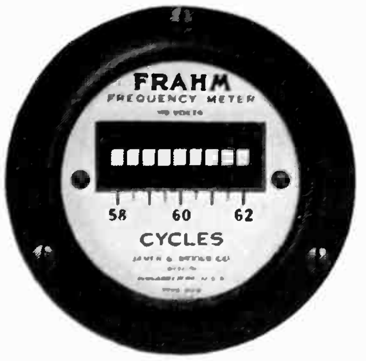
Type 12E5 (GT)

Prototype 6P5 (GT)

TRIODE; heater type; (T-9) glass envelope; seated height 2¾ inches; 6 pin octal base; metal shell to pin No. 1.

e_h = 12.6 v
i_h = .15 amps
e_p = 250 v
e_g = —13.5
i_p = 5 ma
G_m = 1450 μmhos
R_p = 9500 ohms
μ = 13.8
${}_gC_k$ = 3.6 $\mu\mu$f
${}_pC_k$ = 2.6 $\mu\mu$f
${}_gC_p$ = 2.8 $\mu\mu$f
Basing 6—Q





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Write for Bulletin 1555-E

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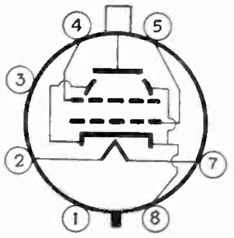
Type 6AL6 (G)

Prototype 6L6 (G)

BEAM Power Amplifier; heater type; (ST-16) glass envelope; seated height $5\frac{1}{8}$ inches (max); skirted miniature top cap; 7 pin medium shell octal base.

$e_h = 6.3$ v
$i_h = .9$ amps
$e_p = e_s = 250$ v
$e_g = -14$ v
$i_{po} = 72$ ma
$i_{so} = 5$ ma
$G_m = 6000$ μmhos
$R_l = 2500$ ohms
$PO = 6.5$ watts (10%)
Basing 6—AM

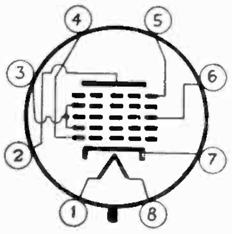


Type 7Q7 (GL)

Prototype 6SA7 (M)

HEPTODE, converter; heater type; (T-9) glass envelope-base; seated height $2\frac{1}{4}$ inches (max); 8 pin loktal base.

$e_h = 7.0$ v
$i_h = .32$ amps
$e_p = 250$ v (max)
$e_{g3} = -35$ v
$e_{g2} = e_{g1} = 100$ v (max)
$e_{g1} = e_{g5} = 0$ v
$i_p = 3.4$ ma
i_{g2+4} 8 ma
$i_{g1} = .5$ mamps
$G_c = 450$ μmhos
$R_p = .8$ megohms
$C_{r\text{-}f\ in} = 9.5$ μμf
$C_{i\text{-}f\ out} = 9.0$ μμf
Basing 8—AL



Type 14J7 (GL)

Prototype 7J7 (GL)

FOREIGN service; triode-hexode, remote cutoff, converter; heater type; (T-9) glass envelope-base; seated height $2\frac{5}{8}$ inches (max); 8 pin loktal base.

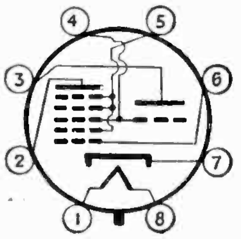
$e_h = 14$ v
$i_h = .16$ amps

TRIODE

$e_p = 150$ v
$e_g = -3$ v
$i_p = 7.5$ ma
$G_m = 1350$ μmhos
$R_p = 10{,}400$ ohms
$\mu = 14$

HEXODE

$e_p = 250$ v (max)
$e_{g2,3,4,6} = 100$ v (max)
$e_{g1} = -3$ v
$i_p = 1.4$ ma
$i_s = 2.8$ ma
$R_p = 1.5$ megohms
$G_c = 310$ μmhos
$C_{r\text{-}f\ in} = 5.5$ μμf
$C_{i\text{-}f\ out} = 7.5$ μμf
Basing 8—AR

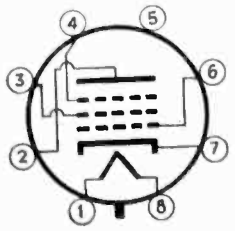


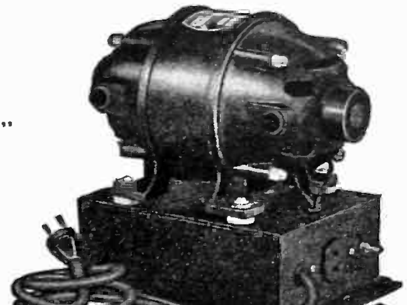
Type 12B7 (ML)

Prototype 12B7 (GL)

R-F PENTODE, remote cutoff; heater type, metal envelope, seated height $2\frac{1}{4}$ inches (max) 8 pin locking base.

$e_h = 12.6$ v
$i_h = .15$ amps
$e_b = 250$ v
$e_c = -3$ v
$i_p = 9.2$ ma
$G_m = 2000$ μmhos
$R_p = .8$ megohms
$C_{input} = 5.5$ μμf
$C_{output} = 7.0$ μμf
$_gC_p = .005$ μμf (max)
Basing 8-V

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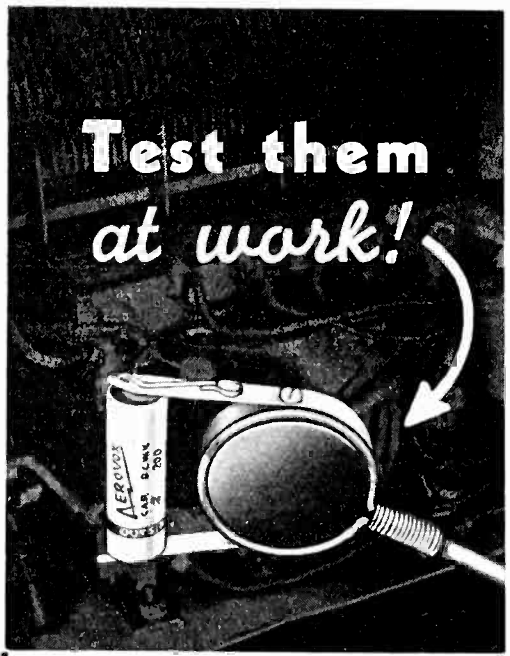

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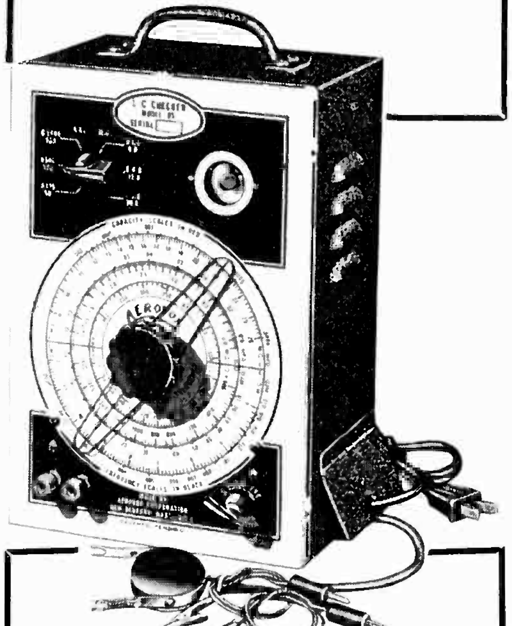

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Type 6M8 (GT)

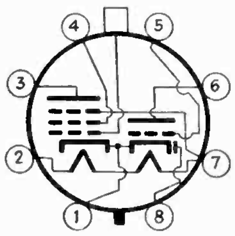
Prototype 25D8 (GT)

FOREIGN Service, diode, triode, pentode; remote cutoff; heater type; (T-9) glass envelope; seated height 2¾ inches; octal base 8 pins.

e_h = 6.3 v
i_h = .6 amps.

TRIODE

e_b = 100 v
i_p = .5 ma
${}_gC_k$ = 3.7 $\mu\mu$f
e_g = 1 v
G_m = 1100 μmhos
${}_pC_k$ = 4 5 $\mu\mu$f
R_p = 91,000 ohms
${}_gC_p$ = 2.5 $\mu\mu$f



PENTODE

e_b = 100 v
i_p = 8.5 ma
C_{in} = 5.2 $\mu\mu$f
e_c = −3 v

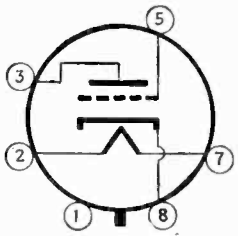
G_m = 1900 ohms
C_{out} = 10.0 $\mu\mu$f
R_p = .2 megs
${}_gC_p$ = .015 $\mu\mu$f
Basing 8—AU

Type 25AC5 (GT)

Prototype 25AC5G

POWER amplifier, triode, positive grid; heater type; (T-9) glass envelope; seated height, 2¾ inches (max); 6 pin octal base.

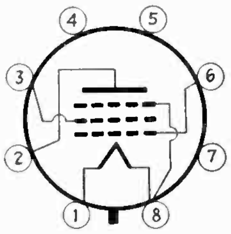
e_h = 25 v
i_h = .3 amps
e_p = 110 v
e_g = ±15 v
i_p = 45 ma
R_p = 15,200 ohms
μ = 58
G_m = 3800 μmhos
R_l = 2000 ohms
PO = 20 watts (10%)
Basing 6—Q



Type 1LB4 (GL)

POWER amplifier pentode; filament type; (T-9) glass envelope base; seated height 2¼ inches (max), 8 pin loktal base.

e_f = 1.4 v
i_f = .05 amps
e_p = 90 v
e_s = 90 v
e_g = −9 v
i_p = 5 ma
i_s = 1 ma
G_m = 925 μmhos
R_p = 12,000 ohms
R_l = 12,000 ohms
PO = .2 watts (10%)
Basing 5--AD



Type 1B8 (GT)

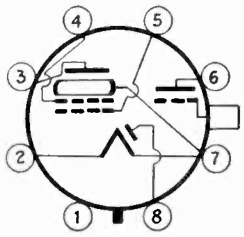
Prototype 1H5, 1T5

DIODE, triode, beam power amplifier; filament type; (T-9) glass envelope; seated height 2¾ inches (max); 8 pin octal base.

e_f = 1.4 v
i_f = .1 amps

TRIODE

e_p = 90 v
e_g = 0 v
i_p = 0.15 ma
μ = 66
R_p = .24 megohms
G_m = 275 μmhos



PENTODE

e_p = e_s = 90 v
e_g = −6 v
i_p = 6.3 ma
i_s = 1.4 ma
G_m = 1150 μmhos
R_l = 14,000 ohms
PO = .21 watts (8.5%)
Basing 8—AW

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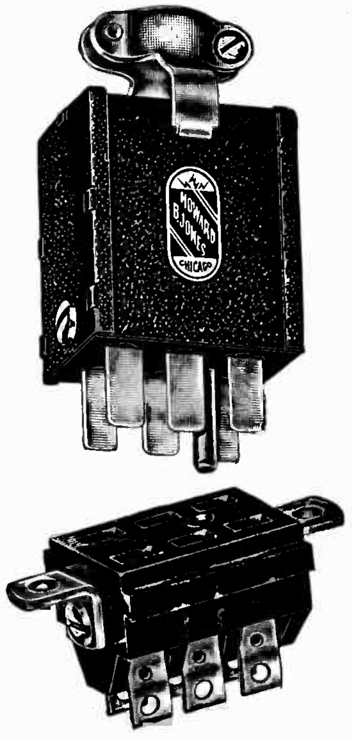

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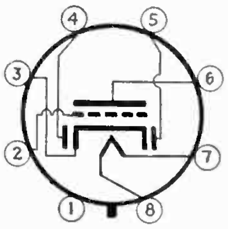
Type 6SQ7 (G)

Double diode, hi mu triode; heater type; (ST-12) glass envelope; seated height 3-9/16 inches (max); 8 pin, small shell octal base.

e_h = 6.3 v
i_h = 0.3 amps
e_p = 250 v
e_g = −2 v
i_p = 0.8 ma
μ = 100
R_p = 91,000
G_m = 1100 μmhos
Basing 8—Q

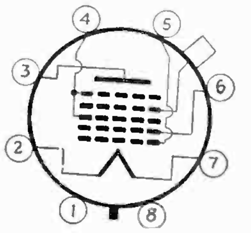


Type 1B7 (GT)

Prototype 1B7 (G)

Pentagrid converter, remote cutoff; filament type; (T-9) glass envelope; seated height 2¾ inches (max); metal shell octal base.

e_f = 1.4 v
i_f = .10 amps
e_b = 90 v
e_c = 0 v
i_p = 1.5 ma
G_c = 350 μmhos
R_p = .35 megohms
$C_{rf\ input}$ = 7.0 $\mu\mu$f
$C_{if\ output}$ = 7.5 $\mu\mu$f
Basing 7—Z

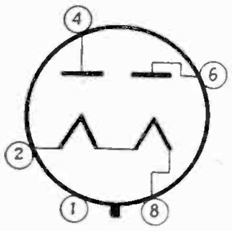


Type 5W4 (GT)

Prototype 5W4 (M)

Full-wave rectifier; filament type; (T-9) glass envelope; seated height 2¾ inches (max); 5 pin octal base.

e_f = 5.0 v
i_f = 1.5 amps
e_{ac} = 400 v (max)
i_{dc} = 90 ma (max)
e_{pi} = 1120 v (max)
Basing 5—T

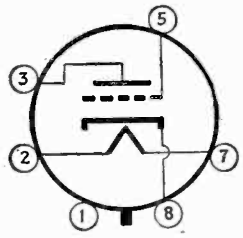


Type 6AE5 (GT)

Prototype 6AE5 (G)

Triode, heater type; (T-9) envelope seated height 2¾ inches (max); 6 pin octal base.

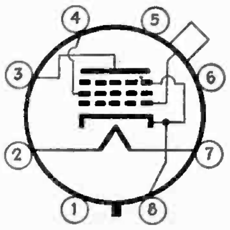
e_h = 6.3 v
i_h = .3 amps
e_p = 95 v
e_g = −15 v
i_p = 7 ma
μ = 4.2
R_p = 3500 ohms
G_m = 1200 μmhos
Basing 6—Q

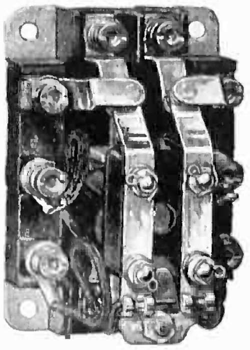


Type 6T6 (GM)

Foreign service, R-F pentode, sharp cutoff; heater type; (T-9) metal sprayed glass envelope; seated height 3-11/16 (max); 6 pin octal base.

e_h = 6.3 v
i_h = .45 ma
e_p = 250 v
e_s = 100 v
e_g = −1 v
i_p = 10 ma
i_s = 2 ma
G_m = 5500 μmhos
R_p = 1 megohm
C_{in} = 8 $\mu\mu$f
C_{out} = 12 $\mu\mu$f
${}_gC_p$ = .02 $\mu\mu$f (max)
Basing 6-Z

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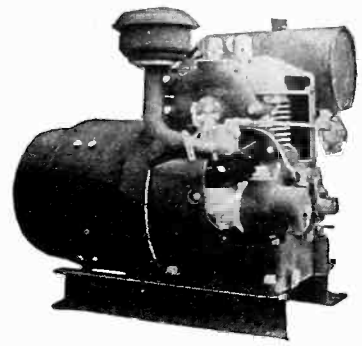
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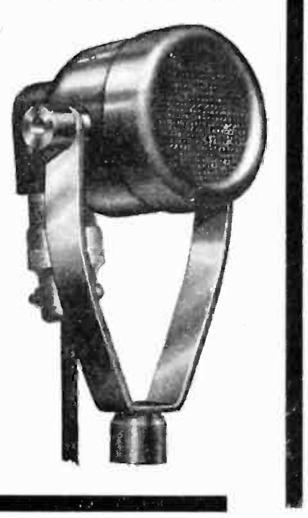
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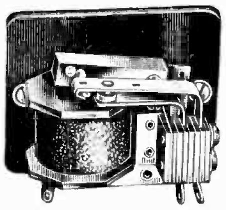

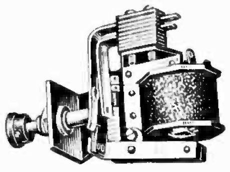

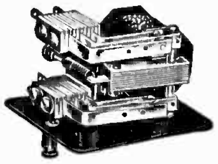

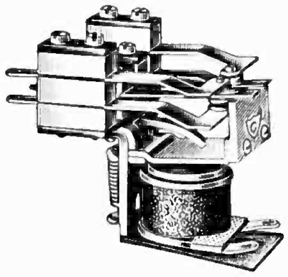

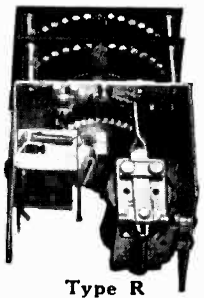

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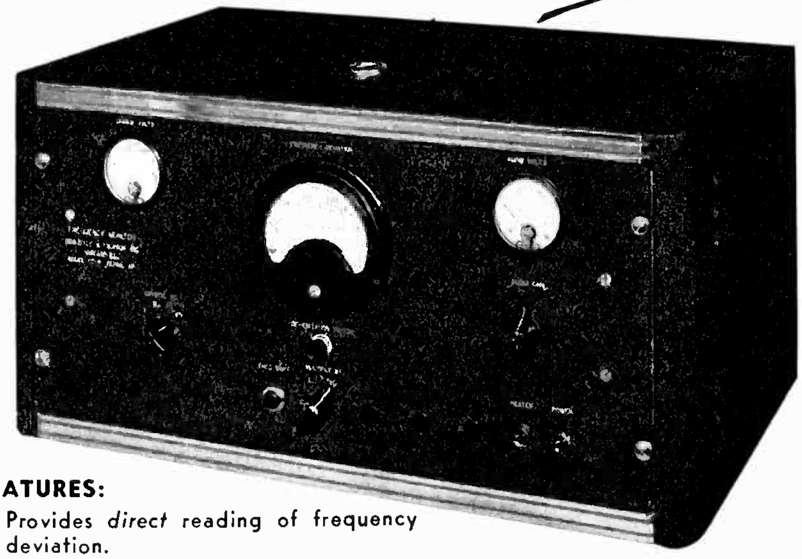

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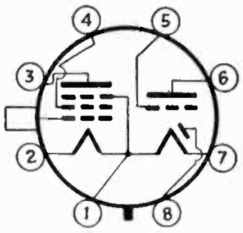
Type 3A8 (GT)

DIODE, triode, pentode; tapped filament type; (T-9) glass envelope; seated height $2\frac{7}{8}$ inches (max); skirted miniature top cap; 8 pin intermediate shell octal base.



$e_f = 2.8$ v
$i_f = .05$ amps

TRIODE SECTION

$e_p = 90$ v
$i_p = .15$ mamps
$e_g = 0$ v
$\mu = 65$
$R_p = .24$ megohms
$G_m = 275$ µmhos
$C_{in} = 2.6$ µµf
$C_{out} = 4.6$ µµf
${}_gC_p = 2.2$ µµf

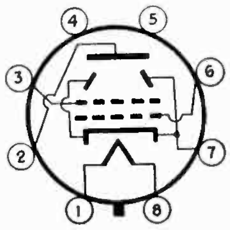
PENTODE SECTION

$e_p = e_s = 90$ v
$e_g = 0$ v
$i_p = 1.2$ mamps
$i_s = .3$ mamps
$G_m = 750$ µmhos
$R_p = .6$ megohms
$C_{in} = 2.6$ µµf
$C_{out} = 10$ µµf
${}_gC_p = .015$ µµf (max)
Basing 8—AS

Type 35A5 (LT)

Prototype 35A5 (GL)

BEAM power amplifier; heater type; (T-9) glass envelope; seated height 2 27/32 inches (max); intermediate 8 pin octalox base.

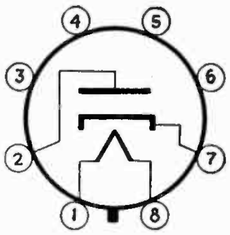


$e_h = 35$ v
$i_h = .15$ amps
$e_p = 110$ v (max)
$e_s = 110$ v (max)
$e_c = —7.5$ v
$i_{po} = 40$ ma
$I_{so} = 3$ ma
$G_m = 5800$ µmhos
$R_p = 14{,}000$ ohms
$R_l = 2500$ ohms
$P_o = 1.5$ watts
(6.5%)
Basing 6—AA

Type 35Z3 (LT)

Prototype 35Z3 (GL)

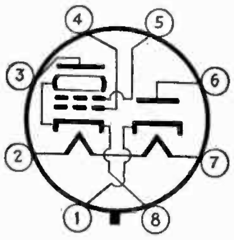
HALFWAVE rectifier; heater type; (T-9) glass envelope seated height 2-$\frac{5}{8}$ inches (max); intermediate octalox 8 pin base.



$e_h = 35$ v
$i_h = .15$ amps
$e_{ac} = 117$ v (max)
$i_{dc} = 100$ ma (max)
e_{drop} @ 200 ma = 16 v
e_{peak} inverse = 700 v
(max)
$i_{peak} = 600$ ma
Basing 4—Z

Type 117L7 (GT)

RECTIFIER, beam power amplifier; heater type; (T-9) glass envelope seated height $2\frac{7}{8}$ inches (max); 8 pin octal base.



$e_h = 117$ v
$i_h = .09$ amps

RECTIFIER

$e_{ac} = 105$ v (max)
$i_{dc} = 75$ ma (max)
e_{drop} @ 150 ma = 16 v

BEAM POWER AMPLIFIER

$e_p = e_s = 105$ v (max)
$e_c = -5.5$ v
$i_p = 45$ ma
$i_s = 4$ ma
$R_p = 20{,}000$ ohms
$G_m = 4{,}000$ µmhos
$R_l = 4{,}000$ ohms
$P_o = 5.5$ watts (5%)
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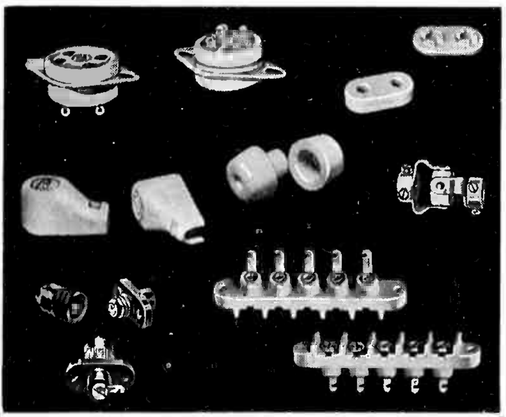

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Type 12K8 (GT)

Prototype 6K8 (GT)

TRIODE, hexode; heater type; (T-9) glass envelope; seated height 2¾ inches (max); 8 pin octal base.

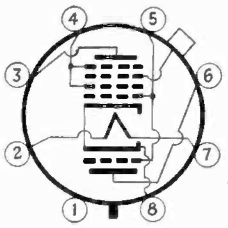
$e_h = 12.6$ v
$i_h = .15$ amps

HEXODE

$e_p = 250$ v (max)
$e_{g2,4} = 100$ v (max)
$e_{g3} = -3$ v (min)
$i_p = 2.5$ ma
$i_s = 6.0$ ma
$G_c = 350\ \mu$mhos
$R_p = .6$ megohms

TRIODE

$e_p = 100$ v
$e_g = 0$ v
$G_m = 3000\ \mu$mhos



$C_{rf\,in} = 6.6\ \mu\mu f$
$C_{if\,out} = 3.5\ \mu\mu f$
Basing 8—K

Type 20J8 (GM)

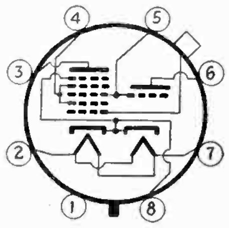
Prototype 6J8 (G)

FOREIGN service, triode, heptode, converter; heater type; (ST-12) metal sprayed glass envelope; seated height 3-25/32 inches (max); small shell 8 pin octal base.

$e_h = 20$ v
$i_h = .15$ v

HEPTODE

$e_p = 250$ v (max)
$e_s = 100$ v (max)
$e_c = -3$ v
$i_p = 1.5$ ma
$i_s = 3.4$ ma
$R_p = 2$ megohms
$G_c = 270\ \mu$mhos
${}_{rf\,in} = 5\ \mu\mu f$
${}_{g}C_p = .012\ \mu\mu f$ (max)



TRIODE

$e_p = 100$ v
$e_o = 0$
$i_p = 15$ ma

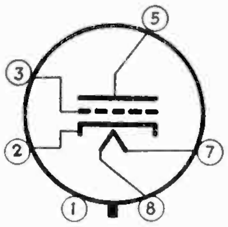
$G_m = 2500\ \mu$mhos
$\mu = 15$
Basing 8—H

Type 12SF5 (M)

Prototype 12SF5 (GT)

HI MU triode; heater type, metal envelope (MT-8) seated height 2-1/16 inches (max); 6 pin octal base.

$e_h = 12.6$ v
$i_h = .15$ amps
$e_p = 250$ v (max)
$e_g = -2$ v
$i_p = .9$ ma
$\mu = 100$
$R_p = 66{,}000$ ohms
$G_m = 1500\ \mu$mhos
${}_{g}C_k = 4.0\ \mu\mu f$
${}_{p}C_k = 3.6\ \mu\mu f$
${}_{g}C_p = 2.4\ \mu\mu f$
Basing 8—P

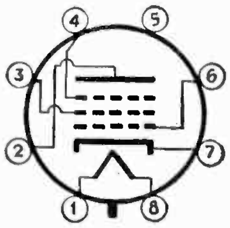


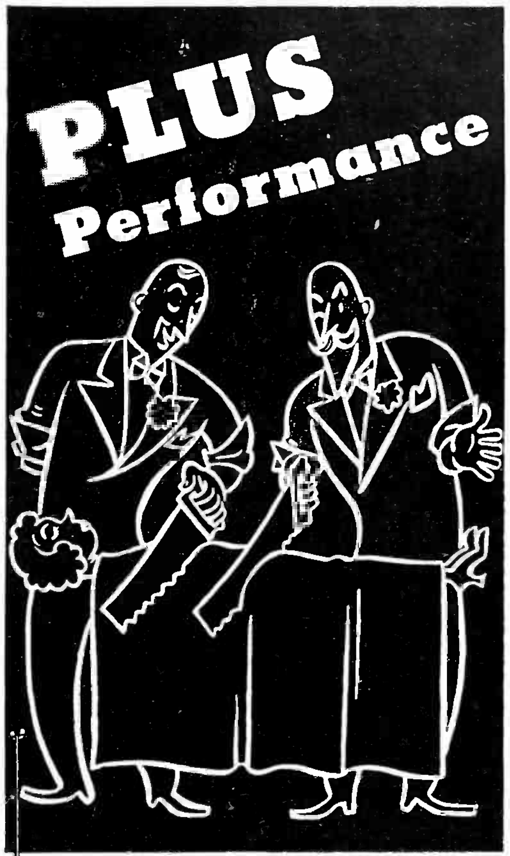
Type 7A7 (LM)

Prototype 7A7 (GL)

R-F PENTODE, remote cutoff; heater type (MT-8); metal envelope; seated height 2-5/16 inches (max); 8 pin intermediate octalox base.

$e_h = 7.0$ v
$i_h = .32$ amps
$e_p = 250$ v (max)
$e_s = 100$ v (max)
$e_c = -3$ v (min)
$i_p = 8.6$ ma
$i_s = 2$ ma
$G_m = 2000\mu$mhos
$R_p = .8$ megohms
$C_{in} = 6\ \mu\mu f$
$C_{out} = 7\ \mu\mu f$
${}_{g}C_p = .005\ \mu\mu f$ (max)
Basing 8—V





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Spectrometer for Audio Frequency

An Electric Wave Analyzer which permits making instantaneous measurements of the amplitudes of any frequency component present in a complex film or electric wave is described by R. K. Hellman in an article, "An Audio Frequency Spectrometer" appearing in the October issue of *Instruments.* As shown in the diagram, the spectrum is made available on the screen of a cathode-ray oscilloscope tube.

While no particularly difficult requirements are imposed upon the type of tube used, one having a screen with fairly long persistence and good alignment of the deflecting system is desirable. Electrostatic deflection is to be preferred to magnetic deflection.

The operation of the system may be described, with reference to Fig. 1, in the following manner. The input voltage is first amplified after which it is fed into a system of band-pass filter connected in parallel. These filters are so designed that each passes a band which is one-third of an octave wide.

Across the output of each filter is connected a copper oxide rectifier through which a condenser is charged. By means of a motor driven rotary disk, the output of each of these charged condensers is selected from a switching mechanism and is applied to the vertical deflecting plates of the oscilloscope. At the same time a displacement voltage is applied to the horizontal deflecting plate so as to give a definite deflection for each band of frequencies to which the various filters respond.

With the arrangement shown, a complex voltage (which may have originally been produced by a complex sound acting on a microphone) is made apparent on the screen of the cathode-ray tube in the usual manner of showing a spectrum as a series of vertical lines. The length of the vertical lines of course determines the amplitude of the various harmonics, whereas the displacement from an arbitrary zero axis determines the approximate frequency. The arrangement permits making a permanent record of the spectrum by means of a small film camera, by reason of the negligible time lag of the reading. There are no limitations due to the transient time of the filters. The speed of the measurement depends upon two factors: (1) on the speed of the rotary switch, the turn of one revolution being the maximum for each condenser to build up its charge, and (2) on the time constant of the rectifier circuit. When recording fast changing sound, this should be smaller than the time required for one revolution.

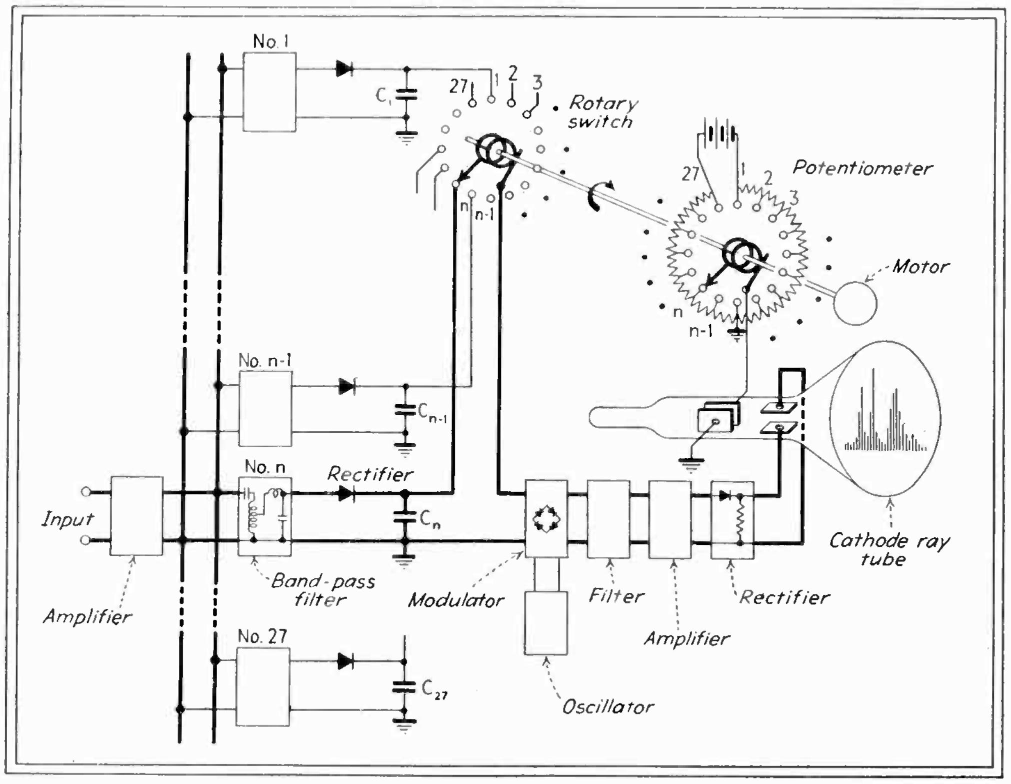


Fig. 1—Diagrammatic representation of the functioning of the audio frequency spectrometer. Only one band-pass filter is shown although twenty-seven are employed in practice. The spectrum appears on the screen of a cathode ray tube

Calculation of Triode Constants

In a Stimulating Article appearing in the July issue of *Electrical Communication* a new theoretical treatment, with experimental verification, is given by J. H. Fremlin on "Calculation of Triode Constants". The equations derived are similar, although somewhat more elaborate, than those which have already been developed by Schottky, Miller, King, Ollendorff, and Vogdes and Elder, since they are derived for a more rigorous case than has been done heretofore. Equations are derived for calculating the anode current and the transconductance for a triode for both the plane and cylindrical electrodes. A significant feature of Dr. Fremlin's derivation is that it is derived completely from the mechanism of a triode rather, as has been done in the past, by deriving the equations indirectly through reference to a diode to which the triode is equivalent. The fact that the equations derived by a consideration of the triode agree with those which have previously been derived by considering the triode as an equivalent diode, provides additional justification (if that is now needed) for early workers who have employed the "equivalent diode" method of approach. Not only is his article significant in that it appears to be the first treatment in which the constants are calculated directly from a triode, but the practical engineer will be interested in the fact that the theoretical equations and experimental curves agree unusually well for the usual type of triode construction. Supplementary equations are derived which apply to the case when the grid wires may be thick, or when the grid pitch is larger than the distances between the grid and the other two electrodes. An appendix gives equations which apply for the correction of initial velocity and when the two supplementary corrections are made, the equations for tube constants are found to hold with good precision for all types of triodes having plane or cylindrical elements.

The expressions most frequently used for the anode current and transconductance of triode are not calculated directly for a triode, but are derived indirectly as follows: Child and Langmuir showed how the space-charge limited current could be calculated for any diode, the electrodes of which were infinite parallel planes or infinite concentric cylinders. Then, if it could be proved that the current through a given triode was exactly that which would pass through a particular diode whose dimension and anode potential were known, this current would be known. The particular diode is called the equivalent diode. Its electrode parameters naturally depend upon those of the triode to which it is equivalent, and if the conception is to be of any value they must be calculable in terms of the anode potential V. The formulas for triode design were calculated on the simple assumption that the diode with cathode-anode distance, $l_D = l_g$ which is the distance between the grid and cathode. Similarly, it was assumed that the anode voltage of the triode was given by $V_D = V_g + DV_a$. Similar formulas are derived for a cylindrical structure by assuming that the radius of the equivalent diode is equal to the cathode-grid radius of the triode. In almost all cases, the formulas have been derived for certain particular conditions which may or may not be fulfilled in practice. For this reason, some of the equations do not give calculated values which agree with those which are determined experimentally.

The author points out that it is possible to calculate the current through a triode without direct reference to a particular equivalent diode. The article shows the derivation for the case of the plane electrode tube as follows:

If a current of density i is flowing between plane electrodes under space-charge limited conditions, the potential distribution will be given by

$$V^{3/2} = kil^2 \qquad (1)$$

where l is the distance of a point from a cathode, and $k = \frac{1}{2.34 \times 10^{-6}}$ if i is measured in amps, per sq. cm. and V is measured in volts. Here the cathode is taken as origin of V and of l, and the effects of initial velocity of the electrons are neglected. The above equation then merely expresses the Child-Langmuir law. The potential distribution is shown in Fig. 1. Suppose that the anode and grid of the triode are introduced into the electron stream at such potentials that the original distribution is unaltered, *i.e.*, so that

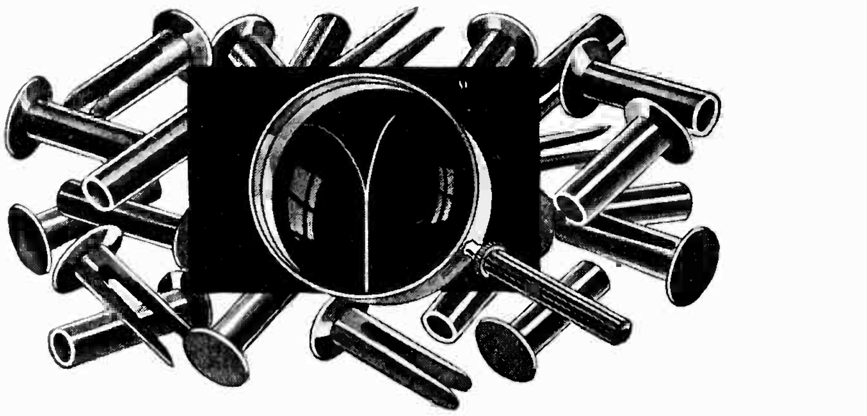
$$\left.\begin{aligned} V_a &= (kil_a^2)^{2/3} \\ V_g &= (kil_g^2)^{2/3} \end{aligned}\right\} \qquad (2)$$

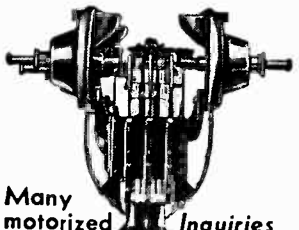
We have now a triode with electrode potentials which are known in terms of the total space current which is passing. It is known that the field at the cathode of a plane triode is given by

$$\frac{\delta V}{\delta l} = \frac{V_g + D\,V_a}{l_g + D\,l_a} \qquad (3)$$

in the absence of space-charge. In this equation $D = \frac{1}{\mu}$ is the reciprocal of the amplification factor, l is distance of a point from the cathode, l_g and l_a is distance of grid and anode, respectively, from the cathode.

When a space-charge-limited current





flows, the cathode field is reduced to zero, and it is known that for any electrode system the current required to do this is proportional to the three-halves power of the cathode field. Hence we know that

$$i = K(V_g + DV_a)^{3/2} \tag{4}$$

where K depends on the dimensions of the tube.

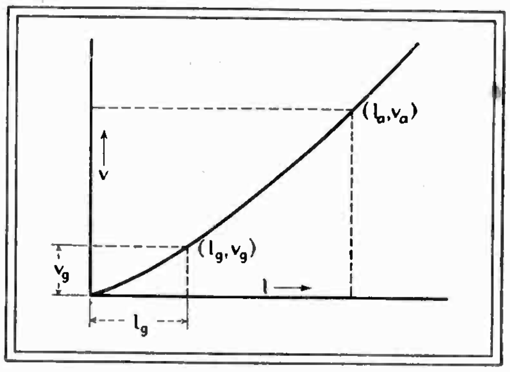


Fig. 1—Potential distribution from cathode (left ordinate axis) to the grid and plate, designated by subscript letters *g* and *p* respectively

Substituting from (2) for V_g, V_a, we have

$$K = \frac{1}{k\,(l_g^{4/3} + Dl_a^{4/3})^{3/2}}, \tag{5}$$

or, in practical units

$$K = \frac{2.34 \times 10^{-6}\,(V_g + DV_a)^{3/2}}{(l_g^{4/3} + Dl_a^{4/3})^{3/2}} \tag{6}$$

Hence

$$i = \frac{2.34 \times 10^{-6}\,(V_g + DV_a)^{3/2}}{(l_g^{4/3} + Dl_a^{4/3})^{3/2}} \tag{7}$$

ampere per volt per unit area.

From (6) and (7) we have also

$$gm = \frac{2.64 \times 10^{-4}\, i^{1/3}}{(l_g^{4/3} + Dl_a^{4/3})} \tag{8}$$

ampere per volt per unit area.

These differ from the usual formulae used only in the replacement of the term $(1 + D)^{3/2}$ by the term $[1 + D\,(l_a/l_g)^{4/3}]^{3/2}$.

It will be noticed that the equation for current has been derived without explicit reference to the equivalent diode. The form of the equations shows that the triode is equivalent to a particular diode, however.

A similar analysis has been carried out to determine the radius and potential of the anode of the equivalent diode for the case of a cylindrical triode. Given that D (or its reciprocal, μ) can be calculated, the results apply equally well to the squirrel-cage or helical grid so long as the emission from the cathode surface is appreciably uniform. Large grid supports cause a definite "beam" effect which makes many circular section tubes obey the formulae for planes more closely than they do those for cylinders. The author does not derive the equations for the case of the triode with cylindrical elements. However, he does give equations for the current per unit length as well as the transconductance, as follows:

$$i_l = \frac{14.7 \times 10^{-6}\,(V_g + DV_a)^{3/2}}{D\,[(r_a\beta_{ca}^2)^{2/3} + (r_g\beta_{cg}^2)^{2/3}]^{3/2}} \tag{9}$$

ampere per unit length, and

$$g_m = \frac{22.0 \times 10^{-6} (V_g + DV_a)^{1/2}}{[(r_g \beta_{cg}{}^2)^{2/3} + D(r_a \beta_{ca}{}^2)^{2/3}]^{3/2}} \qquad (10)$$

In the equation, r_a and r_b are the radii of the anode and grid, respectively, of the cylindrical triodes, and the terms β_{ca} and β_{cg} are Langmuir's function for a cylindrical diode referred to the distance between anode and cathode, and grid and cathode, respectively. It is interesting to compare the equations with those expressions most frequently used for the anode current and transconductance, which are given as follows:

$$i_l = \frac{14.7 \times 10^{-6} (V_g + DV_a)^{3/2}}{r_g \beta_{cg}{}^2 (1 + D)^{3/2}} \qquad (11)$$

ampere per cm., and

$$g_m = \frac{22.0 \times 10^{-6} (V_g + DV_a)^{1/2}}{r_g \beta_{cg}{}^2 (1 + D)^{3/2}} \qquad (12)$$

ampere per volt per cm.

If the more exact equations developed by Fremlin are compared with those above which are usually used, it will be found that the difference between the two equations depends in a fairly complicated way upon the penetration factor D (or the amplification factor which is its reciprocal), the radii of the anode and grid, and two of the Langmuir functions which involve the radial dimensions of the anode and grid with respect to the cathode. If the equations for transconductance are compared, the same state of affair likewise holds. We may consider that the older formulas were not sufficiently rigorous primarily because they did not adequately take account of all of the dimensional effects which are involved.

The equations which have been worked out by Dr. Fremlin, are derived upon the following assumptions: (1) that the grid wires are thin; the formulas hold well as long as the wire diameter is less than 10 per cent of the grid pitch, and (2) that the grid pitch is itself smaller than the distances between the grid and the other electrodes. When the distance between the grid and the cathode becomes equal to the grid pitch the formulas will be in error by about 2 per cent. If the grid is far from the cathode, the grid-anode distance may be considerably less than the grid pitch without causing serious discrepancies as it is lack of uniformity of the field at the cathode that causes the major disturbances observable.

In order to extend the applicability of the equations to cover those dimensional ratios which have not already been adequately taken into account, an expression is derived for the penetration factor, by the use of the construction of electrostatic images. Since the penetration factor, D, is the reciprocal of the amplification factor, the paper may be considered to contain a rigorous derivation for the equations of the amplification factor, at least for triodes having plane electrodes. As might be expected, this equation is

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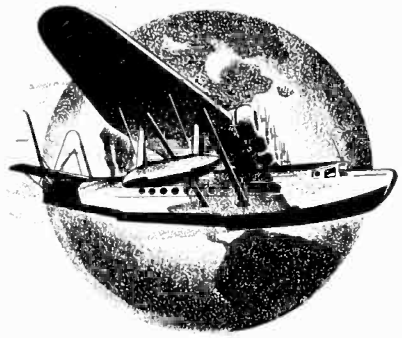

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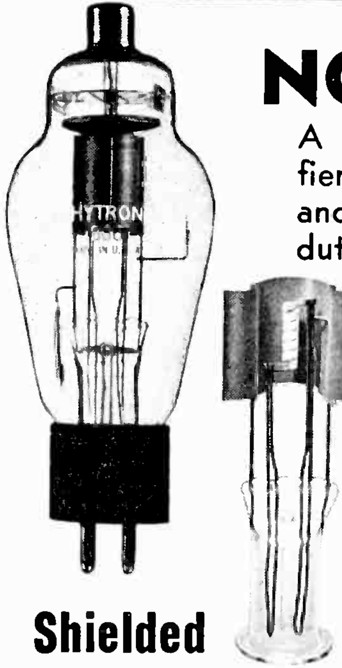

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somewhat more complicated than that derived some years ago by Vogdes and Elder.

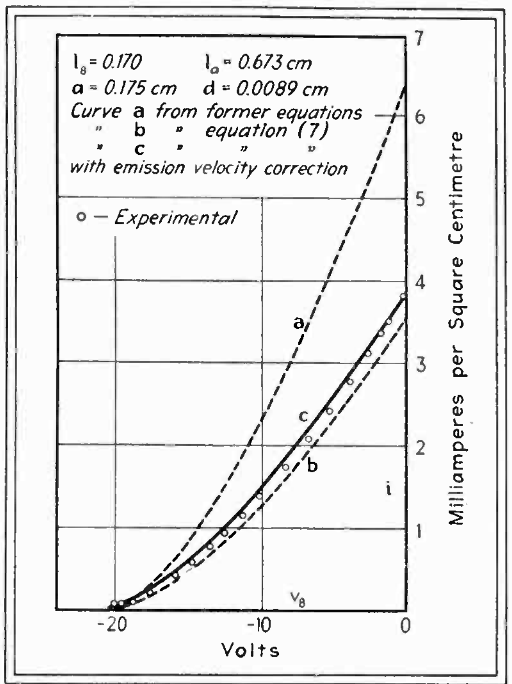

Fig. 2—Plate current relations for an experimental triode

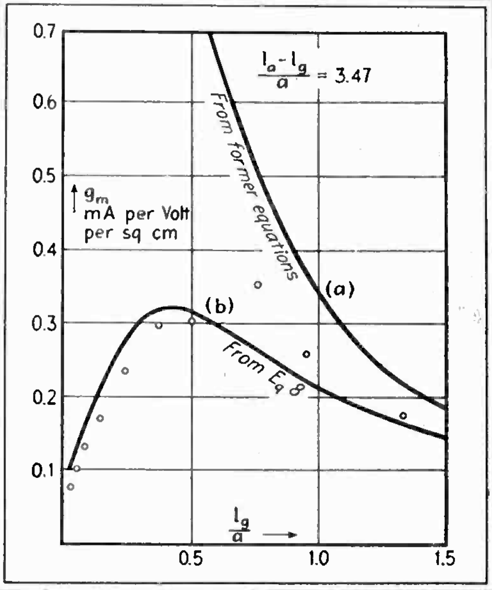

Fig. 3—Transconductance curves with experimentally determined points

In order to verify experimentally, the validity of the equations developed, an experimental triode was constructed so that the various electrode voltages and currents could be measured. The elements of the triode were arranged in such a manner as to be adjustable with respect to one another, and an optical arrangement was put up to measure the distances between the various electrodes. With the arrangement used, the dimensions of the tubes could be changed throughout a rather wide range, and the corresponding voltages and current observed. The paper includes a description of the experimental equipment and technique employed as well as the results of the number of measurements. One of these curves, given in Fig. 2, shows experimental determinations as well as the results of three calculations. Curve *a* is calculated from the formula usually employed for this purpose, while curve *b* is calculated from the formula for plate current derived by Dr. Fremlin. It is observed that curve *a* gives considerably higher values of current than does *b*, although the experimentally determined values are somewhat higher than that shown by curve *b*. By correcting curve *b* for the effect of initial velocity of the electron, by the method which is contained in the article, curve *c* is derived which agrees quite well with the experimental results. Another interesting experimental curve, Fig. 3, shows the transconductance plotted against the cathode-grid distance measured as a fraction of the grid pitch. It will be observed that the experimentally determined points fall much closer to curve *b* than to curve *a*. The theoretical curve given by *b* is that derived in the present paper, whereas that given by *a* is the equation usually used. It will be seen from this curve that the advantage of the new derivation is especially apparent for low values of l_0/a.

• • •

Magnetron High Frequency Generators

AN EXCELLENT GENERAL survey of the motion of electrons in electric and magnetic fields, and the application to magnetrons as ultra-high frequency oscillators is given in the July issue of the *Philips Technical Review* in an article compiled by G. Heller and entitled "The Magnetron As a Generator of Ultra Short Waves." The article is intended for those who are well versed in mathematics and electric circuit theory but who may not be acquainted with the fundamental operation of the magnetron as a generator.

The conditions of oscillation are derived by means of a mechanical analogy from which the essential electric circuit conditions are obtained. The second portion of the article deals with the motion of electrons in various electric and magnetic fields and this introduction is followed by a description of the motion of electrons in the magnetron.

The magnetron consists of a cathode filament, a cylindrical anode, usually divided into a number of sections, and a homogeneous magnetic field parallel to the filament. With such a system, two main types of oscillation can be generated: (1) oscillation of any relatively low frequency, and (2) oscillation with frequency determined by the periodic character of the movement of the electron. In the latter case it is possible to distinguish between radial and tangential movements of electrons. In the case of the first type of oscillation the frequency is subject to the same restrictions as in a radio tube. In the second type, these restrictions do not hold and very short waves can be obtained.

In a magnetron the electrons leave the cathode with a low velocity and are accelerated by a radial field. They

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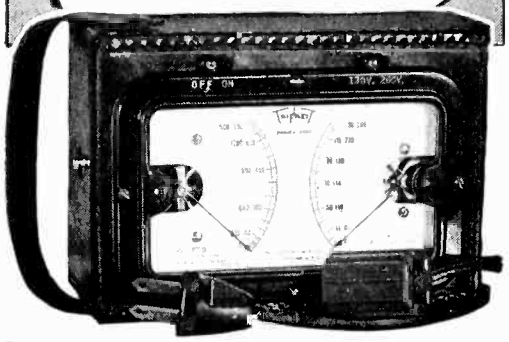

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will be deflected by the magnetic field and curved paths will result. The curvature of their paths at every point is, proportional to the field strength, and inversely proportional to the velocity and thus also to the square root of the potential at the point in question. When the strength of the magnetic field is sufficiently great the electrons cannot reach the anode, and describe a path like that represented in Fig. 1-a.

With a completely symmetrical arrangement the electron emitted would return to its starting point, the cathode. Due to a slight assymmetry, however, it may occur that the electron misses its goal; in that case it describes a second loop similar to the first in shape but turned 90°, and so on, so that a closed orbit of four loops results.

When the strength of the magnetic field is made to decrease, the diameter of the loops increases until at the so-called critical field strength the electrons can reach the anode (Fig. 1-b and c.). At that moment anode current suddenly begins to flow, which current remains practically constant upon further decrease of the strength of the magnetic field.

When the cathode filament is sufficiently thin the critical field strength can easily be calculated. It may then be assumed that the potential is constant in the greatest part of the space and equal to the anode voltage V_a. The electron then describes a circular orbit whose diameter $2r$ at the critical field strength H_k is equal to the radius a of the magnetron.

When the anode cylinder is not continuous but consists of a number of sections with equal potential the paths of the electrons will be practically the same. If, however, there are differences in potential between the sections very divergent forms of orbits may appear.

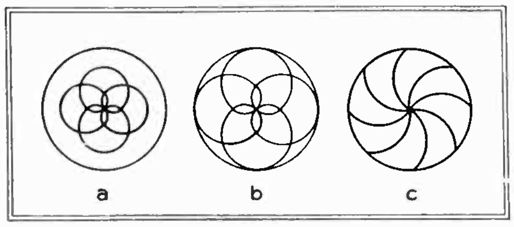

Fig. 1—Paths of electrons in a magnetron for varying relative magnitudes of magnetic fields

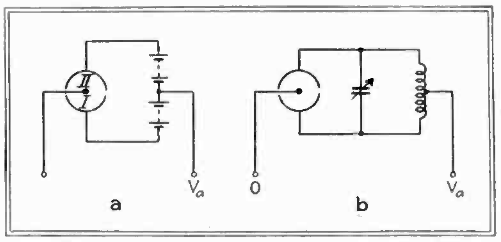

Fig. 2—Static and dynamic schematic diagrams of the magnetron

As an aid to the study of oscillations of relatively low frequencies produced in the magnetron, consider a magnetron with two anode sections (see Fig. 2-a), and with a given anode voltage V_a. Choose a magnetic field so strong

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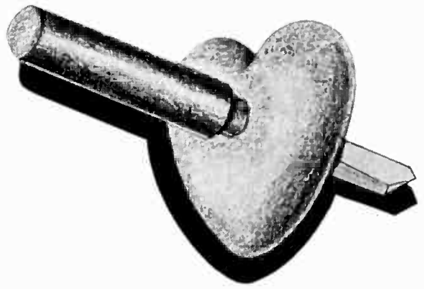

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that no anode current flows. When a difference of potential is caused between the plates by the batteries b_1 and b_2 such that the average voltage remains equal to V_a, anode current is found to flow, and, remarkably enough, it flows to the plate with the lower potential. This shows directly that the magnetron is capable of generating oscillations. If one considers the circuit in Fig. 2-b consisting of a magnetron, an oscillating circuit in which there is an oscillation of a certain amplitude and a battery with the anode voltage V_a, it follows from the above that the electrons accelerated by the alternating voltage always move toward that section whereby the alternating voltage of the oscillating circuit has a retarding action. This is exactly the condition which was derived as necessary for the generation of oscillations.

The above-described mechanism for the generation of oscillations resembles the mechanism in radio tubes inasmuch as the oscillations are generated by means of a negative resistance. Just as in radio tubes, the frequency is limited by the transit time of the electrons which, with strong magnetic fields, will be even longer than in radio tubes because the velocity of translation is inversely proportional to the magnetic field. For this reason, the considered manner of generating of oscillations can only produce oscillations with relatively low frequencies.

With a suitable frequency the condition for the generation of oscillations can be satisfied. Whether or not this takes place does not depend only upon the frequency, but also on the phase of the oscillation at the moment when an electron passes the slit.

When section I has the higher potential at the moment when the electron passes from section I to section II, the electron will give off energy to the oscillating circuit; if, however, the electrons pass the slit at random times no energy will be transferred on an average.

From a closer consideration it is found that the electrons do not pass the slit at random moments, but show a certain preference to pass it in the "correct" phase.

Very short waves can be generated by the tangential oscillations. If V_a is measured in volts and H in gauss, it may be shown that

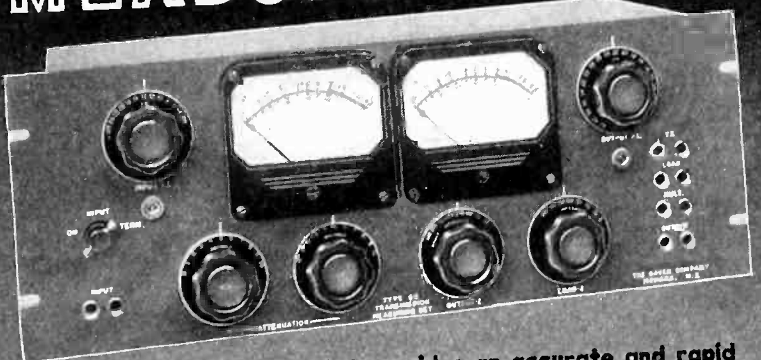
$$\lambda = \frac{600}{n} \frac{Ha^2}{V_a}$$

where a is the distance between anode and cathode.

When the external oscillating circuit is tuned to the radial oscillations of the electrons, the frequency of which is given by the rotating motion of the electrons in the magnetic field, the wave length of the generated wave is given by

$$\lambda = \frac{10{,}700}{H} \text{ cm}$$

Thus by increasing the magnetic field H, very short waves may be produced.

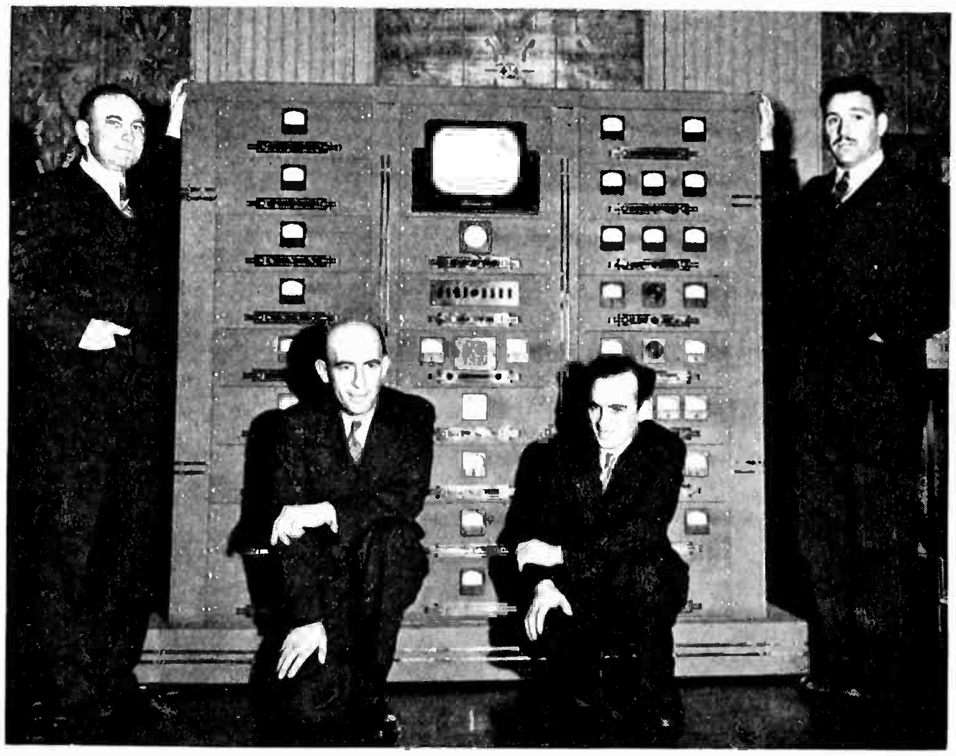


THE INDUSTRY IN REVIEW

News

✦ Oliver C. Spurling, who has been in charge of design and construction of Western Electric factories for thirty years, has retired and is succeeded by Henry L. Ward. . . . Summerill Tubing Co., Bridgeport, Montg. Co., Pa. has a new laboratory to aid in the manufacture of seamless tubing. . . . McMurdo Silver is General Manager and William F. Diehl is Director of Manufacturing of the newly reorganized Airplane and Marine Direction Finder Corp. The plant is located at Clearfield, Pa. . . . A new book on television, "Television Broadcasting: Production, Economics, Technique" by Lenox R. Lohr, president of NBC is announced for spring publication by McGraw-Hill Book Co. . . . Bamberger Broadcasting Service is surveying the New York Metropolitan area for the best place to build its new frequency modulation transmitter. The call letters of the new station will be W2XWI and will operate on 43.3 Mc with 1000 watts of power. . . . The Vocoder (voice coder) is a new development of Bell Labs. A person speaks into it and at the will of the operator, the voice is changed into a whisper, a shout, monotone or with various kinds of inflections. With this instrument a singer is now able to sing a duet with himself. . . . Cincinnati is getting a new high speed teletype fire alarm system. Within three seconds after the signal is flashed from headquarters, the engine house has the information about the location of the fire and within fifteen seconds the apparatus is on its way with a typewritten copy of the alarm. It was developed by the Teletype Corp. . . . The 60th Annual Meeting of the A. S. M. E. will be held in Philadelphia Dec. 4-8. . . . Stewart-Warner Corp. reports a profit of $55,948 for the third quarter of 1939. . . . General Electric sales for the first nine months of the year amounted to $217,900,154, an increase of 13 per cent over last year. The profit available for dividends is $25,022,631, an increase of 43 percent over last year. . . . The chief engineers of the CBS stations gathered at the New York headquarters in September for a three day technical meeting. . . . William B. Campbell was elected director and executive vice-president of National Television Corp.

MOBILE TELEVISION UNIT



The first showing of the first Farnsworth mobile television transmitting unit, designed and built at the firm's laboratory in San Francisco, was one of the highlights of the "open house" and banquet for radio dealers recently. The men who designed and built the mobile unit are, from left to right, F. A. Crooks, Edward Atkinson, Bart Molinari, chief engineer and designer, and John Stagnaro

Literature

Fuses. For many purposes and fuse accessories are described in Catalog No. 8 by Littelfuse, Incorporated, 4757 Ravenswood Ave., Chicago.

Impedance Measurements at High Frequencies with Standard Parts is the title of the feature article in the September issue of the *Experimenter* published by General Radio Co., 30 State St., Cambridge A, Mass.

Insulators. Steatite and Ultra-Steatite antenna insulators, stand-off insulators, lead-in insulators and entrance bushings and coil forms are described in Catalog 100. Also data on physical characteristics of steatite. General Ceramics Co., 30 Rockefeller Plaza, New York.

Condensers. Resistors and Test Instruments are described in the 1939—40 28-page catalog of Aerovox Corp., New Bedford, Mass.

Inkless Recorder. Described in Bulletin GEA-3187A. Limit switches to control machines described in Bulletin GEA-3043, automatic lighting control in Bulletin GEA-2679B, and heat resisting varnished cambric is discussed in Bulletin GEA-3215A. General Electric Co., Schenectady, N. Y.

Wattmeters. Graphic wattmeters are discussed in The Graphic, Bulletin 839 by The Esterline-Angus Co., Indianapolis, Ind.

Insulation Tubing. Specifications and samples given on a chart by Insulation Products, Inc., 3 East 17th St., New York.

Transformers. Power and audio, filters and equalizers with charts and data in Catalog BC-1 by United Transformer Corp., 150 Varick St., New York.

Quartz Crystals. General communication frequency quartz crystal, holders and ovens for frequencies from 20 kc to 30 Mc are described in Catalog G-11 by Bliley Electric Co., Union Station Building, Erie, Pa.

Storage Battery. Edison D-type Cell is described in a booklet by the Edison Storage Battery Division, Thomas A. Edison, Inc., West Orange, N. J.

Platinum. A discussion of Platinum Metals and the Chemical Industry is given in a booklet by Baker & Co., 113 Astor St., Newark, N. J.

Tube Handbook. Characteristics on

Precision Resistor Company

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WIRE WOUND RESISTORS

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584 different radio tube types are given Handbook by National Union Radio Corp., 57 State St., Newark, N. J.

Geophysical Instruments. Described in Catalog No. 116. Also a radium detector in Circular E. Both by Geophysical Instrument Co., 1315 Half St., S. E., Washington, D. C.

Switchgear Control Accessories. Described in Bulletin 72-D by Delta-Star Electric Co., 2400 Block, Fulton St., Chicago.

Service Aids. Cements, solvents, laquers, plugs, etc. are described in Catalog No. 140 by General Cement Mfg. Co., Rockford, Ill.

Solderless Fittings for small copper tube transmission lines described in Bulletin No. 101-D by Isolantite, Inc., 233 Broadway, New York.

Transmitters. Also receivers and parts in Catalog No. 300 by National Company, 61 Sherman St., Malden, Mass.

Service Notes. Complete service data and wiring diagrams on 1938 RCA Victor radio, Victrola models, test equipment and the 1939 television receivers are given in a 448 page book. The price is $1.25. RCA Manufacturing Co., Camden, N. J.

New Products

Capacitors

A SERIES OF DYKANOL impregnated tubular paper capacitors, Type MD, has been introduced by Cornell-Dubilier Electric Corp., South Plainfield, N. J. The following sizes are available: 0.0001 to 0.15 uf at 800 volts, 0.001 to 0.1 uf at 1200 volts and 0.001 to 0.05 uf at 1600 volts. They are noninductively wound with aluminum foil and laminated Kraft paper. Also announced by this company are Types JR, JRC and JRX dry electrolytic capacitors and a series of a-c motor starting capacitors.

Microphone

A NEW MICROPHONE, the 22X, has been announced by The Turner Co., 910 17th St., N. E., Cedar Rapids, Iowa. The frequency range is from 30 to 7000 cps and it has an output level of –52 db. The head is full 90 degrees tilting for semi- and non-directional operation. It has a satin chrome finish. It is shielded and is rugged enough for all kinds of public address jobs.

Sound System

A LOW PRICE mobile public address system, Model 172, for small sound cars or trucks has been announced by Operadio Manufacturing Co., St.

New . . .

PRESTO TURNTABLE

gives perfect reproduction of all makes of transcriptions

Here is a turntable designed for practical operating conditions in broadcasting stations where from two to five different makes of recordings are used daily. In place of the ordinary tone controls this Presto turntable is equipped with a compensating network accurately calibrated to reproduce the full range of NBC-ORTHACOUSTIC, WORLD, A.M.P. and R.C.A. transcriptions, COLUMBIA, DECCA and R.C.A.-VICTOR phonograph records.

A definite setting of the compensator is specified to take care of the individual characteristics of each of these makes of recordings as well as PRESTO instantaneous recordings. Thus you obtain a perfect, uniform reproduction of the full range (50-9,000 cycles) of the finest lateral recordings.

In addition to this valuable feature the Presto 62-A turntable employs a radically new drive system. The turntable rim is equipped with a heavy, live-rubber tire driven by a steel pulley on the motor shaft. With this design vibration is negligible and the speed is as steady as the finest Presto recording turntables. Speed may be changed instantly from 78 to 33⅓ RPM.

The pickup is equipped with a permanent diamond stylus which may be removed if damaged by accident and replaced for a few dollars.

Attractively finished in two tones of gray and chromium, the Presto 62-A turntable will improve both the appearance and performance of your station.

Write today for descriptive folder.

PRESTO RECORDING CORPORATION
242 West 55th Street, New York, N. Y.

A VALUABLE AID FOR YOUR LABORATORY

...and an unusual value!
RCA 5-inch Oscillograph

You'll call this RCA 5-inch oscillograph a worth-while addition to your laboratory.

It embodies all of RCA's skill and experience in oscillograph manufacture. And in addition to performing all the laboratory functions of other RCA Oscillographs, it may also be used for engine pressure measurements and similar applications.

It offers you unusually wide amplifier ranges and its 5-inch screen is easy to read. All controls are conveniently located on front panel. Compact construction assures easy portability. An unusual value at its moderate price. Stock No. 160, net price $130.

Over 335 million RCA radio tubes have been purchased by radio users ... in tubes, as in parts and test equipment, it pays to go RCA All the Way.

RCA Test Equipment

RCA Manufacturing Co., Inc., Camden, N. J.
A Service of the Radio Corporation of America

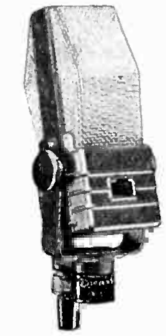
Charles, Ill. It has a 25 watt amplifier, a twelve inch turntable with a 78 rpm motor and crystal pickup, two twelve-inch permanent magnet speakers and a hand type dynamic microphone. Provision is made for remote control. It is designed to operate either from a storage battery or from a 110 volt a-c power line. In order to conserve power, three separate switches are provided for the filaments, genemoter and turntable. This increases the useful length of a battery charge by 25 to 50 per cent.

Condenser

THE KODACAP tubular condenser for 1000 volt operation is announced by Micamold Radio Corp., 1087 Flushing Ave., Brooklyn, N. Y. The dielectric is a special process cellulose derivative which permits the size to be about the same size as the conventional 600 volt condenser of the same capacity rating. Tests show the life of the new condenser to be about three times that of the paper-insulated condenser.

Microphone

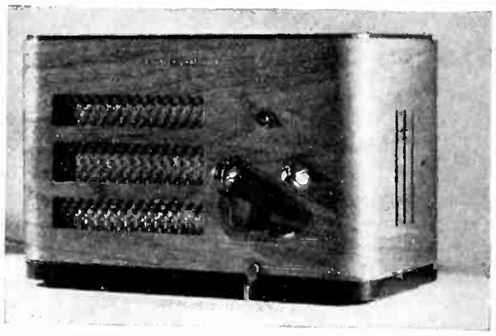
A NEW HIGH fidelity velocity microphone, Model V-1, at a popular price is announced by Electro-Voice Mfg. Co., Inc., South Bend, Ind. It is small in size and flexible in operation. The frequency response is 40 to 10,000 cps substantially flat when placed six inches or more from the sound source. The output is minus 65 db.



Relays

A NEW LINE of 4 and 6 ampere relays for a wide variety of light duty circuit control purposes has been announced by Leach Relay Co., 5915 Avalon Blvd., Los Angeles. The pole pieces are nickel plated, heat treated beryllium copper. All parts are made and assembled so that nothing can twist or turn out of alignment and the relay is isolated from the frame. All iron parts are cadmium plated and canvas base bakelite is used as insulation unless otherwise specified. The relay can be supplied of either a-c or d-c operation.

BEST BUY *in Wireless* INTERCOMMUNICATING *Systems*



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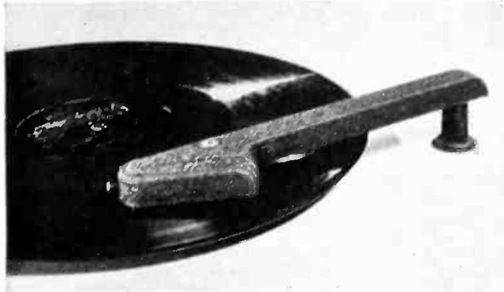
BOSTON 110 Federal St.
NEWARK 24 Central Ave.
JAMAICA, L. I. 90-08 166th St.
BRONX, N. Y. 542 E. Fordham Rd.

Phono Pickups

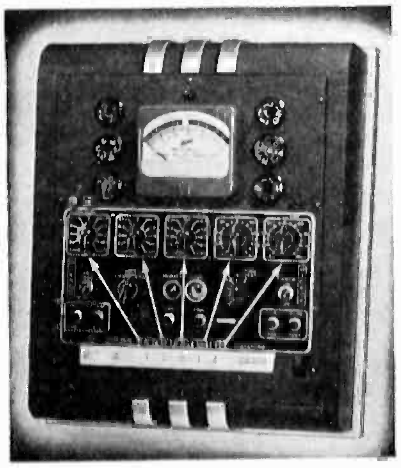
A NEW CRYSTAL phonograph pickup, Series X-79A, is announced by Webster Electric Co., Racine, Wisconsin. The frequency response is from 50 to 8500 cps and it operates with a 2.5 ounce needle pressure. The arm assembly is rubber cushioned which eliminates microphonic feedback and reduces "mechanical reproduction." The single hole mounting facilitates mounting to any motorboard from 1/16 to ½ inch thick. It is available with or without a built-in pilot light.



A NEW CRYSTAL phonograph pickup is also announced by Astatic Microphone Laboratory, Inc., Youngstown, Ohio. It is the Model AB-8 which features spring-axial cushioning. It uses the Astatic Type B cartridge with ebonite waterproof coated crystal element.

Tube Tester

A NEW DYNAMIC MUTUAL conductance Tube Tester, No. 530, is announced by The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland. The meter has three ranges of mutual conductance, 0–3000–6000–15000 micromhos, as well as good, bad and doubtful portions of the scale. The roll chart which indicates the proper positions of the control knobs for the various types of tubes has been enlarged in size. This instrument tests tubes of standard, octal and loktal basings. It is available in both counter types and portable types.

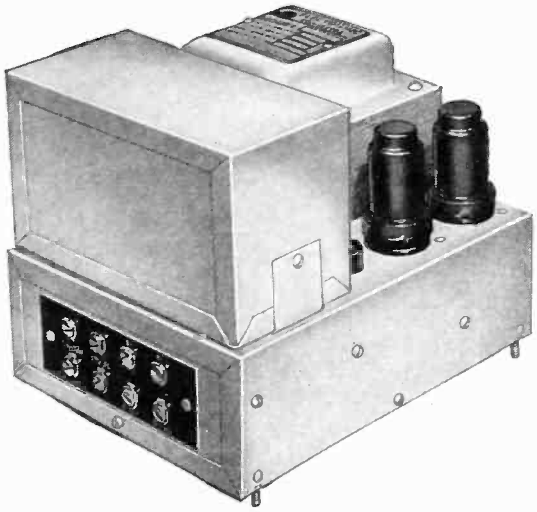


Signal Generator

A LOW COST SIGNAL GENERATOR, Model 702, has been introduced by Radio City Products Co., 88 Park Place, New York. It provides fundamental, continuously variable frequencies from 95

USE PORTAPOWER UNITS

Since their manufacture in 1932, Electronic Power Packs have been thoroughly tested in actual use and are now standard equipment on the products of such outstanding organizations as: Bell Sound Systems, Inc.; Collins Radio Company; Electronic Design Corporation; General Electric Company; The Hallicrafters Inc.; Operadio Manufacturing Company; Pullman Company; Rauland Corporation; Thorardson Electric Manufacturing Co.; Transformer Corporation; U. S. Army Air Corps; The Webster Company, and scores of others.



PORTAPOWER Units are the latest product of this oldest and largest maker of vibrator - type portable power packs. They will be found highly satisfactory for the operation of tranceivers, mobile transmitters, marine, and Pullman equipment.

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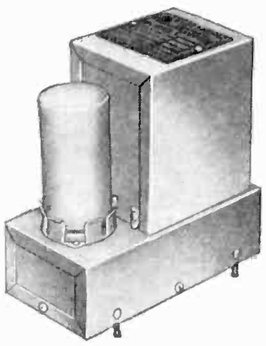
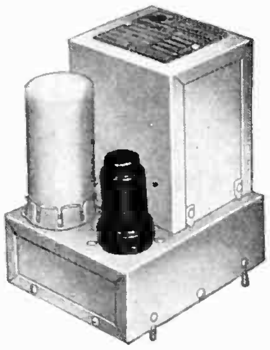


(top) Types 606 and 607
(left) Types 604 and 605
(right) Types 601, 602, 603



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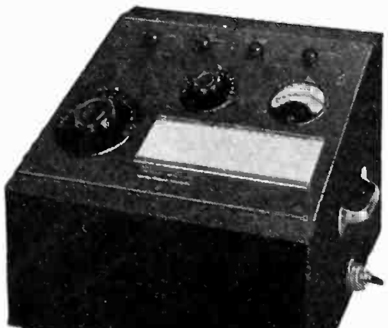
A practical Noise Instrument for

Routine Production Testing

in your plant

Industrial Noise Analyzer RA-273



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- Large indicating meter
- Feedback stabilized amplifier
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- Used with moving coil microphone or vibration unit

FOR THE PLANT—Large number of filter combinations permits segregation of different noises characteristic of specific defects in assembly. Simple controls adaptable to production line conditions. Rugged design insures calibration stability and reliability.

FOR THE ENGINEER—A convenient instrument for wide band frequency analysis, to assist in location and correction of noise sources. Sound level measurement in accordance with A. S. A. standards. For more complete information write to the address below.

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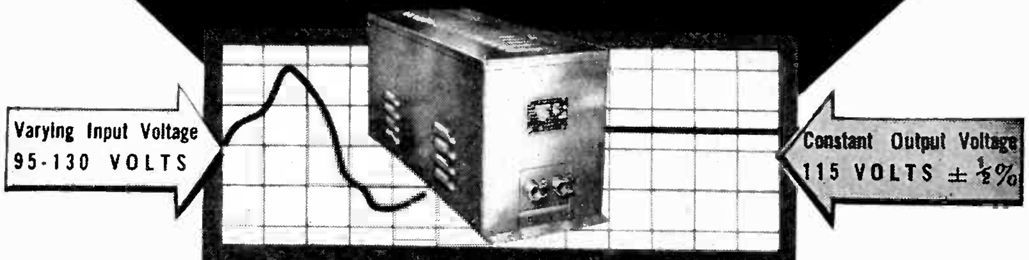
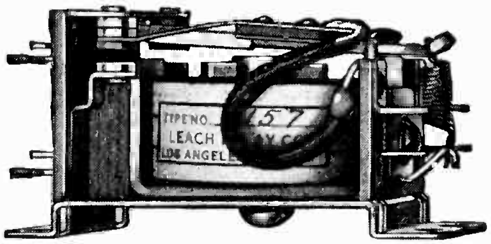




kc to 25 Mc with harmonics extending the useful range to 100 Mc. All ranges are directly calibrated in frequency and provision is made for direct tuning or through a 5 to 1 planetary drive. Triple shielding is provided and in addition the coil assembly, attenuator and r-f circuits are individually double shielded. 400 cps sine wave modulation (30 per cent) is provided by a built-in oscillator. A 5-step ladder attenuator is used and provides an output range from 1 microvolt to ½ volt. It is ac operated and the overall size is 8 inches by 11¾ inches by 5 inches. Also announced by this company is a ac-dc multimeter and a general utility meter.

Power Unit

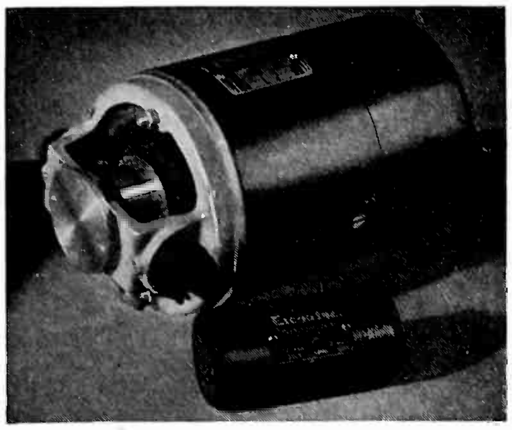
A PORTABLE POWER unit, Model L Porta Power, designed to convert two volt battery radios to all-electric operation is introduced by General Transformer Corp., 1250 West Van Buren St., Chicago. It operates on 105-125 volts, 50-60 cycles and provides A voltage, two volts; B voltage, 67½, 90, 112½, and 135 volts and can be adapted to 45 volts; and C voltage which is variable from 4½ to 22½ volts and two C voltages may be provided if necessary.

Portable Sound System

A 30-WATT PORTABLE Public Address Unit, Model 425-GG, is offered by Operadio Manufacturing Co., St. Charles, Ill., which incorporate individual bass and treble tone compensators in the amplifier. The controls of the unit are set in an illuminated recess in the face of the amplifier. Provision is made for remote control. The unit is contained in two carrying cases, one holding the amplifier, microphone and floor stand and the other, a split case, in each half of which is mounted a 12 inch permanent magnet dynamic speaker. Each speaker cabinet incorporates an infinite baffle.

Mercury Switches

A NEW LINE OF delayed-action mercury switches, in both circuit-opening and circuit-closing types, has just been announced by General Electric Co., Lamp Department, Hoboken, N. J. Time-delay intervals of from ½ to 15 seconds for circuit-opening and from ½ to 10 seconds for circuit closing are available. The delayed-action of the new Kon-nec-tor switches is obtained by the restricted flow of mercury through a small orifice at the bottom of a



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USED in leading Aircraft, Police, Marine and Amateur Transmitters and Receivers where smooth, continuous, trouble-free performance is essential. Available in the widest range made today—a complete line from the smallest of them all to the largest required. Also manufacturers of Converters, Generators, Motors, Alternators.

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MODEL AB-8
CRYSTAL PICKUP

New advanced design incorporating such important features as Spring-Axial Cushioning, Astatic's famous Type B (bakelite encased) Cartridge with new internal damping to assure permanence, a Bender Crystal element with "Ebonite" water-proof coating, and last but not least, a massive new die-cast arm. Accommodates 10" and 12" records. Convenient threaded stud base. Eight-inch mounting centers. Standard finish, statuary bronze with chrome trim. Complete with 4-ft. cable and arm rest. List Price $10.00.

See *Astatic Jobber*
or *Write for Catalog No. 12*

ASTATIC MICROPHONE LABORATORY, Inc.
YOUNGSTOWN, OHIO
Licensed Under Brush Development Co. Patents
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metal chamber inside the switch. When the Kon-nec-tor is tipped, mercury flows into the chamber, then through the orifice until the circuit is immediately restored when the switch is tipped back to normal position. Definite, non-adjustable time intervals are built into the individual switches by varying the amount of mercury and the size of the orifice.

New Type Ionization Gauge

AN IONIZATION GAUGE, Type VG-1, capable of reading the lowest attainable pressures is announced by Distillation Products, Inc., 755 Ridge Road West, Rochester, N. Y. Because of its unique construction, the usual problems of electrical leakage and outgassing are reduced to a minimum. It is designed primarily for reading pressures below 10^{-4} millimeters and is calibrated for dry air. The filament is of pure tungsten, the grid is a spiral of tungsten wire and the collector is a thin film of platinum on the inside of the Pyrex glass envelope. The tubulation is five-eighths of an inch inside diameter and the overall size is 3½ inches high and 1½ inches in diameter. Two grid leads are available so that the grid may be heated electrically for degassing. The envelope being of hard glass may be safely torched with a

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Secure IMPROVED PERFORMANCES. Cores and prices to meet every need—YOU CANNOT AFFORD TO USE ANYTHING INFERIOR.

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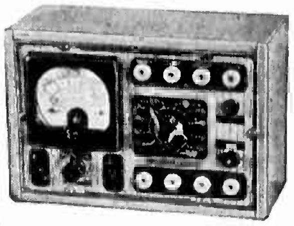
Forget what you've heard about RCP test instrument value. Forget the talk about quality, ingenious engineering, design so advanced it beats obsolescence at its own game. Check the instruments here on a MONEY'S WORTH basis. Look at the features . . . consider the jobs each instrument performs . . . note the low price. Match these instruments if you can dollar for dollar. Now add RCP long-life dependability and you too will insist next time on RCP test equipment at your jobbers. *For complete information on all RCP test instruments send for new free catalog No. 121.*

RCP UNIVERSAL SUPERTESTER MODEL 411

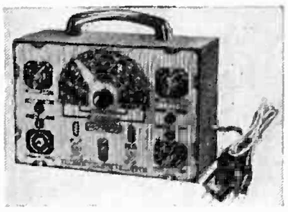


THE MOST COMPREHENSIVE tester ever devised to provide measurements of such accuracy in ranges never before available in small instruments. Use it to check heavy currents, use it in Television testing. Features include: 5 stage AC-DC voltage range to 5000 volts. 3 stage AC-DC current range to 25 amps. DC milliamps 0/10/100. DC microamps 0-200. 4 stage ohmmeter range to 4,000,000 ohms. A.C. milliamps and D.B. ranges. In natural hardwood case. Net $16.25

RCP ELECTRONIC MULTITESTER MODEL 660

ONLY IN AN INSTRUMENT COSTING 2 to 4 times the price will you find the same extraordinary ranges, the sensitivity and facilities for measuring large values this new vacuum tube volt-ohmmeter offers. Ranges up to 6000 volts and 1 billion ohms. Lowest voltage reading 0.1 volts. Gets its unusual sensitivity from an input resistance of 200,000,000 ohms. Total of 12 ranges all on direct reading master scales. Extreme operating simplicity . . . remarkable versatility. Supplied complete in hand-rubbed sloping walnut case. Net $18.85

RCP SIGNAL GENERATOR MODEL 702



EVEN FINER PERFORMANCE than RCP'S former signal generator, and it costs you 30% less. Has all latest improvements in circuit and mechanical design. Extremely wide all wave coverage continuously variable from 95 Kilocycles to 100 Megocycles. Output modulated at will. 30% modulation at 400 cycles, sine wave from self-contained independent 400 cycle circuit. Attenuation in approximate microvolt calibration by means of five step ladder attenuator. Highly attractive professional appearance. AC operated. Net $22.95

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flame. In this way the glass and the collector which is a thin coating on the inside wall are both freed of occluded gases.

Coil Form

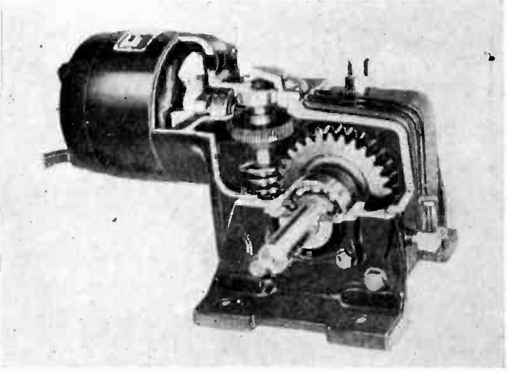
AN ULTRA-LOW-LOSS coil form molded of Amphenol 912 pure polystyrene has been announced by American Phenolic Corp., 1250 West Van Buren St., Chicago. They will not absorb moisture and will maintain the Q of the coil with no insulation losses. The coils may be painted with Liquid 912 coil dope to keep moisture out of winding and to keep winding tight. No holes are provided in this form because of the ease of drilling.

Record Changer

A LOW COST automatic record changing mechanism, identical in design with the changer used in the finest current Victrolas, is announced by RCA Manufacturing Co., Camden, N. J. It will play seven twelve-inch records or eight ten-inch records automatically and records of any size may be played manually. This record changer (Stock No. 9865) has a top loading crystal pickup with an automatic needle ejector. When removing a used needle before loading the pickup, it is only necessary to loosen the needle screw and push the ejector lever down. Dimensions of the motor board are 14¾ inches wide and 11½ deep and the space required above the motorboard is 4¼ inches.

Speed Reducer

A SPEED REDUCER motor designed primarily for very low speeds and high torques has just been announced by Bodine Electric Co., 2264 W. Ohio St., Chicago. The motor develops from 1/50 to 1/20 horsepower, depending on the gear ratio used. Speeds as low as 0.6 rpm and torques as high as 350



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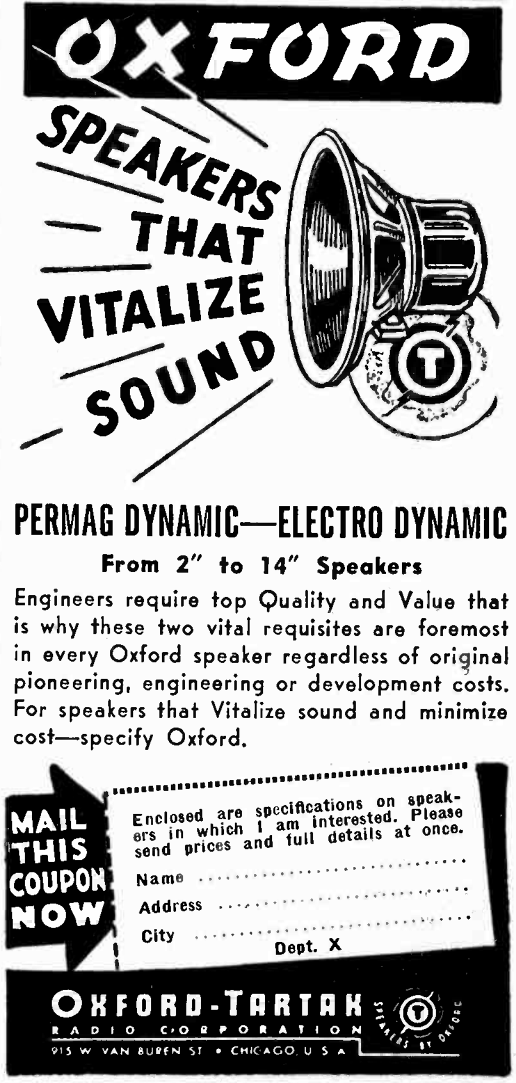

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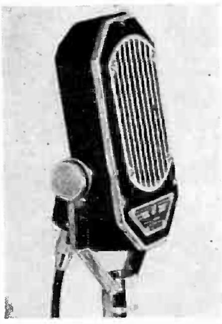
inch-pounds and a speed reduction range from 72 to 1 to 2880 to 1 may be supplied. Lubrication is positive. In normal horizontal mountings, the primary worm is lubricated by an oiling gear and the secondary worm by the secondary gear, both of which dip into the oil. In the usual flange mounting, the primary gear and secondary worm are partially immersed in the oil bath. The worms are ground from hardened steel, the primary gear is of bakelite and the secondary gear is of hard bronze.

Condensers

A NEW LINE OF by-pass and electrolytic condensers, manufactured by a new etching process, is announced by Ariston Laboratory, Chicago. The new process insures a uniformly etched foil and extends the life of the condenser. They are known as the Ariston New Process Condensers.

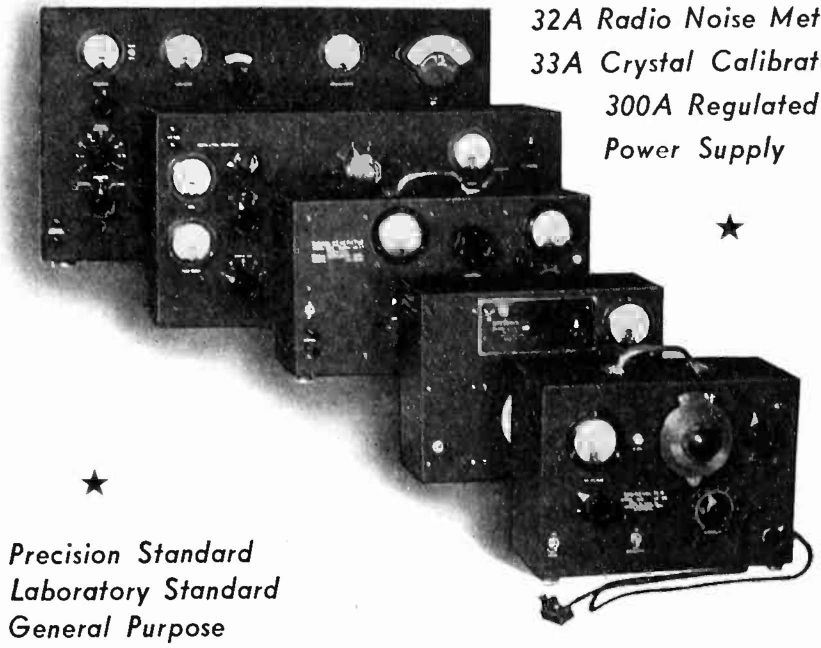
Microphone

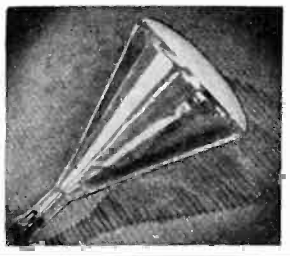
A NEW FOUR magnet velocity microphone known as the M4 was recently announced by Universal Microphone Co., Inglewood, Calif. The frequency range is from 40 to 10,000 cps and the output level is –64 db. It is supplied in a variety of output impedances. A three prong plug is provided to permit grounding of center tap is available except on the high impedance type. It is equipped with adjustable cradle and thumb nuts for tilting and locking the instrument in any desired position.

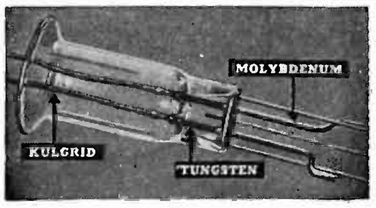


Frequency Monitor

A VISUAL FREQUENCY monitor, Model FD-8, has been announced by Doolittle & Falkner, Inc., 7421 Loomis Blvd., Chicago. The instrument consists essentially of a converter tube operating in conjunction with an integral crystal controlled oscillator which heterodynes the signal being monitored producing an audio beat note. This note is amplified and applied to an electronic counting device which produces a direct indication of frequency deviation on a meter. The meter is calibrated from 0 to 1000 cps, but the range may be extended to 10,000 cps by a switch. The unit may be coupled to the transmitter through a shielded lead and pickup coil or if a number of transmitters are to be measured, sufficient pickup can usually be obtained from a short antenna. The frequency range is from 1600 kc to 50 Mc.







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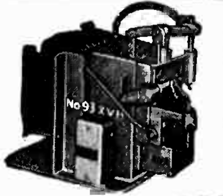

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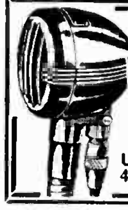

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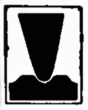

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The Novachord

(Continued from page 19)

become weaker while the accentuated melody is being played. Also the panel "Balancer" control slightly increases or diminishes the volume of the lower half of the keyboard and the timbre controls are helpful. The action of the left sustaining pedal is split at center of keyboard so that only lower half may be sustained if desired.

The foot pedal volume control operates a 350 $\mu\mu$f variable condenser to vary the gain of a preamplifier tube through altering the plate to grid negative feedback. This eliminates the problem of the continuous wear of resistor switch points as well as forming a stepless variable.

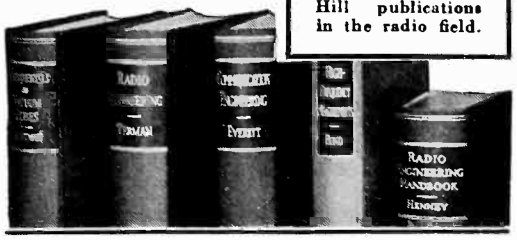
As the loudspeaker is pointed towards the floor at a slanting angle, the high frequencies are diffused and the chance of a listener or player being located within the uncomfortable treble radiation cone lessened.

The power amplifier is a standard Hammond Organ amplifier, using two Type 56 input tubes and four Type 2A3 output tubes in push pull parallel. The power consumption of the entire self-contained instrument is 450 watts, less than what might be expected since the tubes are operated extremely conservatively.

Power Pack

The plate, screen and grid voltages for the oscillators, dividers and control tubes are exceptionally well filtered and isolated by a power pack employing vacuum tubes in place of the usual filter condensers.

Referring to Fig. 9 it is seen that the rectifier tube supplies 250 volts between terminals 1 and 5, with the filtering by the following three tubes. The action is explained as follows. If a small ripple appears in the 250 volt line it will be impressed on the cathode of the first filter tube, 6J7G, through the condensers and will be amplified by the next tube, 6J5G. The amplified ripple will then appear across R_1 and will drive the next tube which is the actual filter, and the plate current of this tube will change in such a way that it opposes the original ripple in the line and is of such value that it cancels it out. Any high frequency ripple introduced by the



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oscillators into the power supply is also filtered out by this system. Tubes 5, 6 and 7 operate similarly for the 65 volt tap on the voltage divider network.

Because the voltage regulation of the output of the 5V4G and supply transformers is poor, the filter tube plates can be considered as operating primarily as variable loads rather than to supply a 180 degree out of phase hum bucking voltage.

Control Panel

The musician's control panel already shown in Fig. 4 will be generally understood from the foregoing description. The "combination" knob set at "percussion" instantly gives the piano effect by mechanically setting up the proper positions of the other knobs for correct piano timbre and envelope. At the "singing" position any previous set-up of knobs is cancelled out and a new combination immediately arranged mechanically, consisting of a mellow tone quality and organ-like attack. The volume knob position determines the maximum volume obtainable by full depression of the foot volume pedal. The Starter is necessary to insure the starting of the pendulum vibratos into motion.

The Novachord is the first commercial pure electronic musical instrument possessing a full keyboard on which chords may be played.

References

(1) Lee DeForest, Patent 1,543,990. Coupleaux-Givelet. U. S. Patent 1,905,996 and others.

(2) For more detailed information refer to Laurens Hammond Patent 2,126,682. Additional material is found in 2,126,464 on control tube.

(3) Related art is found in G. Smiley Patent RE 20,825 and Re 20,831, 1938.

For general information on the entire field read "Electronic Music and Instruments," B. F. Miessner, Proc. I.R.E., Nov. 1936. Vol. 24, No. 11.

Bio-millivoltmeter

(*Continued from page* 25)

former of the saturated field type. In order to produce further refinement in stability, the d-c power supply is shunted by a voltage regulator tube.

The probable error in stability due to variations in circuit elements is halved in this type of circuit as compared to the usual in-line resistance coupled amplifier since all the

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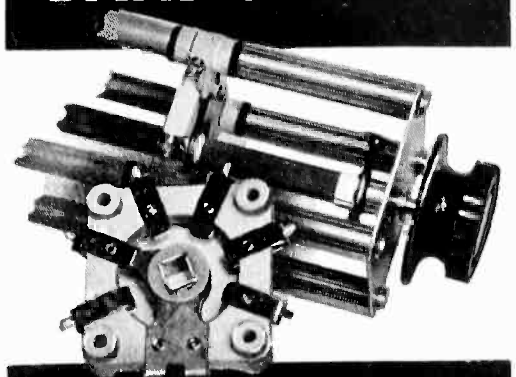

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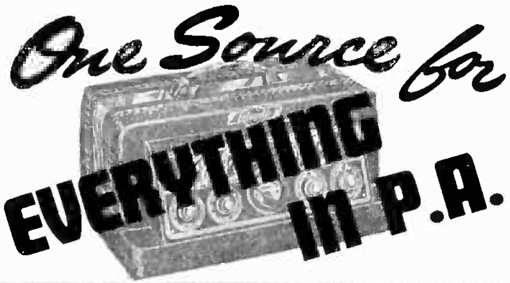

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elements are functionally duplicated in reverse phase. Wherever possible wire wound resistor elements are used and the instrument should be allowed ample time for heating before balancing and using.

Thus far only one stage has been considered. Several stages can be coupled together in this type of amplifier by connecting the plates directly to the input grids of the next stage of amplification. The second stage is functionally identical to the first. The grid potentials of the second stage are highly positive because of this connection. It is therefore necessary to insert a high enough value of resistance between the cathodes of this stage and ground so that the net potential between grid and cathode will be such that the grids are slightly negative (about 1.5 volts). Incidentally, this type of amplifier is unique in that only one high voltage source is utilized in a multi-stage circuit. When using two stages it is of utmost importance that the balancing adjustment (P_1) be accurately set so that the potentials at both plates of the first stage are equal. It is obvious that any inequalities in po-

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Of Electronics, published monthly at Albany, N. Y., for October 1, 1939.

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(My commission expires March 30, 1940)

tential will be amplified in the second stage and render the instrument useless.

The instrument described is linear within the range of zero to 4 millivolts. The total amplification using two stages is 6,000; with only the first stage, a gain of 202 is obtained. The amplification of either stage can be readily increased by decreasing the resistance of the potentiometers P_1 and P_2. However, this procedure would give less flexibility in balancing. A maximum gain of about 20,000 has been obtained in this manner, but such sensitivity is unnecessary. To increase the voltage range of the instrument, a resistance of 1,200 ohms, the critical damping value, may be shunted across the galvanometer. Calibration of the meter is accomplished with a Leeds and Northrup standard cell and standard resistances.

In the first stage, Type 1603 low microphonic tubes were used to remove any possibility of spurious readings due to mechanical vibration. In the second stage, the Type 6J7 was used since, being disposed unsymmetrically relatively close to the power transformer, the metal shell serves to shield the elements from stray fields.

Before operating the instrument, 20 minutes should be allowed for it to reach operating temperature. The galvanometer is switched into the plate circuit of the first stage and by means of the potentiometer P_1 the amplification of both valves is equalized so that the meter reads zero. Then the galvanometer is switched to the output of the second stage which is now balanced by means of potentiometer P_2 so that a zero deflection is again obtained. The machine is now ready to be used. Electrodes should be connected to the input by means of shielded microphone cables having a single pole push switch in the line to close the circuit.

BIBLIOGRAPHY

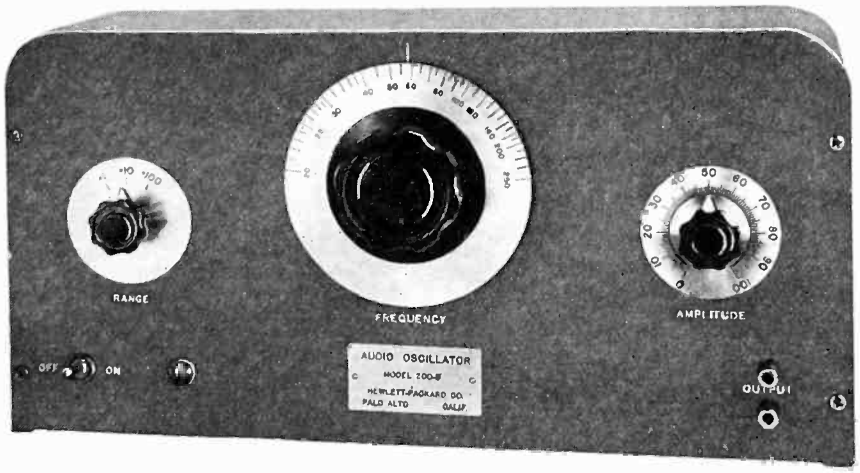
(1) Burr, H. S., and Musselman, L. K. *Yale Jour. Biol. and Med.* 1936, 9, 155.

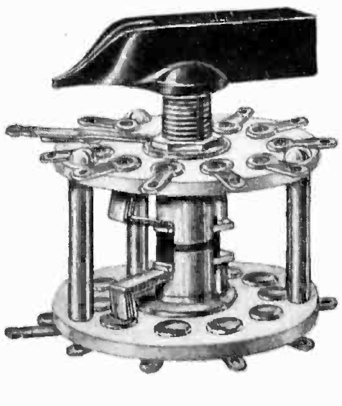
(2) Rock, J., Reboul, J., and Wiggers, H. C. *New Eng. Jour. Med.* 1937, 217, 654.

(3) Rogers, P. V. *Proc. Soc. Exp. Biol. and Med.* 1936, 34, 644.

(4) Burr, H. S., Lane, C. T., and Nims, L. F. *Yale Jour. Biol. and Med.* 1936, 9, 65.

(5) Buchtal, F. and Nielsen, J. O. *Skand. Arch. f. Physiol.* 1936, 73. 203.





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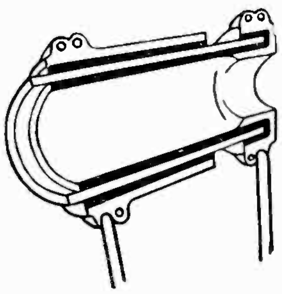

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CENTRALAB ceramic temperature compensating capacitors are desirable because circuit components commonly have a positive drift changing the frequency tuning with changing temperatures. This change is particularly objectionable at higher frequencies as the dial may be logged at one temperature only.

By calculating the amount of positive drift normally present in the radio chassis, CENTRALAB ceramic capacitors with a suitable negative temperature coefficient may be substituted for mica capacitors in the circuit and the overall frequency drift held to a minimum.

Centralab Capacitors may be had with any designated negative temperature coefficient between zero and .0007 mmf. per degree centigrade. Available capacities range from 2 mmf. to 1000 mf.

In delicate and intricate short-wave components in modern receivers the need for accurate tuning is magnified because of increasing interest in world affairs.

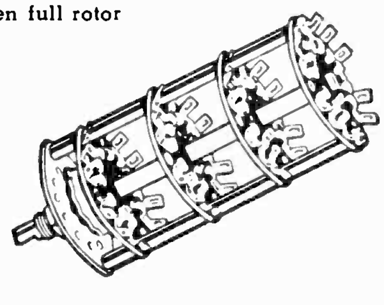
Centralab again steps to the fore with quality parts—engineered in the typical manner. For original equipment or replacements . . . always specify CENTRALAB.

Wave Change Switch

CENTRALAB "H" type switches have the conventional maximum of 12 contact clips per section. These are of the double-wiping type or more specifically one half having a wiping action and the other half a biting action . . . this type is particularly desirable where the switch is only occasionally adjusted. Rotors of hard rubber or ceramic and stators of ceramic are also available where exceedingly low loss is desired.

CENTRALAB "W" type switches are best adapted to good short wave reception because they have substantially lower capacities from clip- to- clip and from clip to ground than equivalent switches of other makes. They also make possible an infinite number of switching combinations because they provide up to 24 insulated clips per section.

Contact clips are of the double wipe type having very long life. Test data shows an actual decrease in contact resistance after 10,000 cycles and less than 20% increase at 50,000 cycles. The capacity between back-to-back insulated clips is .05 mmf. The capacity between full rotor sections is 1.75 mmf.

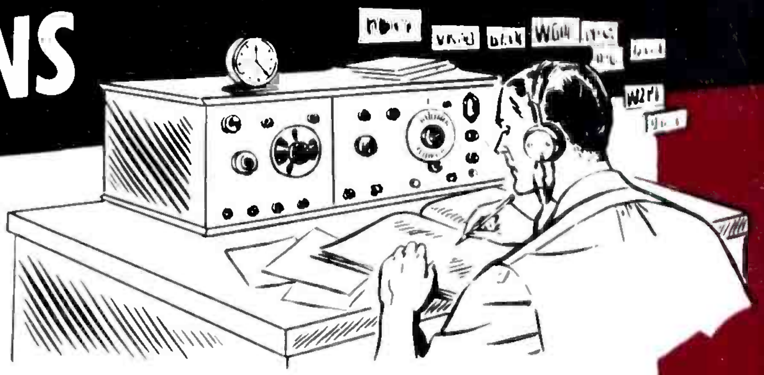


The supreme flexibility of these Wave Change Switches (there are almost infinite variations in the combination of switch functions and number of index positions) plus the inherent quality of every Centralab product makes it imperative to "SPECIFY CENTRALAB" wherever unquestioned performance is required.

Centralab

Div. of GLOBE-UNION Inc.
MILWAUKEE, WIS.

TUBE RATINGS THAT RECOGNIZE TH DIVERSIFIED REQUIREMENTS OF MODER TRANSMITTER APPLICATIONS



The initiation by RCA of a Dual Rating System for many of the most popular RCA Air-cooled Transmitting Tubes marks an important forward step in simplifying the selection of tubes to conform to specific transmitter applications. By recognizing the fact that amateurs, aircraft and police radio users, as well as many others, seldom operate power amplifier tubes under anything like the constant "key-down" conditions on which RCA Class C Telegraphy Ratings have been based, this System paves the way for greater tube economy in many applications.

The two sets of maximum ratings now given for many tubes are designated "Continuous Commercial Service" (CCS) and "Intermittent Commercial and Amateur Service" (ICAS). The CCS ratings are on the same basis as the former maximum ratings. They take into account continuous 18-hour-a-day-or-better service.

The new ICAS ratings, however, permit much greater power input and a relatively large increase in useful power output for intermittent services. They take full account of the rapid progress in tube and transmitter design and are well suited for many amateur and intermittent commercial applications.

The new system provides transmitting-tube ratings which recognize the diversified design requirements of modern transmitter applications. For example, there are numerous applications where the design factors of minimum size, light weight, low initial cost, and maximum power output are far more important than extremely long tube life. In such cases, the set designer may very properly decide that a small tube operated with ICAS ratings better meets his requirements than a larger tube operated with CCS ratings.

***Pioneered and initiated by RCA,* the new ICAS Ratings are your keynote to low initial cost, maximum power output and utmost in true performance.**

CCS

CONTINUOUS COMMERCIAL SERVICE RATING — RCA-810 High-mu Triode

(Class C Telegraphy)

Max. plate voltage, 2,000 V.
Max. d-c plate input, 500 W.
Max. plate dissipation, 125 W.

ICAS

INTERMITTENT COMMERCIAL AND AMATEUR SERVICE — RCA-810

(Class C Telegraphy)

Max. plate voltage, 2,250 V.
Max. d-c plate input, 620 W.
Max. plate dissipation, 150 W.

$13.50 net

ICAS	RCA-802 R-f Amplifier Pentode	CCS
600 V.	Max. plate voltage	500 V.
33W.	Max. d-c plate input	25W.
13W.	Max. plate dissipation	10W.

$3.50 net

	RCA-804 R-f Amplifier Pentode	
1500 V.	Max. plate voltage	1250 V.
150W.	Max. d-c plate input	120W.
50W.	Max. plate dissipation	40W.

$15.00 net

	RCA-806 Tantalum-plate Triode	
3300 V.	Max. plate voltage	3000 V.
1000W.	Max. d-c plate input	600W.
225W.	Max. plate dissipation	150W.

$22.00 net

ICAS	RCA-807 Beam Power Tetrode	CCS
750 V.	Max. plate voltage	600 V.
75W.	Max. d-c plate input	60W.
30W.	Max. plate dissipation	25W.

$3.50 net

	RCA-809 R-f High mu Triode	
1000 V.	Max. plate voltage	750 V.
100W.	Max. d-c plate input	75W.
30W.	Max. plate dissipation	25W.

$2.50 net

	RCA-814 Beam Power Tetrode	
1500 V.	Max. plate voltage	1250 V.
225W.	Max. d-c plate input	180W.
65W.	Max. plate dissipation	50W.

$17.50 net

ICAS	RCA-811 (High mu) RCA-812 (Low mu) Triodes	CCS
1500 V.	Max. plate voltage	1250 V.
225W.	Max. d-c plate input	155W.
55W.	Max. plate dissipation	40W.

$3.50 each net

RCA Radio Tubes

RCA MANUFACTURING CO., INC.,
CAMDEN, N. J.
A Service of The Radio Corporation of America

FIRST IN METAL—FOREMOST IN GLASS—FINEST IN PERFORMANCE