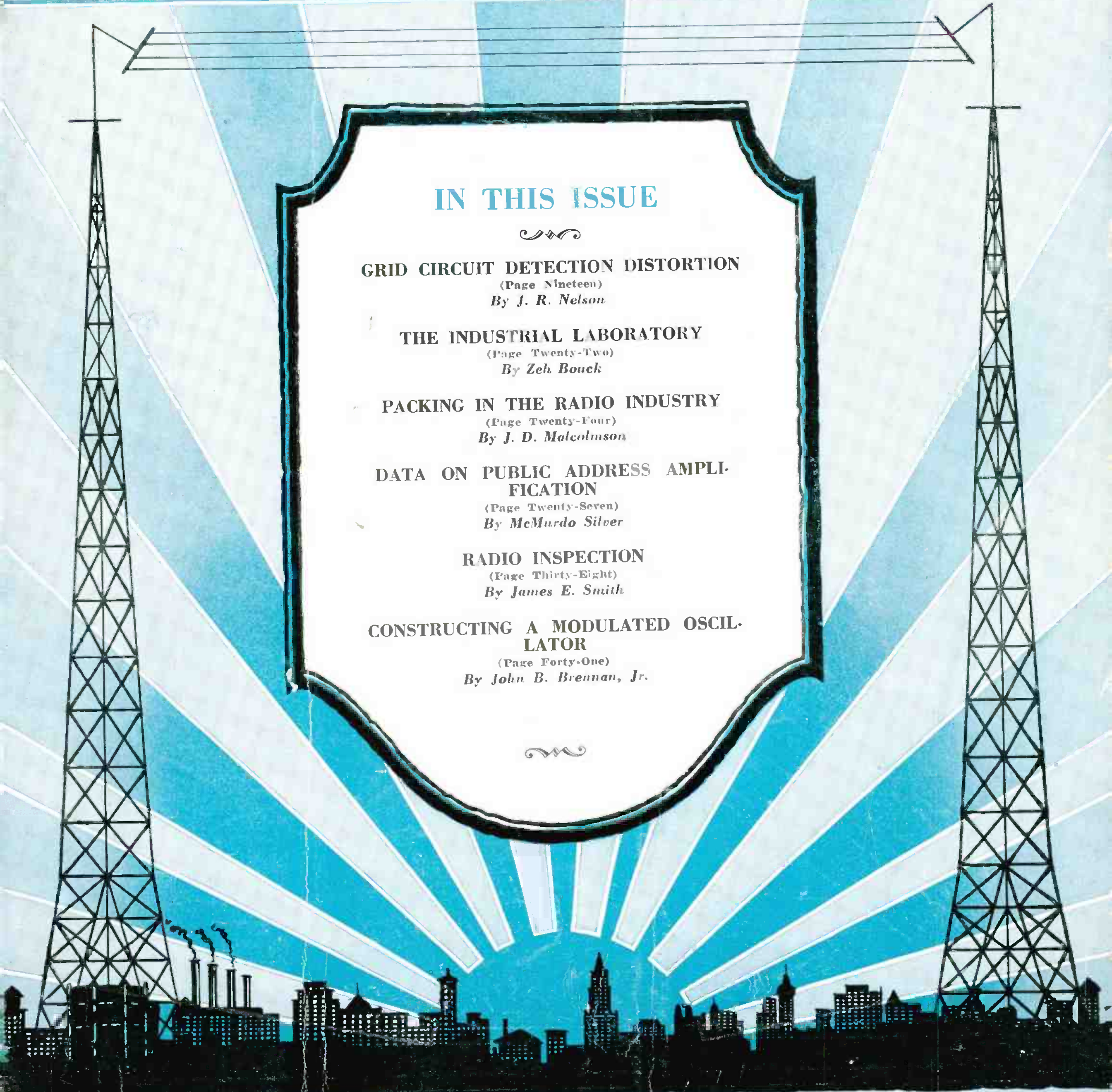
EIGHTH YEAR OF SERVICE

# RADIO ENGINEERING

Vol. VIII | DECEMBER 1928 | Number 12



## IN THIS ISSUE



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The TECHNICAL MAGAZINE of the RADIO INDUSTRY

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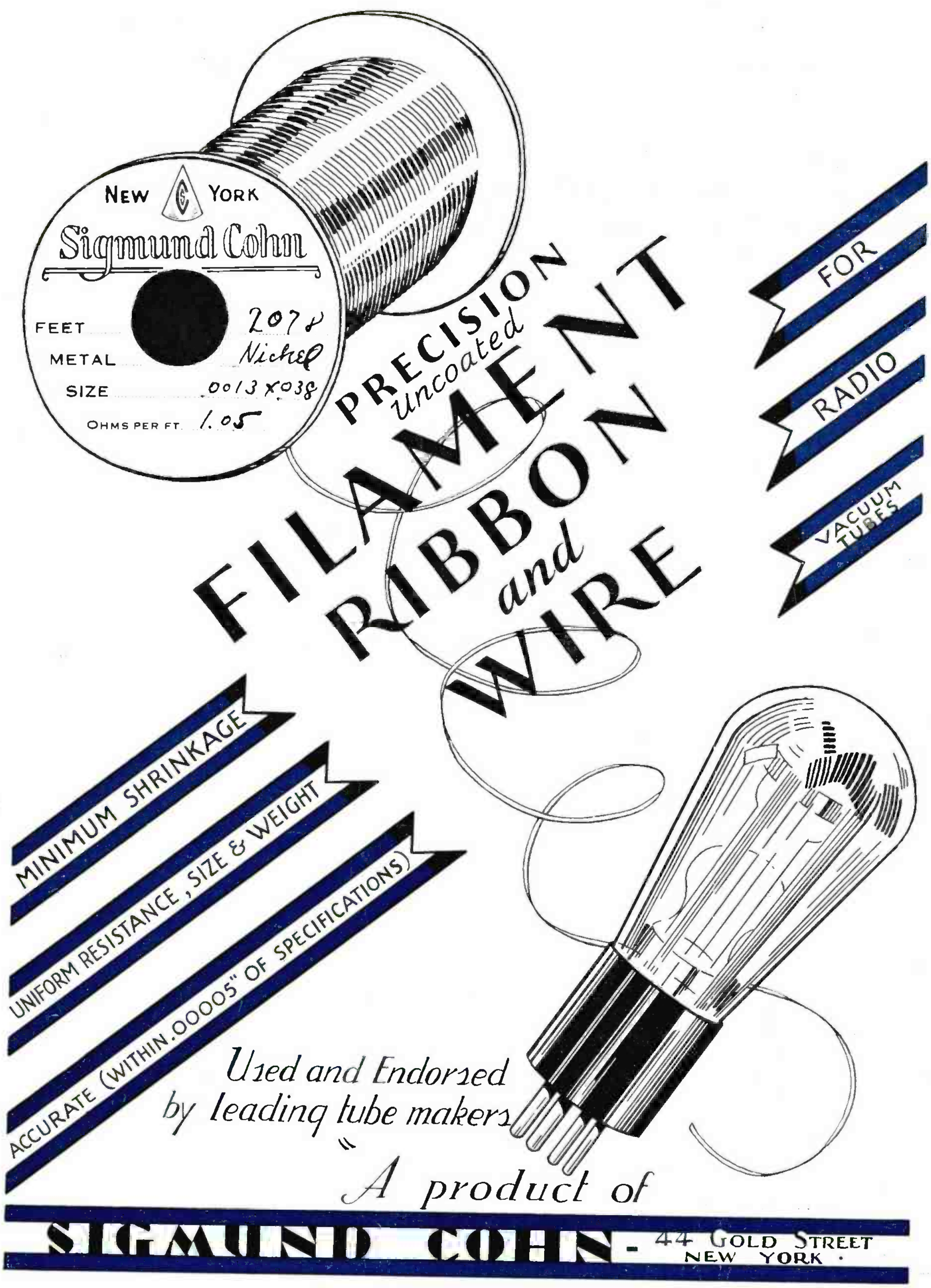


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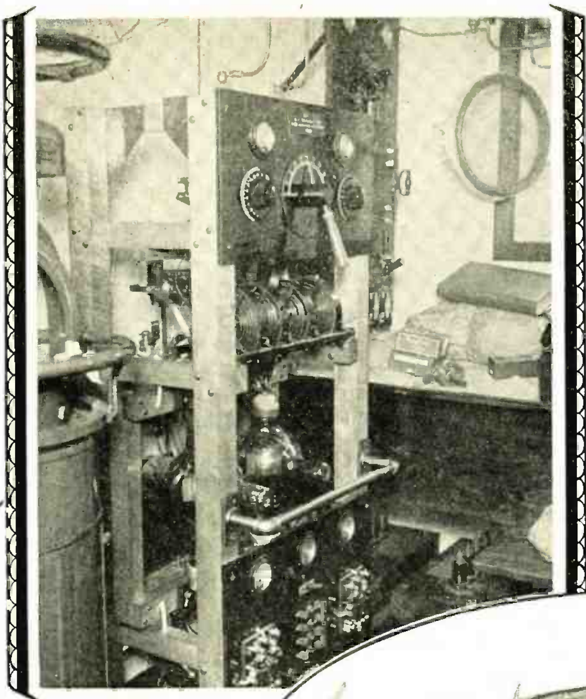
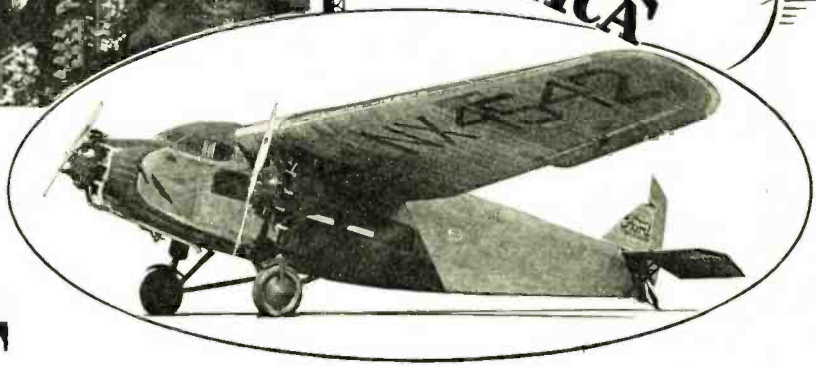


BYRD'S RADIO *is insulated with* FORMICA



FORMICA was used by the engineers who designed the sending and receiving apparatus in use by the expedition for panels, tubing and other insulating parts.

For fifteen years American radio men have known it as excellent insulation for high or low frequency uses. It is high in quality and uniform---Phenol Fibre at its best.

Every year millions of automotive ignition systems, therapeutic apparatus, circuit breakers and electrical devices of all kinds are insulated with Formica. You can depend upon it.

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4638 Spring Grove Avenue Cincinnati, Ohio

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**Made from Anhydrous Bakelite Resins**
**SHEETS TUBES RODS**

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RADIO ENGINEERING

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JOHN F. RIDER

*Editor*
M. L. MUHLEMAN

*Associate Editor*
AUSTIN C. LESCARBOURA

Vol. VIII | DECEMBER 1928 | Number 12

# *Contents*



## *Departments*



## Progressive Obsolescence

RAY M. HUDSON

*Assistant Director, Commercial Standards, Dept. of Commerce*

THE sales manager's job is to extend markets and build up volume. The ways by which he achieves these ends are many. More advertising, more salesmen, more outlets for the product are commonly expected to produce these results.

Among recent proposals in "progressive obsolescence," meaning the quickening of sales by inducing people, who can afford it, to buy a greater variety of goods on the same principle such people now buy autos, radios, and clothes, i. e., "not to wear out but to trade on or discard after a short time, when new and more attractive goods or models come out." While some stimulation of obsolescence is not uneconomic, the danger lies in its probable application to buyers who can not afford it and who might better put more of their income into more permanent investments. That uncontrolled obsolescence has great potentialities for economic waste and loss is obvious. Too high a frequency of purchase is relatively as wasteful for the consumer as too high a frequency in change of design, size, style or model is for the manufacturer and the merchant.

Against such blind grasping for volume are intelligent market analysis; simplification of product to lines in most constant demand; concentration of production and selling effort on the simplified line; reduction of manufacturing and selling cost and consistent reduction in price to the consumer; improvement in quality through scientific research; orderly revamping of product based on intelligent analysis of consumer wants, trends in taste, and ability to buy; the searching out of new uses for, or applications of, the product; and advertising that reckons with all of these matters.

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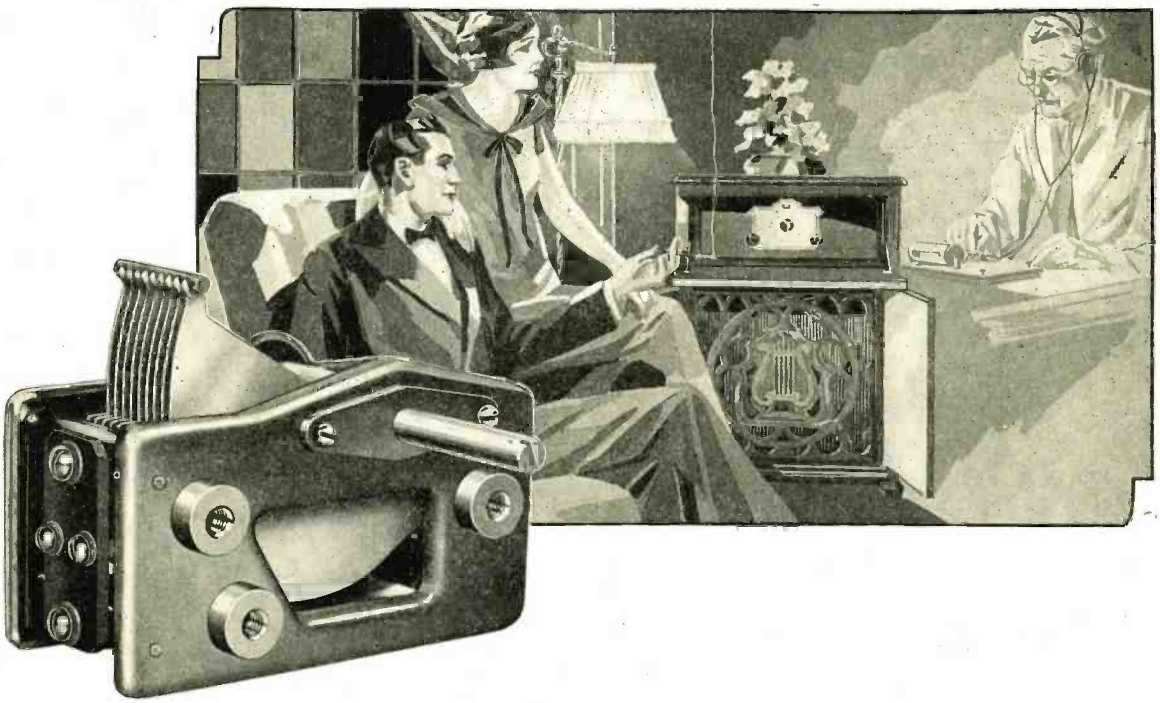
# THE RADIO MARKET



THE radio audience in the United States, by a recent estimate, amounts to over 41,000,000 people. An audience that is constantly growing more critical—demanding sets that more clearly approach perfection. Radio manufacturers realize that more than ever before their success depends on the mechanical perfection of every part. What more logical place to turn than to Scovill for assistance in manufacturing problems? Scovill with its up-to-date research department, its facilities for designing and building any special tools or machinery required, its tremendous capacity for volume production, is known as a dependable source of supply for parts and completed articles of metal such as condensers, condenser parts, metal stampings, screw machine parts, switches, etc. Escutcheons and similar parts can be stamped or etched to meet requirements.

**Scovill means SERVICE to all who require parts or finished products of metal. Great factories equipped with the last word in laboratories, and modern machinery manned by skilled workmen, are at your disposal. 'Phone the nearest Scovill office.**

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# EDITORIAL

*December 1928*

## THE RADIO CONTRACTOR

IN the editorial appearing in the November issue of RADIO ENGINEERING we stated that the present-day professional setbuilder is the future "radio contractor."

Judging from the volume of inquiries received regarding radio contracting there is widespread interest taken in this newly created enterprise.

We have been asked to elaborate on the subject of radio contracting and outline the steps one should take in developing this phase of the radio business. That is by no means a simple undertaking—but we shall attempt to provide a perspective.

We had best define radio contracting as "all radio business having to do with special installations." Such installations are usually of a commercial character and of the many opportunities open there are public address equipment for theatres, auditoriums, schools, road-houses, and so on. This equipment may be used in conjunction with a microphone for speeches or announcements indoors or out-of-doors, with a phonograph pick-up and a single or duplex turntable for the reproduction of music as accompaniment for motion pictures or for dancing, and in connection with a radio receiver for supplying entertainment to large audiences or segregated groups, as in an apartment house, a hotel or a hospital.

The installation of public address equipment is by far the largest business offered the radio contractor. The big point is getting the business. This requires a close study of the locality in which you are to do your business, and a large measure of campaigning. The radio contractor must add to his technical resources the ability to sell. Obviously, it is necessary to acquaint, say the local movie house manager, with the elements of the system and point out its advantages as compared to an organ or an orchestra. In any event, it should be kept in mind that potential buyers are interested mainly in the commercial aspect; will the system cut running costs—likewise, will it increase returns?

In the case of large installations, where there is a chance of some of the equipment becoming unbalanced or out of order, it is advisable to make a servicing and inspection contract with the owner, providing for a weekly or monthly service and inspection tour. This service should preferably carry a flat charge.

The radio contractor should not overlook the opportunities at hand for wiring private homes, apartments, hospitals, yachts, schools, etc., for radio. Here again, campaigning is necessary and in the case of private homes it is a very good plan to make contact with all of the local architects, much as a building contractor does.

The matter of rental is another item worth considering. It is not at all difficult to construct an all-purpose, portable public address unit. Or complete equipment may be purchased. This equipment can be rented out for special occasions such as county fairs, local political campaigns, addresses given in local halls or out-of-doors, the reproduction of special radio features, etc. The rental charge should be sufficient to cover your own time or the time of your assistants for installation and the temporary maintenance. The same equipment can be rented to individuals for lawn parties, dances, etc., to supplant the usual orchestra.

And do not forget the sound business of custom-set building. This should be a part of every radio contractor's business. Custom-set building is profitable whether carried out on a large or a small scale. The radio contractor who is successful in putting over a few commercial deals in his locality is sure to build up an enviable reputation. The prestige so gained will bring in business from well-to-do people, who are anxious to have special radio and phonograph equipment installed in their homes.

M. L. MUHLEMAN, *Editor.*

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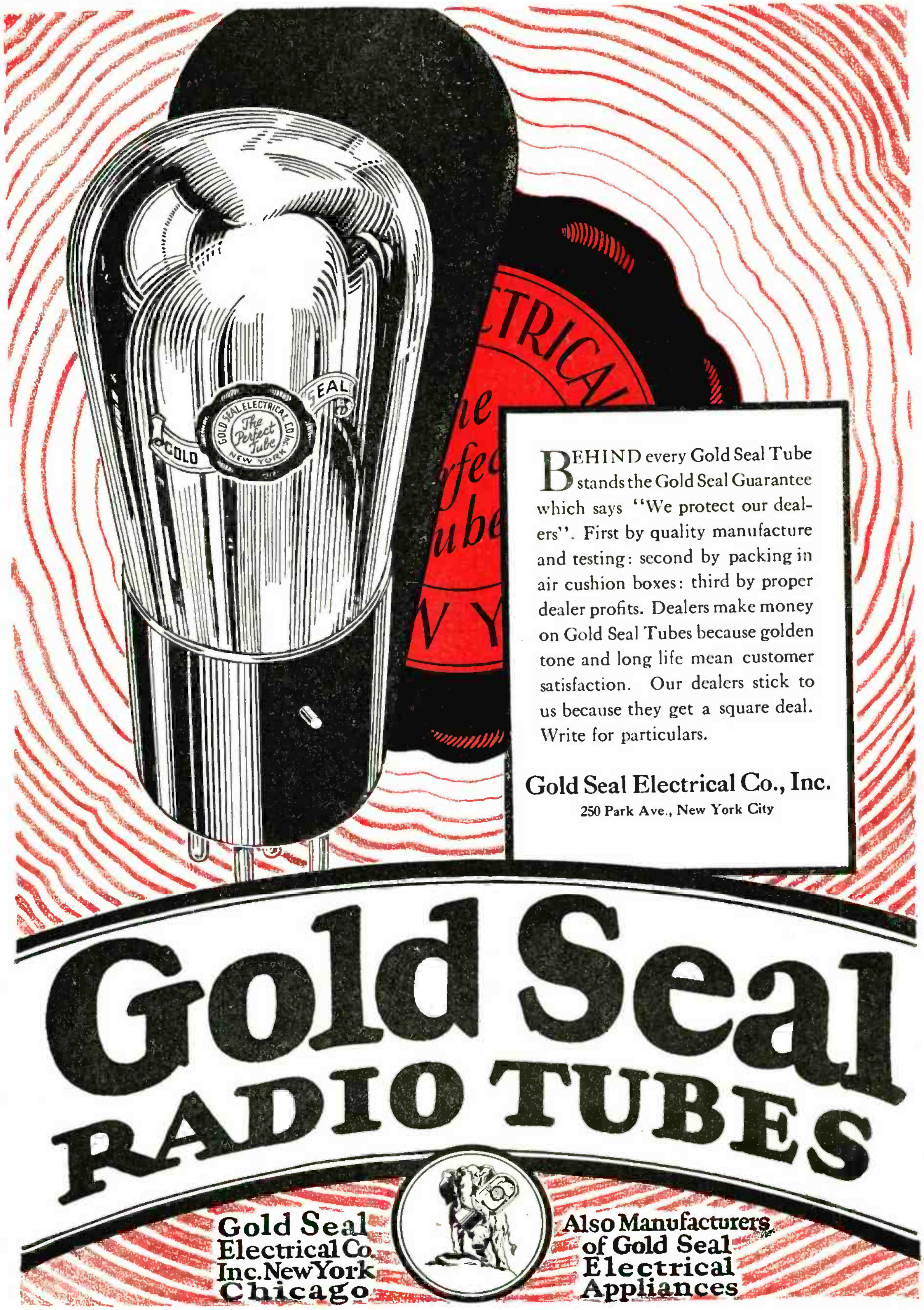


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SM

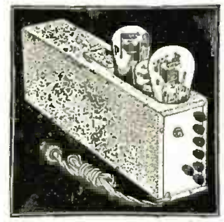
# Huge Amplifying Power

*—250 type tubes, singly or in push-pull, with unbeatable S-M tone quality*

*—built into an existing receiver, or separately for radio and phonograph amplification*

*—at prices below all competition*

*—this is the S-M power amplifier story!*



As a separate two-stage amplifier for homes and small theatres, working from radio or phonograph into a dynamic speaker, using one each '50, '26 and '81 tubes, the S-M 678PD far outclasses, in quality and price, any competitive amplifiers at prices up to double that of the 678PD: WIRED $73; KIT complete $65.

For portable use, to cover 2,000-seat or larger auditoriums, or outdoor crowds of up to 15,000, with optional voice, radio or record input—the S-M 685 three-stage Public-Address Amplifier is ideal. WIRED $160, KIT $125.

Conversion of any existing receiver to use '10 or '50 type power tubes is accomplished with no change of wiring, by using S-M 675ABC power supply which supplies all ABC power for the power tube, and receiver B as well. WIRED, $58; KIT, $54.

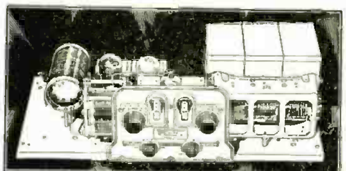
For large theatres, schools, hospitals, auditoriums or stadiums requiring the finest amplifying equipment, the S-M "PA" Rack-and-Panel Amplifiers, consisting of any required number of standard or special unit panels, will provide for any class of coverage. The system illustrated allows optional selection of one of two microphones, radio, or record input, with master gain control, visual volume level indicator, three-stage input amplifier, test meter panel, input amplifier power supply, and two socket-powered push-pull output panels of 15 watts undistorted power output each. With a voltage gain of over 5,000 times, a frequency characteristic flat to 2 T.U.'s from 30 to 4,000 cycles (with cut-off at 4,500 cycles) and with hysteretic distortion practically eliminated, *the performance of S-M "P.A." type amplifiers is unconditionally guaranteed equal or superior to any and all competitive American equipment.*

*Full information on these new amplifiers, as well as on the 720 Screen Grid Six and other S-M sets and kits, is contained in the new December edition of S-M 24-page general catalog. Ask for it, or send two cents for Data Sheet No. 9 covering the 678PD Amplifier.*

*If you build professionally, write us about the Service Station franchises. Or if you don't build, yet want your radio to be custom-made, S-M will gladly refer your inquiry to an Authorized Silver-Marshall Service Station near you.*

*Are you receiving "The Radiobuilder" regularly? Every issue describes new and interesting radio developments. To all Authorized S-M Service Stations, it comes free of charge; to others a nominal charge is made. Use this coupon.*

## SILVER-MARSHALL, Inc.
854 West Jackson Blvd., Chicago, U. S. A.



## S-M 720 Screen Grid Six

*(See description on opposite page.)*

### *Read What They Say About It—*

Gentlemen:
I have had this kit in actual operation for over a month and am astounded with the results. . . Stations which my friends and myself had given up as "lost at sea" have come thru like a ghost from the grave, and dance volume from a loudspeaker from the Pacific coast is a reality instead of a will-o-the-wisp. And knife-edge selectivity. What a treat!
F. Lordan, Galveston, Texas.

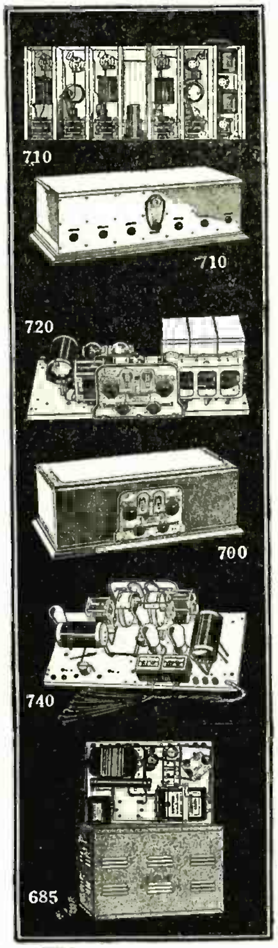
Gentlemen:
On my set, which is a Silver Marshall Screen Grid Six, I am using a loop, and it might be interesting to you to know that in testing with the loop for distance this last week I received (at Rochester, N. Y.) Los Angeles, Hot Springs, Arkansas; Davenport, Iowa; Jacksonville, Florida and Omaha, Nebraska.
Clayton R. Bragg, Rochester, N. Y.

Gentlemen:
Between 4:30 P.M. and 9:00 P.M.—knocking off about an hour for supper—I logged 63 stations within a radius of 2000 miles. Calgary, Alta., Canada, came in with pretty good volume and an Army band in St. Paul, Minn. nearly tore the speaker apart.
Jos. H. Malkin, South Norwalk, Conn.

Gentlemen:
I have built one of your 720 Screen Grid Six Sets. I have never heard anything like it. It goes out and gets them, slices them apart, and brings them in with volume and quality that is almost unbelievable. Its pick-up is great. Stations "pop in" at practically every notch on the dials. There is no interference in this set. If they all operate like mine, there is neither a "cough" nor a squeal "in a carload."
Roy L. Porter, Cincinnati, Ohio.

Silver-Marshall, Inc.
854 W. Jackson Blvd., Chicago, U. S. A.
....Please send me, free, the complete S-M Catalog; also sample copy of The Radiobuilder.
For enclosed ................in stamps, send me the following:
.... 50c Next 12 issues of The Radiobuilder
.... $1.00 Next 25 issues of The Radiobuilder
S-M DATA SHEETS as follows, at 2c each:
....No. 1. 670B, 670ABC Reservoir Power Units
....No. 2. 685 Public Address Unipac
....No. 3. 730, 731, 732 "Round-the-World" Short Wave Sets
....No. 4. 223, 225, 226, 256, 251 Audio Transformers
....No. 5. 720 Screen Grid Six Receiver
....No. 6. 740 "Coast-to-Coast" Screen Grid Four
....No. 7. 675ABC High-Voltage Power Supply and 676 Dynamic Speaker Amplifier
....No. 8. Sargent-Rayment Seven
....No. 9. 678PD Phonograph Amplifier
.............................................Name
.............................................Address

# This Is the Type of Kit that Setbuilders Supply Co. Heartily Recommends and Can Ship from Stock




### 710 Sargent-Rayment Seven

Designed by two famous engineers to give the very extreme of results now possible in broadcast reception, irrespective of cost, the S-M 710 Sargent-Rayment Seven sets an entirely new standard. Exhausting the tremendous distance possibilities of 4-screen-grid R.F. stages—bringing in a station on every 10-kilocycle channel right around its single-control dial (with five auxiliary vernier knobs)—equipped with the unequalled S-M Clough system audio amplifier—yet the 710 is only $175 custom-built complete, or $130 for kit including aluminum cabinet.

### 720 Screen Grid Six

The new S-M 720 embodies in the most perfect form the revolution that screen-grid tubes have brought about in long-distance reception. Three of these tubes in the R.F. stages, with shielded S-M coils, bring in distant stations on the next 10 kc. channel to powerful locals! The new S-M 255 and 256 transformers set a far higher standard of tone quality than ever known before. Custom-built complete in 700 cabinet, $102.00; complete kit, with pierced metal chassis and antique brass escutcheon but without cabinet, $72.50.

### 700 Shielding Cabinet

Beautiful two-tone brown moire finish, with walnut finish wood base, $9.25.

### 740 Coast-to-Coast Four

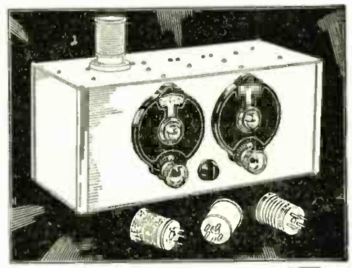
A time-tested and famous circuit—one R.F. stage, regenerative detector (non-radiating) and two A.F. stages—combined with immeasurably finer coils, the high efficiency of the screen-grid tube, all the gain of smooth-working regeneration, and new S-M Clough-system audios, make the 740 the greatest value in the fifty-dollar class. WIRED in 700 cabinet: 740 (for D.C. tubes) $75; 740AC (A.C. tubes) $78. Kit less cabinet: 740, $51; 740AC, $53.

### 680 Series Unipacs

Perfect reproduction and hum-free light-socket operation have made S-M Unipacs famous. There are four types: two single-stage, and two two-stage models, using 210 or 250 tubes singly and in push-pull. Unipacs are available in kit or wired form — some supplying ABC power to receiver — at $81.50 to $117. Also 685 Public-Address—WIRED, $160; KIT, $125.

## Round-the-World Short Wave Sets

*--and that means exactly what it says. As for instance:*



RADIO STATION
CFBO
SAINT JOHN, N. B.
CANADA

Silver-Marshall Inc., Chicago, Ill.

Dear Sirs:—

About two months ago I purchased one of your Round the World Four Short Wave Kits . . .

The first day I had it was on a Sunday and from 12 Noon our time until 12 Midnight I never was without music. This set brought in KDKA, WGY, 5SW Chelmsford England and PCCJ Holland all with Loud Speaker Volume and good modulation.

Since then I have used same in St. John here for rebroadcasting thru our station CFBO.

As I am writing this only to-day I have been able to bring the first two Worlds Series Baseball games and rebroadcast them complete from start to finish.

Please remember that we do not get any daylight reception here at all from either U.S. or Canadian Stations on the B.C.L. band, 200 to 600 Meters.

In closing I can only same that I built over twelve different short wave sets and yet to find the equal of the Round the World Four.

5SW comes in every evening and 50% of the time with loud speaker volume.

Yours very truly
F. D. Thorne
Supt. C F B O

## S-M "Round-the-World" Sets Are Available as Follows

**COMPLETE KIT**

Everything necessary to build the complete four tube r.f. regenerative (non-radiating) short-wave set, including aluminum cabinet and two S-M Clough audio transformers.
730 Complete Kit.....$51.00 730 Set, Wired..........$66.00

**ADAPTER KIT**

Complete with aluminum cabinet, less the two audio stages. Used with an adapter plug, it converts any broadcast receiver for short-wave use. Ideal for Television.
731 Adapter Kit......$36.00 731 Adapter, Wired.....$46.00

**ESSENTIAL KIT**

Contains the two tuning and tickler condensers, four wound plug-in coils, coil socket, and three r.f. chokes, with full instructions for building a 1, 2, 3, or 4 tube set.
732 Essential Kit......................................$16.50

## We are National Distributors of S-M Products

WE carry for your convenience a complete line of S-M Radio Parts and Kits, including the 675ABC High-Voltage Power Unit, 678PD Phonograph Amplifier and all the new Clough audio transformers. Any of these can be shipped at once, as well as all other S-M parts. Our new catalog will be a revelation to you—use the coupon and get it now! LIBERAL DISCOUNTS TO THE TRADE.

*Quick, Courteous Service*

# Setbuilders Supply Co.

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Send me at once, FREE, your big new 100-Page Wholesale Catalog listing S-M and other radio parts, cabinets, consoles, and accessories of highest quality.

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## Rising to the needs of a Great Industry

The requirements of the modern radio are more and more exacting.

As receiving sets improve, coils must be more accurate to keep pace with the fine calibrations of the expert radio engineer.

This is why the world's most successful radio manufacturers turn to Dudlo for their supply of coils for every part of their instruments.

Dudlo coils are not only wound accurately, but every part and material from the core to the outside wrapping is selected and applied with skill; a skill which could only come from an organization trained over many years of making millions upon millions of coils for every electrical need.

No radio unit is any better than its coil, and no coil is any better than the wire in its windings. Dudlo draws and insulates the wire and controls every part and process from the copper rod to the finished coil. A complete service to the radio and electrical industries.

*The Coil's the thing! that makes Radio*

**DUDLO MANUFACTURING COMPANY, FORT WAYNE, INDIANA**

56 Earl St. Newark, N. J. | 105 W. Adams St. Chicago, Ill. | Division of THE GENERAL CABLE CORPORATION | 274 Brannan St. San Francisco, Cal. | 4143 Bingham Ave. St. Louis, Mo.

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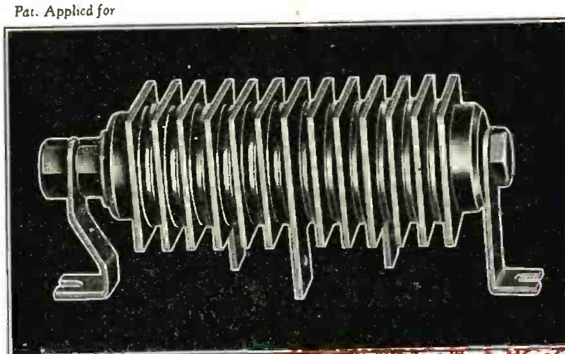
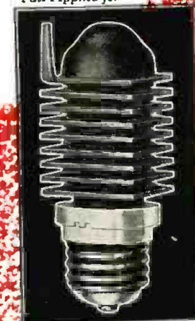
Pat. Applied for



The B-L Rectifier B-24, illustrated at right, is a full-wave unit with an output capacity of from 1 to 3 amperes at 8 to 12 volts. It is equipped with special horizontal mounting brackets for dynamic speakers, etc. List Price, $5.00.

Pat. Applied for



C-110, B-L Rectifying Unit is a single-wave rectifier for replacing charger bulbs. Furnished with either Edison or double-contact screw base. List Price, C-110 $4. C-210 $4. C-310 $4.

Pat. Applied for

D-24, B-L Rectifying Unit is full-wave rectifier for supplying direct current to excite magnetic field coils of dynamic speakers. List price $6

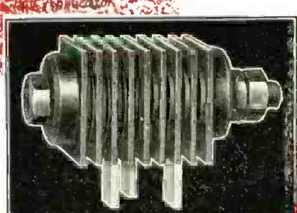
# B-L Rectifiers

## *Used by Large Manufacturers*

Many large manufacturers of power devices and dynamic speakers are using B-L Rectifiers as standard in their equipment, because—Their design is fundamentally right. Extreme care is taken in every step of their manufacture. Each operation is carefully supervised by experts. Each completed unit is subjected to severe laboratory tests before shipment...These facts naturally account for the big swing to B-L Rectifiers and the large volume of repeat orders from manufacturers who have proved their actual merit in actual performance.

There is a B-L Rectifier for every purpose—furnished either in standard capacities—single or full wave or built to your requirements. They are Dry.. Noiseless... Durable... Compact and long lived.

Pat. Applied for



B-12 and B-16, B-L Units, are full-wave rectifiers with an output of 1 to 3 amperes at 6 to 8 volts. For trickle chargers, dynamic speakers and "A" power devices. List price, B-12 $4.50 B-16 $5.00.

**Send for Booklet explaining the characteristics and applications of B-L Rectifiers . . . A post card will bring it.**

**The Benwood Linze Co.**
**St. Louis, Mo., U. S. A.**

**B-L RECTIFIERS**

www.americanradiohistory.com

# To the Radio Trade:

THE Hazeltine Corporation desires to call to the attention of the radio trade the decision rendered November 15, 1928, by Judge Grover M. Moscowitz of the United States District Court for the Eastern District of New York in Brooklyn, in the action brought by the Hazeltine Corporation against E. A. Wildermuth, the Brooklyn distributor of the Atwater Kent Manufacturing Company.

In this decision Judge Moscowitz holds that the radio receivers involved in the action and made by the Atwater Kent Manufacturing Company infringe Hazeltine Patent No. 1,533,858.

*As a result of this decision the Hazeltine Corporation is entitled to an injunction against the defendant, E. A. Wildermuth, and an accounting and recovery of profits, and to damages based on the sale by the defendant of all these receivers.*

Every distributor and dealer selling radio receivers which are an infringement of the Hazeltine patents is liable to the Hazeltine Corporation for profits and damages sustained because of such infringement. *Such profits and damages are independently recoverable entirely apart from any recovery that may be had from the manufacturer.* It is the penalty provided by the Patent Law for handling and selling infringing apparatus.

The decision of Judge Moscowitz is the fourth such favorable decision by Federal Courts, holding infringement and sustaining the validity of the various Hazeltine patents covering the inventions of Professor L. A. Hazeltine as employed in Neutrodyne radio receiving sets.

Judge Moscowitz in his decision held that the use of an inherent neutralizing capacity to effect neutralization is an infringement of the Hazeltine Patent. In most of the modern Neutrodyne receivers manufactured under license a physical neutralizing condenser is used.

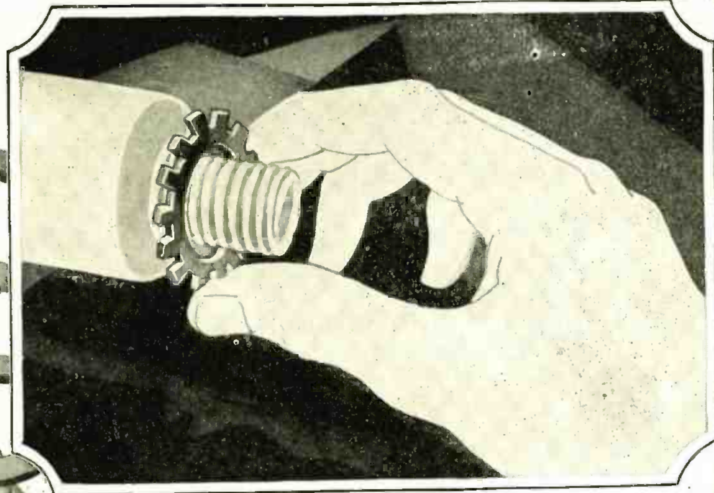
*Distributors and Dealers* — To be safe from infringement and from liability for profits and damages, be sure the radio sets you handle are manufactured under license and therefore fully protected under the Hazeltine Neutrodyne and Latour patents.

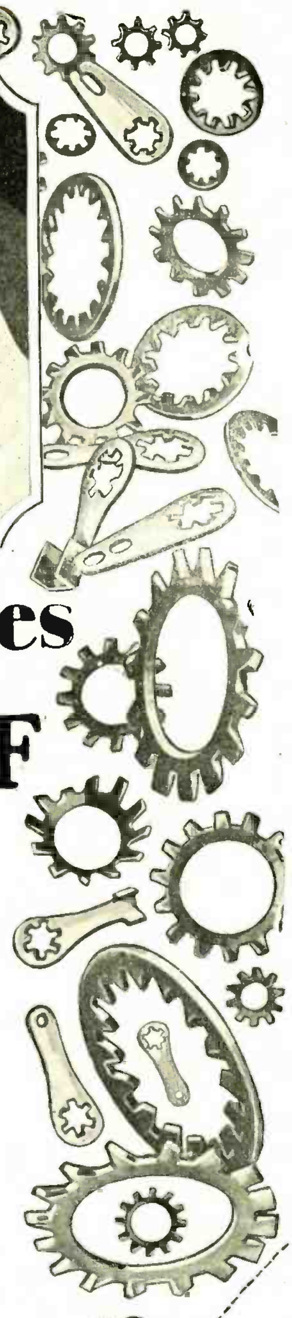
All infringements of these patents will be prosecuted promptly and vigorously by the Hazeltine Corporation.

## HAZELTINE CORPORATION

15 EXCHANGE PLACE, JERSEY CITY, N. J.


www.americanradiohistory.com






# No Chain *of* Troubles *with* SHAKEPROOF

LINKED TOGETHER—washer by washer—the old fashioned way. The troubles, too, were linked meaning production delays, delayed shipments and upset schedules.

Then came Shakeproof, a lock washer that really held with the multiple teeth exerting an even pressure around the nut—no more linking—no more spreading—time saved—money saved, the new Shakeproof way. No wonder industry, large and small alike, has adopted Shakeproof. We want you to try Shakeproof Lock Washers in your own plant. We want you to convince yourself that the Shakeproof way will save you time and money. Mail the coupon at the right for samples of Shakeproof Lock Washers. They will be sent without obligation.

U. S. Patent June 13, 1922. Other patents pending

**SHAKEPROOF**
*Lock Washer Company*
( Division of Illinois Tool Works )
**2509 North Keeler Avenue Chicago, Illinois**

**Free Shop Test Samples**

SHAKEPROOF LOCK WASHER CO.
2509 North Keeler Ave.,
Chicago, Ill.

*Please send me samples of*

☐ Shakeproof Lock Washers to fit bole size ________

☐ Shakeproof Locking Terminals Size ________

Firm Name ________

Address ________

Town ________ State ________

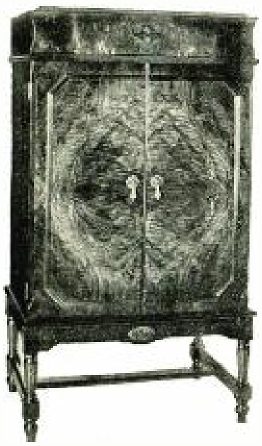
By ________

LAST CALL !

# "R-P-L"

LAST CALL !

## The Radio Receiver That Will Appeal to Your Discriminating Clientele



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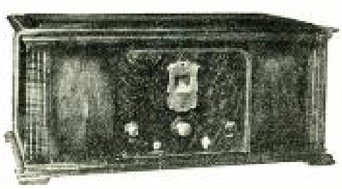

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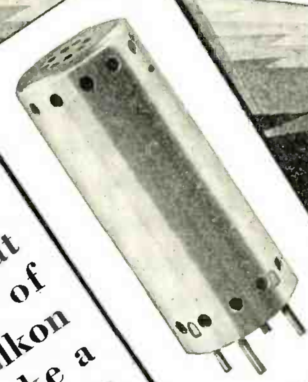

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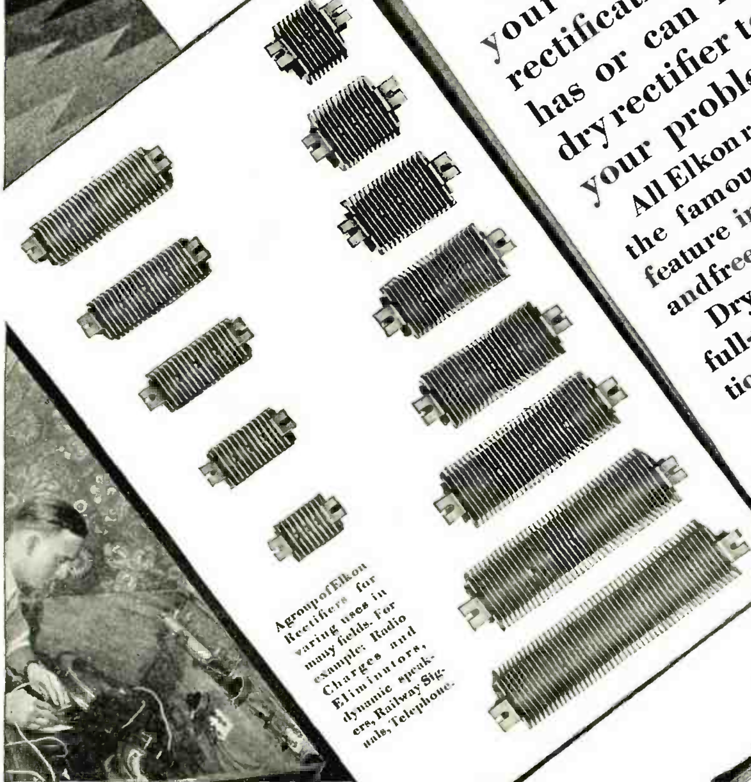

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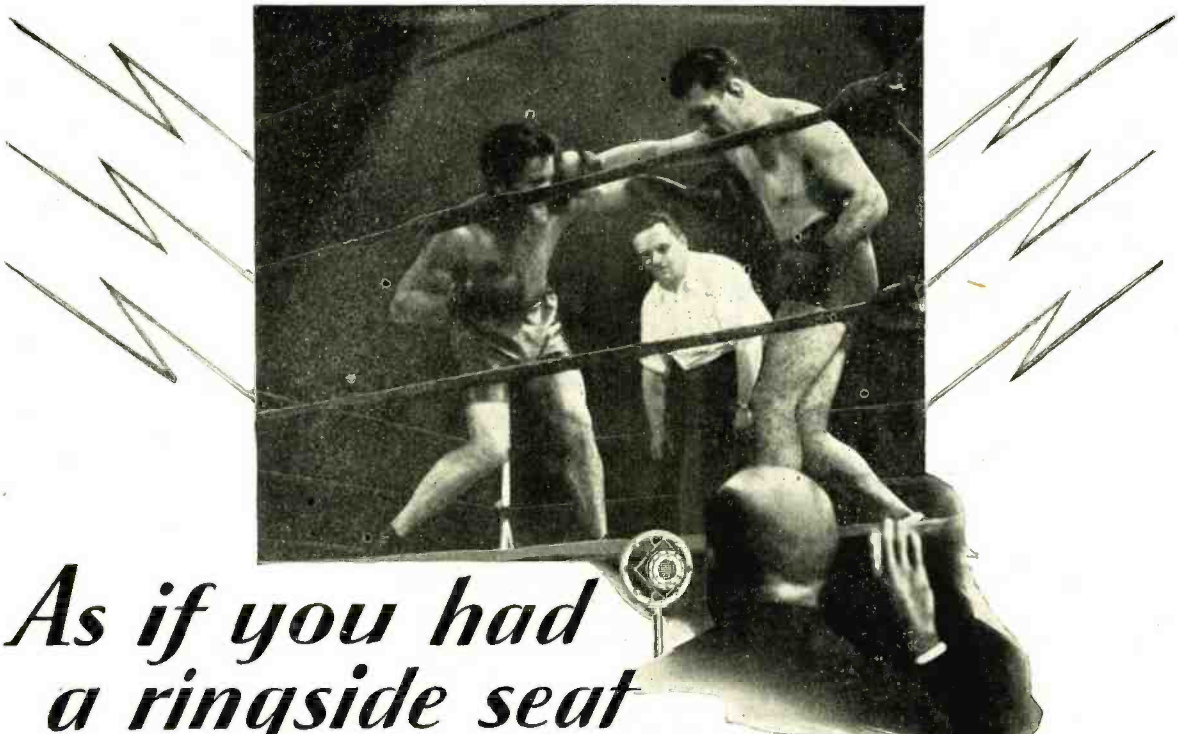

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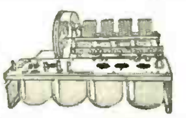

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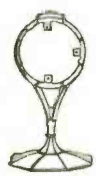

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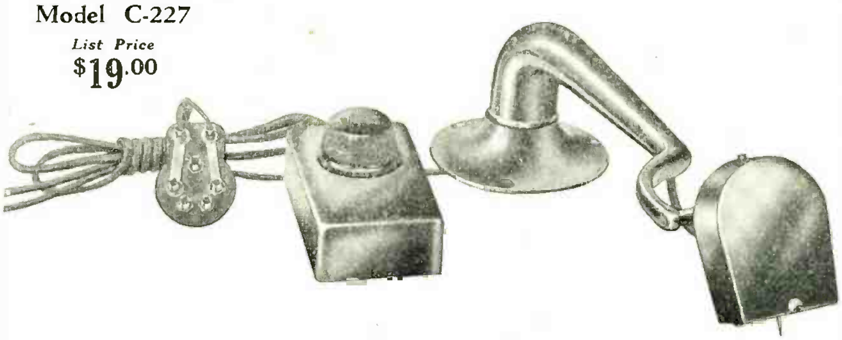

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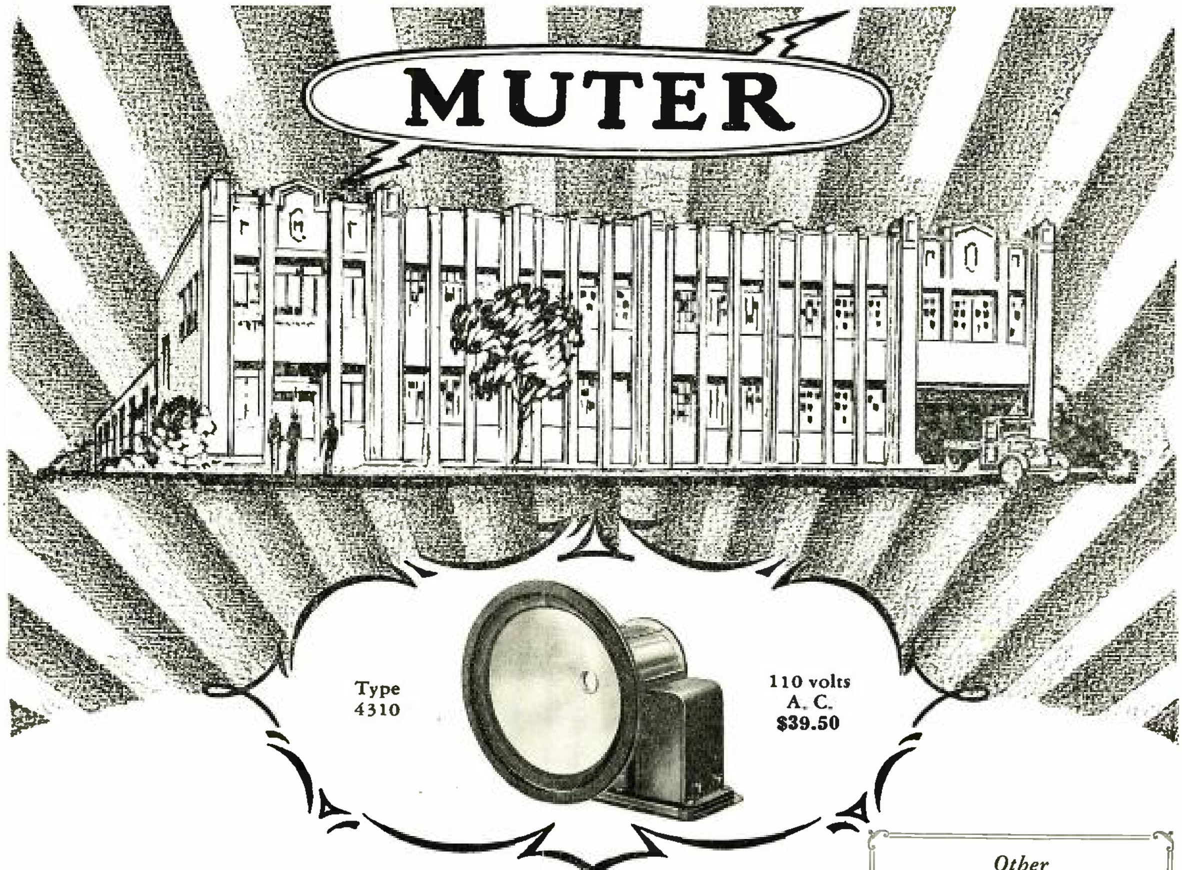


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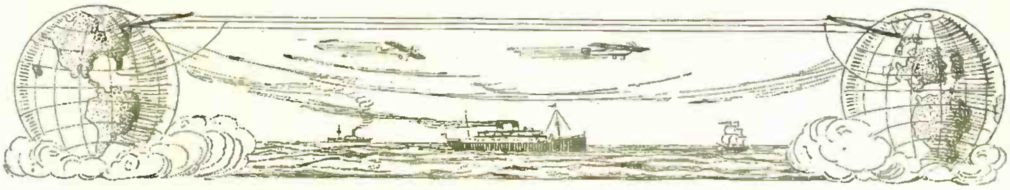

# Grid Circuit Detection Distortion

## *A Comprehensive Study of the Characteristics of the Heater-Type Tube*

*By J. R. Nelson**

UNTIL recently the subject of detection has not had the attention that it deserves. This has been due to a lack of a complete theoretical analysis of the subject. The analysis until several years ago assumed $\mu$ the amplifying factor of the tube constant. The effect of the variation of $\mu$ is appreciable in detection with the three-element tube and is one of the main factors in detection with the screen-grid tube.

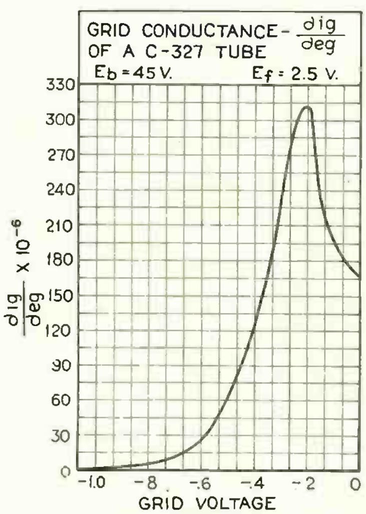


FIG. 2

Grid conductance-grid voltage curve of a 327 tube.

Carson[1], in 1919, summarized and extended the theory of vacuum tube operations and treated detection while assuming $\mu$ constant. Llewellyn[2], in 1926, treated the theory of vacuum tube operation assuming $\mu$ variable. Grid circuit detection was discussed at some length in this article. Browning and Chaffee[3] published, in 1927, a comprehensive paper on the theory of detection. An article by Smith[4] gave a good physical picture of grid leak rectification as far as the grid circuit is concerned.

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The detector as such worked fairly satisfactory. Most of the theoretical and practical work for improving radio receivers had been spent on improving the audio and radio-frequency amplifiers until the subject of detection was better understood. Very good audio-frequency amplifiers are now available and it seems worthwhile to study the effect of the detector on the audio-frequency system.

In grid circuit detection rectification occurs in the grid circuit and the audio-frequency voltage is amplified by the detector, so the detector is part of the audio system. Chaffee and Browning[3] pointed out the presence of detector audio-frequency distortion and gave some data showing the magnitude of this distortion for various values of circuit constants. The presence of grid circuit detector frequency distortion is also shown by the equations in Llewellyn's[2] article. As the grid circuit detector affects the frequency amplification of the audio system the detector distortion should be studied with the object of keeping it as small as is practical.

### *Grid Circuit Frequency Distortion*

The purpose of this article is to discuss the grid circuit frequency distortion. Enough detection data on the type C-327 tube will be given to calculate the amount of distortion present. The discussion will also show how the magnitude of this distortion may be varied by changing the circuit constants. Two experimentally determined curves of detector frequency distortion present in a commercial set will also be given.

The C-327 was chosen for two reasons. First, the grid-voltage, grid-current characteristic curve of this tube differs from that of the usual type of tube as it starts at a small negative grid bias and rises faster. Second, not much information is available on this type of tube and its use is increasing as the number of sets using it is increasing. The values of detector circuit constants using other types of tubes may be inferred from the study of this type of tube.

Fig. 1 shows the grid-current, grid-voltage characteristic curve of the C-327 with constant plate and heater voltages. The same curve of the CX-301-A is also given for comparison. The differences in slope and starting grid bias are brought out by these curves. The difference in slope requires a different value of external grid resistor for the C-327 tube than for the CX-301A tube, as its conductance is lower than that of the CX-301A around the best operating point.

Fig. 2 shows the value of grid conductance plotted against grid voltage over the useful range of grid voltages. The grid conductance was calculated by dividing $\Delta ig$ by $\Delta eg$ found from Fig. 1. This method is explained in a previous article by the author[5] or any good radio text book dealing with tube characteristics.

Chaffee and Browning[3] give the following formula for the low frequency voltage introduced in the plate of the detector tube:

$$(\text{Det E})_o = \frac{rp}{4}\left[-\,Fgm\,\frac{\delta kg}{\delta eg} + \frac{\delta gm}{\delta eg}\right] M\sqrt{2}\,(\Delta E_o)^2 \qquad (1)$$

Where

M is the per cent modulation

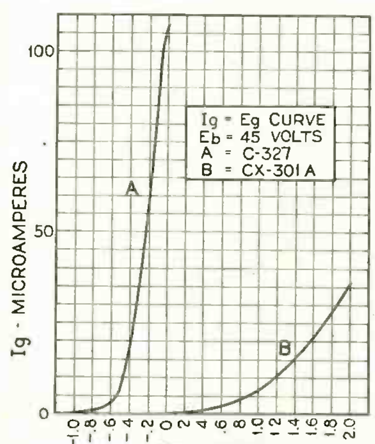


FIG. 1

Grid current-grid voltage curves of 327 and 301-A tubes

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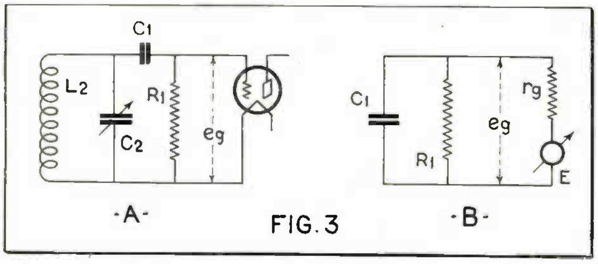


A. Generalized detector input or grid circuit.
B. Equivalent electrical input circuit.

$\Delta E_o$ is the peak value of the input voltage

gm is the mutual conductance of the tube

rp is the internal inpedance of the tube

$\frac{\delta kg}{\delta eg}$ or $\frac{\delta^2 ig}{\delta eg^2}$ is the variation of grid conductance with respect to eg.

$\frac{\delta gm}{\delta eg}$ or $\frac{\delta^2 ip}{\delta eg^2}$ is the variation of mutual conductance with respect to eg.

$$F = \frac{R_1}{\{ R_1^2C_1^2\omega^2+1+R_1kg\ (2+R_1k_g) \}^{\frac{1}{2}}}$$

Where

$R_1$ is the external grid resistor or grid leak

$C_1$ is the external grid condenser

$\omega$ is $2\pi$ times the frequency

kg or $\frac{\Delta ig}{\Delta eg}$ is the grid conductance

The factor $\frac{\delta gm}{\delta eg}$ is the main term in plate rectification and will not be considered here as its effect will be small under most conditions.

Eq. 1 then becomes

$$(\text{Det E})_e = \frac{rp}{4}\left[ -F\frac{\mu}{rp}\frac{\delta kg}{\delta eg}\right]$$

$$= -\frac{F}{4}\mu\frac{\delta kg}{\delta eg} \qquad (2)$$

Where

$\mu$ is the amplification factor of the tube

The factor $\frac{\delta kg}{\delta eg}$ is a function of the tube and operating voltages. It is a measure of the efficiency of the tube as a detector. However, it must be considered in conjunction with rg, as will be shown later, so that a large value of $\frac{\delta kg}{\delta eg}$ with a small value of rg might not be as good an operating point as a smaller value of $\frac{\delta kg}{\delta eg}$ with a large value of rg. The value of $\frac{\delta kg}{\delta eg}$ may be found from the kg-eg curve of Fig. 2 by taking small triangles $\Delta$kg and $\Delta$eg and dividing $\Delta$kg by $\Delta$eg.

The factor F will be the term of most interest here. Examining Eq. 2 we see that any detection distortion must be introduced by F as it is the only term varying with frequency.

Equation 2 is similar to the usual amplifier condition in that the voltage introduced in the plate of the amplifier is

$$Ep = \mu\ eg \qquad (3)$$

In Eq. 2 the voltage

$$(Ep)_e = -\mu\frac{F}{4}\frac{\delta kg}{\delta eg} \qquad (4)$$

The factor $-\frac{F}{4}\frac{\delta kg}{\delta eg}$ is the grid voltage or eg. In order to see what F is consider the circuit in Fig. 3-A. The inductance $L_2$ is practically a short circuit to audio frequencies so that Fig. 3-A, may be replaced by Fig. 3-B. The audio voltage introduced by detection is assumed to be introduced by an internal generator in series with rg, the internal grid resistance. This assumption is justified as the detector voltage is caused by the variation of rg with input voltage amplitude and hence the source of the voltage is in the tube.

The impedance of $C_1$ and $R_1$ in parallel is

$$Z = \frac{R_1}{1+j\omega C_1R_1} \qquad (5)$$

The total impedance $Z_o$ is

$$Z_o = Z+rg = \frac{rg(1+j\omega C_1R_1)+R_1}{1+j\omega C_1R_1} \qquad (6)$$

The grid current ig is

$$ig = \frac{E}{Z_o} = \frac{E(1+j\omega C_1R_1)}{rg(1+j\omega C_1R_1)+R_1} \qquad (7)$$

The voltage eg between the grid and filament is

$$eg = ig\ Z = \frac{ER_1}{rg(1+j\omega C_1R_1)+R_1} \qquad (8)$$

or multiplying and dividing by rg

$$eg = E\frac{rg}{rg}\frac{R_1}{rg(1+j\omega C_1R_1)+R_1}$$

$$= \frac{ER_1}{rg\left[1+j\omega C_1R_1+\frac{R_1}{rg}\right]} \qquad (9)$$

The absolute value of this is

$$eg = \frac{E}{rg}\frac{R_1}{\sqrt{1+\omega_1^2C_1^2R_1^2+R_1kg(2+R_1kg)}}$$

$$\text{or } \frac{E}{rg}F. \qquad (10)$$

is also from Eq. 4

$$eg = -\frac{F}{4}\frac{\delta kg}{\delta eg} \qquad (11)$$

$$\frac{E}{rg}F = -\frac{F}{4}\frac{\delta kg}{\delta eg} \qquad (12)$$

or

$$E = -\frac{rg}{4}\frac{\delta kg}{\delta eg} \qquad (13)$$

The factor F is then merely the ratio of the external impedance Z to the total impedance multiplied by rg. As the external impedance Z is a function of frequency and constants that we choose the grid circuit will cause distortion. As rectification occurs in the grid circuit and the audio frequency is amplified by the detector tube the audio system as a whole will not have the same frequency amplification characteristic as the audio amplifier alone.

The factor F not only depends upon the frequency and size of $C_1$ but also on the values of $R_1$ and kg or 1/rg. The smaller $R_1$ and $C_1$ are the less F will vary with frequency.

Fig. 4 shows $-F\ gm\frac{\delta kg}{\delta eg}$ plotted.

Curve A is for zero frequency and Curve B is for 3000 cycles. The value of $C_1$ used in the calculations was 250 micromicrofarads. In plotting these curves it was assumed that the tube would be operated in the usual manner, that is, $R_1$ would be returned to the cathode. The values of $R_1$ to pass through zero and the different operating voltages were calculated from Fig. 1.

$$Fgm\frac{dkg}{deg} = -\frac{R}{\sqrt{R_1^2w^2C_1^2+1+R_1kg(2+R_1kg)}}gm\frac{dkg}{deg}$$

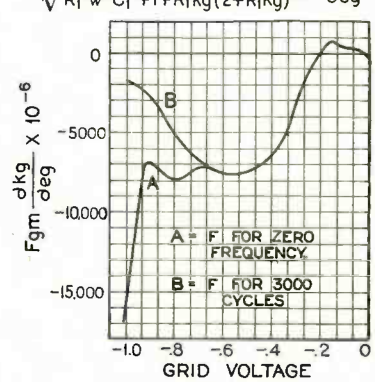


FIG.4

Low frequency plate voltage plotted against grid voltage.

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1. For example, the value of $R_1$ to pass through —0.7 volt and zero may be found as follows: from Fig. 1 ig is three microamperes and from Ohm's Law $R_1$ is 0.7 divided by $3 \times 10^{-6}$ or 233,000 ohms. The value of kg at this voltage is found from Fig. 2 to be $26 \times 10^{-6}$ mhos. The value of $\delta kg/\delta eg$ was calculated from Fig. 2 as explained previously. The value of gm was found from the Ib-Eg curve with constant plate voltage, as explained for finding kg. The value of $\Delta Ib$ is divided by $\Delta eg$ at the different voltages. The value of gm is shown plotted in Fig. 5.

The value of 3000 cycles for B of Fig. 4 was chosen arbitrarily. In the region where A and B coincide or do not differ much the detector introduces very little distortion up to 3000 cycles. Curve A for zero frequency is practically the same curve as would be obtained for a low frequency up to about 100 cycles.

A and B of Fig. 4 coincide for voltages greater than —.7 volt. If the grid is more negative than about —.8 volt serious frequency distortion occurs. Good detection action is obtained in the range of —.4 to —.7 volt with practically no frequency distortion. The calues of $R_1$ required to place —.4 to —.7 volt on the grid vary from 60,000 ohms to 750,000 ohms.

In choosing $R_1$ as far as the detector and audio system are concerned it would be better to choose 60,000 ohms in order to have the frequency distortion negligible. When the radio-frequency tuned circuit preceding the detector is considered $R_1$ should have as high a value as possible. The reason for this is that the grid leak adds resistance to the tuned circuit and the higher the grid resistance the less it affects the tuned circuit. The resistance added to the tuned circuit lowers the amplification and hence the voltage applied to the grid of the tube, and broadens the resonance curve making the selectivity poorer.

Fig. 6 shows two experimentally determined curves of detector frequency distortion of a commercial set. A is the amplification frequency characteristic of the audio amplifier. B is the frequency-response curve of the detector and audio amplifier using the two megohm grid leak furnished with the set. C is the same curve as B with a one-half megohm grid leak substituted for the two megohm grid leak. Both curves have more frequency distortion at 3000 cycles than that calculated from Fig. 4. The reason for this is that the input capacity is neglected in Fig. 4 while it is effective in the experimentally determined curves.

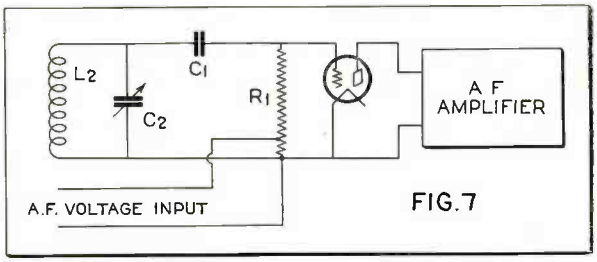


FIG.7

Circuit arrangement for determining the audio frequency characteristic curve of the audio amplifier with detector.

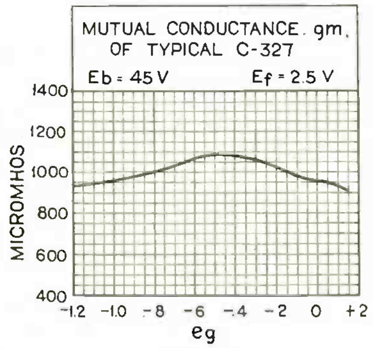


FIG.5

Mutual conductance curve of the 327 tube.

Curves B and C were determined by the method given in an article by Ballantine[6]. Briefly, this method consists of determining the audio-frequency characteristic curve of the amplifier in the usual method, then taking the same curve with the input placed in series with the grid leak, as shown in Fig. 7. The value of the input voltage is known so that the amplification curve is plotted for this connection. The two curves are brought together by multiplying the ordinates of the second curve by the factor required to make the curves coincide at a low frequency. The difference between the two curves is the loss caused by detector frequency distortion.

In seeking a remedy for frequency distortion we are faced by the fact that $R_1$ must be by-passed by a condenser, if we are to obtain most of the voltage developed across the coil on the grid. Experience has shown that $C_1$ should not be much less than about 250 micro-microfarads. With the conventional system of audio impedance our only remedy is to lower $R_1$.

In the C-327 the detector sensitivity is about the same if a .25 to .5 megohm grid leak is used as it would be for a 2 megohm grid leak. In general, however, there would probably be some loss in detector sensitivity if a low value of grid leak was used. It is easier to correct for the detector frequency distortion when using a C-327 as the loss in sensitivity is not as much as it would be for a general purpose tube such as the CX-301A where the detector sensitivity is less for a low value of grid leak than for a high value of grid leak.

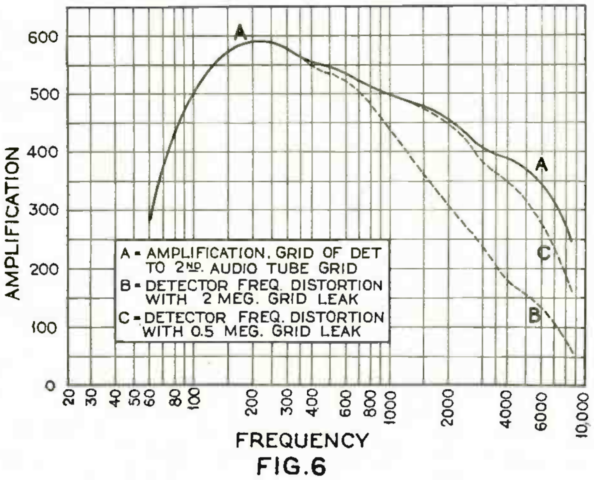


FIG.6

Frequency distortion curves of; A, audio amplifier; B, detector, with 2 meg. leak, and audio amplifier; C, the same as B but with a 0.5 meg. leak.

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# The Industrial Laboratory

## *The Purpose and Equipment of the Radio Manufacturer's Laboratory*

By Zeh Bouck*

THE industrial laboratory is an essential adjunct to modern manufacturing on a large scale. This is doubly true when the product involves unusual engineering considerations, as is the case of all "technical" apparatus.

The radio laboratory should be so equipped and designed as to serve four useful purposes to the manufacturer. While these endeavors merge with one another they may be classified, with reasonable definition, in the following categories:

Primarily the purpose of the radio laboratory is to design the product to be manufactured.

Secondly, the laboratory must adapt the product to the exigencies of production—often a task equal to that of the original conception.

Thirdly, the raw materials going into the production must be up to the standards specified in the engineering design, necessitating a consistent check in the laboratory.

Lastly, the final product must be tested. While the testing of each individual unit in the production line would severely limit the utility of the laboratory, the design of adequate testing apparatus for production runs devolves upon the engineering department.

It is almost needless to point out that the efficiency and efficacy of a laboratory is directly dependent upon two factors, the equipment and the personnel. Both of these should be chosen with a careful consideration of the nature of the work involved. The personnel, or rather a part of it—the chief engineer and his assistant—comes first, and the equipment follows in accordance with their specifications.

* *Arcturus Radio Company, Newark, N. J.*

### *A Well Instituted Laboratory*

An idea of the functioning of the industrial laboratory is conveyed in the description of one of the most successful laboratories associated with radio manufacturing. The laboratory proper is located reasonably close to the three factories and general offices of the company—a matter of convenience. The laboratory occupies a building by itself, a consideration of still greater moment, resulting in the elimination of factory noises and electrical interference. The location of the present laboratory was chosen only after radio tests had indicated a reasonable freedom from inductive and radiated electrical effects. The laboratory is housed in a two-story brick building, the basement of which is utilized as a stock room. The first floor contains the electrical, chemical and glass blowing laboratories, as well as the laboratory office and drafting rooms. The upper floor is used as a special testing laboratory for rejected products.

The company manufactures alternating current tubes of every type and design, including heater and filament tubes and high and low voltage types. The problems associated with the design and production of so complete a tube line, and which necessarily involve considerable research on the part of the laboratory, are numerous, the major considerations being outlined as follows:

(1) The elimination of hum.

(2) The adaptation of the tubes to standard circuits and sets.

(3) Filament and heater regulation with power line changes.

(4) The life of the tube.

(5) Thermal characteristics of oxides, ceramics, vacuum and metals.

(6) Degasification.

(7) The mechanics of manufacture.

(8) Uniformity.

(9) The design of different tubes for special purposes.

(10) The chemistry of glasses, metals, strontium, barium, and other oxides.

It is obvious that the engineering considerations of tube manufacture embrace a general course in physics with specialization in such subjects as thermo-dynamics, chemistry, electricity and tube geometry.

The laboratory employs a staff of eight men, including a glass blower, a chemist, a draftsman and five engineers.

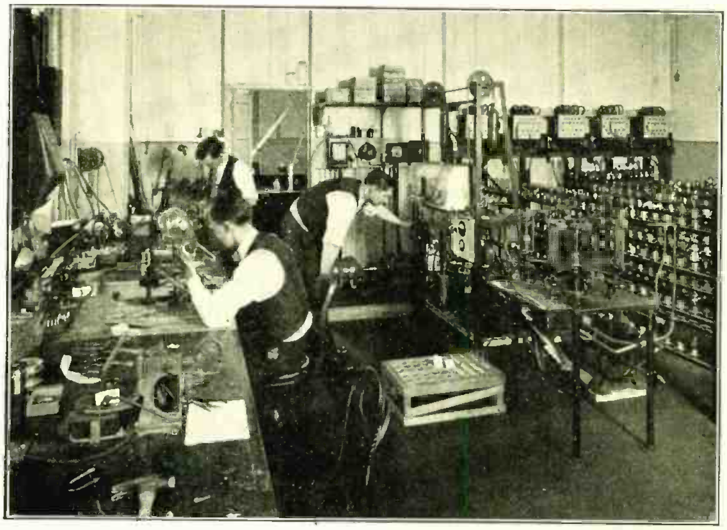

Fig. 1. A miniature tube factory. In this room the elements are constructed, glass blown, tubes evacuated and bombarded and placed on life test. The test racks in the right background accommodate 600 tubes.

### *The Design of the Tube*

The original design of a tube involves months of research, perfecting and modifying types converging toward the desired qualifications. It is relatively easy to predetermine the electrical characteristics of the tubes and these are quickly checked on the testing board, built up around a tube bridge as a nucleus. In addition to the bridge there is a static characteristic board and a special static test board for shield grid tubes.

Particular attention must be paid to the presence of hum in A. C. tube design, and hum measurements are checked and rechecked on special amplifiers, favoring sixty and one hundred and twenty cycle impulses and on a string oscillograph. Also the adaptability of the tube to various circuits and receivers must be determined and a comparison made with the products of competing manufacture, calling into service radio and audio frequency oscillators and vacuum tube voltmeters.

The design of production testing equipment for the factory is also a function of the laboratory. Only special and specimen tubes, and those peculiarly defective are turned over to the laboratory for test.

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## Fitting the Tube for Production

And so the laboratory turns out a practically perfect product. But before the tube is turned over to the draftsman, the question of the production man must be answered. Can the tubes be made quickly and economically? It is one thing to design and construct in the laboratory a tube having the desired electrical characteristics—but it is another matter to adapt the tube to the postulates of production.

The laboratory incorporates a complete tube factory, in which every process of production is duplicated. Production problems, and they are many, are considered and solved before the tube leaves the laboratory, considerably reducing the changes and alterations invariably imposed upon an incomplete design by factory methods.

Photograph Fig. 1 shows the glass blowing and factory section of the laboratory. The elements are mounted here and degasified, exactly as they are in the main plants. In the center of the photograph are seen the vacuum pump with mercury aspirator and oven. The actual average daily output of this miniature factory is about six tubes a day.

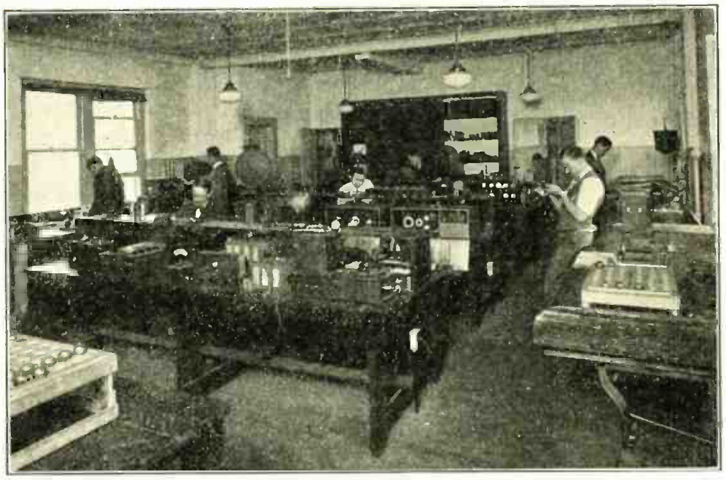

Fig. 3. The Electrical laboratory. A completely equipped laboratory for every phase of radio research and experimentation.

## The Chemical Laboratory

The chemical constituents of the original tubes must be accurately analyzed, and a check be made upon those going into production runs. This is the job of the chemical laboratory, shown in Fig. 2, which is fully equipped for qualitative and quantitative analysis. The chemical laboratory also incorporates complete electroplating equipment.

The testing of the final product is facilitated by special apparatus designed and constructed in the laboratory, which, needless to say, maintains a fully equipped shop. Special capacity bridges with amplifiers are used to check null points in hum and similar tests. An internal tube short test has been devised that indicates instantly, by means of pilot lights, the position of the short. Capacity bridges are arranged to simplify other tests, while attenuation and decade boxes play their part in amplification measurements. The electrical laboratory is shown in Fig. 3.

## Life Test

The life of a tube is a consideration of equal importance to the sales and engineering departments. The life test racks shown in Fig. 1 accommodate six hundred tubes of various filament and heater voltages. Special racks are provided for rectifying tubes. The tubes are life-tested under special and general conditions, average use being simulated in the majority of instances by automatic switches turning the tubes on and off at predetermined intervals.

The importance of the laboratory to a modern commercial enterprise cannot be overestimated. To limit its activity by poor financial support is never a saving, for upon the efforts of the laboratory are dependent the economy of production, the perfection and ultimate sale of the product.

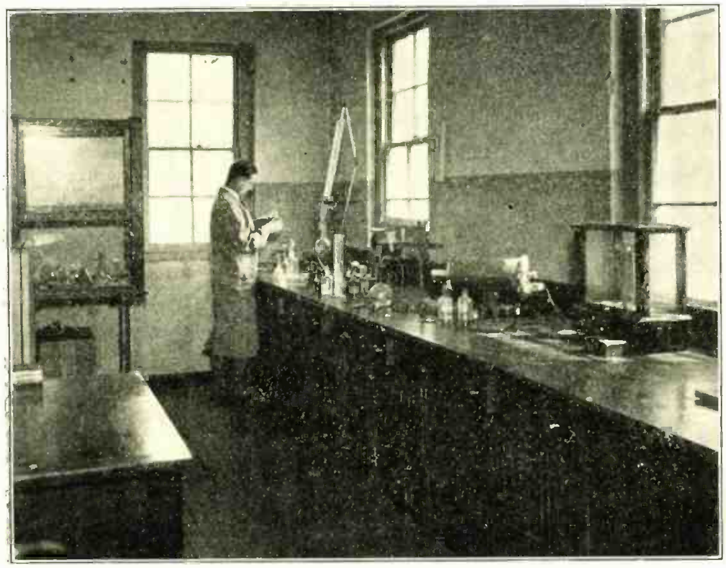

Fig. 2. The Chemical laboratory plays an important part in the design of the vacuum tube. The satisfactory operation of the completed product depends in no small degree upon the accurate analysis of the electron emitting material.

# The Safety Factors in Tubes

MANY capable engineers in designing power amplifier equipment apparently disregard all safety factors when it comes to tube calculations. Transformers, condensers and associated devices are chosen to safely withstand overloads far in excess of expected values, all of which is as it should be. Nevertheless, practically all power amplifiers on the market are working the tubes at the outset up to the very limit of their rated capacity. The inconsistency of this practice is apparent.

It is true that many components such as transformers, etc., are rated with the safety factor allowed for but this is not true in the case of *tubes*. When the operating data of a tube indicates maximum values this represents a figure that should never be exceeded.

The temptation to get a brilliant initial performance is often responsible for the overloading of the tubes but this is invariably done at the expense of useful life. A thorough understanding of power tube capabilities is required to insure co-ordination in power amplifier design.

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# Corrugated Shipping Containers in the Radio Industry

*A Very Interesting Article Regarding the Problems of Radio Packing and the Manner in Which They Have Been Surmounted*

By J. D. Malcolmson*

IF the cost were no object, almost any shipping department could possibly work out some method for shipping the various products of the radio factories safely. However. cost is a most important factor in this case, just as it is in all industries today. Therefore. in order to have a minimum cost and a maximum safety factor in the shipping of radio goods. the industry has turned to the corrugated container for a means to give it both these desirable points.

MR. J. D. MALCOLMSON

The radio industry has been responsible for a great advance in the art of designing these containers, because its products represent a combination of concentrated fragility and high value rarely encountered in the field of merchandising. It has been found that corrugated fibre board has proved itself to be the best answer to the shipping problems of the radio manufacturer. This is due primarily to its low cost, light weight, cleanliness and ease of packing and unpacking, its shock absorbing and cushion construction, as well as its susceptibility to artistic printing.

The light weight of a corrugated container effects a very marked reduction in freight charges and it is an invitation to handlers to pick up the case with the hands—without fear of nails or splinters—instead of rolling, dropping and the use of hooks, which would be natural with a heavier box.

The real proof of any shipping container's worth is its ability to withstand the freight handling. Before employing a new type of container it has been customary to determine this ability by an elaborate series of test shipments. However, there are three objections to making these tests; viz., the length of time necessary; the expense and risk involved and the uncertainty of the results, because of the lack of knowledge of just how the box was handled.

In order to overcome these three objections and to ascertain just how good the containers are, a laboratory tester has been devised, this taking the form of a revolving drum. See Fig. 1. Impartial laboratories, such as those at Madison and the Mellon Institute, have found that this method of testing foretells almost exactly the fate of boxes that are shipped in the ordinary manner. The drum tester consists of a hexagonal tumbler, about six feet along the diagonals, driven by an electric motor. Instead of the usual revolution counter a device registers the number of bumps that the box receives as the drum revolves.

Analyzing the typical fibre container of radio goods, it is found that the four salient points that determine the package's ability to withstand freight handling are:

(1) The strength of the container.
(2) The manner of inner packing.
(3) The fit of the contents.
(4) The nature of the contents, whether a set, speaker, battery eliminator or vacuum tubes.

### The Strength of the Container

No doubt the majority of complaints can be traced to the use of containers that have not been thoroughly tested, containers that have not been properly sealed, etc. We cannot overlook these abuses, but a discussion of them is out of place in an article of this nature. It should be noted in passing that many shippers who want the best, too often buy their containers on a price basis only and without due regard to actual strength or proper design. Corrugated and fibre packing materials, like most other things, may be had in all grades and care should be exercised in the choice of them. Lack of this care often results in prejudice against the corrugated fibre container, which it must be remembered, is not just a box, but a combination of container and inner packing which is the result of a vast amount of thought and experimenting.

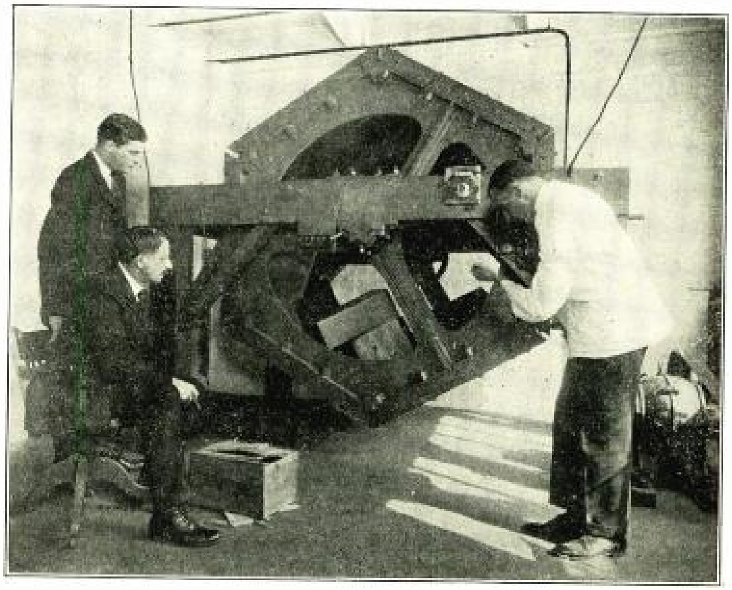

Fig. 1. The Gair Drum Tester, which has been used to develop some of the most famous radio packages now in use.

* *Package Engineer, Robert Gair Company.*

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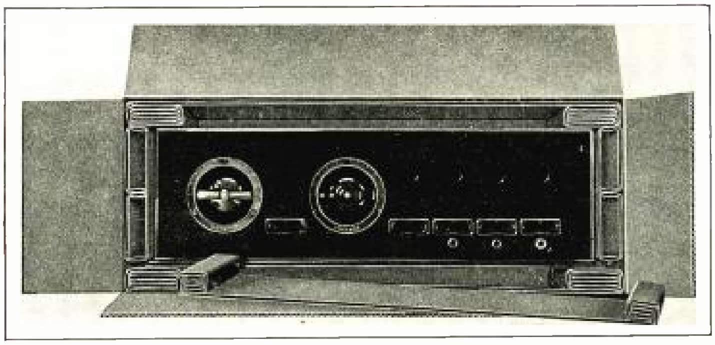

Fig. 2. An ingenious, yet economical, method for packing a large radio set. Note creased sheet in front which protects dials, when packed, by being glued to center flap.

### *The Inner Packing*

The most important part of the package is the inner packing. For this reason the package engineer has as his fundamental rule, *work from the center out*. This does not mean that the inner packing must be extra strong, but rather that the design be correct in every particular, including the strength of the container and the fit of the contents. In other words *balanced construction* is essential. It is desired to emphasize that all too often it is the inner packing that is the weak link in the chain.

By balanced construction is meant adequate strength in every part without wasted strength in any one section. Wasted money is the result of wasted strength and we might sum up these ideas with this definition of a container: *The ideal shipping container is one that will deliver its contents in perfect condition and then fall to pieces.*

The inner packing of a loud speaker, for instance, is made of corrugated board, ingeniously creased and die-cut to "float" the speaker and eliminate all shocks. These shocks are absorbed by the interior design as well as the cellular construction of the inner packing and of the outer walls of the case. Therefore, the use of excelsior or other mussy expedients is unnecessary. This not only pleases the customer, but also eliminates any chances of small particles getting into the delicate mechanism. As all the inner design is uniform for a given model, the packing operation is greatly speeded up and the manner of unpacking is also quite obvious to the customer.

### *Packing a Receiver*

Each of the many different receivers presents its own packing problems, but it is also true that certain details must be observed in the packing of any receiver. For example, as every set is in some sort of a cabinet or console, it must be so packed that the finish of the cabinet be unimpaired when the package is opened by the customer. The package must also be sufficiently strong so that it will resist all sudden shocks that might throw out of adjustment or break some of the relatively delicate components of the receiver.

In Fig. 2 is shown a receiver with a plain cabinet packed in a container which came through the test of the tumbling drum in a satisfactory manner. The back of the set is raised from the bottom of the containers so there is a dead air space to take up shocks and preserve the cabinet's finish. The creased sheet of corrugated fibre lying across the flaps of the box, is placed over the front panel to protect the dials and keep the cabinet immobile in its container.

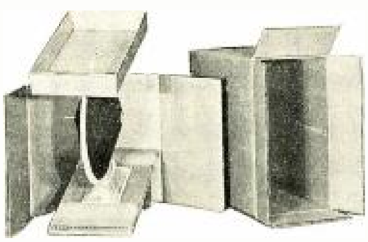

Fig. 3. Corrugated packing for a cone speaker, designed in the Gair Laboratories. The bottom protection consists of three die cut pads. The waste from the rectangular die cut hole has been used under the tape to help support the base which in turn rests directly on the flaps of the case.

This method of packing a set is not only ingenious from an engineering point of view, but it is most economical. Remember back several years before corrugated containers were in such wide-spread use. Imagine the proportions of the box that would have been necessary to ship such a receiver across the continent!

### *Packing Loud Speakers*

The great majority of loud speakers that are being shipped today have a paper diaphragm and this together with the heavy driving unit makes for an unbalanced condition and quite a nice problem for the package engineer. In the case of the cone-type of speaker shown in Fig. 3 the problem is not as great as the unmounted type shown in Fig. 4. Most speakers of the cone type have a relatively heavy base on which they stand when operating and this gives the package engineer a good starting point.

In Fig. 3 the base is clamped down on a base of corrugated board by means of a strip of the same material on each side, which are held in place by gummed strips of paper. This construction means that the base of the speaker will remain in the center of the bottom of the container. To prevent the top of the paper cone from moving a sheet of corrugated board is folded to resemble the lid of an ordinary box, in the center of which is a slot through which the top edge of the cone protrudes. The size of this "lid" is such that it holds the cone's top firmly in place. Standing behind the speaker may be seen the inner walls of the box, which protect the speaker by reinforcing the outer container.

Fig. 4 illustrates one of the most complex problems of packaging ever presented. As is well known, the paper diaphragm is fastened to its frame by means of a very light, flexible strip of kid or similar material. To this diaphragm is attached the rod from the driving mechanism, which is of extremely delicate construction and easily thrown out of adjustment. The coils and magnet forming the driving mechanism are very heavy in relation to the small weight of the cone itself

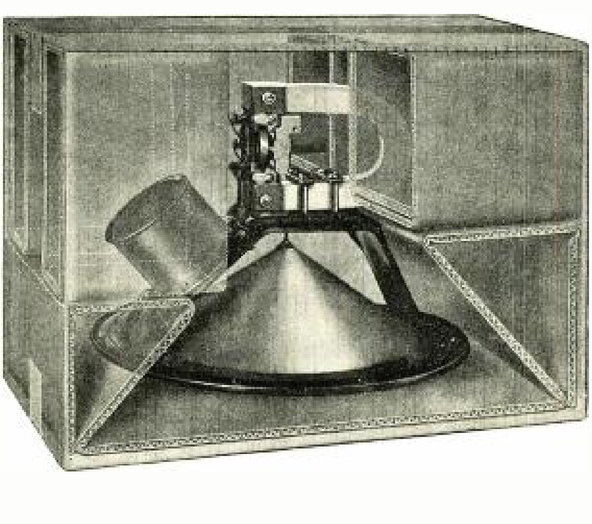

Fig. 4. Loud speaker design for an unusual combination of dead weight (magnet) and extremely fragile soldered connection. Note that the cone has been completely "floated."

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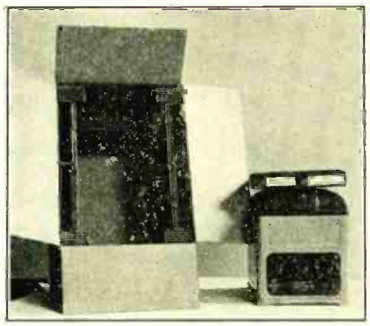

Fig. 5. B-Eliminator case, showing typical interior packing.

and this makes it difficult to bring about a balanced construction in the matter of packing the unit.

As in the case of the speaker illustrated in Fig. 3 the heaviest part of the device is first considered. It may be seen in Fig. 4 that the magnet and coils are supported by the triangular-shaped folded corrugated board at the right and kept in position by the two rectangular partitions. In order to keep the unit from swinging to the left similar triangular partitions are placed at the bottom left of the container. Further stability is furnished by the two rectangular sections of board in the upper left side of the box.

In the case of electro-dynamic speakers the problem becomes more complicated, because here the delicate coil that is attached to the small end of the cone floats in the field of the magnet and the clearance there is extremely small. This means that vibrations must be reduced to a minimum in the packing, so as not to damage this mechanism in transit. Also the relative weights of the cone and driving unit are farther apart than in almost any other type of loud speaker.

### *Battery Eliminators and Vacuum Tubes*

The packing of eliminators does not present such a complex problem, as they are rather rugged devices. The main point for the package engineer to bear in mind is the weight of the apparatus, due to the transformer and chokes. The container, therefore, must be of relatively greater strength than those used for other types of apparatus, which have been described previously.

The sides of the container have been reinforced by extra folds in the partitions, as may be seen in Fig. 5. The small panel carrying the binding posts and plugs is held off from the end of the container by means of the two folds of corrugated board at the lower end of the box, these folds supporting the eliminator at the sides where the metal case joins the panel.

The packing of vacuum tubes for shipment was not an entirely new problem to the package engineer, for he had been already confronted with the problem of packing electric lamps.

However, in the case of tubes their value is greater and therefore is more of an incentive for theft. Concealed pilferage—the removal of several tubes from their individual cartons without disturbing the appearance of the entire container—is practically impossible with corrugated boxes. The two outer flaps are very carefully fitted together and pasted down over their whole surface to the inner flaps. This means that if they are pried open before the box reaches its destination, the outer covering of paper on the corrugated board will tear away from the inner lining, making it an impossibility to repair the damage to the container. By the use of these boxes of corrugated board pilferage has been cut down to a minimum.

As can be seen from Fig. 6 an inner box is formed by folding corrugated board so that the boxes containing the tubes will "float" within the outer container. The sections of these two boxes have been cut away in the illustration so that the construction needs very little description here. It was found that when these cartons were given a test in the revolving drum tester, equivalent to a railroad journey of 20,000 miles, the breakage was deemed to be negligible. Of course the type of box used to house the individual tube is also made to "float" the contents, which greatly aids the package engineer.

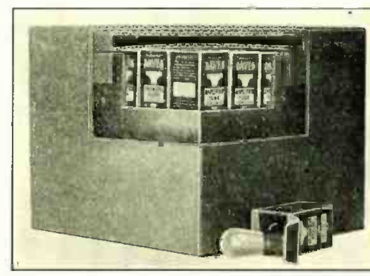

Fig. 6. Vacuum tubes in "G-air-Cell" folding boxes and shipped in typical "floating construction."

# Book Review

*THE WORLD OF ATOMS. By Arthur Haas, Ph.D., Prof. of Physics in the Univ. of Vienna, translated by Horace S. Uhler, Ph. D., Assoc. Prof. of Physics, Yale Univ. 139 pages. Illustrated. 6 x 9¼ inches. Stiff buckram binding. Published by D. Van Nostrand Co., Inc., 8 Warren St., New York City.* Price $3.00.

The average man engaged in radio research and engineering today when in college learned that there were such things as atoms and electrons. He was told that electrons and protons in certain combinations made certain chemical elements. Also he learned that under given conditions electrons moved about in a metal wire resulting in a condition called a flow of electric current.

And that is about all that the student in electrical engineering has time to gather about electrons; for he is generally too busy finding out why alternators generate and transformers work as they do. However, once out of college and if his work happens to carry him into the research laboratory he finds out that electrons and protons are mighty interesting and important.

This is especially true for the worker in the radio research laboratory. If the theory of electrons had not been so well set up and proven to be correct, where would we be today? It is quite needless to go into detail.

Information about the electronic theory appears in many places, but usually it is so snowed under with formidable formulae, that the seeker after enlightenment is generally nonplussed and discouraged, especially if his college mathematics are several years behind him. It is, therefore, a relief and a pleasure to find a source of information where formulae, are absent and the facts set forth in terms that are technical but understandable to the average man who wants to know about such things.

Dr. Haas has incorporated ten lectures on the atomic world into his book and it is a pleasure to read and learn. These lectures contain interesting philosophical discussions of the structure of matter and outline the views and theories of well-known authorities. Excellent treatment is presented on Millikan's work on electricity, Rutherford and his atomic model, isotopy, synthetic helium. Bohr's hypothesis, Huygen's principle, atomic mechanics and so on.

Not only does Dr. Haas tell of the various functions of electrons but he tells simply and clearly how these functions were thought of and then proved to be existant. This, to the reviewer, proved to be one of the most interesting phases of the book.

The lecture headings are Matter and Electricity. The Building-Stones of Atoms; Light-Quanta; Spectra and Energy Levels; The Elements; The Atom as a Planetary System; Molecules; Radio Activity; Transformations of the Elements and Wave Mechanics of the Atom. These mere headings serve but to give a very meagre idea of the excellence of the material which follows them. In short, if you are interested in the sub-microscopic world and if you want to receive an excellent picture of the whole subject, we recommend "The World of Atoms." We read it from cover to cover.

**NEXT MONTH'S FEATURES**

*Among the articles to be presented in the January issue of* RADIO ENGINEERING, *which will be of special interest are: "Sound Projector Systems for Motion-Picture Theatres," by E. O. Scriven, of the Bell Telephone Laboratories; "Characteristics of Electric Wave Filters," by C. E. Farrar, Asst. Professor of Electrical Engineering, University of Idaho; "Gas in Metal Parts of Vacuum Tubes," by J. H. Ramage, Metallurgist, Westinghouse Lamp Company, and "The Rating of Radio Receivers," by the Engineering Staff, General Radio Company.*

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# Some Practical Data on Public Address Amplification

*The Application of Power Amplifiers to All Classes of Service, and Data on the Fundamental Requirements*

*By McMurdo Silver**

A DAY never passes which does not bring to the desk of the writer at least one inquiry from a professional setbuilder, service man, engineer, school, hospital, theatre, or manufacturer, seeking not only quotations, but general information on power amplification systems suitable for group coverage. With the possibly selfish motive of obviating a considerable volume of personal correspondence, the main purpose of which has been to convey a general idea of public, or group, address systems to correspondents, the material herewith has been gathered together. It is hoped that it will be of assistance to readers of RADIO ENGINEERING, even if one important underlying idea, the profits to be made by qualified professional setbuilders and service men from "P. A." sales and installation work, appeals only to a small portion of all readers.

### *Classification as to Requirements*

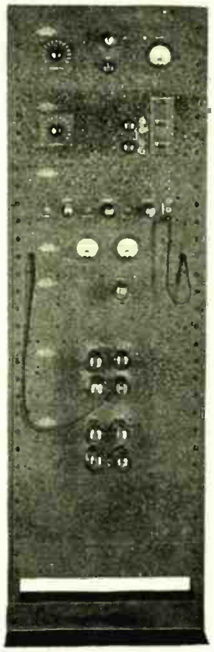
In the same mail in which one correspondent will inquire about a push-pull amplifier using, perhaps, four 250-type tubes to cover a 500 seat theatre, another writer will ask for a system, to cost, maybe, one hundred dollars, capable of covering possibly 15,000 people out-of-doors, so scanty seems to be the popular knowledge of the equipment, and its approximate cost, required for given classes of service. Usually, however, the whole problem of such service seems to be visualized from the extremes of undersize receiving amplifiers, or oversize transmitting tubes not particularly suited to audio amplification and "giant" horns, as well as from all possible intermediate viewpoints.

Public or group address systems may be conveniently divided into three sections, (a) input apparatus, such as microphone, radio set, or phonograph record pickup; (b) vacuum tube amplifying equipment; and (c) loud speakers, or sound projectors. If voice coverage only is required, the whole system should have a substantially flat frequency characteristic from about 200 to 2,000 cycles, whereas for really high quality music, as from radio or record input sources, the flat frequency range should extend from 80 or 100 cycles up to at least 4,000 cycles, possibly higher. In other words, all frequencies within these ranges should pass through the system with substantially uniform amplification. The power output of the system should be sufficient to give the coverage desired, while the overall amplification should be sufficient to boost the weakest signal input to be encountered in practise to the full output of the system. It seems well to risk being accused of placing the cart before the horse, and to start at the output end in an attempt to clarify these requirements.

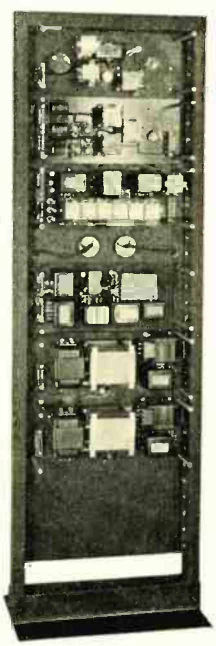
It has been found experimentally, and confirmed in a number of tests and installations that, assuming a frequency characteristic flat from 80 to 4,000 or 4,500 cycles, a power of 400 to 700 milliwatts delivered to an average reproducer is adequate to provide home entertainment at volume levels giving a natural impression; from 700 to 800, or possibly 1,000 milliwatts (1 watt) seems desirable for dancing in the average home. These figures apply equally well in practise to magnetic or dynamic speakers for home, school-room, or apartment use. For auditoriums and theatres seating 500 to 1,000 people, with all seats occupied, from three to five watts delivered to one or two reproducers will produce an impression of natural volume, replacing an orchestra quite effectively. Systems delivering about five watts to two reproducers give adequate coverage of one thousand to two thousand seat theatres. For houses of from two thousand seats up, higher powers are needed; from fifteen to thirty watts delivered to four to eight speakers being desirable to insure safe reserve capacity for 3,000 to 6,000 seat houses. The above figures contemplate indoor operation, under draped or damped surroundings, and in practise give an impression of naturalness, but not of deafening, ear-splitting volume; rather, a volume level at which music or speech may be listened to with enjoyment.

For outdoor operation, good coverage of crowds of ten to fifteen thousand people can be had with five watts, delivered to from one to six speakers, while fifteen watts will make coverage more effective, and allow a reserve for unfavorable absorption conditions such as might be encountered in portable work. Thirty watts appears sufficient for crowds of ten to twenty thousand or more people, depending upon grouping and absorption.

Accepting the above power figures as a practical guide, the problem is



Left: Fig. 3-A. A de luxe type of public address amplifier. The flexible rack and panel type of assembly allows the design of equipment for any desired service. At the top of the rack is a vacuum tube voltmeter, used as a visual volume level indicator. Below it is the input control panel, followed by a three-stage input amplifier.



Right: Fig. 3-B. A rear view of the rack and panel amplifier. The heavy aluminum dust covers, which fit over the apparatus assembly upon each panel, have been removed to show the construction of each individual panel. Each panel is 21 inches long and 4 or 8 inches wide. They are bolted into a channel iron frame.

* *Silver-Marshall, Inc.*

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what type of loud speakers or projectors to utilize for different classes of service to most effectively utilize these powers. One of the first considerations is whether microphone, as differentiated from radio or record input source, is to be employed. If a microphone is to be used, as in a church or auditorium to pick up a speaker's voice, which is to be amplified for the benefit of listeners in the same hall in which the microphone is placed, it is essential that the loud speakers be shielded, and project the amplified voice away from the microphone. Reaction between speakers or projectors will cause "singing," and, in the final analysis, the amount of "gain" or amplification that can usually be employed is determined by such reaction. For voice alone, projectors with a good frequency characteristic from 200 to 2,000 cycles will be satisfactory, but they must be of a type to project sound away from the microphone, to the audience. Horns, therefore, of the "morning glory" type, are usually preferable when "mike" and loud speakers are in the same room; or out-of-doors, where reaction between them is possible. Where reaction is not possible ("mike" shielded from loud speakers, as when in another room), projectors of a less directional type are preferable, since better frequency characteristics can usually be had with such types.

### *Radio and Record Reproduction*

For radio or record reproduction of music and voice, loud speakers giving greater diffusion are preferable. So-called air-chrome, cone, or coiled exponential projectors are satisfactory, though public opinion seems at present to favor dynamic reproducing units in large baffles. In general, dynamic or air-chrome speakers seem preferable, with large air-column types comparing very favorably.

The number of projectors to be used depends upon the area to be covered and the power that the individual projectors can safely handle without serious distortion or actual damage. For home reproduction, involving amplifier outputs of 400 to 1,000 milliwatts, almost any good speaker can be selected to suit personal taste. Air-chrome speakers or dynamic units in baffles 16 to 30 inches square are excellent, and will handle the power involved nicely. For radio or record reproduction in a theatre or auditorium seating up to 500 people, or possibly 1,000, with amplifier outputs of 3 to 5 watts, one good dynamic unit in a 40 inch square baffle is usually more than adequate; one large air-chrome (36 inch square) speaker is sometimes satisfactory, though many of the linen diaphragm speakers are equipped with woefully inadequate driving units and it is usually best to employ two. Air-column horns, such as the one referred to above, are often satisfactory. Two dynamic projectors are generally sufficient for 1,000 to 2,000 seat houses, when fed from a good 5-watt amplifier.

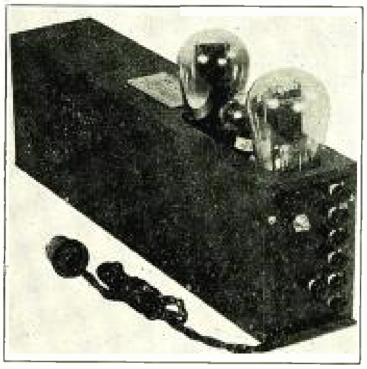

Fig. 1. A compact socket-powered amplifier with one '26, one '50, and one '81 tube.

### *Microphone Operation*

For microphone operation "morning glory" horns or other air-column speakers are best—two or three for 500 seat halls, and about four to six, or even eight, for 2,000 seat halls.

A good rule of thumb is to allow so many watts per speaker. One, two at the most, two watts can be allowed for small air-chrome type speakers or small air-column horns, such as morning glories. Two to possibly three watts can be allowed for large linen diaphragm speakers. Dynamic units in small baffles (under 20 inches square) are not economical for group address service and their use should be discouraged in favor of dynamic units in large baffles (36 inches to 40 inches square). Two to four watts can be allowed for large baffle dynamic projectors. These ratings, which may be considered conservative by some, generous by others, have been found to be good guides in practical installations.

From the foregoing data any service man can estimate the power required for a given group address installation, and choose the approximate number and type of projectors needed to give the desired coverage. The selection of amplifier and input apparatus remains to be made.

### *Selection of Tubes*

For home use, involving powers of 400 to 700 milliwatts, an amplifier using one 171 output tube operated at *maximum rated voltage* is usually adequate. If greater power is required, two 171's in push-pull will give a maximum output of 2 or more watts if efficiently operated. One 210 would give a maximum of about 1.5 watts; there seems little or no justification for using 210 tubes, singly or in push-pull, since one 250 tube will develop as much undistorted power as two 210's in push-pull, while two 171's at low voltages are preferable to one 210 tube at maximum rated voltages. One 250 tube will develop about 4.6 watts; two in a *good* push-pull amplifier about three times as much—actually, about 15 watts. Power output curves are seen in Fig. 4, taken on actual operating output stages. Maximum allowable distortion can be conservatively taken as 2 TU's down; useful operating ranges are above the dotted line for each curve. There is some question as to how far they may be exceeded; this must remain for individual decision. Of course, these powers can only be obtained when load conditions are optimum; projectors must be connected to amplifier outputs with considerable care and thought.

In general, one 171 is usually adequate for home entertainment; two 171's in push-pull are more than ample (not, however, at the operating voltages encountered in most commercial radio receivers). The next most logical step is, not to the older 210 tubes, but to the new 250. One 250 is more than ample for the homes of even "volume hounds," and, in the experience of several large manufacturers of theatrical phonographs, is adequate for up to 2,000 seat houses (or for outdoor crowds of up to 10,000 people). Two 250's in push-pull, or, at the most, two or three 250 push-pull stages in parallel, will handle the largest theatre or stadium ordinarily encountered, with ample reserve capacity.

### *Voltage Gain*

Having determined the type of power output tube needed to develop the power required for any given installation, the amplification to precede the power tube which will be necessary can be determined. To drive a 171 tube to its maximum capacity of 700 milliwatts, an r.m.s. signal voltage applied to the grid of about 28 volts (40 volts

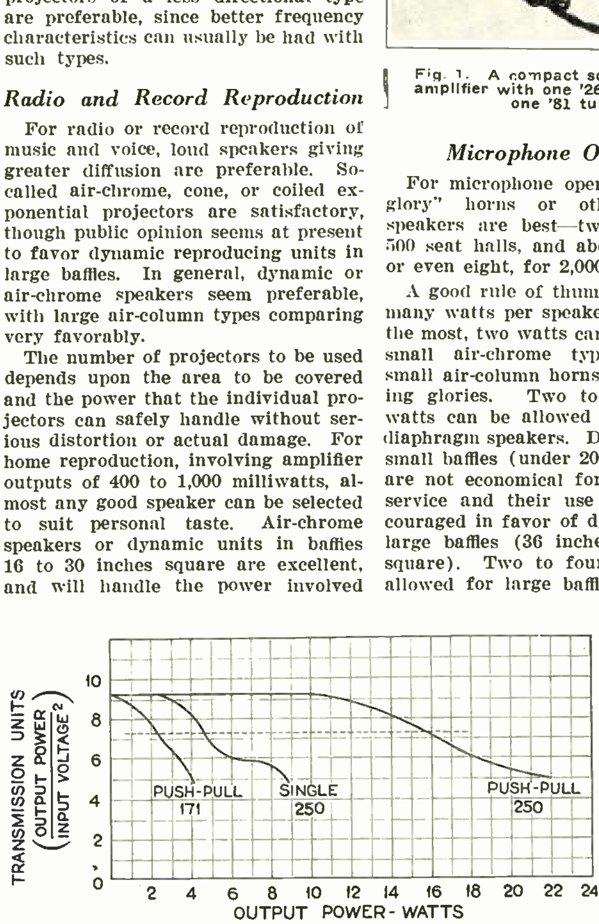


FIG. 4

Curves indicating the relative undistorted power outputs obtainable in practise from standard power tubes. Only the portion of the curve above the dotted line should ordinarily be used as distortion becomes serious below this point.

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| Number and Type of Tubes in Output Stage | Undistorted Output, at Max. Voltages, In Watts | R.M.S. Signal Voltage Needed at Grid of Power Tube | Voltage Gain Needed with Various Inputs | | |
|---|---|---|---|---|---|
| | | | Mike (.05 V.) | Pickup (1.0 V.) | Radio Detector (.3 V.) |
| 1–171 | .7 | 28 | 569 | 28 | 93 |
| 2–171's in push-pull | 2.1 (approx.) | 35 | 700 | 35 | 117 |
| 1–250 | 4.6 | 60 | 1,200 | 60 | 200 |
| 2–250's in push-pull | 15 (approx.) | 79 | 1,580 | 79 | 260 |
| 4–250's in push-pull (2 stages in parallel) | 30 (approx.) | 79 | 1,580 | 79 | 260 |

Note: All Figures Are for R. M. S. Voltages.

peak) is needed: a push-pull 171 stage will need about 35 volts per tube to develop 2 watts. A single 250 tube will require about 60 volts r.m.s. to turn out 4.6 watts; a push-pull 250 stage about 79 volts per tube to turn out about 15 watts.

Looking at the input apparatus, it is safe to assume that an average radio set detector tube will turn out an audio signal voltage of about .3 volt without serious distortion. The average commercial magnetic record pickup will develop about 1.0 volt. Good double-button microphones can develop about .05 volt though in ordinary use their output may fall quite low. By dividing the power tube grid voltage given above by the output voltage of the radio detector, record pickup or microphone, the voltage gain needed between input and power tube can be found approximately. The following table summarizes the results in practical form:

From the above table, it is possible to design an input amplifier, which. placed between a given input device, will operate any specified power output stage to capacity. This can be most simply done if really good coupling transformers of known and dependable characteristics are available, by assuming the gain of any combination of tubes (excluding the power tube) and transformers to be the product of $\mu$ and effective transformation ratios respectively.

### *Representative Amplifiers*

In Figs. 1, 2, 3-A, and 3-B are illustrated several amplifiers of varying coverage capacity and service. The foregoing data can be given practical meaning by consideration of these units and their characteristics.

In Fig. 1 is a socket-powered two stage amplifier for radio or record input, which is intended to operate with one dynamic speaker having a 110 volt D.C. field (the field obtains current through its use as a choke in the filter circuit). It will operate two dynamic speakers having external field excitation upon the addition of a choke coil outside its case. This amplifier is most interesting as it is the commercial equivalent of the units furnished to several makers of theatrical phonographs catering to theatres of 1,000 to 2,000 seats with great success. The unit consists of a power supply incorporating one 281 rectifier tube supplying "A" and "C" power to one 226 and one 250 tube, and a maximum "B" voltage of 450 to the 250 tube when an external plate choke is used. In this amplifier one 4.3:1 input transformer, one 226 tube, and one 3.5:1 second stage transformer give a gain of about 120. Reference to the table shows more than adequate gain for record amplification, but insufficient gain to operate the 250 tube to full capacity from a radio detector tube without overloading. (The remedy is to use a highly grid-biased detector with a high plate voltage, capable of turning out several volts without serious distortion.) This amplifier is not suited to microphone operation.

In Fig. 2 is illustrated an amplifier primarily designed for portable voice work, and used with considerable success, not only by theatres, experimenters, etc., but by the U. S. Shipping Board for its exhibits at many state and county fairs. It is shown with a hand and broadcast microphone (single and double button respectively), and two morning glory projectors. Socket powered, it uses one each 227, 226, and 250 tubes with two 281 rectifiers. For radio or record input, the gain, made up by three transformers and the 227 and 226 tubes, is about 2.5x8x2.5x8x2.5=1,000 (approximately). For voice, the transformation ratio of the input transformer is about 18, so that the total gain is 18x8x2.5x8x2.5=7,200. In practise, these gain figures are halved by stabilizing resistances, for such high gain could not be maintained in practise in so compact a socket powered amplifier. The actual usable gain is higher, in any case, than the figures of 1,200, 60, and 200 times indicated in the table. The frequency curve of this amplifier indicates that while it is quite satisfactory for voice, it is not so good for music as is the unit of Fig. 1. Flexibility of service, however, is in its favor.

### *Public Address Amplifier*

In Fig. 3-A and 3-B is illustrated an excellent example of a group address amplifier at its best. This system is made up of unit panels 21 inches long and 4 inches or 8 inches wide, bolted into a channel iron frame. It is socket powered, except only for microphone battery, and, being very flexible, can be developed to provide from 15 to 120 watts (or more if needed) of undistorted power output by adding output amplifier panels.

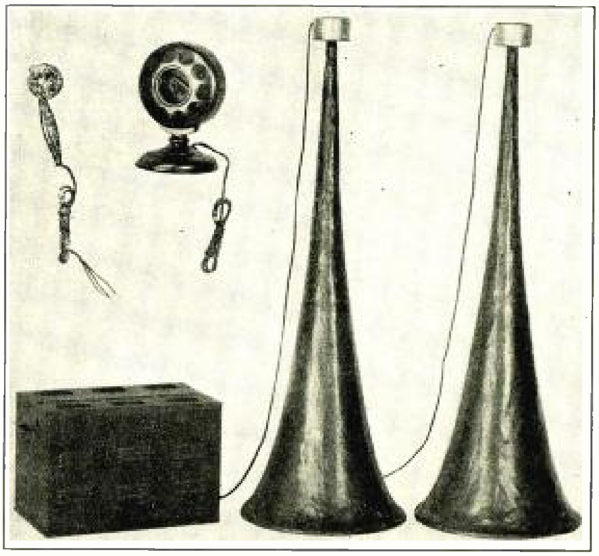

Fig. 2. A portable socket-powered P. A. amplifier with "morning glory" horns. Typical hand and broadcast microphones are shown, but are not to scale.

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At the top is a vacuum tube voltmeter used as a visual volume level indicator. It has a calibration adjustment, and direct reading gain control (30 TU in 15 steps of 2 TU each). Below it is an input control panel allowing selection of one of two microphones, or radio or record input. Microphone current is adjustable and can be measured at jacks. A 15 step master gain control regulates volume in 2 TU steps which give just perceptible intensity changes. Below is a three stage input amplifier using one each 227, 226, and 171-A tubes (two 226's in push-pull could replace the 171-A nicely). This amplifier has no adjustments except hum balances; three jacks permit measurement of plate current of the three tubes. Below it is a test meter panel carrying one 0-50 and one 0-200 milliammeter equipped with cords and plugs. Next down is an A-B-C power supply unit for the three stage input amplifier; and at the bottom are two identical push-pull output amplifiers each using two 250 and 281 tubes, with an undistorted power output capacity of 15 watts each, or 30 watts for both.

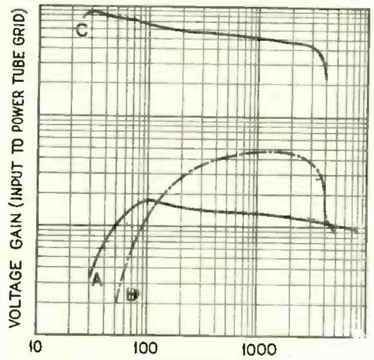


FIG. 5

Gain-frequency curves of the amplifiers illustrated. Curve A is for the amplifier of Fig. 1, B for that of Fig. 2 and C for that of Fig. 3-A-B.

Blank panels for additional push-pull channels or output control apparatus, are at the bottom of the rack. All panels and their dust covers, which fit over all apparatus attached to their rear surfaces, are of heavy aluminum—necessary for quiet A.C. operation.

The entire amplifier has a stable gain of about 5,000 for radio or record input and a frequency characteristic as in Fig. 5. Its 30 watts will operate ten dynamic projectors to cover, not one, but actually four to five 2,000 seat theatres or one very large theatre, hotel, auditorium, or stadium. If preferred, it will deliver 500 milliwatts to each of sixty speakers for hotel, apartment, or hospital reproduction at a good volume level and with excellent quality.

Due to the difficulty of building an A.C. amplifier having a gain of 5,000 (or much more for microphone operation), the makers do not furnish data for the assembly of amplifiers of this class.

In conclusion, it is not felt that it would serve a purpose worthy of the space involved to summarize the requirements and data set forth. For those interested in group or public address work, it would be preferable to re-read this article, to assimilate fully all data, or retain it for future reference, since it attempts to cover some of the simpler, but apparently troublesome, phases of such work.

# The Mathematics of Radio

*Dealing With the Operation of Vacuum Tubes as Voltage and Power Amplifiers, the Determination of Power Out-put and a Summary of B-Power Units*

*By John F. Rider, Associate Editor*

PART XIII

EXPERIMENTAL determinations of the relative degree of sensitivity of the grid leak and condenser system and the grid bias system of detection shows the former to be several times more sensitive than the latter. With respect to power input capacity however, the latter is preferred since it permits the application of greater input signal voltage. This condition is of interest in the selection of the detector system for any one installation. The probable detector input voltage, as governed by the amplification preceding the detector tube, influence the selection of the detector system. For example, grid bias detection should always be used for the second detector in a superheterodyne receiver, whereas grid leak and condenser detection should be employed for the first detector or mixer tube. The trend towards multi-stage screen-grid radio frequency amplifiers will undoubtedly make necessary the use of the grid bias system of detection in place of the prevalent grid leak and condenser system, utilized in the present day tuned radio frequency receivers.

Relative to amplification with the three element tube, we considered thus far the voltage amplification. The discussion however, did not entail an analysis of the actual amplification within the tube and the need for the grid bias utilized in every receiver but seldom fully comprehended. The purpose of the grid bias is to shift the characteristic curve to a certain position where the input grid signal voltage variations will be faithfully reproduced in magnified form in the plate circuit. Assuming correct operating conditions, the wave form of the plate current variation is an exact duplicate of the wave shape of the signal voltage applied to the grid. If however, the conditions are incorrect, the wave form of the plate current variations is not an enlarged duplicate of the input signal wave form. Reference to Fig. 76 shows one phenomenon. These curves are simply illustrations of what is to be discussed and not curves of standard tubes. Referring to curve C, let us imagine a grid bias of 4 volts and a signal input voltage of 4 volts. Let us further assume that the normal plate current with the grid bias applied and no signal voltage, is 4 milliamperes, represented by the point O. If now the signal voltage is applied, the plate current will fluctuate between the points $O^1$ and $O^2$. The plate current will first decrease 1.85 milliamperes and then increase 1.5 milliamperes. It is clearly evident that the plate current variations are unequal and that the positive half is flattened, consequently the output is distorted. If we now increase the grid bias to 6 volts, at which time the normal plate current is 3 milliamperes, and apply the grid signal voltage, the grid voltage will fluctuate between the points X1 and X2, 4 volts each side of the point where X intersects curve C. Under such circumstances, the plate

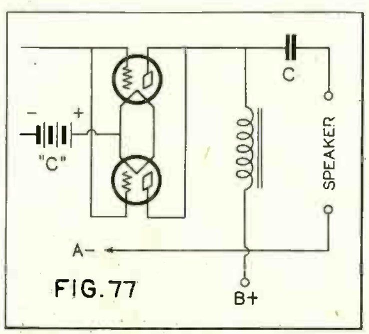


FIG. 77

Power amplifier with the tubes connected in parallel.

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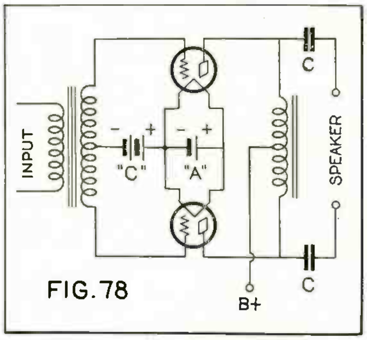
current will fluctuate between 1 and 5 milliamperes, that is, decreasing from 3 to 1 milliampere, a decrease of 2 milliamperes and will increase from 3 to 5 milliamperes, an increase of 2 milliamperes. Under such conditions, that is, uniform increase and decrease in the plate current, the wave form of the plate current variations due to the signal applied to the grid, is a faithful reproduction of the applied signal wave form. It is evident from the foregoing that the original




A push-pull power amplifier, employing a push-pull impedance in the output circuit.

grid bias of 4 volts was insufficient and that a grid bias of 6 volts was necessary.

With respect to the relation between the grid bias and permissible signal voltage, the effective signal voltage which may be applied to the grid of a tube, is equivalent to .707 of the applied grid bias. Insufficient grid bias for any one value of input voltage will cause the flow of grid current which phenomenon is to be avoided in all amplifiers since it is detrimental to faithful amplification, reduces amplification, causes distortion by the introduction of harmonics and in the case of transformers, alters the operating characteristic of the coupling unit.

One of the greatest fallacies existing today among radio men is the acceptance of amplifier performance as indicated by the operating characteristic of a lone coupling unit or of any one system. The average tube characteristic is not of general utility unless the characteristic is that existing when the tube is tested under operating conditions. The load in the plate circuit is of great importance and must be taken into consideration. A non inductive load, such as a resistance, displays one effect whereas an inductive resistance such as a transformer primary or a plate choke displays another effect. This information however, is of interest only when a detailed analysis is made. The pheonomena of C bias is ever present.

### *Grid Current*

Excessive C bias is as harmful as insufficient C bias in amplying systems. The effect noted with insufficient C bias when the positive half of the cycle is flattened or chopped off, is reproduced with excessive bias, but in this instance the negative half is flattened and distortion is the result. The selection of the C bias is not a function of the signal voltage but is governed solely by the vacuum tube and its filament and plate voltages. If under certain conditions when the required value of C bias is applied, elimination of grid current due to excessive signal input cannot be remedied by the application of a greater value of grid bias, unless the plate voltage is increased. If this is impossible, the remedy lies in the reduction of the input signal voltage, or in the use of a different tube with greater input voltage capacity. Once the correct value of grid bias has been applied, any value of signal voltage between a small amount and the limiting value previously quoted, may be applied to the tube. The fact that the grid bias is far in excess of the applied signal voltage, is of no consequence and should not be classed as being excessive, since the grid bias is associated with the tube characteristic and not the signal voltage.

Vacuum tubes are classified under two headings. Voltage amplifiers and power amplifiers. While it is possible to interchange these tubes, that is, utilize a voltage amplifier as a power amplifier, and vice versa, such procedure is not followed because of the results obtained. Voltage amplifiers are usually the tubes possessed of a high value of amplification constant and consequently of high output impedance. Power amplifiers on the other hand, are tubes possessed of low values of amplification constant and low values of output impedance. Tubes of the former classification are the screen-grid and the high "mu" whereas tubes of the latter classification are the 171, the 210 and 250. The standard 201-A can be classified as a voltage amplifier since its use is of this nature, despite the fact that its "mu" or amplification constant is much lower than that of the tubes specifically designed for voltage amplification. The utility of the tube governs its classification. For voltage amplification, the load upon the tube should be infinite whereas for power amplification and the attainment of undistorted power, the load should be equal to twice the tube output impedance. With respect to the voltage amplifier and the mention of infinite impedance, it should be understood that this value is impossible and that a finite value is used.

Voltage amplifiers are not employed as power amplifiers for two reasons. First because the output impedance is very high and second because the permissible signal voltage (input) decreases as the amplification constant is increased. This characteristic is a function of tube design. An examination of the average run of power tubes will show that a lowering of output impedance results in a decrease in amplification constant and an increase in the permissible input signal voltage. Hence the use of special tubes as the output tubes or power amplifiers in an audio amplifier.

### *The Square Law*

The operation of a voltage amplifier differs in another respect from the power amplifier, and this is the square law followed in power amplification. The output voltage available in a voltage amplifier tube is in proportion to the input voltage. That is to say, a volt input makes available in the output circuit, a voltage equal to the input times the "mu." Doubling the input voltage, will increase the output voltage twofold. In power amplification however, where we convert the input voltage into power, the output power is proportional to the square of the input. In other words, doubling the input voltage increases the output power 4 times. Conversely halving the input voltage, decreases the available power to one quarter of its original value.

The above facts pertaining to power tubes or output tubes is of importance in the selection of a tube to perform a certain function, and in the arrangement of the output tube circuit. Interested individuals are too prone to overlook the fact that the rated power output of a power tube is available only when the maximum permissible input signal voltage is being applied. Lack of comprehension of this phenomenon leads to the selection of high power tubes and the attainment of power output much less than anticipated. An example of this is the use of a 250 tube in place of a 171, when the available signal voltage is only 18 volts r.m.s., a value much less than is required by the 250 for maximum output. The selection of a power tube should be based upon the output power

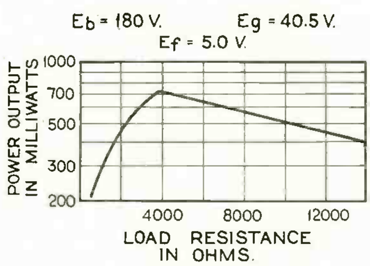



FIG. 79

Power curve of a 171 tube, indicating the relation of power output to load resistance.

required and the available signal voltage. For example, the rated output of a 171 is obtained when the signal voltage applied to the grid is .707 of 40.5 volts, and with a 250, the input voltage must be .707 of 87 volts. These input values are the r.m.s. values. The peak values of this signal voltage are equal to 1.414 times the r.m.s. values.

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### *Impedance Relations*

The selection of the output system of an audio amplifier, that is, if it is to be the conventional arrangement, parallel or push-pull, is based upon existing conditions and requirements. Since the impedance relation between the output tube and the speaker plays an important role in the power output, a certain optimum condition must exist. If we consider the magnetic type of speaker such as the every-day cone, its impedance with respect to the tube load is a function of frequency, increasing as the applied frequency is increased and decreasing as the applied frequency is decreased, and realizing the need for a certain load impedance, we immediately visualize a certain requirement for the tube output impedance. It must of necessity be low, since at zero frequency, the limiting load is 1000 ohms. It is true that the average load impedance is usually considered to be 4000 ohms, in which case normal use of the 171 and the 250 are satisfactory, but in actuality the impedance of the magnetic type of speaker is much lower at frequencies between 30 and 100 cycles. Hence the need for lowering the output tube impedance.

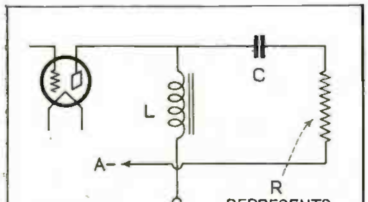


FIG. 80

Method of determining power output of a vacuum tube.

Since resistances in parallel afford a final value less than any one of the units in the combination, paralleled tubes offer the means of obtaining low output impedance. See Fig. 77. If, however, we operate upon the premise that the average speaker impedance is 4000 ohms, as is being done in actual practice, although we do not agree with the practice, paralleled tubes find application with another purpose in mind. This is to obtain greater output for the same input signal. The power output available when two tubes are connected in parallel is not twice the output of a single tube, despite the average conception. In our experiments we have found 30% as the maximum gain, under normal operating conditions. However, if the sole aim is the lowering of the output tube impedance, paralleled tubes is the solution. In this arrangement it is imperative that the tubes employed possess identical characteristics.

Another popular arrangement is the push-pull system, shown in Fig. 78. The impedance of such a circuit is equal to twice the impedance of a single tube, and four tubes arranged in a parallel push-pull arrangement are required to produce a final impedance equal to that of a single tube. With respect to the power available from such a circuit, it is essential to remember that twice the original input voltage is required.

Another significant fact is ever present in the discussion of audio amplifiers, one which influences the selection of paralleled or push-pull output systems. This is particularly true with A.C. installations, and when the load impedance is low. A low load impedance results in a dynamic characteristic, which greatly limits the permissible input voltage and results in the generation of harmonics which are even multiples of the input frequency, and present in the speaker output. The elimination of these harmonics in the conventional output stage and in the paralleled stage is possible only by reducing the input signal voltage, thus reducing the grid swing and the plate current variations. In the push-pull system however, these harmonic voltages balance out in the plate circuit and are not passed to the speaker. Consequently, the working range of the system is not limited to the straight portion of each tube characteristic. Instead, the operating range is the combined characteristics of the two tubes, thus minimizing the effects of the bends in the tube characteristics. A low load impedance tends to increase the curvature and decrease its undistorted power output capacity. Connected in push-pull fashion, the effect is to straighten this curvature. The push-pull system of connection is also of aid when A.C. filament supply is used, because the hum voltages balance out in the plate circuit and are not passed to the speaker.

Judging from the above, push-pull systems are of great advantage . . . This is true, providing that the impedance relation between the output system and the load is correct and that the required input voltage is available. The use of the push-pull arrangement for the sole purpose of eliminating hum voltage is not justified, since freedon from hum is possible with the conventional and the paralleled arrangements, by correctly designing the system. Tubes such as the 250 do not lend themselves to satisfactory operation in push-pull systems, because of the high signal voltage required, and because of the high signal voltage permissible with the individual tube when used in the conventional or paralleled manner. The high permissable input voltage and the low value of output impedance, makes this tube ideal for conventional or paralleled connection.

The introduction of the dynamic speaker with its high tube load impedance eliminates to a large extent the need for a very low value of tube output impedance, that is, the paralleling of tubes. This, however, does not mean that tubes other than power tubes may be utilized in the output stages.

### *Determining Power Output*

An explanation of the method of calculating the power output (undistorted) of output tubes is impossible in these pages at this time, since it involves much space, hence a rough method of determining the power output of the output stage in operation might be of interest. In contrast to the voltage amplifying characteristic of a vacuum tube, the power output is based upon a different law, as mentioned and the method of plotting the power is shown in Fig. 79, illustrating the power output of a 171 tube under ideal conditions, with varying values of plate load. It is generally understood that maximum power is available when the load impedance is equal to the impedance of the supply, but when considering vacuum tube operation this is not the ideal condition for maximum *undistorted* power. The attainment of the above is the use of a load impedance equal to twice the tube output impedance. The method of determining the power output under such conditions is shown in Fig. 80. This is a rough method but works very well.

Assuming a high value of impedance for the plate choke L and a perfect condenser at C, the voltage across R, a resistance replacing the speaker impedance, and equal to twice the tube output impedance, is the IR drop in

Typical high-voltage, full-wave rectification. B-eliminator circuit. The 4 M.F. condenser is subject to a heavy voltage strain.

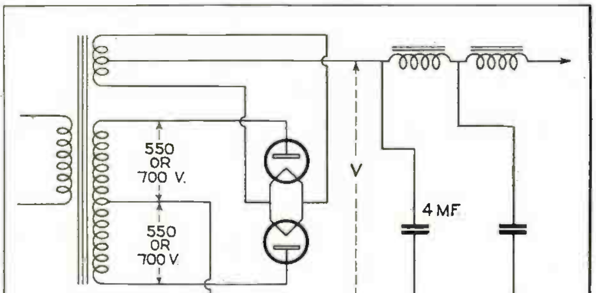


FIG. 81

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the circuit. Since no power is lost in the condenser and since the current in a series circuit is equal in all parts of a circuit, the current in the CR, circuit shown is equal to the voltage across R divided by the resistance of R. In actual experiments we made C very large. Continuing, the power in the circuit is therefore $I^2R$. A more detailed explanation is as follows: Assuming the circuit shown and a 171 tube, a 4 mfd. condenser and a resistance of 4000 ohms. The frequency applied is 120 cycles. The reactance of the condenser at this frequency is 333 ohms. The total impedance is

$$Z = \sqrt{333^2 + 4000^2}$$

$$Z = 4014 \text{ ohms}$$

We do not know the input voltage or the voltage available in the tube, but we measure the voltage across the resistance R and it is 77.7 volts peak. This voltage is measured with a vacuum tube voltmeter. The effective voltage is .707 at 77.7 or 55 volts. The current flow in the circuit is equal to

$$\frac{55}{4000} \text{ or .01375 ampere}$$

We use the value of 4000 ohms instead of 4014 ohms as the total impedance because the voltage drop of 55 volts across the resistance is the result of some value of current flow governed by the total impedance, across the resistance of 4000 ohms. Since the current flow is the same in any part of a series circuit, the voltage across the condenser is .0137 x 333 or 4.56 volts. The voltage across the resistance is 55 volts and the vector sum of these voltages is

$$E = \sqrt{20.79 + 3025}$$

$$E = 55.2 \text{ volts.}$$

Assuming a perfect condenser, the power factor of the circuit is

$$\cos \phi = \frac{4000}{4014}$$

$$\cos \phi = .996$$

The power in the circuit is equal to $E \times I \times \cos \phi = 55.2 \times .01375 \times .996 =$ 756 milliwatts or power equals $.01375^2 \times 4000 = 756$ milliwatts.

The above example is a satisfactory method for the determination of actual power output, when the speaker impedance is replaced with a resistance, and it is applicable to all tube circuits.

The approximate undistorted power output of a tube is equal to

$$P = \frac{mu^2 \times Eg^2}{9 \text{ Rp}} \text{ where}$$

"mu" is the amplification constant of the tube

Eg is the peak signal voltage

Rp is the tube output resistance

According to this formula the power should be doubled when tubes are paralleled, but the writer, after testing approximately 350 tubes in parallel combinations, has as yet failed to obtain an increase greater than 30%. After all is said and done, we cannot consider ideal theoretical conditions, but must base our application upon actual practice.

### *B-Eliminators*

We cannot conclude without discussing "B" battery eliminators. These units find extensive application, but unfortunately some of the important phenomena associated with them are not clearly understood, despite the fact that they are of importance when the eliminators are placed into operation.

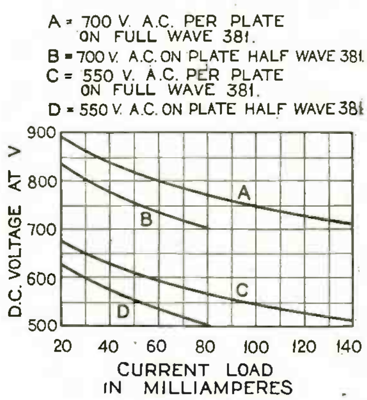


FIG. 82

Current-voltage curves of high and low voltage, single and double wave B-eliminators.

In the first place the unit is a limited current output device, and the voltage output is governed by the current drain; the greater the current load, the less the output voltage. Consequently every unit has a definite voltage regulation curve. Take for example the B-eliminator shown in Fig. 81. It is a full-wave arrangement employing two 381 tubes. With 700 volts A.C. applied to each plate, we obtain the curve so designated in Fig. 82, when the current load is varied according to the values mentioned. The voltage values shown are those available at V in Fig. 81. When the A.C. voltage applied to the plates is 550 volts, the curve so designated in Fig. 82 is obtained. It is clearly evident that the voltage falls as the current load is increased, and that a certain value of voltage is available at a certain current drain. This is of importance in the design of a B-power unit. As an illustration let us assume the B-eliminator shown. It has been constructed to supply a 250 tube. Judging from the associated curve in Fig. 82, the voltage (D.C.) available at V is approximately 725 volts at a current drain of 140 mils. We must consider a certain voltage drop in the filter chokes. If the drain is 140 mils and the D.C. resistance of the chokes used is 300 ohms, the voltage drop in the system will be 42 volts. The average installation, however, does not consume 140 mils, consequently, the available voltage will be much higher than 725 volts, less the voltage drop in the filter and the drop due to the current drain of the voltage distributing system. Hence the voltage applied to the tube or tubes, as the case may be, will be far in excess of the required rating. This is mentioned as a bit of information invariably neglected, when the average man constructs a B-unit. Proper provision should be made to drop the voltage to the correct value.

The available voltages when a half-wave system is employed (381 tube) and the A.C. voltage applied is 700 and 550 volts respectively, are shown in Fig. 82. In each instance it is approximately doubled when full-wave rectification is employed. With respect to such circuits, it is essential to remember that the life of the filter condensers nearest the rectifying system is dependent upon its A.C. voltage rating and consideration of the peak voltage must be made when this condenser is selected. Another important item pertaining to the satisfactory operation of the complete unit is the selection of the by-pass condenser values. This was discussed in a preceding chapter and is quoted here as a reminder.

If we have succeeded in clarifying some of the puzzling phenomena associated with radio receivers and equipment, the purpose of "The Mathematics of Radio" will have been fulfilled.

*(This concludes Mr. Rider's series of articles on "The Mathematics of Radio.")*

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## Accuracy in Beat Note Measuring

*Editor,* RADIO ENGINEERING:

I note with interest in the September issue of RADIO ENGINEERING an article entitled "Beat Note Method for Measuring Small Capacities" by G. B. Gelder.

It might be of interest to know that more than a year ago, while engaged in research work in the radio laboratory of the Stewart-Warner Speedometer Corporation, the writer had occasion to use the beat note method for measuring small capacities.

By the addition of an audio amplifier and the introduction of a 1,000 cycle note from an audio oscillator, it was possible to heterodyne the 1,000 cycle note with the beat note obtained from the radio frequency oscillators and obtain a second beat note which made possible an even greater degree of accuracy than 0.2% to 0.4%.

M. W. UTTERBACK,
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Radio Station WHAS.

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# The Engineering Rise in Radio

*By Donald McNicol*
*Fellow A.I.E.E., Fellow I.R.E., Past-President, Institute of Radio Engineers*

PART VII

## *Need for a More Dependable Detector*

IN the year 1899, the minds of the formost workers turned to the need for a detector which would be a current-operated device; that is, a quantitative, rather than a qualitative instrument such as the coherer. At this time a number of thinkers, almost simultaneously, instituted experimental inquiry into the possibility of utilizing the electrolytic principle in the design of detectors. Previously, sharp needle points in contact with oxidized metal surfaces had been used with a fair degree of success, and it was a logical concept to investigate effects produced by electric waves when a metal electrode was placed in contact with an electrolyte.

Some of the scientists who at that time, or a little later, made discoveries which were of value, were: Pupin, Fessenden, deForest and Vreeland, in America; Neugschwender, Aschkinass and Schlöemilch, in Germany, and Ferrie, in France.

Neugschwender had, in 1898, performed an experiment as follows: The silverplating on the reverse side of a section of mirror glass was divided into two completely separated parts by means of a razor cut. On the slit a drop of water was deposited, and then an electric circuit was made up consisting of a cell of battery, a telephone receiver and the two separated sections of silverplating on the glass. When this detecting arrangement was subjected to the effects of electric waves produced in the neighborhood, it was noted that the resistance of the circuit increased considerably, remaining at or near maximum so long as wave transmission was continued; immediately resuming normal resistance when radiation ceased.

Aschkinass, a year later, noted the same effect, and upon his notes being published, Neugschwender again took up the subject, on this occasion examining with a powerful microscope the edges of the silverplating on the opposite sides of the slit at the point where the drop of water had been placed, when it was discovered that an electrolytic action had taken place; minute particles of the silverplating had been torn away from the anode side of the gap by the action of the local battery current.

DeForest and Smythe, in America, in 1899, carried out identical experiments and out of these deliberations came a detector which they called a "Responder." It consisted of a tube fitted with two metal plugs separated by a space of about one one-hundredth of an inch, the space filled with an electrolysable viscuous mixture of oil or glycerine, water, peroxide of lead and metal powder.

It was deForest's belief that the action of the responder was essentially electrolytic in character, current flow from the local battery causing minute particles to be detached from the anode and carried across the electrolyte to the cathode; thus, in effect, causing to be built across the gap a bridge of conducting particles which

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quickly lowered the electrical resistance of the gap. In the responder, de Forest facilitated the bridge-building process by immersing the particles of metal powder in the glycerine and water electrolyte. One of the most fascinating stories in all electrical research is deForest's account[3] of how he observed the establishment of the conducting paths across minute gaps: "Tiny ferry-boats, each laden with its little electric charge, unloading its invisible cargo at the opposite electrode," and the disruption of these conducting paths when subjected to radiation from a transmitter of electric waves.

On October 28, 1899, Dr. Pupin read before the American Physical Society, a paper describing the principle of electrolytic detectors of electric waves.

In one arrangement of elements[4] one of the electrodes was very small, and the electrolyte consisted of nitric acid.

Schlöemilch, in November 1903, reported the discovery of what he called "polarization cells" employing very small Wollaston wire anodes, with gold or platinum cores, silverplated so that they might be drawn to very small diameters. When down to a diameter of two or three mils the silver-plating was dissolved away. The employment of a wire of such small diameter closely simulated the conducting path condition existing in the deForest responder when the minute metallic bridges were built up by electrolytic action.

Professor Fessenden, earlier in 1903, introduced a detector of this same order which he named a Barretter. A platinum wire anode was reduced to a diameter of .00006 inch, being employed, in association with larger terminal wires, in the form of a small loop shielded from the air by being sealed in a tube. The name "barretter" was derived from an old French word "Barretter" meaning "exchange" since it was believed to possess the property of exchanging the energy of the received oscillations for a continuous current. The principle of the hot-wire barretter as designed by Fessenden, was that if a wire having a specific heat factor of such value that the latent energy required to raise its temperature to a certain excess above the air is relatively compared with the energy lost by radiation during the time of a signal; then if such a wire is connected in a local battery circuit, when a given amount of current flows through it there will be a corresponding change in the magnitude of the current produced by the local battery. The action, apparently being thermal. The extreme delicacy of the minute wire loop was rather troublesome from an operating view-point, and although it was convenient to substitute new barretter units, it was the experience that frequently the wire of the loop was disrupted due to excess of current.

## *The Liquid Barretter*

In Fessenden's work the hot-wire barretter early gave way to the liquid barretter, in which a column of liquid was substituted for the platinum wire previously used. A Wollaston wire of three mils diameter was so mounted that one of its ends was immersed in an acid or alkaline solution contained in a small platinum vessel. This detector was patented by Fessenden on

[3] *Electrolytic Receivers in Wireless Telegraphy. deForest. International Electrical Congress, St. Louis, Missouri,* 1904.

[4] *U. S. Patent* 713,045, *April* 1, 1898.

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May 5, 1903. Fessenden's explanation of the theory of action of this detector was that the effect of incoming electric waves was to decrease the electrical resistance of the path through the detector, from bare point to platinum container, since the temperature coefficients of liquids is generally negative, and as the resistance is decreased instead of being increased, the signal effect was primary rather than secondary.

From its inception, the bare-point electrolytic detector was an alluring subject for the genus-investigator. Here was a detector of electric waves which possessed all of the worthy traits of the best of the previously used imperfect-contact coherers, and none of their eccentricities. It was automatic. It required no external decohering accessory, and was, from the scientist's viewpoint a beautiful device. There is little to wonder at that numerous bright minds had been at work on the idea, and less wonder that there followed seemingly unending controversy anent the priority of discovery.

The historian's intuition leads him to make special note of those forward steps around which raged dispute as to principles involved, and as to priority of discovery. Writers of national and political history undoubtedly are, due to this same consideration, guided unerringly to *turning points* and to key situations.

The German savants mentioned in the foregoing undoubtedly were on the right track, but, judging from the records, it is not apparent that they immediately carried the investigation far enough. Or, it is possible that the scientists engaged in this inquiry were not early enough in close touch with their compatriots who were at the time seeking to improve the operation of the early wireless telegraph installations.

In the *Electrical World*, New York, issue of May 6, 1905, Andre Blondel published a letter presenting the claim of Captain Ferrie, of France, to the invention of the electrolytic detector. This was, of course, a little late in the day to present the claim, and in prior and subsequent literature there was no outstanding support of Ferrie's claim to invention.

In America, in 1903, deForest and Fessenden, who were independently delving into this very subject, were actively engaged in promoting wireless telegraph services. Research and engineering practice were on the same bench, which, largely accounts for the immediate, wide use of the electrolytic detector after its introduction.

A brilliant young engineer, not to be overlooked in these matters, is Frederick K. Vreeland, who at twenty-two years of age became first assistant engineer in the works of the Crocker-Wheeler Electric Company, at Ampere, New Jersey, remaining in that position from 1896 until 1900. In the latter year Mr. Vreeland engaged in research which immediately brought him into the field of "Wireless" engineering. In a book entitled "Maxwell's Theory and Wireless Telegraphy" published by Vreeland, in January, 1904, appears the following reference to his connection with electrolytic detector development, presumably in 1903: "Another electrolytic detector was developed by the writer (Vreeland) in the course of a series of attempts to magnify the heating effects of Fessenden's barretter by immersing the wire in a liquid of high temperature coefficient and low specific heat, which was made a part of the local circuit. The attempt was unsuccessful, but it led to the discovery that a simple electrolytic cell, when polarized to the proper critical point by current from a local battery, is remarkably sensitive."

Although subsequent court decisions

S. M. KINTNER

sustained Professor Fessenden's patent grant for the electrolytic detector, a writer recording the engineering growth of radio is concerned more with the principle of operation of an invention; with contributions of merit; with collaboration, and with the progress made collectively, than with exact dates which inevitably must be authenticated by court decree in order that an inventor may enjoy his monopoly. A chronicler always is well served in his task when there is in truth "glory enough for all."

It is a commentary on the existing facilities for physical exploration available to the workers of 1903, and to the processes of reasoning that prompt scientific investigators to form definite conclusions, when we examine the views expounded at that time, and later, bearing on the principle of operation of the electrolytic detector.

Prescience being a gift denied most mortals, the workers of 1903, could not know that the simple, rugged, crystal detector, and the wonder-working audion, as detectors, were but three years away. The electrolytic detector was then a thing in hand, an accessory to radio more sensitive than the devices previously employed for the same purpose. With the introduction of de Forest's responder, and Fessenden's hot-wire barretter (even after the wire loop of the latter was replaced by a bare-point anode) debate continued as to the principle of operation when under the influence of electric waves.

Dr. deForest, as already stated, held that the device was electrolytic in its nature. Fessenden held that it operated in virtue of heat generated in the electrolyte immediately surrounding the immersed portion of the fine wire, when Hertz waves actuated the detector. Schlöemilch,[5] was in doubt as to whether it operated in virtue of its polarization capacity or its ohmic resistance. M. Reich,[6] in Germany, believed that it acted by the polarization of the small surface of the immersed portion of the fine wire anode, and his opinion was shared, both on experimental and theoretical grounds, by M. Dieckmann,[7] in Germany. Vreeland stated that the action was electrolytic, dependent upon polarization.

Late in the year 1904, Dr. J. E. Ives carried out a series of experiments with a view to determining precisely the nature of the action. In these examinations he was aided by valuable suggestions from Greenleaf Whittier Pickard, a young engineer, at that time twenty-seven years of age and who had been a student of radio since 1898. The Ives investigation was stated to have shown that the detector was electrolytic in action, and not a heat-operated device; its operation depending upon the polarization by electrolysis of that portion of the surface of the fine patinum wire in contact with the electrolyte. The ability of the device to respond to Hertz radiation was explained by Ives as resulting from an e.m.f. generated in the antenna by the intercepted waves, the e.m.f. causing a partial breaking-down of the polarization layer enveloping the fine point, thus reducing the resistance of the local circuit in which the translating device (telephone receiver) was connected. Mr. Pickard carried out a separate series of experiments and it was stated by Dr. Ives that Pickard's results were in accord with his own findings.

The electrolytic detector was employed by Fessenden as late as 1908-09, in his experiments in wireless telephony; two or three years after the introduction of crystal detectors, and the audion.

It may here be noted that in an experimental investigation carried out

[5 6 7] *Electrical World and Engineer, New York, December* 10, 1894.

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by Dr. L. W. Austin, in 1906,[8] the resistance of the electrolytic detector for slowly alternating currents varied from about 20,000 to 400 ohms, according to the polarizing e.m.f. applied.

### *Magnetic Detectors*

In the early transmitters the amount of energy radiated was not great, with the result that in receiving antenna systems the energy available was quite small. So small, in fact, that the possibility of using electromagnetic receivers, of the wire telegraph order, was thought to be impracticable. The idea, however, was not overlooked that a way might be found to utilize the active field created around a coiled section of the receiving antenna to actuate an indicating device.

Fessenden and S. M. Kintner, 1889, experimented with galvanometer type receiving systems. In one arrangement the two series field coils of a mirror galvanometer were connected directly in the antenna circuit, the moving element being a suspended ring, mounted at an angle of 45 degrees to the plane of the two field coils. For the small actuating current available the arrangement was not promising, mainly owing to the fact that the current in the ring was in nearly 90 degrees phase-relation with the magnetic field producing it, with consequent small torque.

Kintner, later extended the experiments in an attempt to devise a receiver having a rotary field. Two-phase currents were obtained by spacing two vertical antennas one-quarter wave length apart, each antenna connected to two field coils in series, surrounding the movable element of the galvanometer. This was an early attempt to apply wire line engineering to the problems of radio.

At an earlier date, 1896, Ernest Rutherford, in England, directed attention to experiments he had made with special forms of electromagnetic receivers. The distance covered was short; about one-half mile, and the elementary form of receiver used was too slow in operation to compete with the coherer.

The subject was not lost sight of, and Mr. Marconi, in 1902,[9] introduced a form of magnetic detector which from the start proved to be a dependable receiver, being widely used in Marconi stations throughout the following five or six years. (See Fig. 10.)

This detector consisted of a band of fine iron wires, magnetized by being passed through a magnetic field produced by a pair of horse-shoe type, permanent magnets. The moving, magnetized band passed through the core space of a primary coil, the secondary winding being connected to a telephone receiver. The primary winding was connected in series with the antenna and earth, and it may be recognized that the arrangement was simply that of a miniature transformer, except that the core moved continuously, lengthwise, through the primary coil.

Antenna current, due to the incoming electric waves, passed through the primary winding and, as at each dot or dash the magnetic conditions of the windings were altered, the telephone receiver reproduced the signal picked up by the antenna.

DeForest, in 1903,[10] brought out a magnetic detector consisting of a number of cores disposed about a common axis, separate coils for the cores being connected in series. Permanent magnets closely associated with the coils were rotated upon a coincident axis.

Receivers of the magnetic detector type came within the ken of the electrical engineer used to working with electromagnetic devices. Here was a detector which had nothing to do with loose filings or imperfect contacts. The energy produced in the receiving antenna by passing electric waves was applied directly to a magnetic coil.

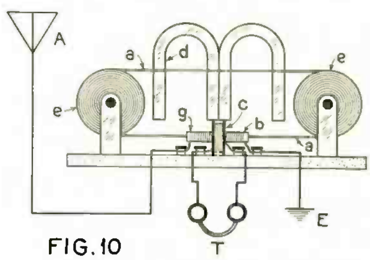


FIG. 10

General construction of Marconi's Magnetic Detector.

In 1905, Ewing and Walter, in England, introduced an improved form of magnetic detector, in which two small, continuous-current magneto machines, with shuttle-wound armatures were connected with their e.m.f's in opposition, so adjusted that normally no current flowed in the terminal circuit. The core of one armature, instead of being made up of the usual laminations, was formed of a coil of iron wire, the ends of which were brought out and connected to the receiving circuit. The antenna current, therefore, affected the core, producing the effect of increasing its permeability. Hence the winding of that armature revolved in a stronger field, generating a higher e.m.f., upsetting the electrical balance of the system, the output being in the nature of a direct current capable of actuating a galvanometer, a sensitive relay, or a telephone receiver. The device was, perhaps, based on Ewing's hysteresis tester, which measured the drag between the field, and the iron, when one of these is moving. Integration undoubtedly played a large part in the effectiveness of the instrument as a detector. The speed of rotation was from five to eight revolutions per second.

### *Crystal Detectors*

The International Electrical Congress, held in St. Louis, Missouri, in the year 1904, turned out to be a sort of clearing house for information on all lines of electrical development. At this meeting scientists from all progressive countries either presented original technical papers on current practice, or discussed the papers presented by others.

By the year 1904, considerable progress had been made in wireless signaling. A year previously the first International Conference on this subject, participated in by representatives of the various national governments, was held in Berlin, Germany.

(*At the Berlin Conference of* 1903, *the word "Radio" was officially designated to replace the word "Wireless." In previous chapters in this work the author has employed the word "wireless," except in a few special references, in order to preserve terminology contemporaneous with the growth of the art, so long as that term was universally employed.*)

At the St. Louis Congress the papers presented by the scientists working on radio problems contained the last word of accomplishment. The papers presented included John Stone Stone's article on "The Theory of Wireless Telegraphy," Dr. K. E. Guthe's paper on "Coherer Action," Dr. deForest's paper on "Electrolytic Receivers in Wireless Telegraphy," and Dr. Fleming's paper on "The Present State of Wireless Telegraphy."

In view of the steep rise in the extension of wireless signaling for practical purposes which followed the introduction of the electrolytic detector, the crystal detectors, and the audion, within two years thereafter, it is interesting to consider the state of the detector art at the time of the St. Louis Congress.

About that time Dr. Fleming made an attempt in his writings to popularize the word "kumascope" as a name for any form of detector of Hertz waves, but the idea did not take favorably in other countries and, as a consequence, did not long continue in the literature of the art.

Fleming's paper of 1904 clearly reflects the status of the detector, just prior to the advent of the electrolytic device. He stated:

*"It is impossible to describe here a tithe of the forms of kumascopes which have been devised, but it is probably correct to say that all the effective Hertzian wave telegraphic work is being done at present either by a few forms of contact kumascopes. the principal one of which is the nickel-silver filings tube of Marconi (the coherer), or else by means of some form of magnetic kumascope (magnetic detector)."*

[8] *Bulletin, Bureau of Standards, Vol.* 2, *No.* 2.

[9] *U. S. Patents* 884, 986 ; 87, 88 *and* 89.
[10] *U. S. Patent* 887,069.

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Thus all of the early, wonderful transatlantic wireless telegraph experiments; ship-shore, and ship-to-ship long distance trials had been carried out with the coherer, and later the magnetic detector as the receiver-actuating instrumentality.

A point worth noting here is that in 1904 there was no hint of crystal detectors or electronic bulb detectors. But, as was the case with Hertz's discovery, and with Branly's, it is instructive, and significant, to observe how quickly after the introduction of crystals, and the audion, prior investigations were unearthed which were claimed as being contributory; indeed, in certain aspects, as being anticipatory.

The extreme simplicity of the crystal detector, its cheapness and its sensitiveness diverted the minds of many investigators away from possibilities of betterment of strictly electromagnetic devices, as a result of which the crystal form of detector very quickly reached a high degree of perfection, and was widely used.

In 1906 G. W. Pickard[11] invented the silicon detector. In that year, also, General H. H. C. Dunwoody[12], at that time with the American deForest Wireless Telegraph Company, invented the carborundum detector.

The word "invented" is used here in a conventional sense, and as marking the time at which crystal detectors appeared in the field of operation. When it happens that a recognized inventor of a new device, or of an important improvement, is the person in a position to disclose a considerable amount of prior investigation and development along the same line, the subject is doubly interesting, and the inventor then, naturally, occupies a fairly secure position.

Mr. Pickard, early in 1902[13], observed that certain of the so-called self-restoring coherers, notably the carbon-steel microphonic type, were operative without the use of local battery. The necessary condition of this operation seemed to be a good electrical contact between the elements, as distinguished from the light, or coherer type of contact. Later, in that year, Pickard noted that almost any junction of dissimilar conductors made an operative wave-detector, provided certain conditions of area of contact, and pressure, were complied with. Still later, he investigated electric furnace products, which from their hardness, high specific resistance, and relative infusibility, seemed suitable as constant thermo-junctions of small area. After trial of a large number of elements and compounds, pure silicon was found to possess high thermo-electromotive force against any metal contact, a relatively high and constant contact resistance, and great stability. The outcome was the invention of a detector formed of a silicon surface and a small metal point pressed in good contact therewith. (See Fig. 11.)

In 1905 Dr. L. W. Austin[14], while conducting an investigation into certain matters connected with electromagnetic wave phenomena, for Fessenden interests, independently discovered that thermo-electric contacts acted as detectors of electric waves. The term "thermo-electric" is used at this point because it was current in 1906 as accounting for the action of detectors of the type here considered.

Sixteen years before Branly; fourteen years before Hertz; in fact, in Maxwell's time, 1874, Ferdinand Braun,[15] in Germany published an account of his investigations of the asymmetric or unilateral conduction of current by certain of the natural (mineral) metal sulphides. Obviously, Braun's inquiry was not for the purpose of discovering a means of detecting electric waves, but had to do with the properties of crystals as elements of conducting circuits.

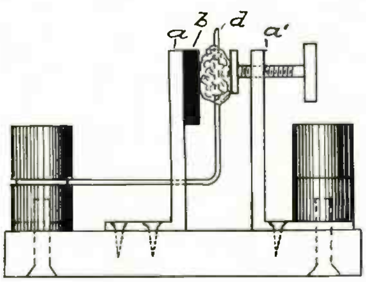


Fig. 11. Crystal detector employing silicon or galena. a and a' are brass standards; b, is an insulating segment, and d, the contact wire.

As previously stated, General Dunwoody developed the carborundum detector in 1906. Pickard, also, had experimented with carborundum crystals early in that year, determining that the most stable form was a single crystal, clamped edgewise between two flat copper terminals. A potentiometer-shunted source of local battery was employed to create a minute flow of current in one direction through the crystal and its contacts.

Dr. deForest,[16] discussing the Dunwoody carborundum detector stated that its sensitiveness was independent of pressure of contact. He believed that the area of contact was important, and that the detector operated on the thermo-electric principle.

When it is stated that as late as the year 1927, the theory of operation of the partially oxidized disk rectifier widely used for charging storage batteries from alternating current sources, is a matter of conjecture, it may be realized that in 1906, there was much of mystery in the performance of similar assemblies used to respond to electric waves.

Braun, in his day, advanced the tentative theory that perhaps there was an expansion of the crystalline structure, due to the applied e.m.f., the expansion acting in one direction to increase the effective area or number of minute contact points of one of the metal electrodes with the mineral, and in the other to decrease this area; a sort of Peltier effect, but by no means convincing.

J. A. Fleming,[17] in England, and G. W. Pierce,[18] in America, carried out investigations into the behavior of crystals as wave detectors, at a time when various theories were under consideration, including that of electrolysis, and thermo-electric action. Both of these gentlemen were inclined to favor for the thermo-electric idea. The problem was continuously attacked, however, and while the secret was not uncovered, that progress was made which, by a process of elimination, narrows the array of hypotheses kept to the fore until disposed of.

Writing, in 1909,[19] about the behavior of molybdenite as an element of a detector, Professor Pierce said: "The large thermo-electromotive force of molybdenite against the common metals, together with its large negative temperature coefficient of resistance, lends plausibility to the hypothesis that the rectification is due to thermo-electricity." Professor Pierce was aware of the considerations which pointed away from the "heat" theory, and in his later writings did not support the idea.

Fleming, as late as 1915, was still in doubt about the theory of operation of crystal detectors, stating:[20] "It is possible that the cause may be thermo-electric . . . ."

Dr. L. W. Austin,[21] concluded from observations made in his investigation of the subject that the rectified current being in general approximately proportional to the square of the alternating current applied, naturally suggested heat action.

Various other experimenters[22] found it difficult to abandon the thermo-electric theory of the crystal detector. The probability that there would be a heat effect at the junction of the metal point and the surface of the crystal was one that it did not seem possible to explain away.

(*To be continued*)

[11] *U. S. Patents* 836,531 *and* 877,451.
[12] *U. S. Patent* 837,616.
[13] *Electrical World, New York, November* 24, 1906, *p.* 1003.

[14] *U. S. Patent Application* 319,241, *May* 29, 1906.
[15] *"On the Conduction of Current Through Sulpho-Metals." Poggendorff's Annalen, Vol.* 153, *p.* 550, 1874.
[16] *Electrical World, New York, September* 8, 1906.

[17] *Cassier's Magazine, September,* 1908, *pp.* 458-464.
[18] *Physical Review, June,* 1907.
[19] *The Electrician, London, December* 24, 1909, *pp.* 425-27.
[20] *Elementary Manual of Radio Telegraphy and Radio Telephony, page* 224.
[21] *Some Contact Rectifiers of Electric Current,* 1908. *Bulletin, Bureau of Standards.*
[22] *V. C. Wynne. Modern Electrics, New York, September,* 1913, *p.* 551.

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# Radio Inspection

## *A Technical Description of the Numerous Tests Given Radio Components and Complete Receivers*

By James E. Smith*

IT may not be common knowledge among all of you who will read this article, that all the parts that go into a radio receiver in the factory are submitted to rather rigid and severe inspections, and that in addition to this, the completed receiver is also submitted to certain tests that prove whether or not the equipment will work satisfactorily when finally placed in the home of the purchaser.

To tell the truth, this is not peculiar of the radio industry alone; rigid inspections and tests are conducted in almost all branches of industry, the type and severity of the tests depending upon the nature of the product and the kind of performance that is expected of it. For instance, in the steel industry, in the building of steel structures, bridges, etc., it is of the utmost importance that the steel that is used be subjected to the most severe tests of strength, endurance and so forth, for the lives of human beings are certainly sufficiently important to warrant such tests.

But tests are also required even where human lives are not at stake; it is of the greatest importance to the manufacturer and the distributor of many kinds of products that once he sells his product it stay sold. By that we mean that once it has come into the customer's possession, he must not experience a lot of trouble with it, and even, perhaps, return it to the dealer from whom he bought it, and demand that his money be returned. The customer must be satisfied, for this is the basis of all good business. It is well known that a satisfied customer will come back again, for he has learned where to buy good goods, and where he gets his money's worth.

Further than this, there is a considerable amount of expense involved in repairing things that go wrong. When troubles occur in radio sets that

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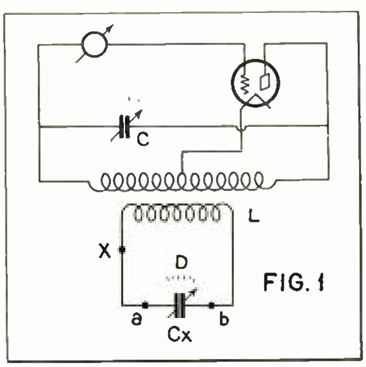


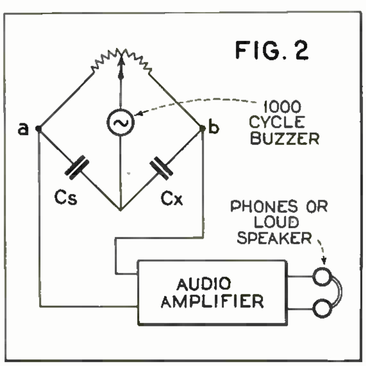

*Mr. Smith's article deals principally with the character and type of tests given manufactured receivers. Obviously, the systems and circuits covered apply equally as well to the field of the service man and professional set builder.*

*The various testing and measuring circuits outlined are comparatively simple of structure and, aside from the meters employed, the equipment is inexpensive.*

*Mr. Smith's article ties in very nicely with Mr. Brennan's description of a modulated oscillator, directly following—Editor.*

have been placed in homes by the distributors, and the purchaser makes his complaint, it costs the dealer money to send his service man out to repair the damage, or to correct the defect. If he does not do this satisfactorily, the customer will in many cases return the set.

It is up to the factory therefore, to send out sets that do not go wrong. And the only way in which the factory can be assured that all the sets which it sends out not only work, but carry with them an assurance that they will continue to work when placed in the customer's home, is to maintain a rigid and systematic system of inspection. All of the more reliable radio manufacturers do this, and it will be of interest to those who have in mind the radio profession as their life's work,




Above: Circuit arrangement for checking the value of fixed condensers, using the bridge method.
Left: Employing an oscillator for checking the value of variable tuning condensers.
Right: Bridge circuit for checking the value of high inductance chokes.

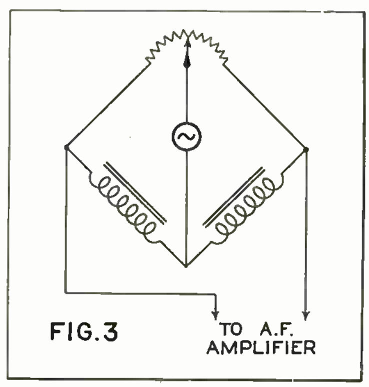
that this branch of the radio industry requires the services of thousands of trained men, and presents many opportunities for those whose training is above the average, because of the great responsibility attached to the proper inspecting of radio sets and parts.

### *Average Required Tests*

There are two kinds of inspection, or rather, the inspection of radio equipment may be classed under two heads—mechanical inspection and electrical inspection. The mechanical inspection deals only with the mechanical features of the receivers and parts—raw materials, sizes, bearings, cabinets, etc. The electrical inspection is what we are mainly concerned with in this article, and includes such things as the measurement or checking of inductance of coils, capacity of condensers and so forth. The following list will indicate the tests that are required in the average radio receiver. It will be noted that this list is divided into three main parts, the radio-frequency amplifier, the audio-frequency amplifier, and the power-pack. Then there are subdivisions of each of these parts, applying to the parts or components before they are assembled into the chassis and overall tests of the various sub-assemblies. This will be understood more clearly as we proceed.

### *Radio-Frequency Amplifier*

*Variometer, or other antenna coupling device*
*Variable Condensers, including the main tuning condensers, midget condensers, neutralizing condensers, etc.*
*Radio-Frequency Transformers (The Coils).*
*By-Pass Condensers*
*Volume Controls*
*Rheostats*
*Grid-Suppressors*
*Grid-Leaks*
*Grid-Condensers*

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### *Audio-Frequency Amplifier*

*Audio-Frequency Transformers*
*Coupling Resistances*
*Coupling Condensers*
*Coupling Impedances*
(*The three preceding items are for sets which employ resistance or impedance coupling*)
*By-Pass Condensers*
*Output Choke Coils*
*Output Condensers*

### *Power-Packs*

*Filter Condensers*
*Filter Chokes*
*Resistances* (*or Voltage Dividers*)
*By-Pass Condensers*
*Power Transformers*

### *Loud-Speaker*

*Output Choke Coil or Transformer*
*Output Condenser*
*Voice Coils*
*Field Coils*

It must not be forgotten that the mechanical features have been omitted from the above list; only the electrical or radio features are considered in this article

It will be noted that in all four divisions of the list the main features to be checked are those three which form the foundations of electrical engineering—inductance, capacity, resistance. Thus, coils are checked for their inductance, whether this be small or large, small inductances are checked at radio frequency, while the large inductances are checked at audio frequencies. Condensers are checked for their capacity and rheostats, voltage dividers (or potentiometers) are checked for their resistance.

Besides the checking of these main features, certain pieces of apparatus should be tested for electrical leakage or breakdown. For instance, by-pass condensers, or filter condensers, should be tested for breakdown at voltages quite in excess of the voltages on which they are to operate. This is to ensure that there is a suitable factor of safety available, in case of accidental short-circuits or sudden rises of line voltage, etc., which may occur.

### *Checking Tuning Condensers*

Tuning condensers are generally checked in circuits which carry high-frequency current. For instance, Fig. 1 shows an oscillator, to which is coupled a coil L. The condenser C is set to any desired position, depending upon the setting of the condenser being tested, $C_x$ at which the check is to be made. At a and b, then, a standard condenser is connected. This condenser is turned carefully and when the needle of the meter in the grid circuit "dips" lowest the reading of the dial (at D) is noted. After all, all condensers which should tune exactly the

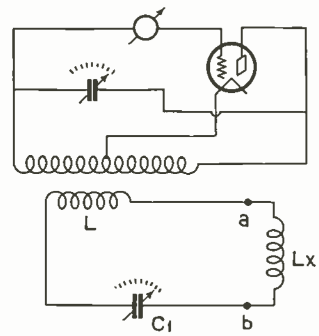


FIG. 5

Circuit, employing an R.F. oscillator, for matching tuning inductances.

same as the standard condenser should "resonate" at the same dial setting when connected in place of $C_x$. If they do not they must be adjusted so that they do. In practice a certain "tolerance" is maintained; that is, it is required that the condensers resonate at the proper dial setting *plus or minus* a certain number of divisions, depending upon the accuracy required.

There are many variations of this method, but fundamentally they are all the same. A circuit carrying the condenser to be checked is coupled to an oscillator, and is then tuned to resonance with it. The difference is generally found to be the way in which resonance is determined. For example, a thermo-galvanometer may be connected at X; in this case a more powerful oscillator is required, and resonance is indicated by a maximum deflection of this meter.

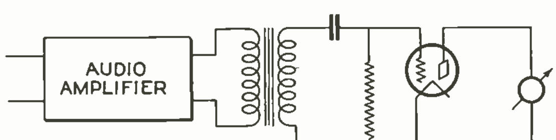


FIG. 4

Showing how to connect up a vacuum tube voltmeter for obtaining visual readings for testing and checking.

### *Checking Fixed Condensers*

Grid condensers, small by-pass condensers, etc., may be tested very conveniently in audio-frequency bridge circuits, and they need not be checked as accurately as tuning condensers. Fig. 2 shows a simple arrangement, in which an ordinary potentiometer forms two arms of the bridge, and the standard condenser $C_s$ for the third arm. The condenser to be checked is connected in the fourth arm, at $C_x$.A 1000 cycle buzzer, or a vacuum tube operated tuning fork (preferably) supplies power to the bridge. The points a, b, connect to an A. F. amplifier which finally feeds into a pair of phones or loud-speaker. When the condenser being checked is exactly the same as the standard condenser, no sound will be heard in the phones when the potentiometer is at its middle position. If $C_s$ differs from $C_x$, the potentiometer will have to be rotated one way or the other in order to find the position at which the sound in the phones disappears. If a permanent set-up is made, the potentiometer can be directly calibrated in microfarads instead of merely in arbitrary divisions.

There are various modifications of this bridge by means of which it can be made to furnish very accurate checks on the condensers. The large condensers which are used in the filter circuits of the power packs can also be tested in this manner, as well as the inductances of the large choke coils, loud-speaker coils, etc. Fig. 3 shows how this is done. The operation of the bridge is always the same. If it is desired, a visual indication of balance may be used instead of an oral one. For example, in Fig. 3, the output of the audio amplifier of Fig. 2 may feed into an output transformer, which works into a vacuum tube voltmeter, as shown in Fig 4. This vacuum tube voltmeter has in its plate circuit a milliammeter. When the proper balance is obtained the milliammeter reads lowest. The vacuum tube is here used as a rectifier of the audio frequency note. The milliammeter will always indicate a certain minimum amount of current flowing in the plate circuit of the tube, but this is constant. The instant any signal voltage is applied to the input of the tube, as when the bridge is "off" balance, the plate current is increased in proportion to

Two typical bridge circuits employed for measuring the value of resistances.

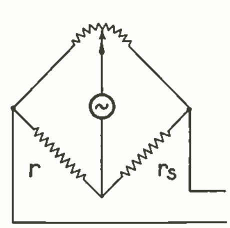


FIG.6

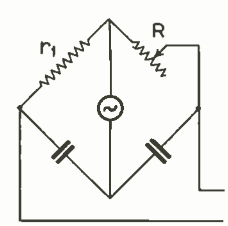


FIG.7

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the strength of the signal. Clearly the signal is least when the milliammeter reads least.

### *Matching Tuning Inductances*

Tuning coils must be matched just as accurately as the tuning condeners. It is clear that there would be no use of matching the condensers if the coils were not matched, or vice-versa. Coils are checked in about the same way as the condensers are checked, using tuned circuits and various ways of indicating resonance. Fig. 5 shows schematically a simple method, which is very similar to that of Fig. 1.

A coil L, of only a few turns of wire, is coupled loosely to the oscillator. In series with it is a variable condenser $C_1$. The tuning coil to be checked is connected in series with these two at the points a and b. With the condenser in the oscillator circuit set at any desired position, so as to fix the wavelength or frequency at which the check is to be made, the condenser $C_1$ is tuned until the grid meter indicates resonance by its "dip." $C_1$ should always resonate at the same dial setting for all the coils that are to be matched, and how much the coils vary is indicated by how the dial setting of $C_1$ varies for the different coils.

### *Measuring Resistors*

The bridge methods described in connection with Figs. 2, 3, and 4, may be applied successfully to the check and measuring of resistances, in which case all four arms of the bridge contain resistances. Fig. 6 illustrates the system. The resistance r is the standard, and $r_x$ is the resistance being checked. The operation of the bridge is the same as has been described before.

It is not necessary that a potentiometer be used in these bridges to furnish two arms of the bridge; only one arm need be varied, in which case the second arm must contain a fixed resistance. The system is shown in Fig. 7, in which R is the variable resistance and $r_1$ is the fixed resistance which must be inserted to complete the bridge.

### *Sensitivity Test*

Now, in addition to making tests on the individual parts, which have been described above, it is necessary to make other tests of various sub-assemblies, and even of the entirely complete receiver. For example, it is to be made certain that the receiver is sufficiently sensitive, and that it must not oscillate. A method of testing the sensitivity of a receiver is illustrated diagrammatically in Fig. 8. A shielded oscillator furnishes power to a coil $L_1$, in series with which is a milliammeter and a resistance r. By keeping the reading of the meter always the same, regardless of what the frequency of the oscillator may be, the voltage across the resistance r will always be the same. This can be controlled at different settings of the oscillator by varying the coupling between $L_1$ and the oscillator.

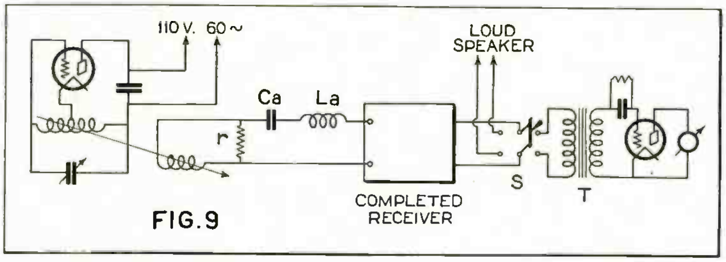

FIG. 9

Circuit arrangement for testing the sensitivity of a complete radio receiver. This system uses a modulated oscillator and either aural or visual indication.

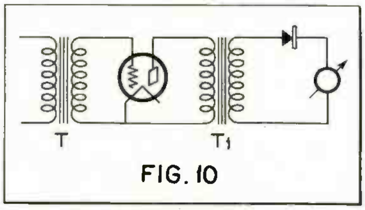

FIG. 10

A more sensitive indicating device which can be employed in connection with the circuit of Fig. 9.

This constant voltage across r is then impressed on the input circuit of the receiver. The condenser $C_a$ and the inductance $L_a$ simulate the antenna capacity and inductance respectively. The signal is amplified by the R. F. amplifier of the receiver, and is rectified by the detector. A microammeter connected in the plate circuit of the detector as shown in Fig. 8, and a local circuit consisting of a small battery and a variable resistance is connected in shunt with the meter. When there is no signal flowing, the "B" supply causes a flow of current through the meter in the direction indicated by the arrow a. The local battery E tends to cause a flow of current through the meter in the direction indicated by the arrow b. Now, when there is no signal applied to the detector, it is possible to adjust the resistance R so that the two tendencies nullify each other and the microammeter indicates zero. Then, when a signal is applied, as when the set is tuned to the oscillator, the meter will indicate the *change* of plate current caused by the signal, and the magnitude of this change is a direct measure of the sensitivity of the receiver. The same detector tube is used for all such tests.

### *Second Method*

Another method of doing the same thing is shown in Fig. 9; this method has the advantage that it also furnishes a check on the audio amplifier. This time the oscillator is modulated; in order to simplify matters, and to make sure the degree of modulation is always the same, it may be often desirable to make the modulation complete, that is, 100 per cent. Such an arrangement is illustrated in Fig. 9, in which the plate of the oscillator is energized directly from the 60 cycle, 110 volts mains. The oscillator feeds into a pick-up coil and resistance r as described before, and through the artificial antenna $C_a$ and $L_a$ into the antenna and ground binding posts of the receiver. To the loud-speaker terminals of the set is connected a transformer. A double pole double throw switch S enables one to connect the output of the set either to a loud-speaker, or to a transformer T. This transformer feeds into a vacuum tube voltmeter which has in its plate circuit a milliammeter as described in connection with Fig. 4. The deflection of this milliammeter is then a measure of the sensitivity of the receiver.

A more sensitive indication may be obtained by using the method shown in Fig. 10. The transformer T feeds into a vacuum tube which acts as an amplifier, in the plate circuit of which is another transformer $T_1$. In the secondary of this transformer is connected a carborundum fixed crystal rectifier and a microammeter The advantage of this method is that it enables one to use a very sensitive meter.

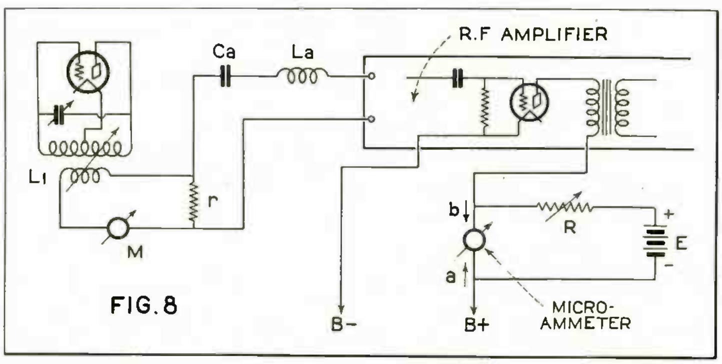

FIG. 8

Circuit arrangement employed for testing the sensitivity of an R.F. amplifier. A shielded R.F. oscillator is used.

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# Constructing a Modulated Oscillator

*A Handy Piece of Apparatus for the Professional Set-Builder, Service Man and Experimenter*

*By John B. Brennan, Jr.*

THIS article outlines the construction of a combination radio-audio frequency oscillator which is exceedingly useful to the professional set-builder, service man and experimenter because it allows him to make quick, effective tests not only on the receivers he builds but also to check the relative efficiency of various pieces of apparatus which is employed in the construction of such receivers.

Not so many years ago it was common practice to test the receptive qualities of a receiver by hitching up a buzzer in the antenna circuit and noting whether there was a response in the 'phones attached to the receiver. While this method was crude, nevertheless it was more or less effective. To calibrate a receiver it required the use of a wavemeter fitted with a buzzer so that the tone of the buzzer could be picked up on the receiver to be tested at the particular wave-length setting of the wavemeter.

The oscillator described here does this same job (besides many others, as listed elsewhere) in a more efficient way. By its use more accurate calibrations can be obtained due to the fact that the oscillator for generating radio frequencies can be made to produce a very sharp resonance curve. Taking the place of the old buzzer method of generating an audio tone is the audio oscillator which is coupled to the radio oscillator so that the wave of the radio frequency oscillator can be modulated and therefore picked up on any receiver.

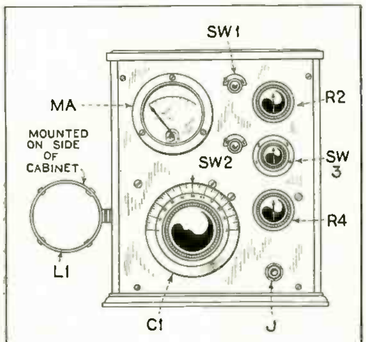


FIG. 2

A front panel view of the completed device.

### Adaptability of Device

Such an instrument is useful in the following ways; as a radio frequency oscillator it can be used as a heterodyne wavemeter, as a radio frequency generator or driver, to measure the gain per stage of a radio frequency amplifier, to measure the frequency range of radio frequency amplifiers, to determine the tuning range of inductances and to measure the frequency range of coil-condenser combinations. As an audio frequency oscillator the instrument is useful as a source of tone for testing the continuity of receiver circuits, for measuring capacity, inductance and resistance and for measuring the overall gain of audio frequency amplifiers. When used as a combined radio-audio oscillator, otherwise known as a modulated oscillator it can, with the aid of a receiver, measure unknown frequencies (as in the case of short-wave reception where it is desired to know the frequency adjustment of an amateur short-wave station); for measuring the tuning range of receivers and for setting a receiver to a known frequency.

In the particular instrument described here 3-volt tubes have been employed in both the radio and audio oscillators because they render very satisfactory service over a comparatively long period of time requiring only one 4½-volt "C" battery for filament illumination and one 22½-volt "B" or "C" battery for plate supply. If the instrument cabinet is deep enough these batteries may be placed inside. If not, they may be fastened by brackets to the rear outside wall of the cabinet.

### Description of Device

For obtaining accurate resonance indications a 0-1½ ma. milliammeter is included in the grid circuit of the radio oscillator. In operation a sharp dip of the needle of the meter, when the oscillator is coupled to the receiver or coil to be measured, will indicate reasonance. By loosening the coupling a more accurate resonance indication will be obtained.

By using plug-in coils in the radio oscillator it is possible, with the one tuning condenser, to obtain a wavelength range of from 15 meters to 550 meters. If it is desired to go higher than this, then by shunting a .0001 mfd. fixed mica condenser across the rotor and stator sections of the tuning condenser the range may be extended to 725 meters.

The audio oscillator has a closed circuit jack located in its plate circuit so that a pair of 'phones may be plugged in to hear the nature of the tone. By means of a switch connected to four condensers of the fixed type it is possible to obtain four different audio tones. The four condensers listed are satisfactory for general purposes but if the builder desires to obtain a tone of a definite frequency he will have to experiment for himself with other values of condenser until the desired tone is obtained.

### Construction

The instrument built by the author and illustrated here employs a panel 7¼ inches wide by 8⅝ inches long simply because that size of cabinet was available. There is no reason, of course, why a larger size of panel and cabinet may not be used. Simply maintain the same general layout of the instruments on the panel as shown in the accompanying drawings.

### Operation and Calibration

Calibration of the oscillator is not so difficult as it sounds. The procedure to be followed will be explained for the broadcast band of frequencies, the same procedure holding true for the short-wave band and intermediate band. A simple one tube regenerative detector is all that is necessary as an accessory. Insert the broadcast range coil in its mounting, place the oscillator near the regenerative detector, or instead connect the hinged coil in series with the antenna-ground lead of the regenerative detector, and then turn on both the detector and the radio oscillator. Begin at the high end of the detector tuning dial. When a station is tuned in determine its identity and wavelength. Usually this is possible by listening for the station's call letters and then by referring to a newspaper or call book listing that station's wavelength the frequency adjustment may be obtained. Now, without moving the dial of the detector tuning condenser rotate the dial of the oscillator. As resonance is approached it will be seen that the needle of the meter begins to fall back and then after resonance is passed the needle resumes its former steady position. By moving the hinged coil away from the secondary coil a lesser degree of coupling is obtained which results in a more sharply defined but reduced dip in the meter needle. At this point of dip the oscillator is in resonance with the regenerative detector whose wavelength setting is now known to be that of the station received and a notation can be made indicating the setting of the oscillator dial for that particular wavelength. By moving down on the detector tuning dial other stations can be picked up and the radio oscillator brought in resonance with the detector circuit. In

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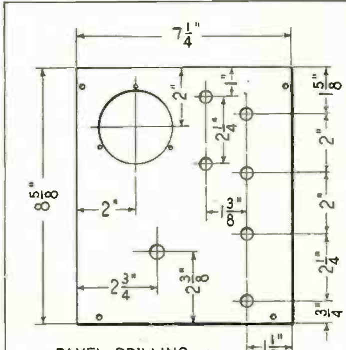
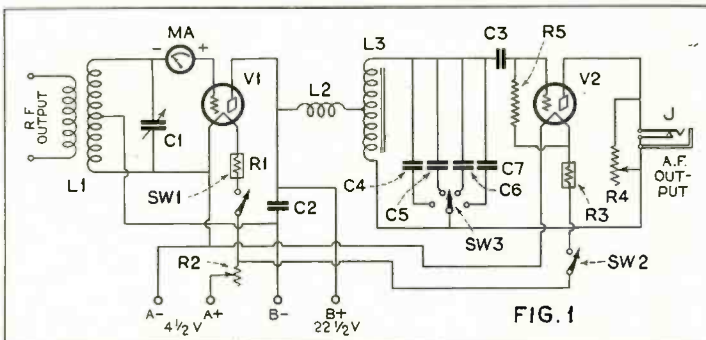



· PANEL DRILLING LAYOUT ·

FIG. 3

Dimensional details for the front panel.




The complete schematic diagram of the modulated oscillator described in this article.

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# Robertson-Davis Automatic Super-Six

*By Merwyn Heald**

THE radio fan gets a new thrill this season with the advent of automatic radio. The receiver that makes this possible is the new Automatic Super-Six (A.C. screen-grid operated) a product of the Robertson-Davis Company, Inc. of Chicago, well-known as the designers of the long-distance superheterodyne receivers, the Melo-Heald Eleven and the Hot Spot 14. Though this new receiver uses but six tubes, its ability for selectivity and distant reception is actually improved, and the automatic tuning feature makes it possible to bring in a desired station and cut out any other station being played by the simple expedient of pressing a button.

The name is a virtual description, for the Automatic Super-Six is a six-tube set using the superheterodyne circuit. It is entirely A.C. operated, using only the A.C. type of tube. The intermediate amplifier, which gives a tremendous gain per stage, is made up of three A.C. screen-grid tubes. The other three tubes are of the conventional A.C. variety.

Plug-in type transformers are used throughout. Both the primary and the secondary of these transformers are tuned and coupling is at optimum. The aluminum shields are sufficiently well removed so that effective resistance is not seriously increased. The intermediates are peaked at a frequency of 485 kilocycles, which is the most favored for one spot reception.

### Automatic Biasing

The chassis, which is entirely wired, is completely shielded in an aluminum case. Two rows of sockets project through this shield for receiving the plug-in type transformers and the tubes. Automatic bias resistors are built in the chassis thereby eliminating excessive leads.

Tuning is accomplished with a single drum dial by using a special condenser arrangement to tune the oscillator in unison with the aerial condenser. A trimmer condenser of .000050 mfd. capacity is provided to compensate for the slight difference caused by aerial lengths and power variations.

The volume control automatically governs the output of the receiver by limiting the amplification of the intermediate amplifiers. Because of this feature any desired amount of volume can be used without interfering with the performance of the set.

Ten kilocycle separation between high powered locals, and extreme distant stations is assured.

As it is impossible to force the receiver into a state of oscillation, no potentiometer being used on the intermediates, it is entirely free from all squeals and howls, which are characteristic of many receivers of this type.

Any length of antenna may be used, or the antenna lead, from the set may be grounded for the pick-up system.

### Short-Wave Reception

Another feature of this receiver is that short-wave coils can be supplied. The bands covered are 20–40, 40–80 and 80–120 meters. The standard chassis effectively covers the 200–555 meter band.

The receiver chassis is available in two types, one with and one without the automatic tuning feature. The panel of each is the same as far as the main tuning controls are concerned, except that the automatic chassis panel has the main tuning controls offset to the left to provide room for mounting the automatic station finder. On the standard chassis the tuning controls are located in the center of the panel.

### Automatic Tuning

Automatic tuning is permitted by a mechanical circuit switch control arranged so that the dial condensers are automatically removed whenever a selection is made on the automatic station finder. With this arrangement independent capacities are substituted for any predetermined automatic selection. The automatic condensers are uncalibrated and are simply set by a novel arrangement which permits the setting of the automatic oscillator or antenna condenser independent of its mate.

Any six stations can be selected and these can be changed at will. The desired station is tuned in on the drum dial and is then quickly transferred to the automatic tuner by two simple adjustments. When the six desired stations are adjusted to the automatic tuner, they are marked on the index holder. One button controls each of the six stations, another button is provided for manual operation of the set with the drum dial, and still another button is for use in adjusting the automatic station finder to the desired stations. Depressing any one of the buttons automatically releases any other depressed button and instantly throws into the circuit the two condensers which have previously been tuned to this desired frequency.

The method of setting the automatic tuner to a predetermined frequency is very simple. The desired station is first located on the drum dial. The button controlling one set of condensers on the automatic tuner is then depressed. A non-locking button on the automatic station finder is also depressed and held so until the station has been set upon one circuit. The function of this button is to retain control of one circuit on the drum dial, while the other is adjusted on the automatic tuner. After one circuit is adjusted for resonance the non-locking button is released and the other circuit tuned.

### The Audio Amplifier

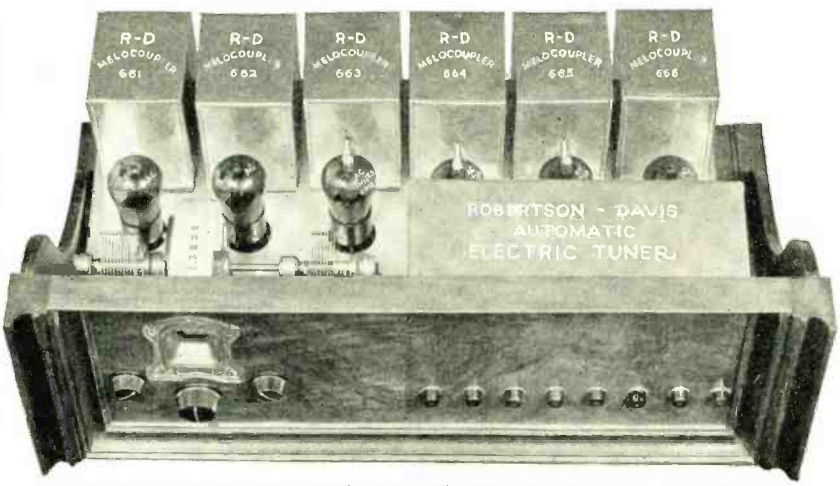
The audio which consists of one straight stage, followed by 210's in push pull, is made up in the form of a power amplifier, which also carries all the filament transformers and the chokes which supply all required "B" voltages.

An adjustable tap on one of the resistors supplies 110 volt D.C. fields for dynamic speakers. If this field is not desired, the two field binding posts may be short circuited, the tap adjusted, and the amplifier will function normally when an ordinary speaker is used.

A 20,000 ohm tapped resistor is provided for furnishing the necessary "B" voltage to the set under any line condition.

If it is desired to use the 250 tube, a standard Thordarson 250 power amplifier is recommended.

With these many new features, easy of assembly, simplicity of operation, quality of reception, ability to bring in distance, one spot tuning, and a high over-all amplification, the new Robertson-Davis A.C. Screen-Grid Automatic Super-Six seems well entitled to the considerable interest and enthusiastic reception that have been accorded it by radio fans and set-builders throughout the United States and Canada. At last, automatic radio has really and truly arrived, with all of the refinements indigenous to the finest dial-tuned set.




Full view of the Robertson-Davis Automatic Super-Six Receiver. Note the row of push buttons, which accomplish the automatic tuning.

* *Chief Engineer, Robertson-Davis Co., Inc.*

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In addition to the convenient automatic feature, the extreme sensitivity and selectivity of this receiver assures excellent reception during the daytime, as well as in the evening. Facilities are also provided in the power amplifier for the operation of a phonograph pick-up, converting the program from the air to your phonograph record.

Every possible factor of interference has been eliminated from this receiver. Iron and steel, which are usually the cause of undesirable coupling in any receiver, are not used; only aluminum, copper and brass are used throughout, assuring faithful service from the precision coils and transformers.

The audio for this receiver is all carried in a separate unit—none contained in the set proper. This eliminates the trouble from magnetic fields experienced with other A.C. and D.C. receivers.

LIST OF PARTS REQUIRED

1—Chassis Assembly; wired, laboratory-tested and sealed complete in a genuine aluminum case.

1—Volume Control; comes wired to chassis assembly with flexible leads.

1—Trimmer Condenser; comes wired to chassis assembly with flexible leads.

1—Dial Light; comes wired to chassis assembly with flexible leads.

1—Tuning Assembly; consisting of two variable condensers and one drum-dial, all mounted on special brass bracket with one shaft turning all units.

1—Walnut Drilled Front Panel.

1—Escutcheon Plate for Drum-Dial.

3—Bakelite Tuning Control Knobs.

6—Melocouplers, No. 661 to No. 666 inclusive, new plug-in type, aluminum shielded.

1—Package Hardware.

1—Automatic Electric Tuner (optional); wired, laboratory-tested and fastened as a part of chassis assembly when automatic tuning is desired and electric tuner is specified on order.

1—Complete set of blue prints and instructions.

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# New Short-Wave D.X. Receiver

## *By Perry O. Briggs**

A VERY few years ago, when short-wave radio was in its infancy, a fad originated, namely, Low Loss. An obscure but ambitious "ham" one day, for lack of suitable material, wound coils and wired a receiver of his own construction with copper busbar of prodigious size. It so happened that the strength of signals received by this obstreperous conglomoration were considerably greater than those received by an outfit of conventional design. Not only was the strength of the signals received perceptibly greater, but signals covering amazing distances were intercepted to which the adjacent outfit failed to respond. Radio mathematicians immediately hauled out their dusty, dog-eared, calculus books and after wading waist-deep in maxima and minima, proceeded to instruct a credulous radio world that all this Low Loss propaganda was pure bunk. However, Low Loss is still a serious consideration in the design of a short-wave receiver. Low Loss is firmly rooted in the amateur radio heart and it will take considerably more than mathematics to eradicate it.

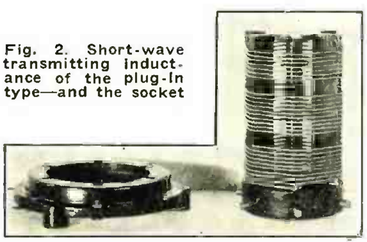

Fig. 2. Short-wave transmitting inductance of the plug-in type—and the socket

It is rapidly becoming general practice to economize to the last cubic inch in the design of high frequency receivers. Sad to relate, oftentimes all consideration of high frequency loss are totally overlooked. In the construction of the receiver to be described, all attempt to economize space is totally disregarded and forgotten. This receiver stands high, wide and handsome in its attractive crystalline lacquer finished metal cabinet.

Several considerations are kept in mind in the design of this particular receiver. First, the use to which it will be put. The radio listening world can be definitely divided into two parts, namely, the communicating amateur and the broadcast listener. To the last mentioned worthy individual we hereby respectfully dedicate this receiver.

A second consideration was that of the proper circuit to incorporate in a receiver to be used solely by a broadcast listener. The ideal circuit would be one employing a minimum number of controls. Likewise, extreme simplicity is highly desirable. As a result of much experimentation and deliberation, the three circuit tuner, a detector employing resistance control of regeneration, and a two stage amplifier were selected as the simplest and most effective as well as the most easily understood circuit. This is shown in Fig. 1. The last consideration but by no means the least, was the use of low loss apparatus. We incorporated every single low loss principle we were capable of bringing to mind. All leads which carry radio frequency are kept as short and direct as possible consistent with a fairly symmetrical layout.

During the process of development of this receiver, irrespective of its simplicity, it was conclusively proven that next to a sensitive detector, the worth of a receiver as far as selectivity and sensitivity are concerned, depends entirely upon the coil-condenser combination. Furthermore, 90% of all losses occur in this circuit. Therefore, it behooved us to use a coil and a condenser of extra low loss design and it is readily seen in the accompanying illustrations that we have followed this so-called unconventional path.

By employing a variable resistance shunted by a fairly high capacity to eliminate contact noises, the frequency drift which always occurs when regeneration is attempted by other methods, is practically eliminated. The receiver may be set to oscillating and the tuner may be varied through a wide frequency range without resetting the regeneration control knob.

### *The Inductances*

The tuning range of the receiver is from 100 to 10 meters (3,000 to 30,000 kilocycles). The three coils are so wound that there is a generous overlap of the frequency range between them. These coils consist of heavy enamelled copper wire wound on hexagonal ribbed bakelite forms. These may be plugged into a bakelite mounting which has positive contact devices.

Considerable mental exercise and deliberation was spent in developing a coil form which would offer the lowest radio frequency losses and best form factor. All attempts to make this coil form of diminutive size were abandoned simply on the hunch that a highly concentrated coil field would introduce losses and would be undesirable for use in a high frequency circuit. Comparative tests were made between all available types of inductances which are flooding the market at the present time. These were tests conducted in a laboratory where every available means of measuring signal strength, both aural and visual, were at hand. We picked on one particular long distance station as a source of signal strength because of its consistency and regular schedule. We then calculated the inductance of the coil we were using to receive this signal and wound a series of coils, using different forms, with approximately the same inductance. We could then rapidly change coils and derive voltage readings by the use of a vacuum tube voltmeter. A very great number of these tests were run every hour of the day and under every condition of weather. Averages were taken and comparisons made between the different coils. From this mass of data, some very surprising results were obtained and conclusions made. We were able to rate the different coils in percent efficiency and although the percentages in some cases ran closely together, we were able to glean considerable knowledge in the design of proper coils and coil forms. The same tuning condenser was used throughout all the observations. The coil which has been designed and constructed, as shown in Fig. 2, has employed in its makeup all the good points of other inductances on the market and it far surpasses any of them.

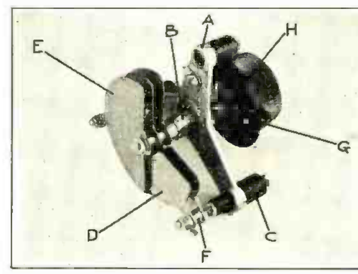


Fig. 3. The low capacity variable condenser used in the receiver.

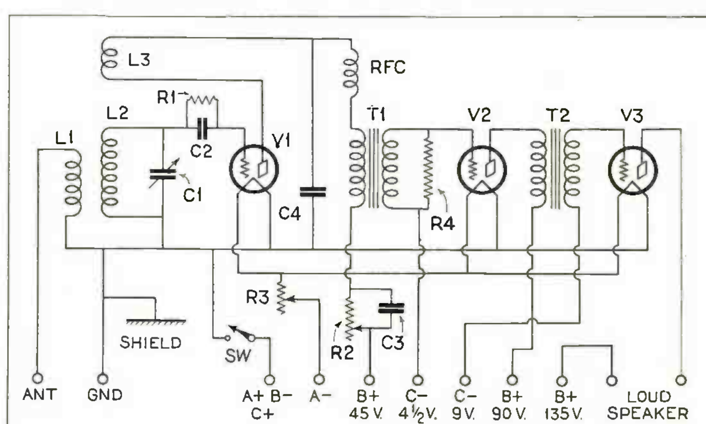


Fig. 1. The schematic diagram of the Short-Wave D.X. Receiver. The values are: $C_1$, 200 mmf.; $C_2$, 200 mmf.; $C_3$, 1 mf.; $C_4$, 1000 mmf.; $R_1$, 2.5 meg.; $R_2$, 50,000 ohms; $R_3$, 10 ohms; $R_4$, 200,000 ohms.

* *Radio Engineering Laboratories.*

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### *The Variable Condenser*

After attacking and defeating the tremendous but seemingly simple problem of designing a coil, we next pitched into the variable condenser of which there are more types and kinds than any single item in the radio field of commercial endeavor.

The best coil was selected from the covey and in conjunction with this particular coil, comparative tests were made between a large number of variable condensers.

Exactly the same procedure was followed. Incidentally, a good quiet vernier of smooth control was sought. Some of the poor construction which was run into in the present-day design of condensers, was actually pitiful. Some of the capacity curves which were derived by test, were as crooked as the Witch of Agnesi. After exhaustive observations and tests on more than a dozen different types of "low loss straight line frequency and capacity" condensers, we gave up in disgust and decided to design a variable condenser that would be a world beater. It has been so designed and built and far exceeds our greatest expectations. A close-up of this condenser appears in Fig. 3. Its unusual merits appear in alphabetical order below.

**A**—This one-piece cast aluminum frame is of rugged design. The three projections are symmetrically spaced around the thick center bushing which is drilled to retain the bearing mechanism. The ends of these projections are drilled and tapped to retain hard rubber mounting bushings.

**B**—The bearing mechanism: This absolutely prevents all end play. It is mercury-filled thus providing infallible and noiseless contact at all times. It is radically new and the design has been patented.

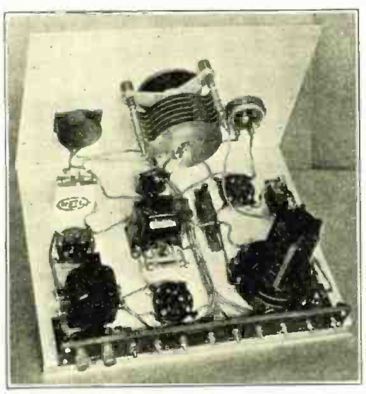

Fig. 5. Interior view of the receiver. Note the systematic layout of the components.

**C**—The hard rubber mounting bushings provide an opportunity to mount this condenser on a metal panel and still be effectively isolated from it. The condenser may then be used for many purposes.

**D**—These stator plates are of heavy sheet brass, polished and lacquered and are not easily warped out of shape. No attempt has been made to make this a straight line frequency condenser.

**E**—The rotor plates are likewise of polished and lacquered sheet brass and are firmly attached and accurately spaced on the shaft.

**F**—Here is a feature not found in other variable condensers of modern design. The stator plates are spaced by washers on threaded brass rods. Any number of stator plates may be added or subtracted from the total number, thus changing the maximum capacity of the condenser to any value desired. In this manner the tuning range of the condenser may be increased or decreased to cover any desired frequency range. The rotor and stator plates are so attached to the shaft and frame, that there are positively no bumps in the capacity curve due to the elements approaching each other during rotation of the rotor plates.

**G**—This washer in the bearing mechanism absolutely eliminates any possibility of end play in the rotor shaft. There is also a take-up adjustment so that compensation against wear may be accomplished. The shaft was coupled to a motor and run constantly day and night for a period of a week which is equal to the usage that a variable condenser would receive under normal operating conditions in an amateur station during fifty years. At the end of this exhaustive test, there was still *not a bit of end play!*

**H**—The shaft is of the standard size of one quarter of an inch so that any knob or pointer may be attached. It is readily seen from the above description that this is a condenser built to last a lifetime. Its truly low loss principles make this condenser a superior mechanism of ingenuity and engineering.

The combination of the above described coil and condenser when embodied in this receiver is the keynote to the great sensitivity and selectivity observed.

### *Grid Condenser and Leak*

Now that the details of the most important parts of the tuner have been thoroughly expounded, let us proceed to advise in regard to the numerous other minor details, all of which play a considerable part in the success of the outfit.

It is rarely taken into consideration in the building of any receiver, the extreme importance in selecting the proper amount of capacity and resistance in the grid condenser and grid leak combination. This sadly neglected subject was discussed theoretically in a most interesting article entitled "Some Principles of Grid-Leak Grid Condenser Detection", by Frederick Emmons Terman which appeared in the October issue of *The Proceedings of The Institute of Radio Engineers*. Through the deductions expounded by this article, which advocates grid condenser capacities between 150 and 250 mmfds. we have compromised and have embodied a grid condenser of 200 mmfd. capacity.

Since the receiver is to be used mainly for radio telephone broadcast reception in which the audio frequencies range between 15 and 5000 cycles, a grid leak of 2.5 megohms is used. This value affords the most sensitive and uniform detection at least sacrifice of tone quality and attenuation of the high audio frequencies.

The selection of suitable sockets next presented itself. The spring mounted socket was not found desirable inasmuch as at high frequencies, the swinging tube set up considerable "wobbulation" in the received signal. Firm sockets are employed and if there is a tendency toward noise due to vibrating elements, rubber tube jackets are used over the tubes to eliminate this unpleasant condition. This last disadvantage is far more easily overcome than the former.

The radio market was scoured for a variable resistor that was positive in its variation and absolutely free from backlash. Such a resistor was found in the roller bearing type. By shunting this resistor with a one mfd. condenser, all contact noise was eliminated and a regeneration control was obtained that far surpassed any other method. It is quiet in operation and there is no backlash to "fudge up" the incoming signal. This resistor is of fairly low ohmic range. Not more than 50,000 ohms variation is needed in controlling regeneration. To use more resistance makes the oscillating fringe too abrupt.

All by-pass condensers are of the molded mica type and little need be said about them except that they are entirely satisfactory. The audio transformers used are of rugged construction and 5 to 1 ratio. The secondary of the first audio transformer is shunted by a fixed resistance of 200,000 ohms to eliminate the deadly "fringe howl" which is so disturbing in high frequency operation. The two audio amplifiers are C biased thus lending a quality of reproduction which equals any high priced long wave broadcast receiver on the market.

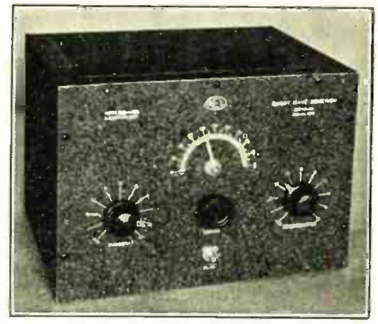

Fig. 4. A front panel view of the completed short-wave receiver.

Again, in contradiction to present day kinks, an "old-fashioned" binding post strip is utilized for making connections to the external accessories. This minimizes the chances of burning out all the tubes at one fell swoop when a wrench or screwdriver falls among the terminals of a congested gang plug-in terminal.

### *Results Obtained*

Needless to say, the results obtained on this outfit are well nigh to phenomenal. We doubt if there is a short wave broadcast receiver on the market at the present time which will bring in the foreign broadcasting stations with loud-speaker volume. Remember, this set does not employ screen-grid tubes. We can safely say that this receiver is the equal of any screen grid set obtainable and it is far simpler and far easier on the batteries.

Very few broadcast fans realize the amount of entertainment which exists below the tuning range of their ordinary receivers. The frequency range which exists between 100 and 10 meters is twenty-five times greater than that which exists in a custom built high wave broadcast receiver. This feature alone is attractive. Think of it! Twenty times the number of channels. Among the high powered broadcast stations operating below 100 meters are KDKA, 58.8 meters; WGY, 65 and 100 meters; 5SW, London, 23 meters and countless others scattered throughout the world, many of which furnish excellent programs and rebroadcast entertainment.

It is hard to foretell where short waves are leading us, but it becomes more apparent every day that the high frequency end of the radio spectrum is the only truly practical solution to the heartbreaking problem of proper station allocation. It would be a wise procedure to initiate the general listening public into the secrets of short-wave radio and, in our belief, a receiver such as has been outlined above offers an economical, effective and simple means of approaching this intriguing subject from the right direction.

# 222 Short-Wave Converter

*By Perry S. Graffam*

As the one stage R. F. with regenerative detector rapidly became the outstanding circuit arrangement in home built receivers during the great broadcast building era, so has a similar circuit taken the short wave field. With this type of set just beginning to be appreciated, vast numbers of parts have been sold for these receivers.

The circuit used in short waves, however, uses an untuned input rather than a tuned antenna circuit, and in this way, differs from the accepted broadcast practice. This tube has several purposes. It permits the use of an antenna of any length without adjustment; it gives some amplification to the incoming signal; and most important of all, it prevents squeals from going out to the neighboring sets. This latter point may not impress some of our recent listeners, but those who listened in two or more years ago will never forget the so-called "blooping" that characterized every evening's entertainment in those days. With the great increase in the number of short wave receivers, this same condition will occur down in those frequencies unless a blocking tube is used to prevent regeneration radiation.

A general impression among many peo-

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ple. not familiar with short waves, is that a completely new receiver must be built to get the myriad programs on the air down there. This is not the case however. The short wave receiver differs only in the tuning section. From the detector on, the arrangement is identical with any radiocast receiver.

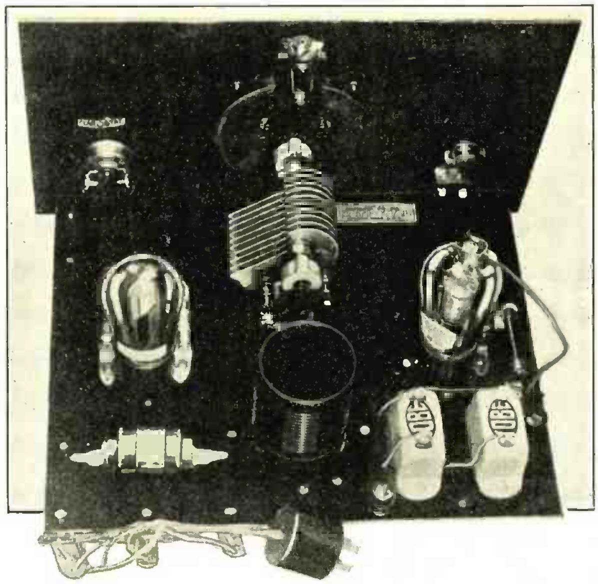
A simple converter which will permit one to use this most popular of short wave circuits, in connection with their present radiocast receiver, is described in this article. After completing it, one merely has to remove their detector tube and insert the plug of the converter in its place. The detector tube is then placed in the converter and you can then tune in around the world.

It hardly seems necessary to go into any specific constructional details, for the accompanying illustration and schematic diagram tell the whole story. Only few parts are needed and the placing of these is indicated.

Any old tube may be used for the plug-in socket base. The glass should be broken, and the other material in the base cleaned out. The four brass tips will come into view, and the necessary connecting leads should be soldered to these. The plug may then be filled with wax. This takes care of three of the four external leads to the set. The 135 volt connection is made onto a binding post at the rear of the unit.

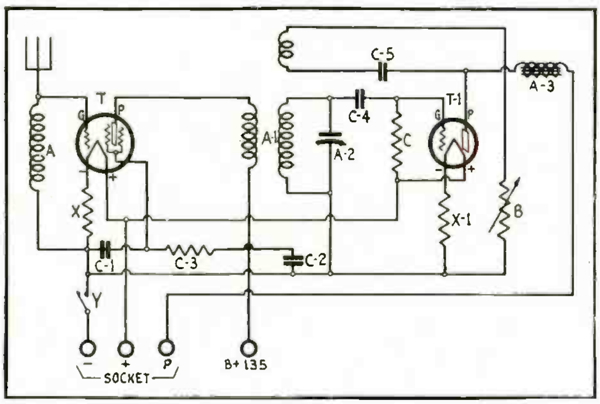
Readers have perhaps little idea of the radio sport that lies in wait for them down on the shorter waves. Up until this year there was so little to listen to except code that a set hardly seemed worthwhile, but now, any number of stations are broadcasting on these wavelengths. Stations all over the North American continent are heard during daylight hours, some of which cannot be heard even at night time on a good radiocast receiver.

But the real thrill comes in the transoceanic reception. 5SW, the British Broadcasting Company's station at Chelmsford, England, can be picked up from five on until seven p. m. Eastern Standard Time, and under favorable conditions may be brought up to loudspeaker strength. This station usually closes with an hour of dance music, and when you can clearly hear the music, dancers' voices, the hand clapping for encores from the Savoy Hotel in London, right from your own loudspeaker, you are getting real radio thrills.



Rear view of the 222 Short-Wave Converter, which has but one tuning control. Regeneration is effectively controlled by a Clarostat.

Now Germany is just completing a powerful short wave station with which they expect to radiocast excellent programs to the whole world. A particularly strong station is the one in Eindhoven, Holland, which puts on regular programs for use in the British colonies and other remote points. This station is more widely heard than any other short wave station in the world according to many reports. The thoughts of getting distant places like these usually conjure up visions of super-priced receivers using fourteen tubes, and totally out of the reach of the average fan to build, buy or operate. But, thanks to the gift of short waves, this is not the case. Just build up the little simple unit described herewith; connect it to your present radiocast receiver, and like Monte Cristo, you can say, "The World is mine!"




Schematic diagram of the 222 Short-Wave Converter. Note that the parallel feed system is used in the detector circuit. Regeneration is controlled by the resistance B.

LIST OF PARTS REQUIRED

1—National Short-Wave Kit (consisting of front and sub-panels, set of plug-in coils, tuning condenser and choke).
1—Clarostat Grid Leak.
1—Tobe 8-meg. Tinon Leak.
2—Tobe 0.5 mfd. By-Pass Condensers.
1—Tobe 2000 ohm Veritas Resistance.
1—Tobe .00025 mfd. Vacuum Condenser.
1—Tobe .001 mfd. Vacuum Condenser.
1—622 Amperite.
1—1-A Amperite.
1—Yaxley Switch.

# Precision Resistance-Coupled Amplifiers

*By Engineering Staff*
*International Resistance Company*

THE resistance-coupled amplifiers in common use today have two inherent disadvantages. In the first place, they require altogether too many B and C batteries; in the second place, they are unstable. It is true that reasonably stable amplifiers have been built—amplifiers with a maximum gain of 70 T.U. and a variation of less than 10 T.U. over a range extending from 30 to 6000 cycles. There are, however, many instances when an amplifier capable of handling direct and audio frequency voltages up to 10,000 and even 30,000 cycles, is highly desirable.

### *Excellent Frequency Characteristics*

Such an amplifier has recently been designed in England, and, after much experimentation, its basic principles have been successfully applied to standard American vacuum tubes. Here in America, we have developed two remarkably stable amplifiers. The first is capable of giving an excellent gain on direct voltages and audio frequency voltages up to 10,000 cycles, while the second gives these same results up to 30,000 cycles. In both amplifiers the uniformity throughout the frequency range leaves little to be desired. In one model having three stages, the overall gain is approximately 60 T.U. with less than 10 T.U. variation between 0 and 300 cycles, and 6 T.U. between 3000 and 6000 cycles. For use in a broadcast receiver, an amplifier of this type will provide excellent results for moderate power output, since the frequency band necessary for excellent reception extends from 30 cycles to 6000 cycles. It has the added advantages of simplicity and low cost, but its particular field of application is found wherever it is necessary to amplify direct voltages or very low frequency alternating voltages.

A three-stage amplifier, operating on this principle, is shown in Fig. 1. It will be noted that the amplifier is resistance-coupled throughout. The A, B and C batteries are all in series. For convenience, a separate C battery of 1.5 volts is used in the first stage. The condenser for the

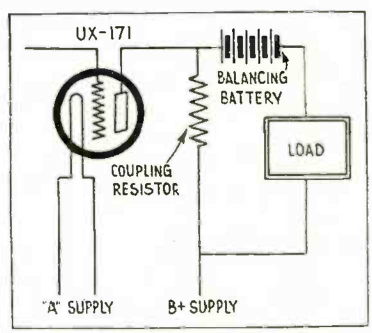



Fig. 2. Method used for amplifying direct voltages.

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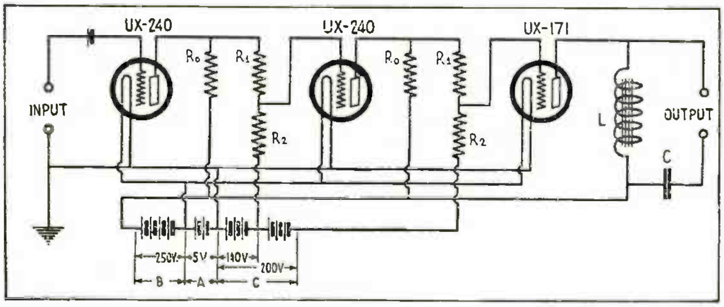



Fig. 1. Diagram of the straight resistance coupled A.F. amplifier. The values of the components are: $R_0$, 0.5 meg.; $R_1$, 0.75 meg.; $R_2$, 1.0 meg.; L, 30 henries; C. 4 M.F.

speaker filter must be large enough to pass the lowest desired frequency. For 30-cycle alternating current, this condenser should be at least 4 mfd. The condenser cannot be used at all for direct-current amplification.

Because of the uniform gain of this amplifier, it becomes necessary to employ precision, noiseless, permanent resistors, preferably of the metallized type.

For use in amplifying direct voltages, and alternating voltages of less than 30 cycles, the output choke in the last stage may be replaced by an output resistance having a value of twice the plate resistance of its associated tube, together with a battery so connected that its tends to send current through the output resistance in a direction opposite to the current from the B supply, as shown in Fig. 2. When the voltage of this battery is properly adjusted, there will be no current through the load when there is no voltage impressed upon the input of the amplifier.

The accurately plotted curve of the response of this amplifier shows a practically flat portion from less than 30 cycles up to 1000 cycles, with a gradual falling off up to 10,000 cycles. A gain of 60 T.U. is maintained up to 1000 cycles, followed by a gradual falling off to 40 T.U. at 10,000 cycles. The decreased gain at the higher frequencies is attributed to the high effective inter-electrode capacity of the high-mu tubes. It will be noted, therefore, that the overall gain of such an amplifier is approximately the same as that obtained in the usual resistance-condenser coupled amplifier, while the frequency characteristic is flat over a longer range.

### *Adjusting Amplifier*

In adjusting the amplifier, milliammeters should be placed in the plate circuits, and the C bias adjusted until the milliammeters show the rated current for each tube. Such an amplifier is extremely stable under proper operating conditions. Changes of 1 or 2 per cent in the B or C batteries do not affect the operation appreciably. To use the amplifier as an electrostatic voltmeter for direct voltages, the C bias of the last tube is slowly increased until the plate current, as read on a milliammeter in the plate circuit of the last tube, reaches zero. The amplifier can then be calibrated in terms of plate current in the last stage, with known direct voltage.

In the laboratory the amplifier shown in Fig. 1 was operated throughout from storage B-batteries. The A battery was the usual 6-volt storage battery. The B-battery was a 250-volt storage battery, and the C-battery a 200-volt storage battery. There is no reason, however, why a good B-supply device could not be used in place of the B and C storage batteries, provided sufficient by-pass condensers are employed across the taps of the supply in order to prevent conductive coupling between stages of the amplifier.

### *Television Amplifier*

Our second amplifier is not primarily intended for broadcast reception, although it may be employed for that purpose. It has a gain-frequency characteristic which is flat from below 30 cycles to above 15,000 cycles, decreasing only 7 T.U. at 30,000 cycles. This amplifier is especially well adapted to television experiments and to any purpose requiring uniform amplification over the entire audio-frequency band. The overall gain of this particular model is 54 T.U.

The circuit, shown in Fig. 3, is quite novel. The first two stages employ the standard screen-grid or 222 tube, while the last stage calls for a Western Electric type 101-D tube, although any power tube may be employed in the last stage with slight alterations. It will be noted that the first two tubes are connected according to the screen-grid method. This decreases the effect of grid-plate capacity, with its resultant dropping of the gain-frequency characteristic at the higher frequencies. However, for a still flatter characteristic, the equalizer, shown in the output circuit of the last tube, has been inserted. This equalizer, comprising a series circuit containing an inductance (choke coil) of approximately 750 millihenries, and a resistance of 3500 ohms, is connected across the load. It acts as a high-pass filter, the value of the resistance governing the amount of signal lost at the low frequencies.

In this amplifier the plate and grid bias voltages are somewhat critical. Shielding of the amplifier, however, is entirely unnecessary.

Although this amplifier requires a high voltage and is somewhat critical in its initial adjustment, its performance is so extraordinary good that this staff has found no other to take its place where high and uniform amplification over the entire audio-frequency band is required.

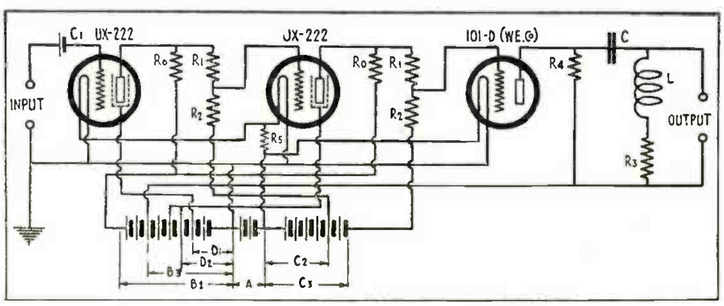



Fig. 3. Diagram of the television amplifier. The values are: $R_0$ 0.25 meg.; $R_1$, 0.75 meg.; $R_2$, 1.0 meg.; $R_3$, 3500 ohms; $R_4$, 6000 ohms; $R_5$, 10 ohms; L, 750 M.H.; C, 4 MF.; A. 6 v.; $B_1$ 450 v.; $B_3$ 270 v.; $C_1$ o to-4 v., variable; $C_2$,-160 v.; $C_3$,-166 v.; $D_1$,-39 v, and $D_2$,-42 v.

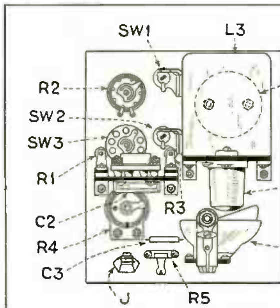
## CONSTRUCTING A MODULATED OSCILLATOR

(*Continued from page* 41)

this way a number of points may be obtained, which when plotted on cross-section paper will result in atuning curve.

When calibrating the short-wave coils those who know how, may pick out the harmonies of stations operating in the broadcast range and so obtain a number of calibration points. Otherwise it is necessary to identify short-wave stations on a receiver and follow the same procedure as stated above.

To operate the oscillator it is merely necessary to turn on the switch for either the radio or audio sections or both, if it is to be used as a combination oscillator, and then with the rheostat adjust the response to a desired value. Then if it is desired to determine the tuning range of a coil-condenser combination in a receiver, merely couple it close to the oscillator, set the test circuit at maximum and then rotate the oscillator dial. Not only will resonance be indicated by the grid meter but also if a pair of 'phones are attached to the receiver being tested a modulated carrier will be heard. Then the same procedure may be followed at the minimum setting of the receiver dial. Where it is desired to regulate the amount of audio tone the variable resistance shunting the output jack may be adjusted to the desired setting.




-BACK VIEW-
FIG. 4

Rear panel view of the modulated oscillator.

### LIST OF PARTS REQUIRED

C1—One Hammarlund Midline Condenser, .0001 mfd.

C2—One Tobe By-pass Condenser, 1 mfd.

C3—One Tinytobe Condenser, .0001 mfd.

C4—One Tinytobe Condenser, .00015 mfd.

C5—One Tinytobe Condenser, .0005 mfd.

C6—One Tinytobe Condenser, .0015 mfd.

C7—One Tinytobe Condenser, .01 mfd.

R1, R3—Two Amperites, type 4v-199.

R2—One Yaxley Rheostat, 10 ohms, No. 510.

R4—One Electrad Royalty Variable Resistance, type L, 0 to 500,000 ohms.

SW1, SW2—Two Yaxley Battery Switches, No. 10.

SW3—One Yaxley 4-point Inductance Switch, No. 44.

L1—One Aero Coil Kit, No. LWT-12, with additional coils, Nos. 4 and 5.

L2—One Hammarlund R. F. Choke Coil, No. 85.

L3—One Silver-Marshall Output Push-Pull Transformer, No. 231.

Two Benjamin Red Top Sockets, No. 9040.

One Yaxley Closed Circuit Jack, No. 2.

One National Velvet Vernier Dial, type A. 3⅜ inches.

R5—One Durham Grid Leak, .5 meg.

One Durham Single Resistor Mount.

Two CeCo BX tubes.

One Panel 3/16 inches by 7¼ inches by 8⅝ inches.

One Cabinet, to take above panel.

One Box Corwico "Braidite."

One Eveready 4½-volt battery and one 22½-volt battery.

Miscellaneous bakelite strip and brass strip.

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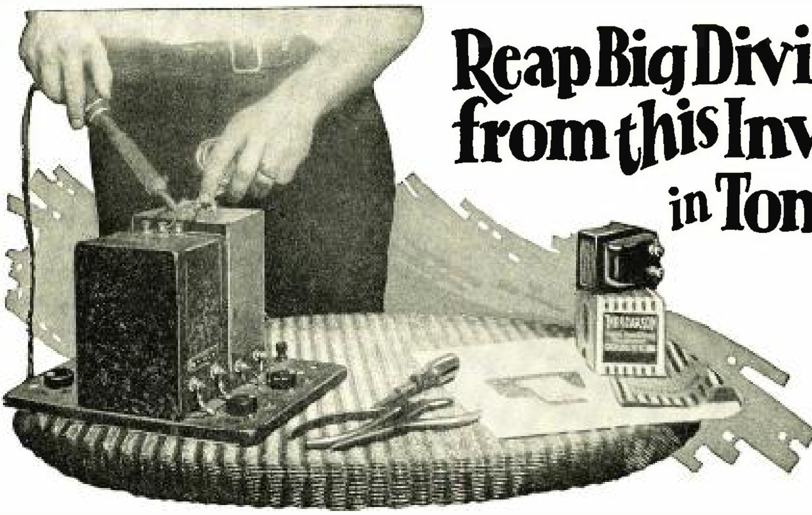
# Reap Big Dividends from this Investment in Tone Quality



## A Thordarson Power Amplifier (Home Constructed) Will Transform Your Radio Into a Real Musical Instrument

WITH the insistent demand for quality reproduction, power amplification has become a vital radio necessity. Today, it is hard to find a radio set manufacturer who does not employ one or more power tubes in the output stage of his receiver.

There is no need, however, for you to discard your present radio instrument in spite of the fact that it is outclassed by newer models with power amplification. You can build a Thordarson Power Amplifier which, attached to your receiver, will provide a fullness and richness of reproduction that will equal or surpass the finest offerings of the present season.

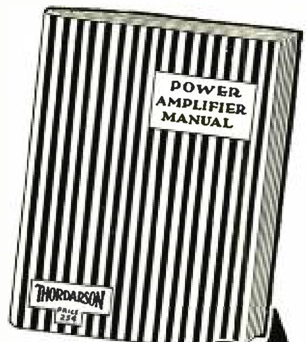
Thordarson Power Amplifiers are exceedingly easy to assemble, even for the man with no previous radio experience. Only the simplest tools are used. Specific instructions with clear-cut photographs, layouts and diagrams insure success in home construction.

Whether your present receiver is factory made or custom built one of these amplifiers may be attached with equal ease. In fact, most Thordarson Amplifiers require absolutely no changes in the wiring of the receiver itself, attachment being made by means of a special plug which fits the last audio socket of the receiver.

Thordarson Power Amplifiers for the home constructor and professional set builder range from the simple plate supply unit up to the heavy-duty three stage units employing the 250 type power tube in push-pull arrangement. These power amplifiers cover the requirements for every purpose and every pocket-book. They may be used with any type of horn, cone or dynamic speaker.

With a background of over thirty-three years manufacturing quality transformers, it is only natural that so many manufacturers of receiving sets of undisputed superiority have turned to Thordarson as the logical source of their audio and power supply transformers. The discriminating home constructor will do well to follow the lead of these manufacturers when buying his power amplifier.

Write to the factory today, enclosing 25c for the new "Power Amplifier Manual"—just off the press.




*New!*

**No Amateur or Professional Set Builder Should Be Without This Book—**

**"POWER AMPLIFIER MANUAL"**

A simple, yet complete, treatise on the subject of audio and power amplification, including full information on building, servicing, and testing power amplifiers in general. Also contains detailed specific construction data on twelve individual power units, with clear-cut layouts and diagrams of each.

**25c**

**Send 25c in Cash or Stamps for This New Book—** ***Just Off the Press!***

# THORDARSON
## RADIO TRANSFORMERS

SUPREME IN MUSICAL PERFORMANCE

**MAIL THIS COUPON TO-DAY!**

THORDARSON ELECTRIC MANUFACTURING CO.
500 West Huron Street, Chicago, Illinois

Gentlemen: Please send me your new "Power Amplifier Manual" for which I am enclosing 25c. ☐

Please send me free of charge your instruction sheet on the amplifier I have checked below:
171 Single ☐. 171 Push-Pull ☐. 210 Single ☐. 210 Push-Pull (1 Stage) ☐. 210 Push-Pull (2 Stage) ☐. 250 Single (1 Stage) ☐. 250 Single (2 Stage) ☐. 250 Push-Pull (3 Stage) ☐. 210 Phonograph Amplifier ☐.

Name..........................................

Street and No..........................................

Town.......................... State..........................

3586 K

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## FEDERATED PLANS FOR CONVENTION MATERIALIZING

Plans for the coming Convention of the Federated Radio Trade Association are rapidly nearing completion. The Convention will be held in Buffalo, February 18-19-20, 1929, at the Hotel Statler. The Buffalo Radio Trade Association and the Rochester Radio Trade Association have combined to form a joint reception for the benefit of all visiting radio tradesmen. The plans that are now under way calls for speeches to be made by Mr. Harold J. Wrape, President of the Federated, Major H Frost, President of the R. M. A., Mr. Wm. Hedges, President of the National Association of Broadcasters, together with a thorough discussion on the present broadcasting situation by the Hon. Frank D. Scott of Washington, D. C.. Judge Van Allen of Buffalo, will also present a paper of the legal aspects of radio merchandise.

It is planned to make the first day open for all visitors and members to hear worth while addresses and to discuss problems pertinent to the radio trade. The second day will be devoted to the individual sectional meetings for problems of their own particular need. The third day will be a joint meeting with election of a new Board of Directors, and officers for the coming year. The Federated plans on making this the most worth while and successful Convention which they have ever held. It will be the first one in which the individual groups of distributors have a chance to participate in the activities pertaining directly to their own particular phase in merchandising.

The Board of Directors of the Federated will meet within the next thirty days to complete and discuss further activities for this Convention.

The executive officers of the Federated wish to announce the application of the Indiana Radio Trade Association of Indianapolis, Indiana, and the Radio Division of the Cincinnati Electric Club, Cincinnati, Ohio.

The Federated wishes to extend at this early date an invitation to every radio tardesmen to attend this Convention.

## NOTED PATENT AUTHORITY NOW ON RAYTHEON STAFF

Realizing the importance of patents as a foundation for permanent radio enterprise, the Raytheon Manufacturing Company of Cambridge, Mass., has established a patent and legal department under the supervision of LeRoy Williams. Mr. Williams has been associated with the Cadillac Motor Company and with the Westinghouse Electric & Mfg. Co., in the capacity of patent counsel. He is a recognized authority on radio patents and litigation, having specialized in the radio patent art during the past few years. Mr. Williams has been elected Secretary of the Raytheon organization and a member of the Board of Directors.

## KNOWLES JOINS SILVER-MARSHALL

Mr. Hugh S. Knowles, B.S., M.A., a graduate of Columbia University and the possessor of an enviable reputation has joined the engineering staff of Silver-Marshall, Inc. Mr. Knowles has been until recently in charge of radio engineering and research for the Hammarlund Manufacturing Company. His radio experience dates however, from the early days; as far back as 1914 he was operating a "ham station." Alternating with his studies at the Alabama Polytechnic Institute he "saw the world" as a sea-going "op" with R.C.A. An ambition to extend his engineering knowledge took him to Columbia University, where he was for two years in charge of experimental work at the University stations 2FK and 2XM. The first trans-Atlantic Belin picture transmission test was made possible through the use of receiving equipment designed by Mr. Knowles at Columbia. In recent years he was in charge of research and equipment development with the W. J. Murdock Company, which concern he left, later to join the Hammarlund Manufacturing Co. in charge of radio research. Two years on the technical staff of "Popular Radio" helped also to give Mr. Knowles a very direct insight into the problems of the set-builder.

## ARTHUR MOSS ELECTED PRESIDENT OF ELECTRAD, INC.

Mr. Arthur Moss, treasurer of Electrad, Inc., in charge of sales and advertising since the company was formed, has been elected president of the company.

Electrad, Inc., about five years ago began manufacturing a wide range of high-class radio parts at 428 Broadway, which address was retained until the beginning of last year. From the very inception of the company, its line met a ready acceptance on the part of both the general public and of radio set manufacturers.

**MR. ARTHUR MOSS**
**President, Electrad, Inc.**

Under Mr. Moss' management, the company's sales have rapidly increased, until it is now recognized as one of the leaders in the industry. Since January, 1927, the company has been located at 175 Varick St., in much more commodious space and with greatly expanded factory facilities.

Mr. Moss' accession to the presidency of Electrad, Inc., is significant as undoubtedly indicating a distinctly progressive policy within the organization that bids fair toward its further growth.

## LYNCH LEAVES CECO

In a letter, addressed to all the CeCo jobbers in the New York Metropolitan District, Arthur H. Lynch, who has made the CeCo name respected in that territory as well as throughout the country by his honest sales policies and exceptional publicity efforts, announces that his relations with CeCo terminated November 15th.

Lynch says that he approves of this move on the part of the CeCo Manufacturing Co., and assures the CeCo jobbers that they will be given even better service by the factory in the future. He makes no bones about the fact that the change is not of his own choice and expresses his thanks for the co-operation and the support which his jobbers have given him.

In spite of rumors to the contrary, Mr. Lynch says he is not associated with any other tube company, although several have made offers to him as soon as they learned of the impending break with CeCo.

Lynch and CeCo have been synonymous in this territory for some time and it is gratifying to find a severance of this nature unaccompanied by the vituperation customary under such conditions.

## KESSLER JOINS ROYAL-EASTERN

S. J. Kessler resigned from Allen-Rogers-Madison to take hold of the new mail order division established by the Royal-Eastern Electrical Supply Co., 16-18 West 22nd street, New York City. Royal-Eastern is one of the largest radio ditsributors and has been in business thirty-one years.

## L. M. CLEMENT WITH KOLSTER

Kolster Radio Corporation announces the engagement of Mr. Lewis M. Clement, until recently Chief Engineer of the Fada Company, to head the new Kolster research laboratories at Newark.

Mr. Clement, prior to his connection with the Fada Company, was for many years a radio engineer for Western Electric Company and took a leading part in the development of carrier current and wired radio for Western Electric.

Mr. Clement's appointment is part of the expansion program planned by Kolster in connection with the important contracts just consummated with the North American Company for the manufacture of apparatus for North American's subsidiary, Wired Radio, Inc.

## RADIO PIONEERS' DINNER

Radio pioneers of Union County, New Jersey, to the number of forty, accompanied by their wives, attended a re-union banquet at the Elizabeth Carteret Hotel, Elizabeth, N. J., on the evening of November 8.

Robert H. Horning, of Roselle Park, N. J., was toastmaster. Most of those present were members of the old Roselle Park Radio Club which went out of existence some years ago when the members grew up and separated.

The music accompanying the dinner, and for dancing was furnished by radio.

The speaker of the evening was Donald McNicol, past president of the Institute of Radio Engineers. Mr. McNicol related reminiscences of the early days of radio. As his connection with the art extends back to the year 1899, he was able to tell many amusing as well as instructive stories about the beginnings of radio.

## CECO INCREASES PRODUCTION FACILITIES

Material additions to the production facilities of the CeCo Mfg. Company of Providence, R. I. are reported.

The expansion of the business has been such that material additional to floor space has been made and plans are in preparation for an additional building of large dimensions.

Much new equipment of the latest design is being installed; yet despite these time saving and necessary changes, two shifts are still required to meet the constantly increasing demand for CeCo Tubes.

It is stated that the CeCo Tube business for October was 100% increase over the business for September. Also more than 100% increase over the business of October of last year.

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# Let's Get Serious About Short Wave Broadcast Reception

THE present-day broadcast station reallocations and chain programs are making great inroads in the enthusiasm of the broadcast listener. Real DX on the high broadcast waves is a thing of the past. Short waves are offering new worlds for exploitation. The ultra-modern broadcast listener seeks his entertainment below 100 meters.

For those not desiring to build their own receivers, we have a complete three tube broadcast short wave receiver kit, furnished with metal case and aluminum front panel and finished in black crystalline lacquer. The tuning condenser is equipped with a noiseless friction vernier, and the dial scale is directly engraved on the front panel. Each part has been carefully corrected and tested. Comprehensive instruction booklet enables any one to successfully assemble and place in operation this unique receiver. Three REL inductances are furnished with each receiver. These coils are so wound that there is a generous frequency overlap between them. There is no part of the frequency range between 15 and 100 meters that cannot be reached in tuning. Kit price $45.00.

Kit may be secured completely assembled, wired and tested under laboratory supervision at a moderate additional cost.

Have you secured your data on Amateur Transmitters and Receivers? If not, send your 25c for the second edition of the REL catalog.

Three blug-in coils and one coil base constitute the essential inductances for the ideal short wave broadcast receiver. Wave length range 15 to 100 meters. Cat. 182CBA coil kit, Price $10.


Type No. 181 High Frequency Condenser. A condenser which meets the requirements of short wave operation. Patented rotar shaft bearing makes positive contact between tho shaft and the frame infallible. It embodies many other exclusive features. Also made in a combination continuously variable vernier condenser and semi-fixed tank model.

**RADIO ENGINEERING LABORATORIES**

**98 WILBUR AVENUE, LONG ISLAND CITY**


# CONDENSER TISSUES

**NO Radio set is any better than its weakest link, and the weakest link is very often a filter Condenser. No Condenser is any better than the thin strips of Insulating Tissue which separate the layers of metal foil. A pinhole or a speck of metal in the Condenser Tissue means a breakdown of the Condenser, with the entire set put out of commission.**

**DEXSTAR Condenser Paper is regarded by Radio experts as being the highest grade Insulating Tissue ever made—the freest from defects, the most uniform in quality, the most lasting under exacting and unusual requirements. DEXSTAR Condenser Tissue is the specialized product of a paper mill which has excelled in Tissue Paper production for three generations.**

***RADIO designers and builders should have the assurance that Condensers which they use are made with DEXSTAR Condenser Tissues. It is insurance against many radio troubles. The leading Condenser manufacturers are now using DEXSTAR Condenser Tissues exclusively.***

**C. H. DEXTER & SONS, INC.**

***Makers of Highest Grade Thin Papers***

**WINDSOR LOCKS, CONN.**

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## PHILCO PURCHASES NEW PLANT

The Philadelphia Storage Battery Company, makers of Philco all-electric radios, announce the purchase of an additional 100,000 square feet of ground with a large factory building, which will enable the company to double its output of radio sets. Improvements to cost nearly $750,000 already have begun on the property and buildings, which are located at Allegheny and C streets, just one block from the present Philco factory.

The newest Philco purchase gives this concern a total of six factories in and near Philadelphia. The new building will be used first of all for production of parts, and secondly it will be used to relieve the Philco speaker factory, at Germantown, Pa., of its present congestion.

## DE FOREST PRESIDENT ANNOUNCES ADVISORY COMMITTEE

As a further measure in perfecting the administration of the affairs of his organization, James W. Garside, President of the DeForest Radio Company of Jersey City, N. J., now announces the appointment of the following to the DeForest Advisory Committee:

Wiley R. Reynolds (Chairman of Board, Reynolds Spring Company); Powel Crosley, Jr. (President, The Crosley Radio Corporation); P. Chauncey Anderson (Pendleton, Anderson, Iselin & Riggs) Samuel E. Darby, Jr. (Darby & Darby).

Added to the foregoing are the following members, ex-officio:

A. J. Drexel Biddle, Jr., Chairman of the Board, DeForest Radio Company, and James W. Garside, President, DeForst Radio Company.

## RADIO EXPORTS GAIN

Exports of radio apparatus as a class during September increased $359,374 compared with the same period last year. The individual items under this class making the largest gains were receiving sets and receiving set components, these classes of apparatus increasing $246,715 and $113,529, respectively. Receiving set accessories showed a slight increase and exports of tubes decreased somewhat.

Canada, of course, is our most important market for radio apparatus, shipments of receiving sets to that country during September amounting to $362,613, receiving set components $168,005 and receiving set accessories $155,081.

Argentina continues to offer a good market for both receiving sets and for components, shipments of such material amounting to $33,591 and $57,499 during September. Italy took receiving sets valued at $21,800 during the month under review and Mexico $10,300 worth.

The United Kingdom offers only a limited market although exports during September showed a gain compared with the previous months this year.

## TWO NEW FACTORIES FOR ARCTURUS

The Arcturus Radio Company, of Newark, New Jersey, recently acquired two new plants, located on Frelinghuysen and Elizabeth Avenues, tripling their space and production facilities. The company now operates four plants, one in Harrison, New Jersey, and three in Newark, as well as a separately situated laboratory, also in the latter city.

The Newark plants are located within a few blocks of each other, the production line virtually running between them. Plant No. 3 is devoted to receiving, and the manufacture of small parts. The assembly and evacuation takes place in plant No. 2, while the tubes are based, tested and shipped from plant No. 4. The Harrison factory, plant No. 1, also performs the imtermediate operations taking care of the overflow to the main plant.

The executive offices have been moved from the Sherman Avenue plant to 220 Elizabeth Avenue.

## A NEW RADIO SERVICE

A radio information clearing house is announced by John F. Rider, President of the Radio Treatise Co., 1440 Broadway, New York City. The purpose of the organization is to supply radio data of all nature, in adddition to a regular consulting service. Special attention is being paid for the needs of broadcast receiver owners, custom-set builders and service men who desire specific information pertaining to the design and construction of units within their field of operation.

## KOLSTER ESTABLISHES RESEARCH DIVISION

Stuart C. Mahanay, radio editor of the Curtis Publishing Co., has increased his field of activity by joining the Kolster Radio Corporation of Newark, New Jersey, to establish a market research division under the direction of Major Herbert H. Frost, Vice-President in charge of merchandising. He has just left New York for an extended survey along the Pacific Coast.

## RADIO WHOLESALERS ASSOCIATION ENLARGES ACTIVITIES

The Radio Wholesalers Association which is now rapidly going to the front as one of the foremost trade associations in the country, is daily enlarging the activities of the association for the benefit of their members.

One of the newest plans upon which they are working, is that of a credit and collection department. Plans for this important work are being developed by a special Collection Service Committee. The results of their survey and activities in the collection field will be made to the Board of Directors of the Radio Wholesalers Association which will meet about December 1st.

This collection service joins with the insurance plan and the national finance plan which are also being inaugurated for the members.

### *Serial Number Act*

The proposed Serial Number Act which the Radio Wholesalers Association have created after a complete survey of all the laws in the various states effecting the removal or defacement of serial numbers on radio apparatus, is being presented to the various state legislatures through local associations. This is considered to be a very meritorious piece of work on the part of the association which will greatly aid in providing legal protection for the public and the legitimate distributor.

The Radio Wholesalers Association is rapidly being recognized by leading distributors all over the entire country and during the past thirty days, *twenty-three* prominent radio jobbers have sent their application in to the association. President Peter Sampson has selected Harold J. Wrape, President of the Federated to assume the duties of the temporary Chairman of the Membership Committee, in addition to his already heavy duties in association work. This Chairmanship is being placed with Mr. Wrape because of the fact that Mr. J. F. Connell of the Kruse-Connell Company of Indianapolis, was very seriously injured in an automobile accident two weeks ago and is not expected back at his work until after the first of the year.

The Association is arranging a very complete and comprehensive schedule for their part of the program in the coming Federated Convention on Wednesday, February 19th. The members will be counted upon to ratify and adopt the various plans which have been authorized by the Board of Directors. The Association has set as a goal 125 members by January 1st and all indications are that they will have them.

The executive offices wish to announce the acceptance of the following companies:

The Automobile Equipment Co., Detroit, Mich.

Jos. M. Zamoiski Company, Baltimore, Md.

G. J. Seedman Company, Inc., Brooklyn, N. Y.

J. C. Gordon Company, St. Louis, Mo.

Howard Cranfill Company, South Bend, Ind.

Radio Equipment Co. of Texas, Dallas, Texas.

Rocky Mountain Radio Corp., Denver, Colo.

Harger & Blish, Inc., Des Moines, Ia.

Nevada Auto Supply Co., Reno, Nev.

Radio Equipment Co., South Bend, Ind.

The Cooper Louisville Co., Louisville, Ky.

The Roberts-Toledo Co., Toledo, Ohio.

R. S. Proudfit Co., Lincoln, Nebr.

Capitol Electric Co., Indianapolis, Ind.

Falls Equipment Co., Buffalo, N. Y.

## E. R. FISKE APPOINTED CECO DIST. MANAGER

Mr. Edward R. Fiske, formerly assistant to Mr. Steinle, Sales Manager of the CeCo Manufacturing Company, has recently been appointed District Manager for the Metropolitan area. Mr. Fiske will have his office for the present at 154 Nassau Street, New York City.

## RCA OPENS NEW BRANCH SALES OFFICE IN ATLANTA

Announcement of the establishment of a new branch office with warehouse and service station facilities, in Atlanta, Georgia, was made today, by J. L. Ray, general sales manager of the Radio Corporation of America. Pierre Boucheron, formerly advertising and publicity manager of the RCA, has been appointed southern district sales manager in charge of the new office. Mr. C. R. Westbrook, formerly connected with the New York sales offices, has been appointed assistant district sales manager.

## HOLCK PRODUCTS, INC.

The Holck Products Corporation was recently organized in New York City for the purpose of manufacturing an improved form of loud speaker. The Holck Corporation is licensed under the Whitmore patent No. 1,674,796, covering a double, cloth diaphragm under tension. The drive in the new Holck speaker will be magnetic.

Edgar Sisson, Jr., is president of the newly formed concern, Harlow D. Gaines, secretary and treasurer and William C. Erb, Vice President.

## RADIO AND ASSOCIATED STOCK QUOTATIONS

| Company | Oct. 3 | Nov. 2 | Dec. 3 | Company | Oct. 3 | Nov. 2 | Dec. 3 |
|---|---|---|---|---|---|---|---|
| Acoustic Products | 19½ | 20¾ | 24 | Kellogg | 14½ | 17¾ | 19¼ |
| All-Am. Mohawk | 19½ | 39¾ | 40 | Kodel "A" | 27 | 20 | 24¾ |
| American Bosch | 33⅞ | 34⅝ | 41⅝ | Kolster | 74¾ | 83 | 91¼ |
| Bruns - Balke Collen (Com.) | 57⅜ | 52½ | 54¼ | Magnavox | 4 | 15½ | 15 |
| CeCo Mfg | ...... | ...... | 68 | Polymet | 35½ | ...... | 52 |
| Crosley "A" | 59 | 63 | 87½ | Radio (Com.) | 209½ | 228½ | 407 |
| Davega | 34 | 38¼ | 38⅜ | Raytheon | 51⅜ | 53½ | 69 |
| De Forest | 14¾ | 21 | 22¾ | Sangamo | 32½ | 34 | 35 |
| Dubilier | 4¾ | 5 | 10 | Sonatron | 114¾ | 127 | 157½ |
| Erla | 24 | 24⅛ | 22 | Sparks-Withington | 146 | 160 | 170 |
| Fansteel | 16¾ | 15⅞ | 15⅛ | Stromberg Carlson | 24½ | 26 | 30 |
| Formica | 25 | 24¾ | 24 | Stewart-Warner | 103¾ | 105⅛ | 116¼ |
| Freed-Eisemann | 4⅞ | 4¾ | 5⅛ | Utah | 61¾ | 59½ | 56 |
| Freshman | 11⅞ | 12⅜ | 13⅞ | Tower | 3⅛ | 3½ | 9 |
| General Elec. (Com.) | 164¾ | 167 | 197 | Union Carbide (Com.) | 188½ | 191 | 199¾ |
| Gold Seal | 8¾ | 10 | 19⅛ | Victor (Com.) | 109⅛ | 121⅜ | 138½ |
| Grigsby-Grunow (new) | 312 | n. 111 | n. 143 | Westinghouse | 104⅞ | 113⅝ | 135 |
| Hazeltine | 16 | 21⅛ | 50 | Weston (Com.) | 25½ | 22¾ | 23½ |
| | | | | Zenith (new) | 110 | 193 | n. 57 |

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# LONG LIFE

## IS THE PRIME REQUISITE OF A FILTER CONDENSER.

## THE SPECIAL *OIL PROCESS* USED IN THE MANUFACTURE OF *ACRACON* CONDENSERS ENABLES THEIR LIFE TO BE RECKONED IN *YEARS* NOT HOURS.

ACRACON

CONDENSER CORPORATION OF AMERICA

259-271 CORNELISON AVE., JERSEY CITY, N.J.

---

"YOU CAN FORGET THE CONDENSERS, IF THEY ARE DUBILIER'S"


## Eliminate Interference with one of these Devices

The advent of partial and complete electrification of radio sets has brought about new problems resulting from the picking up of stray power line noises.

These scientifically designed interference eliminators will make your set operate as quietly as with batteries.

Types 1 ($5.00) and 2 ($7.50) are of condenser design; the No. 2 unit having double the No. 1 capacity.

Type 3 makes use of a specially designed filter net work. This unit because of its highly developed choke coil and shunt condenser system has wonderfully fine filter characteristics. Price $15.00.

### Dubilier Light Socket Aerial

*"A Moulded Bakelite Product"*

A simple device plugged into any light socket—does away with aerials and lightning arrestors. Will work on any set. No current consumed. If your dealer can't supply you, write to us direct. Price $1.50.

Address Dept. 72 for free catalog

# Dubilier

**CONDENSER CORPORATION**

10 East 43rd Street, New York City

www.americanradiohistory.com

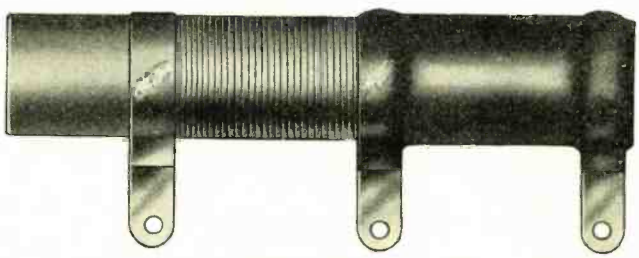
# NEW DEVELOPMENTS OF THE MONTH

## LAUTZ SILVER-WELDED RESISTORS

The Lautz Manufacturing Co., Inc., of 245 N. J. R. R. Ave., Newark, N. J., have introduced a new form of wire-wound resistor that has a number of major improvements to its credit.

As indicated by the accompanying knocked-down illustration, the resistance wire is wound on a bare refractory tube. The ends of the wire are attached to large copper terminal rings and silver-welded thereto. It is claimed that this silver welding practically does away with terminal joint trouble and reduces the operating temperature coefficient.

After the wire is wound on the bare tube and the silver welding accomplished, the unit is coated with a heavy enamel, which is baked on.



The Lautz silver-welded, wire wound resistance unit.

## BUCKINGHAM ELECTRIC PHONOGRAPH PICKUP

The Buckingham Radio Corporation, of 440 West Superior St., Chicago, have placed on the market an excellent electromagnetic type phonograph pickup and adapters.

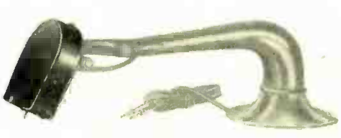
The Model C pickup, shown below, is furnished primarily for manufacturers. The tone arm, which is made of die cast brass has been carefully designed to give the correct support to the pickup unit. This reduces wear on the records.

The pickup unit employs a small horseshoe magnet, with magnet windings, and an iron armature to which the needle is attached. Balancing of the needle and armature is accomplished by the adjustment of a small set screw at the top of the case.

The Model C227 unit is the same as the Model C unit with the addition of a volume control unit and an adapter.

Buckingham is manufacturing two adapters for their pickups so that they may be used in conjunction with any type of radio receiver. The Model 227 adapter will fit any five-prong tube. The Model 201 adapter will accommodate any four-prong tube.

The list prices of the units and adapters are as follows: Model C, $10.45; Model C227, $19.00; Model 227 adapter, $1.35, and Model 201 adapter, $1.25.



The new Buckingham Model C phonograph pickup.

## RAYTHEON INTRODUCES NEW A.C. HEATER TUBE

A radically different heater type A.C. tube has just been introduced by the Raytheon Manufacturing Company of Cambridge, Mass., which promises to satisfy the most exacting demands in socket-power operation.

To begin with, the Ray-227 Raytheon has a novel form of heater. Instead of the usual insulator tubing, threaded with the heater wire, this tube makes use of a metal cylinder enclosing a centered helical heating wire supported at top and bottom by passing through holes in insulating corks. It is claimed that this construction possesses several distinct advantages; long life is assured in the absence of frictional wear, chemical action and unequal heating between wire and surrounding insulator. The heating time is reduced to from 8 to 15 seconds, as against 15 to 45 seconds where a considerable mass of insulating material must be brought up to heat. The heater wire is uniformly heated in this case, as against the hot spots existing in the wire threaded in insulating tubing; and even though the wire is exposed in the center of the cathode cylinder, it cannot touch the surrounding metal because of positive positioning under tension. Hum has been reduced to an absolute minimum, while the "breathing" effect, or rise and fall of signal strength, is entirely eliminated.

In addition to the novel heater, the Ray-227 employs the novel Raytheon four-post stem characteristic of all Raytheon tubes. This comprises a cruciform glass press to carry four support wires which are tied together at the top with a mica spacer in the form of an "R." Hence, rigidly anchored and reinforced at top and bottom in all directions, the elements are permanently positioned in producing precisely matched tubes.

## DONGAN RADIO INTERFERENCE FILTERS

The astonishing growth of the radio industry has been paralleled, to a certain degree, by the increasing popularity of oil heating for homes. Oil burners, now considered the standard for home heating in many parts of the United States, have brought about a condition that has caused the radio manufacturer no little concern.

Motor driven oil burners sometimes—not always by any means—set up an interference that mars radio reception. This annoyance to the owner of a new and expensive radio set naturally starts a most troublesome situation with the burden of explanation usually upon the radio dealer who sold the set.

For a long time Dongan laboratories have been experimenting with condensers as a means of eliminating radio interference by oil burners. The result of this work is climaxed in the perfection of two Radio Interference Filters which have been subjected to all the tests of the Underwriters' Laboratories.

One of the new Dongan interference eliminators which are particularly effective in reducing interference from electric refrigerators.

Both models are small and compact and mounted in steel cases equipped with conduit fittings. It is a simple matter to hook up either of these Radio Interference Filters with the oil burner.

D-207 Model contains 8 mfd. total condenser capacity and D-215 contains 4 mfd. total condenser capacity. In addition to these two stock models Dongan will build special designs and capacities to specifications.

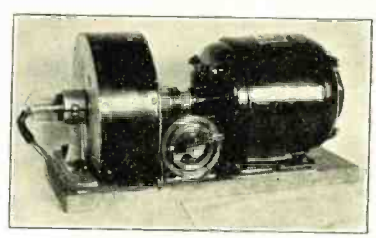
## DUBILIER SPARK SUPPRESSOR

A new type of interference prevention device intended for use directly across sparking or arcing contact points, is now announced by the Dubilier Condenser Corporation of New York City. Aside from reducing the sparking or arcing, thereby preventing "freezing" of points and also adding materially to the life of the points, the Dubilier Spark Suppressor, Type PL 1083, effectively prevents interference with radio receivers in the vicinity. Also, this device serves to eliminate errors in operation caused by sticking contacts.

## OHIO SYNCHRONOUS MOTOR

In Radiomovies, Radiovision, or Television there would seem to be no question but that synchronous motors furnish the most acceptable drive for receiving devices. This is especially true where transmitters and receivers are confined to the city or territory served by a single powerhouse.

The illustration shows a synchronous motor developed especially for this service.



The Ohio synchronous motor shown in connection with a Jenkins scanning drum.

by the Ohio Electric & Controller Co., which is being used to drive the Jenkins scanning drum. Exactness of synchronism and resultant excellent sharpness of picture is due to the peculiar method employed in slotting the motor rotor.

Further information on this motor can be had upon request from The Ohio Electric & Controller Co., 5900 Maurice Ave., Cleveland, O.

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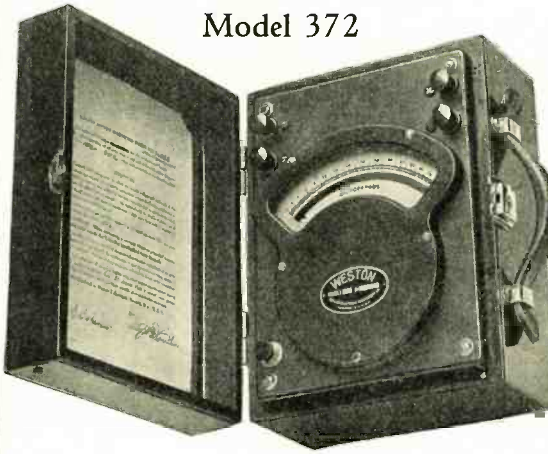
Insure the
ELECTRICAL RELIABILITY
of Your Products
with the WESTON Portable
Direct-Reading
MICROFARADMETER
Model 372



Although many methods have been devised for measuring electrostatic capacity no completely satisfactory means of accurately determining the capacity of electrical circuits, condensers, etc., was available until the introduction of the Weston Model 372 Microfaradmeter.

The ease and rapidity with which capacity measurements may be made with this instrument have caused much more attention to be paid to these values among designing engineers than in the past. This instrument is indispensable to the manufacturer of radio sets, accessories and other electrical equipment where capacity measurements are essential in controlling the quality of the product.

To use this Microfaradmeter it is only necessary to connect two of the four binding posts to a suitable source of alternating current, and the other two binding posts to the circuit or device whose capacity is to be measured, press the contact key and note the deflection of the pointer exactly as in using a voltmeter or ammeter.

Variations in voltage or frequency of the alternating current supply do not appreciably affect the accuracy of measurement, the error being so slight as to have no importance in most classes of testing work. Two forms of this instrument are regularly made—one for operation on 60-cycle circuits and the other on 500-cycle circuits.

For complete information write for Bulletin 3001-E. Also send for copy of Circular J—listing and describing the complete line of Weston Radio Instruments.

Weston Electrical Instrument Corporation
612 Frelinghuysen Ave., Newark, N. J.

Weston
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INSTRUMENTS



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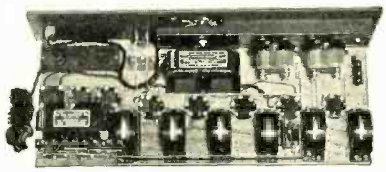
The New Victoreen Circuit for 1929 eclipses all past achievements. It combines unparalleled sensitivity, selectivity and tone quality.



Perfected A. C. Operation

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Either A. C. or D. C.

Write us for complete information regarding the latest Victoreen developments.

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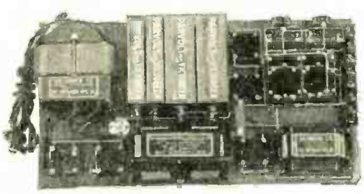
Victoreen
Power Amplifier
and "B" Supply



Here is the last word in a "B" Supply and Power Amplifier. Uses either a UX 250 or 210 in the last stage. Two voltage regulator tubes accurately control the 90 and 180 volt taps, thus making possible accurate determination of proper "C" voltages. There is also a 0 to 90 volt tap, variable; also 450 volts for the power tube.

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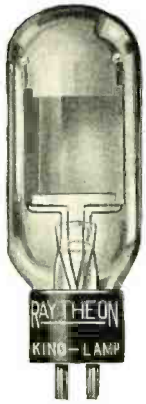
# TWO *Outstanding* Raytheon *Achievements*




## Raytheon Kino-Lamp

Already Raytheon has brought television tubes past the "anything that works" stage to a point where reliability and long life are added to practicability. The Raytheon Kino-Lamp is the long-life television receiving tube—adapted to all systems and made in numerous types.

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## Raytheon Foto-Cell

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*Information and prices upon application*
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The BURT-CELL is made by a new method and should not be confused with any other photo-electric cell. By a special process of electrolysis, the photo-electric metal is introduced into a highly evacuated bulb directly through the glass wall of the bulb, giving photo-electric material of absolute purity. The superiority of the BURT-CELL is due to these features, making possible results never before obtainable. Described in Bulletin No. 271.

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Manufacturing and Consulting Physicist
**327 S. Michigan Ave., Pasadena, Calif.**

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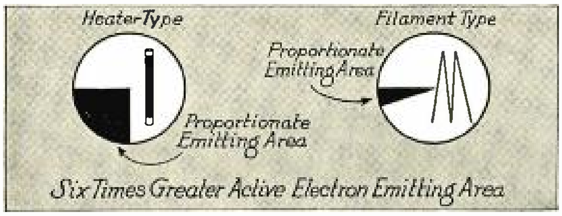


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**That is why Engineers are unanimous in stating that ARCTURUS Tubes are mechanically and electrically the finest tubes made. ARCTURUS RADIO COMPANY, 220 Elizabeth Ave., Newark, N.J.**

**[ Engineering facts have a utility significance to the broadcast listener ]**

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**A-C LONG LIFE TUBES**

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*by* **Dr. Lee de Forest**

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DEJUR-AMSCO CORPORATION

BROOME & LAFAYETTE STS., NEW YORK CITY

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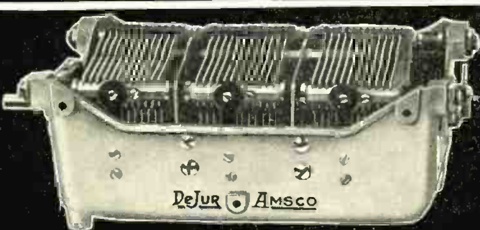
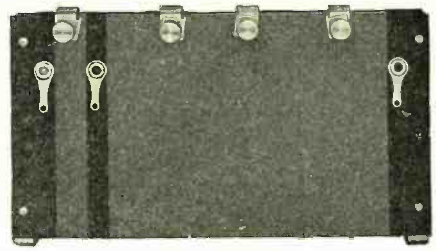



DE JUR-AMSCO "BATHTUB" CONDENSER

# General Radio Type 446 VOLTAGE DIVIDER



Price—$2.75

The Type 446 Voltage Divider has been especially designed for use as an output potentiometer device for 300-volt rectifying systems. It is wound in two sections, one of 15,000 ohms for the plate supply and a 1500-ohm section for obtaining the bias voltage for a power tube. It is equipped with four adjustable sliders, suitably engraved, by means of which any combination of voltage may be obtained from the plate-supply unit. This unit will dissipate 60 watts. If intended for use with a 500-volt rectifying system two voltage dividers should be connected in series.

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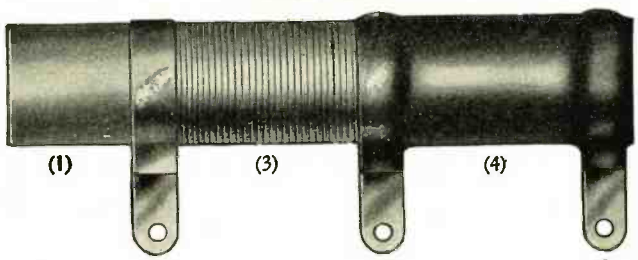
# L. M. C. Silver Welded Resistors

*(Patents pending)*

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3.— L.M.C. Special Resistance Wire

4.— L.M.C. Special Heavy Enamel

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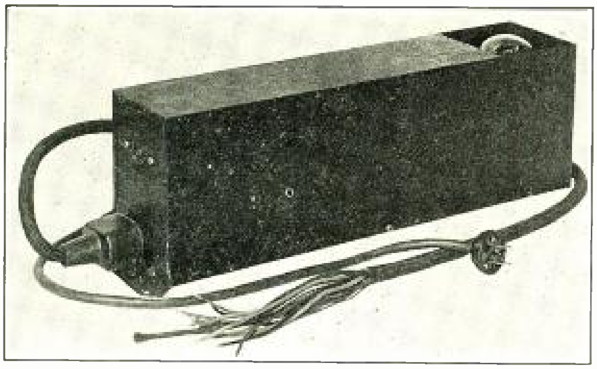

by using an

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a most attractive proposition for jobbers, dealers, set-builders and service men everywhere and a real stimulator for immediate business at a substantial profit.

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Thousands of D. C. receivers on jobbers' and dealers' shelves including privately owned sets are being converted into A. C. sets with A. C. Super-Filter Packs at a saving of over 25% over present costs, a splendid saving to the ultimate consumer and a good business proposition for you.

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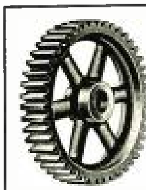

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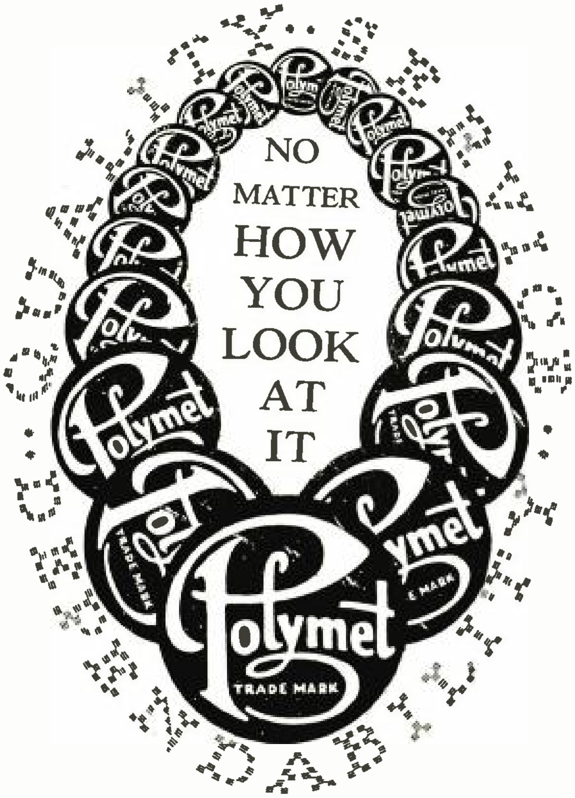


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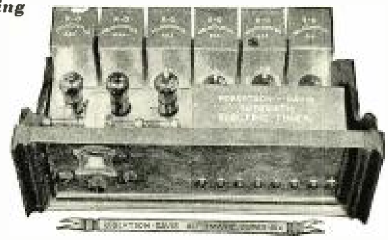
***We Supply Everything***



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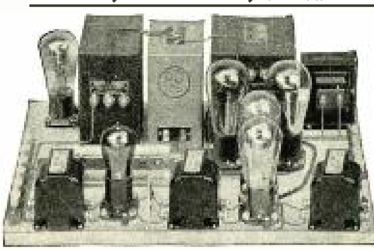
***The Only Automatically Tuned Custom-Built Receiver***



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Are You Now a Set-Builder? (If You Are, Enclose Card or Letterhead.) YES .. ☐ NO ... ☐

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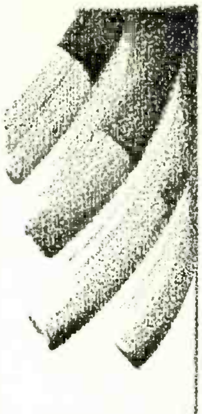

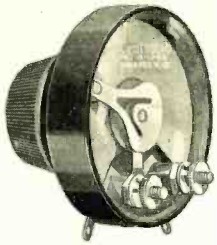

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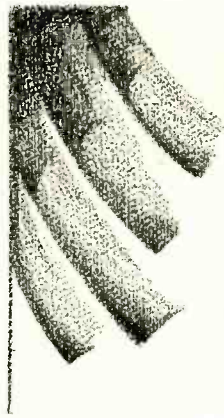
In following resistances: 0-2,000 ohms, 0-50,000 ohms, 0-100,000 ohms, 0-200,000 ohms, 0-500,000 ohms. List Price ........................$2.00

# ONLY CENTRALAB Makes Resistances Like These



The construction and design of a variable resistance is of as great importance as the mere fact that it possesses a certain resistance and will carry a specified current load. Centralab design is such that the resistance unit not only will handle the power but also vary it in a manner so as to derive the greatest efficiency from the receiving set or power unit.

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|---|---|
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| One turn of knob gives complete variation. | Noiseless, smooth and easy adjustment. |
| Insulated shaft and bushing. | Rigidly built; fully guaranteed. |

Made in two and three terminal units to be used as Volume Controls, Radiohms and Potentiometers. Special resistance tapers can be had for any circuit. Send for interesting booklet "Volume and Voltage Controls—Their Use."

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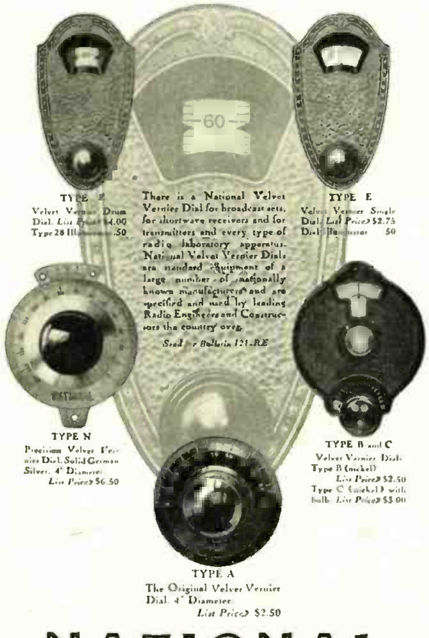

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*Send for Bulletin 121-RE*

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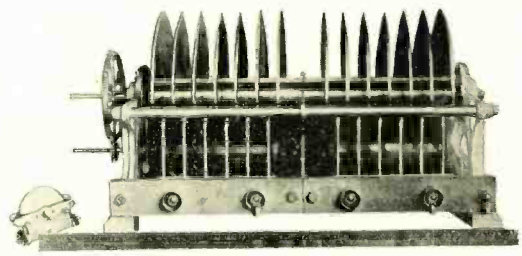

*Type S1967R (Two Elements) Length—25 inches, Height over all—20 inches, Capacity (each element, unconnected)—315 MMF, Breakdown Voltage—15,000 (Rated with condenser placed in a non-oscillating circuit at a frequency of 500 cycles), Weight 65 lbs. Note the difference in size between the standard receiving condenser on the left and the special S1967R.*

# THEY SAID . . . . .

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and they got what you see pictured at the top of this page—a condenser *built* for *transmitting*, just like every other CARDWELL Variable condenser in design but a great deal larger than most of them, and made to suit the job.

To get down to "brass tacks," though, the point we wish to make is that they didn't come to CARDWELL for jewelry, nor for tinware.

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May we send you our literature? A post card or a lengthier communication stating your requirements will bring a prompt reply.

**CARDWELL CONDENSERS for all purposes**
**Variable—Fixed—Transmitting—Receiving**
The Standard of Comparison

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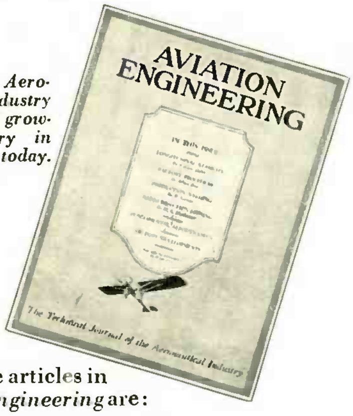
Note—*The Aeronautical Industry is the fastest growing industry in the world today.*




Some of the articles in *Aviation Engineering* are:

- Applications of Radio in the Aviation Field.
- Fundamental Aerodynamics (in installments).
- Welded Joints for Aircraft (Findings of the Bureau of Standards).
- Airplane Propeller Thrust.
- Aeronautic Standards (S. A. E.).
- Roller Bearings in Aircraft.
- Dynamometer Engine Tests.
- A Radio Altimeter—(by E. F. W. Alexanderson).

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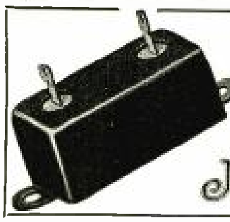

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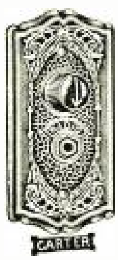



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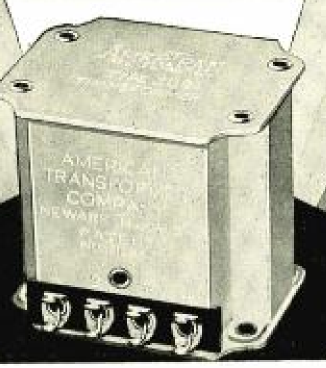


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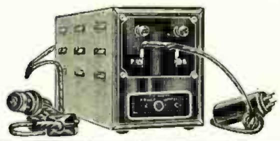

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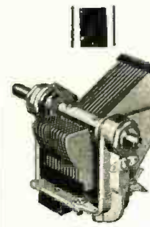

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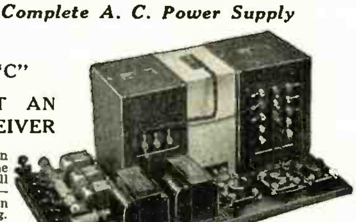

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Addresses of companies listed below, can be found in their advertisements—see index on page 70.

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**JACKS, TIP:**
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Yaxley Co.

**KITS, SHORT WAVE:**
Aero Products, Inc.
Dresner Radio Mfg. Co.
Karas Electric Co.
Radio Engineering Labs.
Silver-Marshall, Inc.

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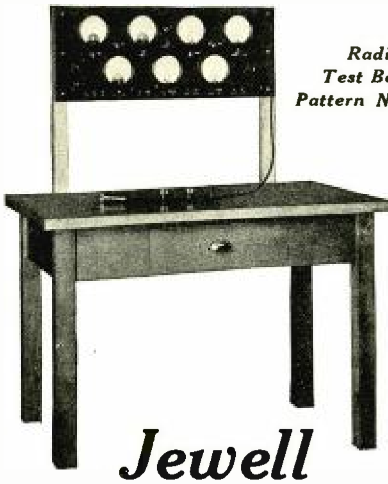
JEWELL

Radio Test Bench Pattern No. 580



# Jewell Radio Test Bench

Many requests from jobbers and dealers have come to us for a service panel or bench which would contain, interconnected, all the instruments necessary to completely check the circuits and general working condition of radio receiving sets and accessories. The Jewell Pattern No. 580 Radio Test Bench has been designed for that purpose.

The bench proper is substantially made of hard maple with a top of generous size 24 x 42 inches. The working surface is 36 inches high. A tool drawer is included.

The testing panel is steel, black enamelled, with all markings engraved directly in the steel and filled with white. The panel carries seven instruments, as follows: 0-7.5 volts D. C.; 0-75 volts D. C.; 0150-300-750 volts D.C.; 800 ohms per volt; 0-15-150 D.C. milliamperes; 0-4-8-16 volts A.C.; 0-150-750 volts A.C., and 0-1.5-15 microfarads.

The panel is supplied with binding posts, so that all instruments can be used individually and with switches to cover all ranges. It is also supplied with a plug and cord, so that all circuits in a radio set can be tested along with the tube, which may be placed in a socket in the panel. A pair of outlets are arranged to be connected to the 110 volt, 60 cycle, A. C. line, so that line voltage may be read and a set plugged into the outlets. Line voltage is also used for measuring the capacity of condensers.

This Radio Test Bench is a well made, carefully designed and practical piece of equipment which jobbers and dealers who have a large quantity of servicing to do will find very efficient as a part of their testing equipment. Large, precision type instruments with long scales can be read to a high degree of accuracy. Readings are simultaneous and independent of each other.

Our descriptive circular Form No. 2004 describes this Radio Test Bench in details. Write for a copy.

*"28 Years Making Good Instruments"*

***Jewell Electrical Instrument Co.***
***1650 Walnut St. — Chicago***

*A New*

# DETECTOR AMPLIFIER

*in*

## Raytheon
**LONG LIFE RADIO TUBE**

Ra— 227


**THE life of a filament-type radio tube is governed entirely by the length of time that its three elements are maintained in their proper relative positions to one another.**

**When one of these elements (filament, grid, or plate) becomes shifted, because of weak mechanical construction or from vibration in shipment, the life of the tube is shortened—frequently by as much as 75%.**

**Unique among radio tubes, the Raytheon permanently maintains the original relative positions of its elements, and eliminates fragility. As these long life tubes cost you no more, they cut maintenance-cost in two.**

***Points:*** **Spacing insulators not in contact with filament; tube heats up quickly; fixed supports give extreme rigidity and doubly strengthen grid and plate; extra heavy heater filament; oxide-coated cathode will not flake off, and gives high emission at low temperature; mica-top fixes and spaces elements, making microphonic noises impossible; 4-pillar construction cross-anchors elements top and bottom; tube characteristics are preserved.**

**RAYTHEON MANUFACTURING CO.**
**CAMBRIDGE · MASS.**

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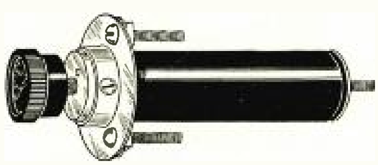
# Fixed and Adjustable Resistors
## *for all Radio Circuits*


## Bradleyunit-B

RADIO manufacturers, set builders and experimenters demand reliable resistors for grid leaks and plate coupling resistors. For such applications Bradleyunit-B has demonstrated its superiority under all tests, because:

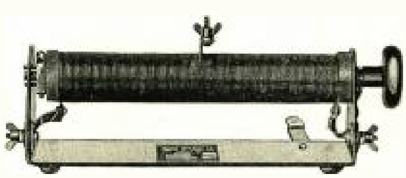
1—*Resistance values are constant irrespective of voltage drop across resistors. Distortion is thus avoided*
2—*Absolutely noiseless*
3—*No aging after long use*
4—*Adequate current capacity*
5—*Rugged, solid-molded construction*
6—*Easily soldered*

***Use the Bradleyunit-B in your Radio Circuits***



## Radiostat

This remarkable graphite compression rheostat, and other types of Allen-Bradley graphite disc rheostats provide stepless, velvet-smooth control for transmitters, scanning disc motors and other apparatus requiring a variable resistance.



## Laboratory Rheostat

Type E-2910 — for general laboratory service. Capacity 200 watts. Maximum current 40 amperes. A handy rheostat for any laboratory.

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National Co.
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Thordarson Electric Mfg. Co.

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Karas Electric Co.
Kodel Elec. & Mfg. Co.
Muter, Leslie Co., Inc.
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Silver-Marshall, Inc.
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General Radio Co.
Kodel Elec. & Mfg. Co.
Muter, Leslie Co., Inc.
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Muter, Leslie F., Co.
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Transformer Co. of America.
Tyrman Co.
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Silver-Marshall, Inc.
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Karas Electric Co.
Muter, Leslie, Co., Inc.
National Co.
Silver-Marshall, Inc.
Scott Transformer Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.
Tyrman Co.
Victoreen Corp.

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Muter, Leslie, Co., Inc.
National Co.
Scott Transformer Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Tyrman Co.
Victoreen Corp.
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Ceco Mfg. Co.
Cunningham, E. T., Co.
De Forest Radio Co.
Gold Seal Elec. Co., Inc.
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Dudlo Mfg. Corp.
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**ZINC, FOIL:**
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Thousands ~ call CeCo the clearest toned longest life - tube on the market


**--it ought to be —here's why!**

THE finest materials skillfully employed by able craftsmen and the foremost laboratory experts give CeCo marked advantages over other tubes. Not only a purer, more pleasing tone, but a longer, more serviceable life.

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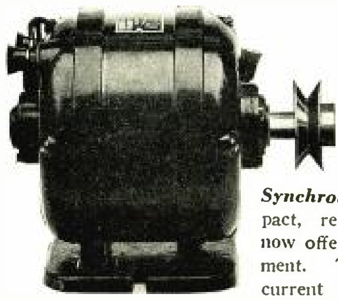
## "ESCO"

### *Synchronous Motors for Television*



***Synchronous motors,*** small, compact, reliable, self starting are now offered for ***Television*** equipment. They require no direct current for excitation, are quiet running and full guaranteed.

Other types of motors suitable for Television may also be supplied.

*Write us about your requirements.*

**ELECTRIC SPECIALTY COMPANY**

TRADE **"ESCO"** MARK

**411 South Street** **Stamford, Conn.**

CORWICO

**Braidite**

HOOK-UP WIRE

"THE BRAID SLIDES BACK"

Here are the features that make Corwico Braidite Hook-up Wire the fastest seller in its line.

It is excellent for all A-C work. It holds its shape permanently after bending. You cannot scorch or burn Braidite with a soldering iron. Braidite is safe to work with and is as convenient as bare wire. The insulation can be easily shoved back far enough for both solder and post connections, sliding back into place after the connection is made. Braidite provides a neat, clean and effective insulation for all exposed areas.

**LIST PRICES—25 ft. Stranded 35c. 25 ft. solid 30c, Red, Green, Yellow, Blue and Black.**

**SPECIAL SAMPLE OFFER TO DEALERS**

Send us the name and address of your jobber and we will send you two packages of Braidite free. One Solid and one Stranded. We do this because we want you to get acquainted with Braidite and prove to yourself its many exclusive features.

**CORNISH WIRE Co**

**30 Church Street New York City**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To the attention of Chief Engineers—Laboratory Heads—Service Managers—Plant Executives:

Radio Engineering should be interesting and helpful to your personnel. Your copy is not always available to your assistants.

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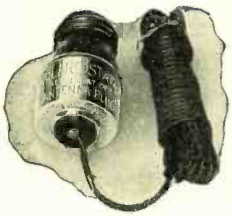
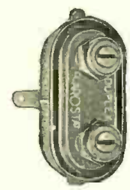
# Leaves from a Service Man's Diary—

**"Have had a busy day — all kinds of service jobs — yet I made out pretty good. I have at last learned to carry around some Clarostat 'First Aids', along with my soldering iron, meters, extra tubes, wire, insulators and so on.**



**"My first job was an eight-tube super-heterodyne of well-known make, that refused to percolate properly. The signals could be picked up, but were weak. Furthermore, there was lots of interference from electrical equipment in the apartment house, as well as from nearby sets. Well, I fished the Clarostat Antenna Plug out of my bag and connected it to the nearest baseboard outlet. For a ground, I used the screw on the brass plate. Say — the way that super-het picked up! I then went up on the roof of the apartment house and found about a hundred antennas. And the lead-in! It was a wow! About eight stories long. Any wonder that super-het didn't get much else but the garbage, until I tried the antenna plug.**

**"The next job was a question of insufficient plate voltage on detector and r.f. tubes of a tuned radio-frequency set, operating on a B-eliminator. The B-eliminator had fixed taps, so the user was stumped. Fortunately, I had a Duplex Clarostat in my bag — I always carry a few with me, so as to take care of resistance requirements, no matter what the range. I fixed up the Duplex to the highest tap, gave the screws a few turns with my screw-driver, and the job was all set.**




**"This afternoon I had a job in the outlying districts. A brand new A-C set was reported to be a cluck. No volume; no distance; no tone. I suspected line voltage — you get that often in the suburbs with long lines and limited transformer capacity. Well, I found the power transformer in the set tapped for 120-volt supply. So I changed that to the 100-volt tap, inserted a Power Clarostat, and demonstrated to the set owner how to compensate for low line voltage. Well, you should see his face when he got that set percolating 100 per cent!**

**"My last job today was in the home of a musician. He was on a rampage. The loud-speaker was too loud, he said. It was too sharp. It was noise, not music. I soon satisfied him, however. Taking a Table Type Clarostat out of my bag, I connected it to loud-speaker and jack. I showed him how his loud-speaker could be provided with a pedal like his beloved piano. He just fell in love with radio then and there."**

***Write*** **for complete data on the entire line of Clarostats — Radio "First Aids" — whether you are a manufacturer, jobber, dealer, service man or experimenter. Don't forget, there's a Clarostat for every purpose where resistance is required.**

**CLAROSTAT MANUFACTURING COMPANY, INC.**

***Specialists in Variable Resistors***

**282 North Sixth Street, Brooklyn, N. Y.**

# CLAROSTAT

Reg. U. S. Pat. Off.

WILLIAMS PRESS, INC., NEW YORK—ALBANY

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QUALITY DONGAN PRODUCTS


# You, Too, Can Have Full-Toned Reception

TWO years ago few, except the experimental engineers, even dreamed of radio reception as it is today. No wonder Radio has come into its own—that politics and sports now reach millions of people here-to-fore but little interested. The life-like reality of reproduction would, indeed, be startling had we not grown accustomed to it gradually.

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You can secure information on Approved Parts — Transformers, Condenser Blocks and Units — for various hook-ups by writing the Dongan Laboratories.

Dongan Electric Manufacturing Co.

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***Custom Set Builders***

can secure any of these items direct from factory at trade discounts.

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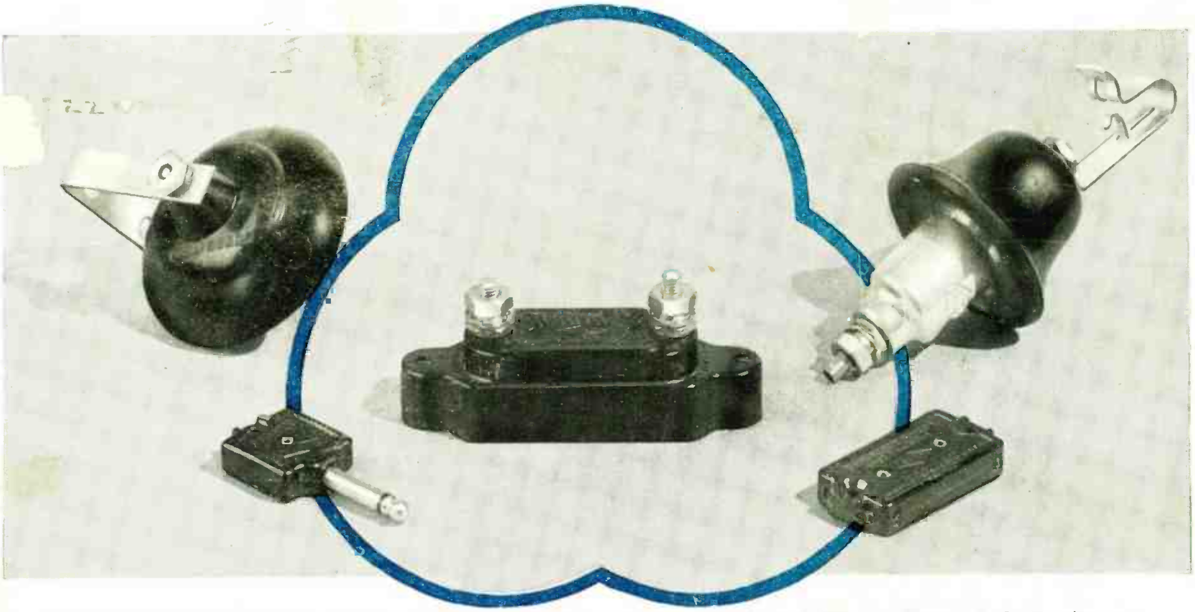

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# Sales were appreciably increased through adopting BAKELITE MOLDED

STORM KING Lightning Arrestors were originally made of porcelain. Excessive breakage in handling and in assembly brought about the adoption of Bakelite Molded, and breakage has been practically eliminated. Not only was this advantage gained, but the wide acceptance of Bakelite Molded by the radio public resulted in an appreciable increase in sales, even during the slack period.

The demonstrated advantages of Bakelite Molded in both production and sales departments, resulted in the use of this material for other Brach products, including the Storm Guard Radio Protector, Vacuum Lightning Arrestor, Radio Plug and Cord Connector. The experience with all of these devices paralleled that with the Storm King. The economy of Bakelite Molded in production—the superior insulation properties which it provides—the value of the trademark BAKELITE as a sales asset, make it the most desirable of all insulating materials for use in radio receivers and parts.

## Bakelite Engineering Service

Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resinoids for radio uses provides a valuable background for the cooperation offered by our engineers and research laboratories. Write for Booklet 38, "Bakelite In Radio."

**BAKELITE CORPORATION**

247 Park Avenue, New York, N. Y. Chicago Office: 635 W. 22nd Street

**BAKELITE CORP. OF CANADA, LTD.**, 163 Dufferin St., Toronto, Ontario, Canada

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