Ninth Year of Service

RADIO ENGINEERING

Vol. IX NOVEMBER 1929 No. 11

IN THIS ISSUE

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The Journal of the Radio Industry

No favor from us *but your privilege, Sir*

You may be highly interested in quantity-production. Perhaps vulcanized fibre will add quality to quantity and reduce manufacturing cost at the same time. It may be that you can use this versatile material—*not* as a substitute; but as an *improvement* upon material you're using now. Hundreds of manufacturers have found that they could improve their product with increased income from increased selling volume.

These producers put it up to our Service Engineering department to help them find out. It's the duty of this staff of chemists and engineers to assist manufacturers to determine whether or not vulcanized fibre will make merchandise better, more swiftly, more economically—whether or not it will help speed sales and money turnover. Write us your requirements and let us help you meet them in the proper grade of National Vulcanized Fibre.

There is a grade of Phenolite of correct mechanical, dielectric and physical properties to meet every electrical or industrial use.

PHENOLITE
Laminated BAKELITE

The electrical industry has discovered many instances where a very thin, very flexible fibre of high dielectric and bending strength is an absolute necessity—and in these cases they have discovered too that Peerless Insulation meets their needs.

PEERLESS INSULATION

NATIONAL VULCANIZED FIBRE

"—the material with a million uses"

SHEETS : RODS : TUBES : SPECIAL SHAPES

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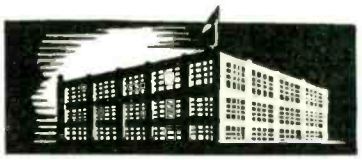
Offices in Principal Cities

50,000 MORE FEET OF FLOOR SPACE for QUICK SERVICE

A new building just being completed is adding 50,000 ft. to the space which Formica has available to provide prompt service to its customers. Practically every year for the last ten, additions have been made to plant to provide more space and equipment.

There is available at a point where quick shipments can be made to any part of industrial America - - - the largest equipment for the production of sheets, tubes and rods, and the largest fabricating equipment in the industry.

A specialized organization has concentrated on just one product for 16 years.



The FORMICA INSULATION CO.
4626 Spring Grove Avenue
CINCINNATI, OHIO

FORMICA
Made from Anhydrous Bakelite Resins
SHEETS TUBES RODS

RADIO ENGINEERING

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JOHN F. RIDER

Vol. IX | November 1929 | Number 11

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Radio Broadcasting

BY ERNEST KAUER
President, CeCo Manufacturing Company

RADIO is an immensely competitive industry and there is no sign that it portends otherwise. In all its various divisions there are many organizations in competition with one another; dozens of tube manufacturers, dozens of furniture manufacturers, dozens of set manufacturers, hundreds of broadcasters. I see no indication that any monopolistic organization in any of the trade divisions is on the way.

There is, however, a cloud on the horizon, and that concerns broadcasting. If the radio industry were in the hands of a monopoly, the broadcasting problem could more easily be remedied. This, the most important feature in the whole radio set-up, has gotten wholly out of control of the radio industry.

I believe in the commercialization of broadcasting. It should pay its own way. But I do not believe in the selfish commercial uses to which so much of the broadcasting time is at present being put. There is too much direct salesmanship and not enough consideration for the radio listener.

The radio industry cannot escape the responsibility for the public's response to broadcasting. It lies within the power of the institutions which compose the industry to make broadcasting what it ought to be. The manufacturing division can well afford to purchase all the time available on the larger networks; the retailing division can well afford to purchase all the time available on local stations. Or if not all, at least the major portion of the time. Controlling it thus, providing suitable material for its use, will insure the desired appreciation of the radio public with an inevitable result of value to the radio industry itself.

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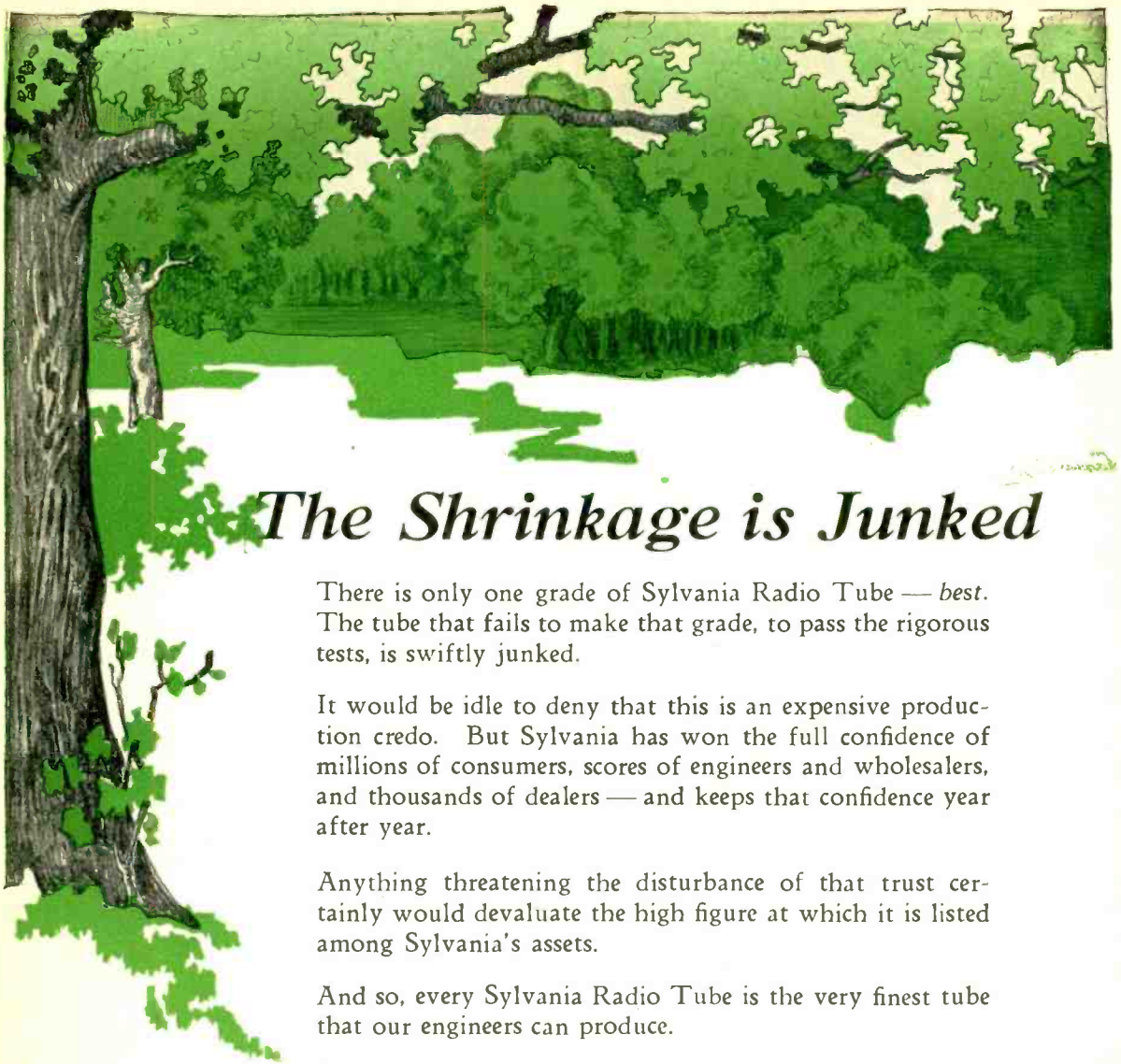


The Shrinkage is Junked

There is only one grade of Sylvania Radio Tube — *best*. The tube that fails to make that grade, to pass the rigorous tests, is swiftly junked.

It would be idle to deny that this is an expensive production credo. But Sylvania has won the full confidence of millions of consumers, scores of engineers and wholesalers, and thousands of dealers — and keeps that confidence year after year.

Anything threatening the disturbance of that trust certainly would devaluate the high figure at which it is listed among Sylvania's assets.

And so, every Sylvania Radio Tube is the very finest tube that our engineers can produce.

No seconds for sale!

SYLVANIA PRODUCTS COMPANY

Emporium **Pennsylvania**

The home of the Sylvania Foresters who are heard each week over WJZ, KDKA, KWK, KYW, WBZ, WBZA, WBT, WHAM, WJR, WLW, WREN, WRVA, KGRC, KPRC, WFAA, WHK, WCCO, KFYR.

Sylvania

RADIO TUBES

Licensed Under RCA Patents

EDITORIAL

November, 1929

RECEIVER DESIGN

ENGINEERS have been devoting the greater part of their time to smoothing out the inherent faults in radio- and audio-frequency circuits. Just so long as new types of vacuum tubes appear on the scene the engineers will have to submit to the rather trying task of retracing their steps and starting out afresh with a new set of conditions to contend with.

Each time radio receivers have been developed to a point verging on the faultless, a new tube has upset the applecart. If we are to believe that history always repeats itself, then we may well expect that just about the time the "screen-grid scare" has been licked and the -45 tube put in its place, a few new tubes will appear on the scene.

In a sense, this annual upheaval is tough on the engineers whose duty it is to re-design radio- and audio-frequency circuits, yet we should all be thankful for any new tubes developed. If we had had to struggle along from year to year with the old ones it might well have been more difficult to bring about a healthy condition of obsolescence.

Since obsolescence is the industry's meal ticket, it might be well to consider how it may be brought about this coming year, in the event that the present type tubes will remain in use. Assuming that they will stay with us, how far can the engineers bring us into the state of healthy obsolescence through the mere improvement of circuits and components?

What qualities can be given to a radio receiver that will make it more appealing . . . so appealing, in fact, that the consumer will feel he cannot possibly be satisfied with his old set? Though sensitivity, selectivity and tonal quality can, no doubt, be improved, it is not safe to assume that sufficient improvement can be gained to throw the sets of this year and the year before into the obsolete class. Neither can the condition be satisfied by greater simplicity and compactness.

It appears, then, that obsolescence must be brought about by adding to the usefulness of the radio set, increasing the factor of convenience and making its appearance more appealing. Then, in the absence of the usual turmoil accompanying radical changes of design, it may be hoped that a new confidence will prevail and "distress buying" will vanish.

The condition can be partially met by studying present and future requirements. First, every radio set, irrespective of type, should have the audio-frequency channel tapped, that it may be used for the electrical reproduction of music and speech from a record and from a film. A switch should be provided, and binding posts included, rather than a jack, so that it will be convenient to connect in an impedance-matching unit, between the input of the amplifier and the source, remembering that the source may not be a pickup, or even a P. E. cell for that matter; there are too many uses to which an audio amplifier can be put.

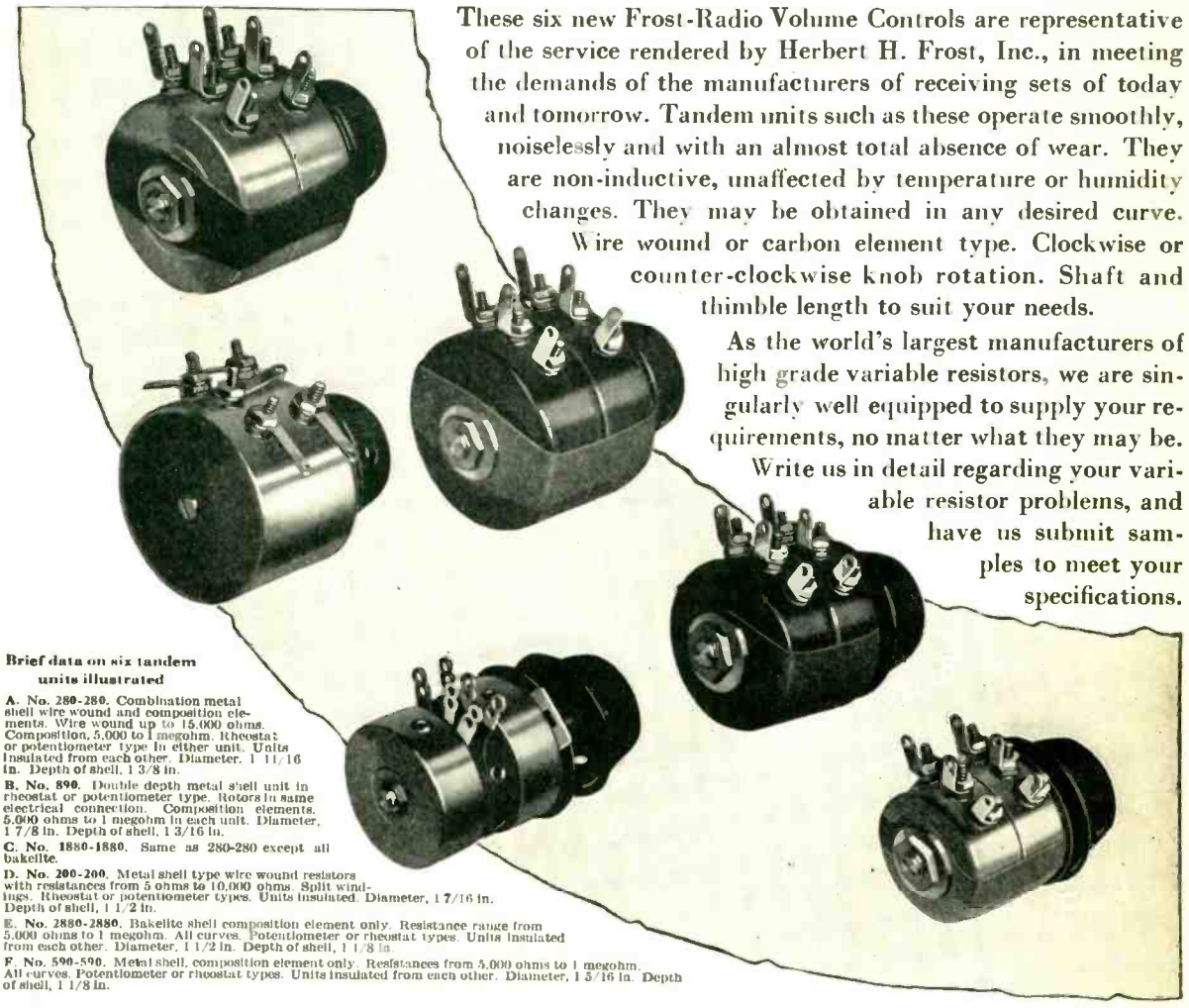
All sets should be equipped with an arrangement that will allow the use of more than one dynamic speaker. People are taking to the idea of having speakers in various rooms, and it is doubtful if they will ever again revert to the electromagnetic type.

Every set should be equipped with a *remotely-operated* "silent switch," if for no other reason than to give one the opportunity of answering the telephone in peace, without having to scoot through a number of rooms to "turn down" the radio. This switch should be supplied *separate* from any remote tuning control that might well be part of the equipment.

These are but a few of the many conveniences that can be added to next year's sets. Undoubtedly there are many which as yet have not been discovered.

M. L. MUHLEMAN, *Editor.*

ANNOUNCING SIX NEW FROST TANDEM UNITS



These six new Frost-Radio Volume Controls are representative of the service rendered by Herbert H. Frost, Inc., in meeting the demands of the manufacturers of receiving sets of today and tomorrow. Tandem units such as these operate smoothly, noiselessly and with an almost total absence of wear. They are non-inductive, unaffected by temperature or humidity changes. They may be obtained in any desired curve. Wire wound or carbon element type. Clockwise or counter-clockwise knob rotation. Shaft and thimble length to suit your needs.

As the world's largest manufacturers of high grade variable resistors, we are singularly well equipped to supply your requirements, no matter what they may be. Write us in detail regarding your variable resistor problems, and have us submit samples to meet your specifications.

Brief data on six tandem units illustrated

A. No. 280-280. Combination metal shell wire wound and composition elements. Wire wound up to 15,000 ohms. Composition, 5,000 to 1 megohm. Rheostat or potentiometer type in either unit. Units insulated from each other. Diameter, 1 11/16 in. Depth of shell, 1 3/8 in.

B. No. 890. Double depth metal shell unit in rheostat or potentiometer type. Rotors in same electrical connection. Composition elements. 5,000 ohms to 1 megohm in each unit. Diameter, 1 7/8 in. Depth of shell, 1 3/16 in.

C. No. 1880-1880. Same as 280-280 except all bakelite.

D. No. 200-200. Metal shell type wire wound resistors with resistances from 5 ohms to 10,000 ohms. Split windings. Rheostat or potentiometer types. Units insulated. Diameter, 1 7/16 in. Depth of shell, 1 1/2 in.

E. No. 2880-2880. Bakelite shell composition element only. Resistance range from 5,000 ohms to 1 megohm. All curves. Potentiometer or rheostat types. Units insulated from each other. Diameter, 1 1/2 in. Depth of shell, 1 1/8 in.

F. No. 590-590. Metal shell, composition element only. Resistances from 5,000 ohms to 1 megohm. All curves. Potentiometer or rheostat types. Units insulated from each other. Diameter, 1 5/16 in. Depth of shell, 1 1/8 in.

HERBERT H. FROST, INC.

Main Offices and Factory **ELKHART, IND.** 160 North La Salle Street Chicago

To All Tube Manufacturers

GILBY SELVAGE MESH

CUT the shrinkage in your production—add to the strength of your product and at the same time enhance its appearance.

Gilby Selvage Mesh is an important improvement in this type screen grid material. A practically solid metal selvage of even surface offers high conductivity with a minimum of transport losses and in addition will lend itself to accurate forming.

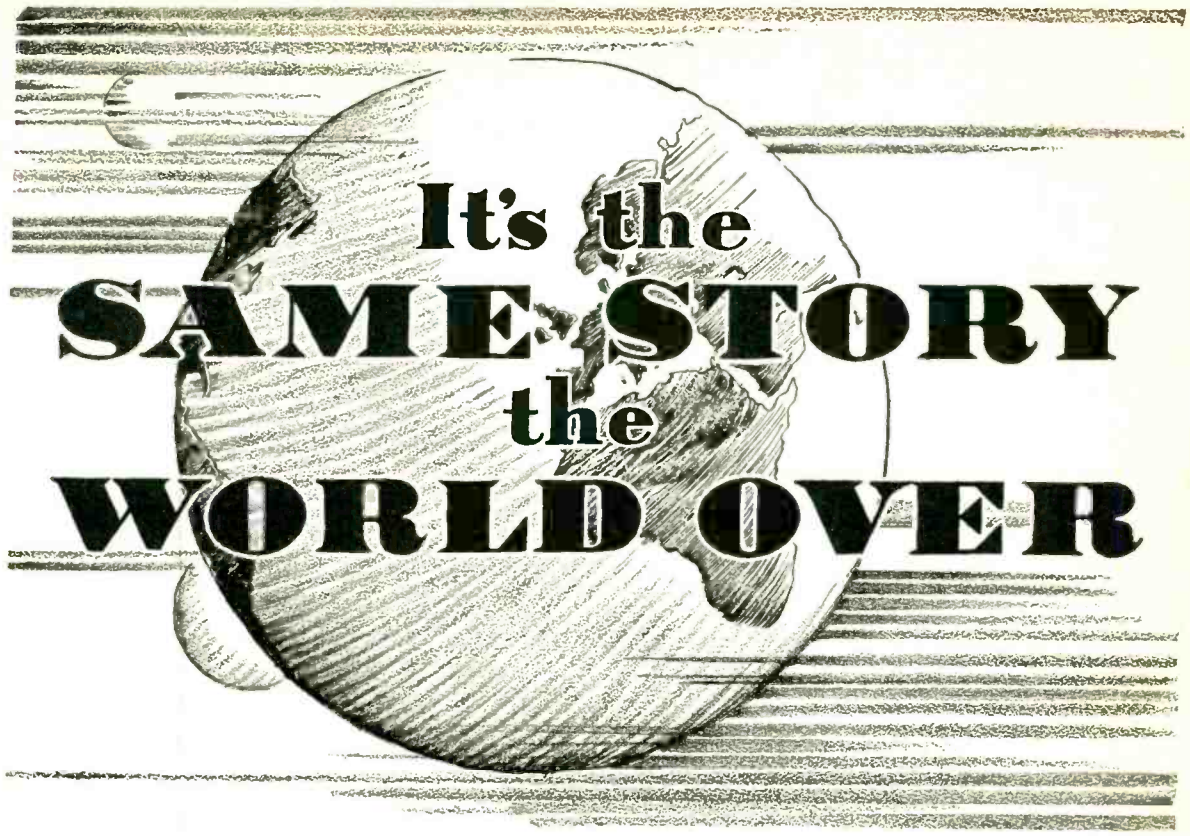
NOTICE IS GIVEN THAT WE HAVE APPLIED FOR PATENT ON THIS PRODUCT.

We will gladly supply detailed information on request.

GILBY WIRE COMPANY

Wilbur B. Driver, President

NEWARK, NEW JERSEY



Jensen Electro-Dynamic Speakers are now supplied to discriminating Europeans by the three leading manufacturers of Europe

THE superiority of Jensen Electro-Dynamic Speakers is not restricted to American recognition. In England and in Europe—among all these people with their appreciation of the finest and best in music and the allied arts—Jensen has won the same indisputable leadership held in this country.

Three of the leading manufacturers whose name and product rank at the very forefront of the radio art in Europe are today supplying discriminating buyers with speakers made in their own plants under agreements permitting the use of Jensen principles and design.

And as in this country, their selection of Jensen was only made after exhaustive laboratory tests and comparisons of every type of dynamic speaker of both American and European manufacture.

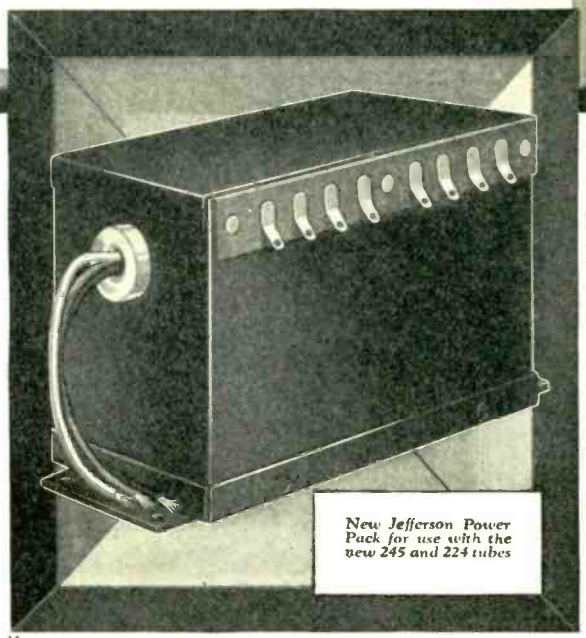
Jensen's world-wide recognition is an asset no manufacturer, dealer or jobber can overlook. Today, tone quality is the keystone in the successful sale of any radio receiver. Shrewd distributors and dealers will continue to prefer sets Jensen equipped—definite assurance of the best the industry has to offer.

Jensen
ELECTRO-DYNAMIC SPEAKERS
LICENSED UNDER LEKTOPHONE PATENTS

Upon request we will be pleased to give you the names of both American and European manufacturers using Jensen Electro-Dynamic Speakers in their current models.

JENSEN RADIO MANUFACTURING CO. · 6601 S. Laramie Ave., Chicago, Ill. · 212 Ninth St., Oakland, Ca.

Engineering Co-operation *to* SOLVE *your* TRANSFORMER PROBLEMS



New Jefferson Power Pack for use with the new 245 and 224 tubes

KEEPING step with the progress of electrical development, Jefferson has maintained a reputation for quality transformers . . . for engineering co-operation in designing and developing transformers for special application.

With the advent of radio, a large and complete engineering department, a research laboratory and a staff of sales engineers was added to render definite assistance in the solution of electrical problems.

Today, numerous radio manufacturers attribute much of the success of their sets, from an electrical standpoint, to the help of Jefferson engineers in the design of their audio and power transformers. Likewise, they have benefited by Jefferson production capacity—which insures prompt deliveries during peak seasons.

These are the services which Jefferson offers you, too—in addition to serving as a reliable source of supply for quality transformers. Our engineering and research departments are maintained to serve you. Let us know your problems.

JEFFERSON ELECTRIC COMPANY
1592 S. LAFLIN STREET CHICAGO, ILL.

Transformers and Chokes for New Power Tubes

As specific evidence of Jefferson engineering progressiveness, we present the new power transformers, designed for use with the new 245 power tube and the 224 shield grid tube. To work with these new transformers, we have a wide range of choke units—heavy single duty chokes—double choke units of conventional design—or staggered choke units, one heavy and one light choke, an especially economical method which minimizes hum and allows maximum voltage on power tubes without overloading the rectifier. Special audio transformers, improved in design, are also available to make use of all the possibilities of these new tubes.

Complete electrical specifications and quotations on these new units will be furnished on request.

JEFFERSON

AUDIO and POWER TRANSFORMERS and CHOKES

(9474)

UNTIL

someone else, who knows and uses your products, says them. Then, such testimonials constitute the strongest kind of endorsement.

That's why Polymet is proud of the things said about Polymet Products:

"Finely Built Products" —*Silver*

"Quality Parts" —*Stewart Warner*

"Definitely Superior Specialized Parts" —*Zenith*

"With Polymet Parts, Perfect Service is Assured" —*King*

"Specialized Parts That Complete the High Quality of Fada Sets" —*Fada*

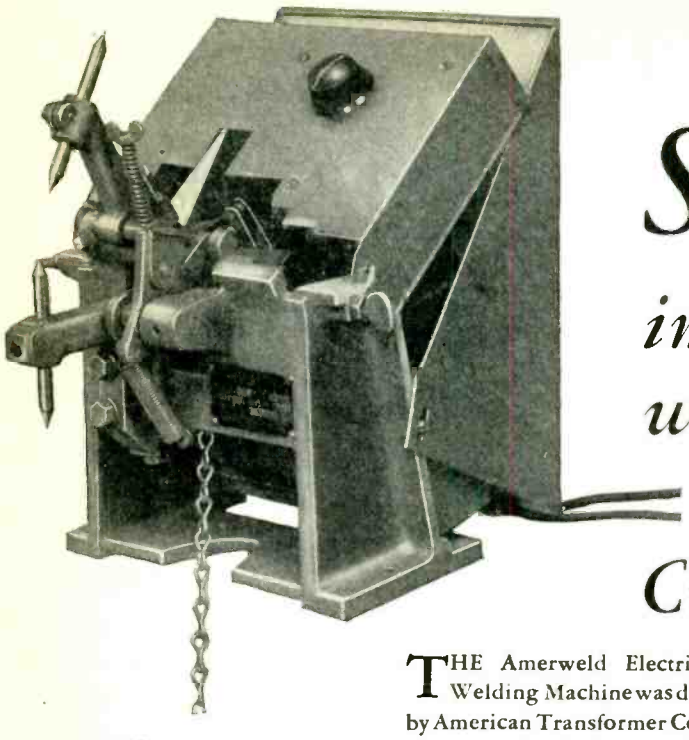
CONDENSERS
RESISTANCES
COILS
TRANSFORMERS

Could our own adjectives ever mean one-half so much as the testimony of such companies as these!

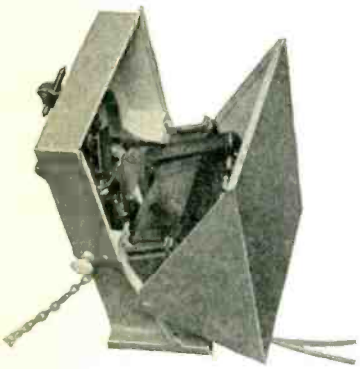
POLYMET MANUFACTURING CORPORATION
839-C E. 134th St. New York City

POLYMET PRODUCTS

Builders of Transformers for every laboratory and industrial application



Speed in Production— with the delicate touch of the Craftsman—

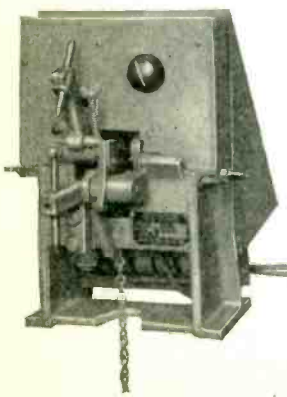


THE Amerweld Electric Spot Welding Machine was designed by American Transformer Company engineers for fusing small metal parts, such as the elements in radio tubes and electric light bulbs, in the manufacture of jewelry, dental supplies, novelties, and for small spot welding of all kinds.

It is simple, quick, reliable, safe, and economical of current—hence inexpensive. Equipped with a Ward Leonard Vitrohm rheostat and adjustable within a useful range, both for intensity of heat and the period of application, Amerweld fills a long felt need. As many welds as required can be made with no loss of time, giving maximum productivity and minimum waste of materials. A battery of fifty Amerwelds can be accommodated on a bench one hundred feet long and six inches deep, reclaiming valuable floor space for other operations.

The machine can be supplied for operations on circuits of any frequency, and voltages up to 550 volts. Standard units are carried in stock for 220 and 110 volts—60 cycles.

For further information write for Bulletin 1125.



Representatives

Atlanta, Ga.—H. Douglas Stier, 101 Marietta Street

Chicago, Ill.—L. C. Hermann, 4433 North Richmond Street, Ravenswood Station

Knoxville, Tenn.—Arthur L. Pollard

Minneapolis, Minn.—Elliott Equipment Co., 708 Sixth Avenue, South.

Montreal, Canada—W. O. Taylor & Co., Ltd., 415 Canada Cement Bldg.

Philadelphia, Pa.—L. D. Joralemon, 112 South 16th Street

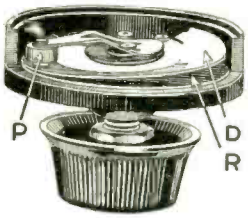
San Francisco, Calif.—James H. Southard, 682 Mission Street

St. Louis, Mo.—J. W. Jones, 432 Pennant Building

AMERWELD *Electric* SPOTWELDER

AMERICAN TRANSFORMER COMPANY 178 EMMET STREET NEWARK, N. J.

HE LOST CONTROL *and* FUMBLED



This shows the exclusive rocking disc construction of Centralab volume control. "R" is the resistance. Contact disc "D" has only a rocking action on the resistance. Pressure arm "P" together with shaft and bushing is fully insulated.

A brilliant play . . . a sure touchdown . . . ruined by a FUMBLED BALL.

The follow thru was bad . . .

. . . a beautiful concert . . . a good radio set . . . a fine speaker . . . all ruined by a faulty volume control.

Instead of an even flow of current the listener is rewarded with an incoherent, sputtering programme.

CENTRALAB equipped receivers ALWAYS permit the reception of a rich, clear, coherent programme—smoothly and without a break.

The tailor uses the same principle as Centralab. He does not want to ruin the garment by placing the iron on it so he places a cloth in between. Centralab controls cannot ruin the resistance because the rocking disc is in between the pressure arm and the resistance.

Centralab

CENTRAL RADIO LABORATORIES

20 Keefe Ave. Milwaukee, Wis.

IMPRESSIONS and EXPRESSIONS

By

AUSTIN C. LESCARBOURA

The Game of Mergers

THE industry is still indulging in the merry game of mergers. Daily, a new merger is announced; more companies lose their identities; proprietors exchange their independence for a block of stock and a job; and stock brokers and bankers wax fat on the profits of throwing in a generous amount of water into an erstwhile substantial capitalization.

Again we issue a mild warning regarding this merger craze. Legitimate merger has always been a good thing, for it reinforces production facilities, reduces costs, and consolidates merchandising outlets with a bigger profit for the producer and a better value to the consumer. However, there are entirely too many mergers these days which are worked purely for the fiscal end. We have in mind the merging of many smaller companies, paying off the former proprietors in a big block of stock of the over-capitalized merger, and with a big percentage of the stock sold by the organizers to the public—with appreciable profits for the financiers. As often as not the former proprietors ultimately wake up to find the stock of far less value than they had anticipated. They have, in truth sold their birthright for a mess of pottage. It is well-nigh impossible for the management of some of the recently merged organizations to show any return on the shares issued, with the result that the shares soon drop down to sickly low levels.

No; we are getting just a bit too much of this merger business. Unless the radio manufacturer is absolutely sure he is entering into a legitimate merger and not merely a screen for stock manipulations and quick cleanup by fiscal agents, he had better fight the battle alone.

It's Not That Bad!

ONE of our estimable contemporaries, which always seems to find sufficient dramatic news in our industry to compete with any daily rabloid newspaper in the matter of thrillers, assures us in its last issue that certain radio and motor manufacturing interests are about to gobble up the entire radio industry at one sitting. Among the dreadful features of this threat, we are told that these interests are buying up the radio shops in many cities and territories, so as to control retail outlets; that many radio manufacturers are being bought up, so as to form a tremendous manufacturing enterprise; and that, all in all a perfect monopoly is being created without regard for the laws of the land which, we believe, still have teeth when it comes to the stifling of legitimate competition.

Of course a new and powerful organization has just been set up by the Radio Corporation of America, and the General Motors Corporation, with the former contributing 4,900,000 and the latter 5,100,000 of dollars, representing 49% and 51% of the stock. A ten million dollar capital is not to be ignored, but on the other hand it is not overbearing, as capitalizations go these days. Frankly, we fail to see where this new organization can monopolize the field, although we frankly admit that it may play an important role in the industry.

There is room for the new organization. It may be depended upon to exploit a place for itself in the growing market. It will no doubt practice the live and let live philosophy which marks all present-day business. Let us treat this new organization as a worthy competitor. Any other course would be decidedly unfair, to begin with.

Exclusive Sales Representation

SOMEONE has said something about the silver lining of the dark cloud. Just now, with an obvious over-production of radio sets and, to a lesser degree, vacuum tubes, and with jobbers and dealers more or less dictating the terms under which they will carry on the merchandising activities of the industry, there is a growing tendency to award exclusive territories to both jobbers and dealers.

Personally, we believe this is really a blessing in disguise. While it may come as a rude surprise to many radio manufacturers, heretofore accustomed to selling anywhere and to anybody, it is actually a step in advance to grant exclusive territories. Obviously, a jobber cannot push a line which is handled by his competitors in the same territory. No jobber is going to put over any real sales efforts on a given line when he feels that such efforts may be helping his competitors as well. It takes money to push any line, and the average jobber, long since grown lazy in the matter of doing a selling job, is not gambling with his money.

The same story holds true for the retailer, and in even greater measure, since his selling efforts are necessarily more intensive and often backed up by an advertising investment. No dealer is going to do any real selling and advertising unless he is assured of a 100% break on the business created.

Grant exclusive territories, therefore, but be sure you grant them to genuine Go Getters!

The Merchandiser's Turn

THE old story of supply and demand is unfolding itself in the radio industry. What with undeniable over-production of radio sets and vacuum tubes in sight even at this early date in the radio season, radio manufacturers have more to offer than the merchandisers are ready to take. Consequently, supply exceeds demand; which, translated into trade terms, means that jobbers and dealers are doing all the dictating and picking this year.

Never before have the jobbers and the dealers been so fortunately fixed in this industry of ours. In most territories, these merchandisers are looking over the offerings and deciding what they will handle and on what terms. Existing discounts are being laughed at in many instances, and both jobbers and dealers are naming their own figures. Also, they are insisting on exclusive representation in many instances, and getting it without argument.

Verily, it is the merchandiser's turn this season. There is no help for it. We have over-produced again, and must suffer the consequences. However, this is perhaps not so much an occasion for weeping as for jubilation. There may be a definite gain, after all, in having the merchandiser tell us what he can and cannot handle, and on what terms. At any rate, the situation is mighty interesting.

"This Cabinet Makes Sales," say Marvin Dealers

FROM dealers everywhere comes the highest praise for this new merchandising idea by Marvin. Introduced just a few short months ago, the Marvin Metal Display Cabinet has already established itself as a successful sales-maker and an absolute stock control for Marvin dealers.

Lithographed in full colors and sturdily constructed of metal, this Marvin Cabinet immediately catches the eye and urges the customer to buy Marvin "Master-Built" —the tubes that *serve better* and *live longer*. Placed on the end of the counter, back against the wall or featured in the window, this cabinet is always rendering good service and telling a story.

Be guided by the experience of other successful dealers and put this Marvin Cabinet to work for you. It holds just about the right number of tubes you want to display. You will find it will reduce the number of tubes you have to carry, simplify your inventory problems and increase your tube profits. It is free to all Marvin dealers. Ask your Marvin distributor or write to us for complete information.

MARVIN RADIO TUBE CORPORATION
Irvington, N. J.
General Sales Office: 225 BROADWAY, NEW YORK

EVERY Saturday night at 8.30 Eastern Standard Time (7:30 Central Standard Time) over Station WJZ and Associated N.B.C. Stations, the Marvin Musicians are making prospects of millions of radio tube users for Marvin dealers. Consistent newspaper advertising and adequate display material assist in telling the story of Marvin "Master-Built"—the tubes that *serve better* and *live longer*.

MARVIN
MASTER-BUILT
RADIO TUBES

Circuit Combinations That Provide Substantially Uniform Signal Selection†

Band-Pass Filter Circuits Combined With Tuned Resonance Circuits in Cascade

*By E. A. Uehling**

THERE has been a marked tendency in recent years in the design of radio broadcast receivers toward the separation of the functions of signal selection and radio-frequency amplification. This trend began a few years ago, when the majority of manufacturers discarded the coupling tube method of supplying the signal in the antenna to the receiver, and has now gone so far that laboratory models have been constructed and commercial receivers have been built in which the complete function of signal selection is accomplished before any amplification of the signal is permitted to take place. This separation of functions has been accomplished through the use of the band-pass filter. Whether or not this separation of functions should be complete remains to be seen after a more thorough study of the band-pass filter has been made. Such filters as are generally used have certain inherent disadvantages which in a practical radio receiver must be eliminated and which in general are most easily eliminated by combining the band-pass filter with other circuits.

"Phantom Stations"

The desirability of adequate signal selection and filtering before amplification is well known to everyone. Due to the non-linear characteristics of amplifier tubes, a certain amount of rectification of the signal takes place in the first stage of amplification as well as in the following stages resulting in a small rectified current available for the modulation of other carriers if they are present. In the neighborhood of a strong broadcast station, as a result, a carrier to which the receiver is tuned will sometimes be modulated by the audio-frequency signal of the partially rectified carrier of the local broadcast station, and both signals will be heard together. This modulation can take place in another way. Two stations whose carrier frequencies are separated by such an amount that their difference falls in the broadcast band can often be heard together when the radio receiver are not impaired, and they quency. The result is the well-known phenomenon of "Phantom Stations." In order to avoid this condition, a more thorough separation of signals is required before any amplification takes place.

The band-pass filter is well known for its selective properties. It has other advantages as well, among them being the flat top characteristic which so adequately permits the transmission of sidebands. As a consequence, sideband cutting is reduced to a minimum, yet the selective properties of the receiver are not impaired, and they may, in fact, be improved. A broadcast receiver must, however, be capable of receiving carriers over a wide range of frequencies. It is here that trouble is encountered in the use of the band-pass filter. Its characteristics at one end of the frequency range may be entirely unlike its characteristics at the other end. A variation in band width with change in frequency is the most evident of these varying characteristics. There are others as well, among them being a marked change in the ratio of the input and output voltages if the coupling between the circuits of the band-pass filter is permitted to have a value less than the critical value at any frequency in the broadcast range. Occasionally there are conditions under which it is desirable to design the circuits in this way.

A band-pass filter in its most simple form consists of two circuits of positive and negative reactance coupled together by means of either a positive or negative reactance or a combination of one or both. Two such circuits, coupled by a negative reactance, are shown in Fig. 1-A. In Fig. 1-B and Fig. 1-C, respectively, similar circuits coupled by a positive reactance are shown; in Fig. 1-D and 1-E the same circuits having a coupling between them consisting of a combination of reactances, and in Fig. 1-F the same circuits again with capacitative and magnetic coupling. The discussion in this paper relating to band-pass circuits will be confined entirely to the two-section type of structure.

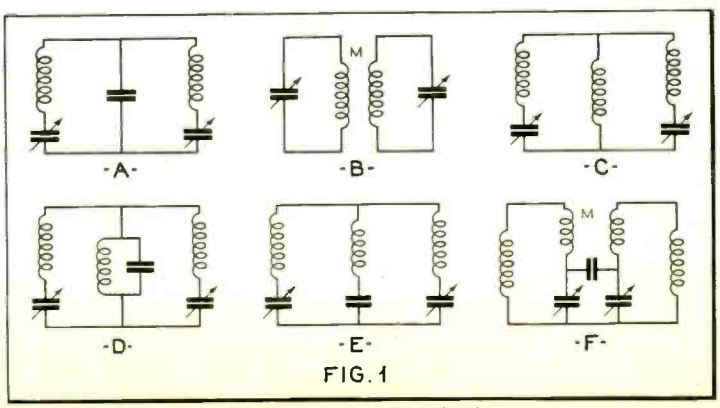


FIG. 1

Typical band-pass filter circuits.

**Engineering Dept., F. A. D. Andrea, Inc.*

† *Delivered before the Radio Club of America, September 11, 1929.*

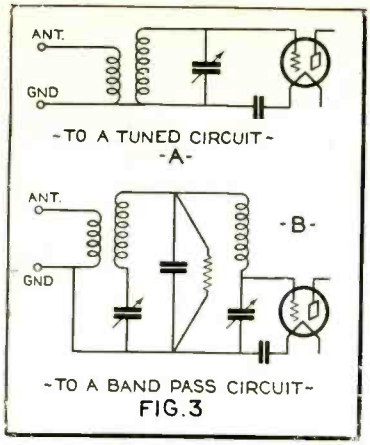


FIG.3

Two methods of antenna coupling.

Two-Section Band-Pass Filter

One of the properties of a two-section band-pass filter as shown in these figures is that to an e.m.f. placed in one of the circuits there will be two frequencies at which the alternating e.m.f. and current will be in phase. These two frequencies occur when the reactance of the first circuit X_1 and of the second circuit X_2 is expressed by

$$X_1 = \pm \sqrt{\frac{R_1}{R_2}(B^2 - R_1 R_2)}$$

and

$$X_2 = \pm \sqrt{\frac{R_2}{R_1}(B^2 - R_1 R_2)}$$

where B is a real quantity and is equal to the coupling reactance, and R_1 and R_2 are the resistances of the first and second circuits, respectively. The coupling between the circuits must be sufficient in which case

$$B^2 > R_1 R_2$$

It is at these two values of reactance given by the above equation, the positive and the negative value, that the two peaks of the band-pass transmission characteristic occur. The radio engineer is interested in the separation of these peaks; for on this separation the selectivity of the receiver and the degree of side-band cutting largely depends. In general, R_1 and R_2 are equal, or nearly so, when loosely coupled to the energizing circuit, so that

$$X_1 = X_2 = \pm \sqrt{B^2 - R^2}$$

The frequency separation of the two peaks can be easily determined. One peak occurs when the reactances X_1 and X_2 are given the positive values of the above equation, and the other peak occurs when the reactances X_1 and X_2 take on the negative value. To determine the frequency separation of the peaks it is necessary only to determine the rate of variation of the reactances with changes in frequency. This is done for an ordinary series circuit which is a generalized form of each of the circuits of the band-pass circuit.

$$X = \omega L - \frac{1}{\omega C}$$

$$\frac{dx}{d\omega} = L + \frac{1}{\omega^2 C}$$

$$\frac{dx}{df} = \frac{dx}{d\omega}\frac{d\omega}{df} = 2\pi L + \frac{2\pi}{\omega^2 C}$$

at resonance

$$\frac{1}{\omega^2 C} = L$$

Then

$$\frac{dx}{df} = 4\pi L$$

$$\frac{df}{dx} = \frac{1}{4\pi L} \qquad (1)$$

Thus, for a small change in frequency near the resonant point of the circuit, the change in frequency per unit change in reactance is equal to $\frac{1}{4\pi L}$. The change in frequency per unit change in reactance is independent of the original value of ω.

As the generated frequency is varied from the value it has at one peak of the transmitted band to its value at the second peak of the transmitted band, the reactance of the individual circuits X_1 and X_2 changes from $\pm\sqrt{B^2 - R^2}$ through zero to $\mp\sqrt{B^2 - R^2}$. The toral change in reactance is then $2\sqrt{B^2 - R^2}$. Integrating equation (1)

$$\frac{df}{dx} = \frac{1}{4\pi L}$$

we have

$$f = \frac{X}{4\pi L}$$

Therefore, the frequency separation of the points of maximum transmission is

$$f = \frac{X}{4\pi L} = \frac{2\sqrt{B^2 - R^2}}{4\pi L} = \frac{\sqrt{B^2 - R^2}}{2\pi L} \qquad (2)$$

The narrower the band width, or the smaller the quantity $\sqrt{B^2 - R^2}$ the greater is the accuracy of this equation. The error introduced by spreading the value of the derivative over the width of the band is, however, very small when radio circuits are considered because of the relatively small value of f as compared with f_r the resonance frequency of the individual circuits.

The frequency width of the transmitted band is usually given by equations which neglect the circuit resistances. According to these formulas the lower frequency peak is given by

$$f_1 = \frac{f_r}{\sqrt{1 + K}}$$

and the higher frequency by

$$f_2 = \frac{f_r}{\sqrt{1 - K}}$$

where f_r is the resonant frequency of one circuit taken alone and K is the coefficient of coupling

$$K = \frac{M}{\sqrt{L_1 L_2}}$$

If

$$L_1 = L_2 = L$$

$$K = \frac{M}{L}$$

Then f, the frequency width of the band is

$$f = f_2 - f_1 = f_r\left[\frac{1}{\sqrt{1 - K}} - \frac{1}{\sqrt{1 + K}}\right] \qquad (3)$$

Circuit Resistance

But the radio engineer cannot afford to neglect circuit resistances when dealing with band-pass filters. This is especially true considering the relatively narrow width of the transmitted band of frequencies and the high value of the radio frequency to which it is referred. Considered in this way, the coupling appears very close to the critical value and in this range the circuit resistances play an

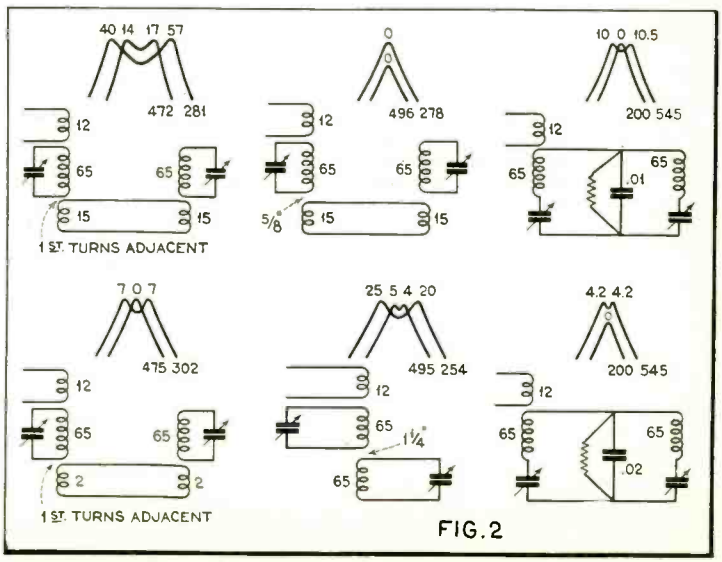


FIG.2

Transmission characteristics of coupled circuits.

extremely important role. It will be evident that for zero circuit resistances all values of coupling are greater than the critical value for (B^2-R^2) would always be greater than zero.

It will be interesting, nevertheless, to show that equation (3) is approximately equal to equation (2) when the resistance term in equation (2) is dropped. The two fractions of equation (3) can be expanded into an infinite series of which all but the first few terms are negligible.

$$\frac{1}{\sqrt{1-K}} = 1 + 1/2\ K + 3/8\ K^2 + \frac{15}{48} K^3 + \frac{105}{384} K^4 + \ldots\ldots$$

$$\frac{1}{\sqrt{1+K}} = 1 - 1/2\ K + 3/8\ K^2 - \frac{15}{48} K^3 + \frac{105}{384} K^4 - \ldots\ldots$$

and

$$f_r = \frac{\omega_r}{2\pi}$$

Substituting these values in equation (3) and neglecting all terms in which K appears to the second and higher degrees

$$f = \frac{\omega_r}{2\pi}\left[1 + \frac{K}{2} + \ldots\ldots - 1 + \frac{K}{2} \ldots\ldots\right] = \frac{\omega}{2\pi} K = \frac{\omega M}{2\pi L}$$

Neglecting the resistance term in equation (2)

$$f = \frac{\sqrt{B^2 - R^2}}{2\pi L}$$

we have

$$f = \frac{B}{2\pi L}$$

and if inductive coupling is used $B = \omega M$ and $f = \frac{\omega M}{2\pi L}$ establishing the approximate equality of the two equations.

Having determined the width of the transmitted band of frequencies and the factors affecting this width, it remains to determine what variations exist when the circuits are tuned to different carrier frequencies in the broadcast range without introducing any change in these circuits except to vary the tuning condensers as is ordinarily done in tuning a receiver made up alone of tuned circuits in cascade. In the process of tuning, L remains unchanged. B, the coupling impedance, will, however, vary, and R will vary. If the quantity (B^2-R^2) can be maintained constant, the transmitted band width will remain constant. R in general increases in value with frequency. B increases in value with frequency if the coupling is inductive and decreases if the coupling is capacitative. It might appear on first consideration that inductive coupling would give more uniform width of band than capacitative coupling. It must be remembered, however, that we are interested not only in the direction in which the coupling impedance varies, but the rate at which it varies

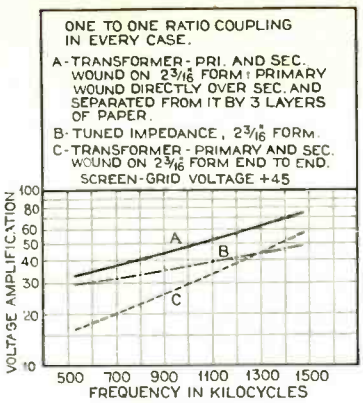


FIG. 5

Amplification of one screen-grid tube with transformer and tuned impedance coupling.

with frequency. The value of quantity (B^2-R^2) may be substantially constant though the individual quantities are varying in opposite directions, provided that the rate of variation of these quantities is actually low. Such is the case under certain conditions.

The rate of variation of B for inductive coupling is

$$\frac{d\,B}{d\,\omega} = \frac{d\,[\omega\,M]}{d\,\omega} = M \qquad (4)$$

The rate of variation of B for capacitative coupling is

$$\frac{d\,B}{d\,\omega} = d\,\frac{\left[\frac{-1}{\omega\,C}\right]}{d\,\omega} = \frac{1}{\omega^2\,C} \qquad (5)$$

In an average radio circuit of fairly low resistance coils and for 10,000-cycle band width at 500 kilocycles, M for inductive coupling, and C for capacitative coupling will have a value such that the values of the two derivatives just given will be approximately the same. As the frequency is increased, the value of equation (4) remains unchanged, which means that for inductive coupling the band width increases constantly as the frequency is increased, the resistance term being more nearly negligible as the peaks of the transmitted band separate from one another. On the other hand, when capacitative coupling is used, we must use equation (5), the value of which decreases with increasing frequency, which means that the rate of decrease of the width of the band as the frequency increases becomes less and less.

Capacity Coupling

While neither type of coupling is wholly desirable from the point of view of changes in band width with changes in frequency, capacity coupling under certain conditions offers the greater possibilities. This is especially true if the band-pass filter is to be combined with other resonant circuits in cascade. Such a combination first of all improves the characteristics of the band-pass filter by flattening the portion of the transmitted curve between the two peaks. In this way the advantages of both types of circuits can be utilized and the combination in most respects is very desirable. A little further study of the characteristics of a combined band-pass filter and resonant circuits will disclose the important advantages which exist in favor of capacity coupling. As already shown, the transmission band becomes more narrow as the frequency is increased. The selectivity of ordinary resonant circuits, however, decreases as the frequency is increased because of the increasing resistance of the circuits. To offset this decrease in selectivity, a band-pass filter that has a very narrow band at high frequencies and a 10,000-cycle band at low frequencies will give an over-all selectivity band that is of almost constant width.

Selectivity curves showing the transmission characteristics of such a combination of circuits are shown in Figs. 9 and 10. In this combination of circuits a capacity-coupled type of band-pass circuit precedes the first amplifier tube and adequately performs the function of signal selection. In the amplifier, tuned circuits are used to couple the amplifier tubes and the detector. These circuits have selectivity characteristics of their own which tend to improve that of the band-pass circuit at the longer wavelengths. At the short wavelengths conditions are reversed. The tuned circuit characteristics are broad at these wavelengths, but in combination with the capacitative-coupled band-pass circuit of extremely sharp selectivity characteristics at these wavelengths, the transmission a few kilocycles off resonance is very materially reduced. The result is a selectivity characteristic at all wavelengths that is substantially uniform.

There are still other possibilities. Radio-frequency amplification tends to

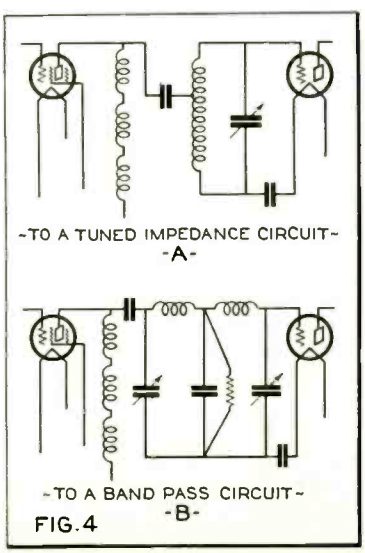


FIG. 4

Two methods of screen-grid coupling.

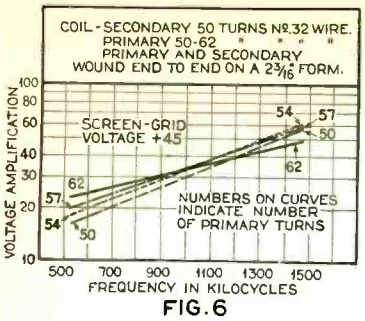


FIG. 6

Amplification of one screen-grid tube with transformer coupling.

increase as the frequency is increased. In some cases this change in amplification can be partially eliminated by the introduction of fixed regeneration that affects the higher wavelengths only, by careful design of the antenna coupling system, by self resonance in the primary circuits of the radio-frequency transformers, and by several other methods. If screen-grid tubes are used, however, this problem becomes more difficult, and if the amplification is made to meet the requirements at 500 kc. it may be so large at 1,500 kc. that over-all regeneration will produce instability. This condition can be partially removed by using a capacity-coupled band-pass filter that has its coupling impedance so adjusted as to pass through the point of critical coupling at some point in the broadcast range. At all frequencies greater than this critical frequency, the gain will be gradually reduced as the frequency is increased with the result that the receiver will have a more nearly uniform amplification curve and the possibility of oscillation at short wavelengths will not be present even though the total amplification is further increased at the longer wavelengths than could otherwise have been done.

Position of Band-Pass Circuit

When the band-pass circuit is used in this way and loosely coupled to the antenna circuit, it will supply to the grid of the first amplifier tube for a given voltage in the antenna circuit, if the coupling between the circuits is sufficient, a voltage equal approximately to one-half the voltage that would have been supplied had an ordinary tuned circuit been used. It does not follow, however, that from the point of view of maximum voltage amplification a more desirable position for the band-pass circuit could have been found. If used in the output circuit of a screen-grid tube, the voltage amplification for the stage would be only one-half the amplification obtainable if a tuned circuit had been used instead. In fact, it is more or less general that when a band-pass circuit is supplied by means of an ideal generator, i. e., one in which the generated current is independent of the load impedance, the voltage amplification is approximately one-half that obtainable if an ordinary tuned circuit had been used instead of the band-pass circuit. If a band-pass circuit is used following a -27 type tube, the loss in amplification as compared with that obtainable with an ordinary tuned circuit, other conditions being identical, is approximately 30% under the best conditions for each type of circuit. This loss in voltage amplification can be shown very easily. Referring to Fig. 3-A where the ordinary antenna circuit is shown, the current in the tuned circuit is given by

$$i_2 = \frac{\omega M e_1}{Z_1' Z_2}$$

where Z_1' is the forward equivalent impedance of the antenna circuit, that is, the impedance of the antenna circuit as influenced by the tuned circuit. But the resonant frequency of the antenna circuit is usually much higher than the highest frequency of the broadcast band and the coupling impedance is usually very small. Therefore,

$$Z_1' = Z_1 \text{ approximately}$$

and

$$i_2 = \frac{\omega M e_1}{Z_1 Z_2} \qquad (6)$$

In Fig. 3-B is shown an antenna circuit coupled to a band-pass circuit. The current in the first of the band-pass circuits, the one to which the antenna is coupled, is given by

$$i_2 = \frac{\omega M e_1}{Z_1' Z_2'}$$

where Z_2' is now the impedance of the first tuned circuit as influenced by the impedance of the following circuit to which it is coupled and not that of the tuned circuit alone as before. Again,

$$Z_1' = Z_1 \text{ approximately}$$

and

$$i_2 = \frac{\omega M e_1}{Z_1 Z_2'} \text{ nearly}$$

If $R_2 = R_3$

$$i_2 = i_3 \qquad (7)$$

and the equation just given holds as well for the current in the final circuit, which is the one in which we are interested.

This equation differs from equation (6) only in the term Z_2' which has replaced Z_2. In the term Z_2'

$$X_2' = X_2 - \frac{\omega^2 M^2}{Z_3^2} X_3 = 0$$

and

$$R_2' = R_2 + \frac{\omega^2 M^2}{Z_3^2} R_3 = 2 R_2$$

Therefore, the denominator of the equation (7) is twice as large as that of equation (6) and the voltage ratio when the band-pass circuit is used is one-half that obtainable with an ordinary tuned circuit. Now assume that the band-pass filter had been placed after one of the screen-grid tubes. The circuit is shown in Fig. 4-B. The load impedance would be that of a tuned circuit and is equal to

$$R_L = \frac{L}{R_1' C}$$

where L is the inductance of the tuning coil, C the capacity of the tuning condenser, and R_1' the resistance of the first circuit as influenced by that of the circuit to which it is coupled. This resistance R_1' is equal to

$$R_1' = R_1 + \frac{\omega^2 M^2}{Z_2^2} R_2 = R_1 + \frac{R_1}{R_2} R_2 = 2 R_1$$

Therefore, the resistance term in the equation for R_L is twice as large for a band-pass circuit as for an ordinary tuned circuit. Therefore, R_L is reduced one-half when the band-pass circuit is used, and the amplification which is equal to

$$g = g_m R_L$$

is also reduced one-half.

R-F. With Screen-Grid Tube

Having considered the problem of signal selection and the selectivity characteristics of a particular type of band-pass filter combined with tuned radio-frequency circuits, we will now turn our attention to the problem of radio-frequency amplification using the screen-grid tube. Both impedance coupling and transformer coupling will be considered. Because of certain characteristics of the screen-grid tube, and in particular the high plate impedance of these tubes, the problem of high amplification per stage is reduced to one of obtaining a high load impedance.

The elementary equation for amplification with a single three- or four-element tube is

$$g = \frac{\mu R_L}{r_p + R_L}$$

This can be transformed and reduced to more simple terms by neglecting the value of R_L whenever it appears with r_p in comparison with which it is small as follows:

$$g = \frac{\mu R_L}{r_p + R_L} \quad \frac{\mu}{r_p} \frac{R_L r_p}{r_p + R_L}$$

$$= G_m R_L \frac{r_p}{r_p + R_L} = G_m R_L \text{ approximately.}$$

The external load impedance is usually obtained by means of a resonant circuit. If an anti-resonant circuit appears directly in the plate circuit, the

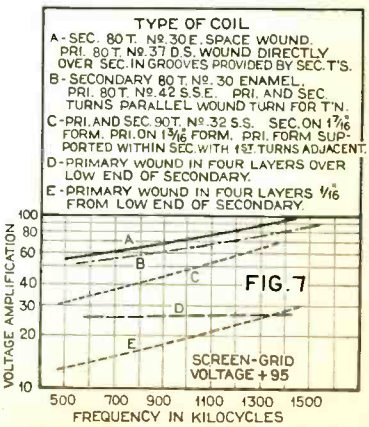


FIG. 7

Amplification of one screen-grid tube with transformer coupling.

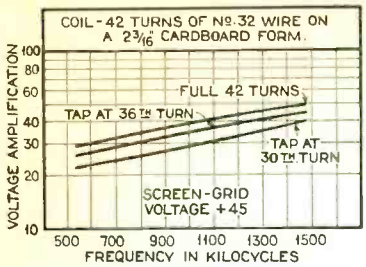


FIG 8

Amplification of one screen-grid tube with tuned Impedance coupling.

load impedance R_L is given by

$$R_L = \frac{L}{R\,C}$$

where L is the inductance of the resonant circuit, C is the capacity and R is the resistance.

If the resonant circuit is coupled inductively to a coil which is located in the external plate circuit the load impedance is given by

$$R_L = \frac{\omega^2 M^2}{R}$$

where ωM is the mutual impedance of the radio-frequency transformer and R is the radio-frequency resistance of the secondary circuit. It will be understood from this equation why ωM must be made so much larger in value when screen-grid tubes are used instead of the —27 type.

A little calculation will show that if M is made so large that it is equal in value to the inductance L of the tuning coil, the value of R_L obtained with transformer coupling is equal to that obtained with impedance coupling. To obtain this value of M the primary inductance will have to be greater in value than the secondary inductance because the coefficient of coupling K cannot be made equal to unity.

A little study of these equations will give us some idea of the possible amplification per stage and the factors that affect this amplification. If the inductance L is equal to 200 microhenrys, the maximum capacity of the tuning condensers will be 419 mmf. or slightly more. The resistance R of the circuit may be of the order of 10 ohms at 550 kc. If impedance coupling is used, the load impedance at 550 kc. will be

$$R_L = \frac{L}{RC} = \frac{200 \cdot 10^{-6}}{10 \cdot 419 \cdot 10^{-12}} = 47700 \text{ ohms},$$

and at 1500 kc. the load impedance, assuming that the resistance R has increased from 10 to 30 ohms, will be

$$R_L = \frac{L}{RC} = \frac{200 \cdot 10^{-6}}{30 \cdot 56 \cdot 10^{-12}} = 119000 \text{ ohms}.$$

The screen-grid tube has a mutual conductance of approximately 1000 micromhos. The amplification per stage is then equal to

$$G = G_m R_L = 1000.10^{-6} \cdot 47{,}700 = 47.7$$

at 550 kc.

The amplification available is found to be directly proportional to the tuning coil inductance and inversely proportional to the circuit resistance. The latter consideraton calls for coils of good shape factor, shielding that does not appreciably intercept the magnetic lines of force of the coil, large size copper wire, low-loss materials in the constructon of coil forms and compensating condenser dielectrics and supports, and good condensers. The value of L should be made as large as practical not only because of the increase in amplification obtainable, but also because the selectivity is improved thereby as is indicated by the equation for the decrement of the tuned circuit, given by

$$\delta = \frac{R}{2\,f\,L}$$

R-F. Choke

When the stages are impedance coupled an r-f. choke coil must be used, to avoid an excessive use of blocking condensers in the tuned circuit, and a grid resistor. The use of such a choke has several advantages. The gain characteristic of the amplifier can be varied considerably by choosing the characteristics of the choke coil. The choke coil impedance must, however, be extremely high at all frequencies to prevent it from adding considerable reactance to the tuned circuit. The characteristics of r-f. choke coils vary considerably with the conditions under which they are used, as for example, the circuit to which they are connected, their proximity to the metal chassis of the receiver, and the iron plate on which this chassis rests in the console and the character of the bolt used to hold the choke coil to the chassis.

Because of the characteristics of the choke coil and because of the effectively closer coupling obtained with tuned impedance circuits, the amplification characteristic in the r-f. stages is in general more uniform than is obtained with transformer coupling. Comparative results for the two types of coupling are shown in Fig. 5. If a different design of r-f. choke coil had been used, a different curve for impedance coupling would have been obtained.

The same latitude in design is permissable with transformer coupling but there are greater practical limitations. In order to obtain a reasonably low ratio of amplification at short waves to that obtained at long waves, the primary inductance must be very large. The effect of increasing primary turns is shown in Fig 6. One reason for the decrease in amplification at the short wavelengths when the primary inductance is increased above a certain value can be understood by considering the equation for transformer coupling. The load impedance we have found equal to:

$$R_L = \frac{\omega^2 M^2}{R_2}$$

The ratio of the voltage across the primary to that impressed on the grid of the preceding tube is then

$$\frac{E_1}{E_g} = G_m R_L = G_m \frac{\omega^2 M^2}{R_2}$$

If the coefficient of coupling between primary and secondary is nearly unity the voltage step-up or step-down between primary and secondary is substantially equal to $\frac{L}{M}$ and the voltage ratio between the grids of successive tubes is then

$$g = G_m \frac{\omega^2 M^2}{R_2} \frac{L}{M}$$

As ωM is increased, the value of the term R_L increases and may reach a value where it is no longer possible to express the equation for amplification without including the term $\frac{r_p}{R_L + r_p}$ which may become considerably less than unity in value. Then the gain will have to be expressed as follows:

$$g = G_m \frac{\omega^2 M^2}{R_2} \frac{r_p}{r_p + \frac{\omega^2 M^2}{R_2}} \frac{L}{M}$$

$$= G_m \frac{r_p}{\frac{r_p R_2}{\omega^2 M^2} + 1} \frac{L}{M}$$

$$= \mu \frac{\omega^2 M^2}{r_p R_2 + \omega^2 M^2} \frac{\omega L}{\omega M}$$

$$= \mu \frac{\omega M}{r_p R_2 + \omega^2 M^2} \omega L$$

With respect to variations in ωM this value of g is a maximum when:

$$\omega^2 M^2 = r_p R_2$$

When $\omega^2 M^2$ is increased in value by varying M to the point where it becomes equal to or greater than $r_p R_2$ there is a decrease in amplification. The decrease in amplification at 200 meters with increasing primary turns as shown by the curves of Fig. 6 may not be explained in this way, however, for it is doubtful whether the conditions for optimum coupling have been satisfied in these tests. These results are more likely due to capacity coupling between primary and secondary which reduces the load impedance of the primary circuit when the num-

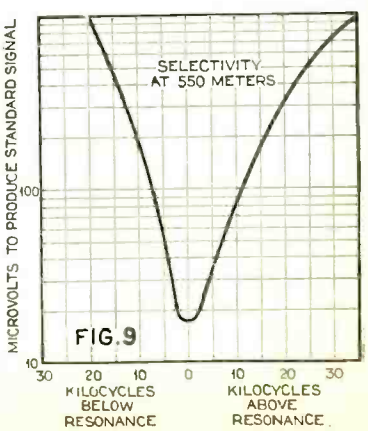
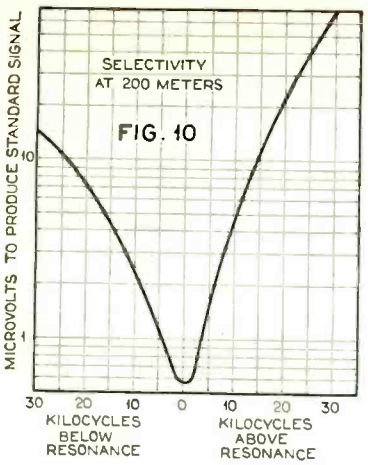


FIG. 9

Microvolts required in a .00025 mf. antenna to produce a standard signal of 50 milliwatts.



Microvolts required in a .00025 mf. antenna to produce a standard signal of 50 milliwatts.

ber of primary turns exceeds that of the secondary.

Effect of Capacity

The effect of capacity between the primary and secondary windings of an r-f. transformer designed for screen-grid tubes is more important than similar capacities have been considered in the past. This capacity has its effect on the amplification per stage and on the frequency range that a given tuning condenser will cover. The latter effect is probably the more important, and is especially noticeable if the primary winding is wound close to the secondary and covering only a portion of the secondary winding. In general, coils with an equal number of turns for both primary and secondary have been found most satisfactory. Especial care must be taken that the stages will tune to the same frequency over the entire broadcast range. Because of the very close coupling required, and the effect of the copper in the primary winding on the distributed capacity of the secondary, these coils may not tune to the same frequency over the broadcast band with the antenna coil or other coils in the receiver that differ from them in construction.

Selectivity requirements may not, in general, permit the use of unity ratio in the design of the radio-frequency transformers. The resistance added to the tuned circuit and due to the tube plate impedance will be equal ro

$$R' = \frac{\omega^2 M^2}{r_p}$$

This may amount to nine or ten ohms at 200 meters. If impedance coupling is used, the same value of resistance is added to the tuned circuit if the full number of turns on the tuning coil is used in the plate circuit of the amplifier tube.

Methods of Measurement

Two distinct methods of measurement have been used in obtaining the experimental data that was necessary for the verification of the theory. Most measurements on radio receivers and circuits require the use of a very small known input voltage. If amplification measurements on a single stage of radio frequency are to be obtained this voltage can be as large as .1 volt and its value must be accurately known. If several stages of radio-frequency amplification or an entire receiver are to be measured, this voltage may have to be less than a millivolt and if a very sensitive receiver is to be measured it may have to be as low as a microvolt, and again the voltage must be accurately known.

There are a number of well-known methods of obtaining a small known voltage of radio frequency. One of these is to pass a current of the desired frequency through a straight copper rod of negligible resistance and to use the reactive voltage drop of a portion of this rod to supply the input voltage. The inducrance of the rod can be calculated by empirical formulas.

A second method is to use the resistance drop of a small non-inductive resistance. It is, however, more difficult to obtain a small accurately known resistance of negligible inductance than it is to obtain a small accurately known inductance of negligible resistance.

A third method is to use a mutual inductance. Empirical formulas for mutual inductance are not, however, as accurately known as for self-inductance, and measured mutual inductances would not be of a sufficiently small value to render them satisfactory for this purpose.

A fourth method is to generate a large voltage of the desired frequency, measure it with a thermocouple meter or vacuum tube meter, and then attenuate it with a radio-frequency attenuator of known characteristics to the desired value.

The first and fourth of these methods have been used to obtain the curves described in this paper. The first method was used exclusively until another method giving smaller voltages was necessary. Then the results obtained by the first method were checked by the fourth and they were found to be reasonably accurate.

The first method is valuable because it can be used conveniently without the need of elaborate apparatus. It is accurate, provided that considerable care has been taken in determining that the calculated impedance and the actual impedance across which the voltage drop is used are identical. For the purpose of these measurements a copper rod .15 cm. in diameter and 25 cm. long was used. The inductance of this rod is given by the formula

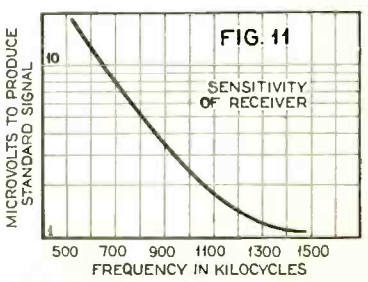
$$L = .002\left[2.303 \log_{10}\frac{4l}{d} - .75\right]$$

where l is the length of the rod in cm., d is the diameter of the rod in cm., and L is the inductance in microhenrys. The inductance of the rod described is then equal to .287 microhenrys, and the reactance is equal to .991 ohm at 550 kc. and 2.703 ohms at 1500 kc. If two milliamperes of current are permitted to pass through the rod at either frequency, the voltage developed between the ends of the rod will be 1982 microvolts at 550 kc. and 5406 microvolts at 1500 kc.

The mechanical and electrical arrangement must be such that the thermocouple meter cannot read current that does not actually pass through the rod. In general, the meter should be connected to the circuit as near ground as possible and the circuit should be grounded at one point only and all capacities to ground for the rest of the circuit should be as low as possible. Sources of error that might be encountered are: a, mutual inductance between the portion of the rod used for supplying the reactive voltage and the ends of the rod whether the end lengths are in the same straight line as the useful portion or not; b, mutual inductance between the useful portion of the rod and the ground wires and metal chassis; c, charging currents in the circuit.

If the measuring equipment is well arranged mechanically and electrically, these errors can be made very small. The errors due to mutual inductances can be eliminated by using instead of a copper rod, a copper rod and sheath concentrically arranged, the sheath acting as a return circuit. The sheath will not eliminate mutual impedances but it will make them more definite and susceptible to calculation. Current flowing in the copper sheath does not produce a magnetic field inside the sheath, yet a mutual inductance between these two branches of the circuit does exist due to the electrostatic fields existing between the electrons comprising the current. The mutual impedance can be calculated, whereupon the resultant impedance of the rod alone becomes known and can be used for supplying the reactive voltage drop.

Thus, having a source of known voltage, we need only an output voltage measuring device to measure the voltage after amplification. A vacuum tube voltmeter is most satisfactory for this purpose because of its slight effect on the apparatus to be measured.



Microvolts required in a .00025 mf. antenna to produce a standard signal of 50 milliwatts.

Amplification is then given as the quotient of the measured output voltage and the known input voltage. Selectivity measurements can be made in the same way, varying either the input frequency or the reactance of the circuit under test.

The curves shown in Figs. 5, 6, 7 and 8, were obtained by the use of the method just described. These results were checked at a later date using a standard signal generator supplying an accurately known voltage across a very small resistance. The latter method is the fourth one mentioned above. For single stage amplification measurements this voltage was applied directly to the grid of the amplifier tube. When making measurements on a complete receiver and

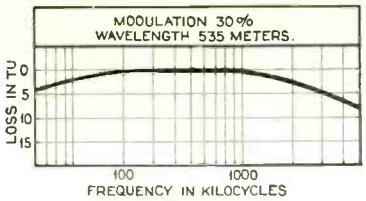


FIG. 12

Fidelity characteristic from antenna to loudspeaker.

when making measurements on the transmission characteristics of band-pass circuits, this voltage was applied to a dummy antenna circuit consisting of the 2-ohm resistance of the signal generator, a .00025 mf. condenser and the primary of the transformer used for coupling to the apparatus being measured. In addition to checking the results obtained by the first method, this method was used to obtain the results of Figs. 2, 9, 10, 11 and 12. The last four figures describe the performance of a laboratory receiver designed according to the principles discussed in this paper. The selectivity curves are of special interest. They illustrate what can be done in the way of maintaining uniform selectivity characteristics in a receiver. Though the selectivity curve at 200 meters is slightly broader than at 545 meters, it is believed that there is an improvement in results over that which is usually achieved with four tuned circuits in the space available for the radio-frequency circuits.

New Plant a Model of Modern Efficiency

Novel Arrangement and Modern Equipment Effect Greater Economies in Production

IN planning and designing their new plant in Long Island City, N. Y., the Allied Die-casting Corporation has endeavored, by every means known to modern engineering, to not only equip their new plant with the finest and most up-to-date operating equipment; but also to utilize the available space to the best advantage, providing the greatest ease in operation and eliminating as much as possible waste in energy and time, thereby developing a high degree of efficiency.

The new Allied building offers 75,000 square feet of ideal space on four floors. Being of daylight construction, with light on all four sides and fully sky-lighted it makes a well-ventilated, cheerful, light, sanitary plant.

Every convenience possible has been supplied for the comfort of employees. Shower baths have been installed for the use of the operators as well as extensive rest and locker rooms.

Maximum Operating Space Obtained

The problem of utilizing the space available to a maximum degree has been solved in several ways. Each floor is constructed with a minimum of supporting pillars consonant with safety. All drains and pipes from die-casting machines and ingot molds pass through the floor structure, eliminating all piping on the floor level. Each floor is heated by unit heaters suspended from the ceiling, no wall or floor space being consumed. These heaters, besides being out of the way, insure a more complete distribution of heat. Being motor driven, the heat is forced throughout each floor and a more uniform temperature results.

To minimize the effort and time usually expended in summoning officials and department heads, who may be in another part of the plant, through the telephone or to their offices when required, a call system has been installed that reaches throughout the entire building. In addition, self-service elevators serve each floor, besides the regular freight elevators, eliminating all stair climbing and waiting for elevator cars.

The entire plant has been designed and the various departments planned along the idea of conserving time and labor. For instance: the Engineering Department is centrally located so that it is in equally close contact with all departments requiring its services or supervision. The die construction department is located on the floor directly beneath the casting department, permitting close contact between these two departments. One of the features of the die construction department is their maple parquet flooring, laid diagonally to eliminate wear and provide a resilient dust proof covering.

The trimming, finishing and machining department is located on the second floor so that the castings produced on the top floor travel down to the second floor and after being processed there, proceed down to the shipping department.

The receiving, shipping and foundry departments are, of course, on the ground floor and in order to facilitate the weighing in and out of material when necessary, large platform scales are sunken in the floor at the loading platform.

As the main boiler of the plant and the furnaces in which the metals are alloyed are all oil fired and a great volume of oil is constantly being delivered, a large oil reservoir is so placed that it can be filled directly from the street by gravity without interfering with the regular loading and unloading of trucks at the entrance.

Roof Space Utilized

On the roof is located a large, fully equipped metallurgical and chemical laboratory for research work, for testing the purity of metals received, for testing alloys and for the development of formulae to provide special alloys for special uses. Also on the roof is located a cooling tower. This tower supplies the water for cooling dies, ingot molds and compressors. The water is retained in a circulating system which not only cools the water, but uses it over and over again, eliminating the use of city water and its waste by allowing it to run off, after passing through the equipment.

Pipe Lines Accessible and Easily Traced

Throughout the entire building the pipe lines used for various purposes are painted different colors, so that they can be easily identified and traced. In addition, all piping is grouped and enclosed in a specially constructed pipe galley, which is provided with many doors permitting quick and ready accessibility.

Monorail System For Handling Heavy Dies

In the die construction department a monorail system is used, so placed that it is available from any part of the bench, which lines the entire wall of the third floor, permitting speedy and easy movement of heavy dies. This monorail system is also used wherever large heavy pieces must be moved about such as in the die storage vaults.

(*Continued on page* 37)

The Control Grid Glow Tube

Technical Data on the Properties and Characteristics of the "Grid-Glow" Tube and Its Numerous Applications

*By W. E. Bonham**

With the advent of the new tri-element gas filled tubes for non-simultaneous relay control of an electric current by grid action, and because of the enormous ratio between the controlled and the controlling energy, there is offered an unlimited field for development work and application for them. These tubes, of which the thyratron and the "grid glow" tubes are types, can be made in sizes for controlling currents of a fraction of a watt or several kilowatts with a very small expenditure of energy in the grid circuit, which in the case of the "grid-glow" tubes, is as small as 10^{-12} watt seconds, with the controlled circuit approximately 10 watts.

Briefly, the "grid-glow" tube is similar to the UX-874 regulator glow tube with the addition of a third element, or grid. Current flow is uni-directional. The voltage bias applied to the grid controls the voltage at which the gas between the anode and the cathode becomes conductive or glows. Hence, its name, "grid-glow" tube.

Factors of Rectification

The rectification in a tube using cold electrodes must be produced by other means than thermal-forced emission as is employed in the thermionic tubes using a filament as the cathode.

At atmospheric pressure, with a potential applied between the two electrodes, there is nearly the same amount of ionizing of the gas atoms near either plate. However, as the pressure decreases, ionization becomes more pronounced near the positive electrode. This is easily explained in that at lower pressure there are fewer gas atoms; therefore, negative electrons being emitted from the negative electrode are more free to accelerate in velocity toward the positive electrode, attaining speed sufficient to produce ionization by collision of the gas atoms in the vicinity of the positive electrode. Thus, at decreased pressure, a gas becomes more conductive.

Were both plates to be of the same size and material, the electron flow would be the same in either direction. The amount of electron emission from a surface is directly proportional to its area. It is also dependent upon the nature of the surface and the energy that is required to remove the electrons from the surface, which varies greatly with different materials.

Aluminum requires little energy for electron emission. Nickel requires considerable energy and even when heated has practically no electron emission.

Thus, by having a cathode of aluminum with a pitted inner surface, a smooth surface anode of nickel, and having the ratio of their areas very large—500 to 1—and in a low pressure gas, the conditions are highly favorable for electron movement in one direction,—cathode to anode.

Construction and Operation

The tube at first appearance is like the radio vacuum tube, the elements and the bulb being mounted on a high-grade base fitted with prongs to fit the standard UX socket. See Fig. 1.

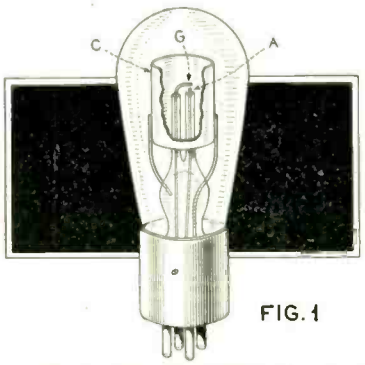


FIG. 1

Showing the construction of the tube: A, smooth surface anode non-emissive; G, grid; C, cathode. With the anode and grid in a length of separate tube the crest leakage between these two elements is reduced resulting in a high "free grid" breakdown voltage. The area and spacing of grid to anode are also factors of "free grid" breakdown, as the electron field density increases as the electrons near the anode and the grid area must vary inversely with the electron density to produce a given biasing effect.

The anode, in order to possess small area, consists of a wire prong only, the tip of which protrudes through a narrow glass tube into the gas. Although the current flow is small, the anode is subject to heat, and is accordingly made of nickel—a non-emissive material. In close proximity to the anode, bent closely over the tip of it and highly insulated, is another nickel wire prong, the grid. The cathode is in the form of an aluminum cylinder approximately one inch in diameter, encircling the anode and the grid. These elements are in nearly 10-mm. pressure, neon, the resultant glow of which is a beautiful orange.

The principle of operation is shown by assuming a d-c. potential to be applied to the anode and cathode, the negative polarity to the cathode. There will then be an emission of negative electrons from the cathode, the speed of which is determined by the voltage applied, and which does not produce an ordinary detectable current flow. At a definite electron velocity corresponding to a definite existing potential between the cathode and the anode, the instant ionizing of the gas atom renders the space between the two electrodes conductive. In this case, the grid remains free, or floating, in which condition it accumulates a negative charge from the cathode emission. This negative charge upon the grid creates a negative space charge about the anode, the effect of which is to repel the negative emission from the cathode, decreasing the electron velocity, and requiring a high applied potential to break down the gas.

Were the grid and the anode to be in metallic connection, the grid could not accumulate a negative charge. Thus, the potential required to produce breakdown is low at 350 volts d-c. as compared to "free grid" breakdown at 900 to 1,000 volts.

Biasing of Grid

Contrary to belief, biasing of the grid is in respect to the anode. With the grid free to accumulate a negative potential, it becomes negative in respect to the anode. When in metallic connection they are at the same potential as zero bias. By placing a positive bias upon the grid, the electron velocity toward the anode will be accelerated, allowing gas to break down at a low potential. The d-c. voltage at which the tube will break down with positive or negative bias to the grid is shown by the d-c. breakdown curve in Fig. 2. With d-c. bias to the grid, the a-c. potential (R. M. S. value) necessary to break down gas is .707, the d-c. value.

After the gas has broken down, the voltage bias upon the grid has practically no effect or changes on the anode cathode current flow because the space about the grid is then positively charged. The strength of this positive charge practically varies in synchronism with the change of the cathode current, so that in case of interruption of current flow for a period of time exceeding the persistance of the positive space charge, the grid can build up negative upon the restoration of the applied voltage preventing breakdown of the gas until the proper voltage is reached, or the biasing charge is removed.

Thus: were a d-c. bias of 100 volts applied to the grid, the d-c. potential required to produce breakdown would

* *Radio Division, Signal Corps. Associate, A.I.E.E.*

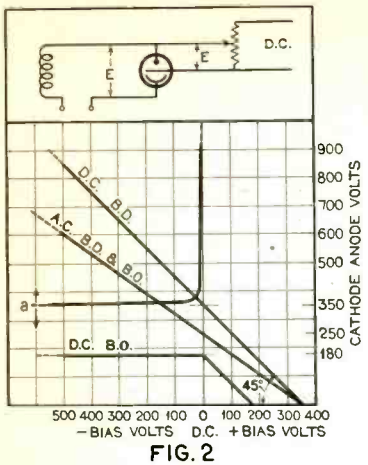


FIG. 2

Graph showing the breakdown (B.D.) and breakoff (B.O.) voltages for a d-c. bias. The a-c. B.D. and B.O. voltages are the same, falling .707 of the d-c. B.D. value. The d-c. B.O. value is 180 for any value of negative bias voltage; however, with a positive bias it decreases to zero in the ratio 1 to 1. The sensitivity curve is shown for the breakdown value of 350 having no numerical value except to show the relative sensitivity at different bias voltages. The sensitivity for a breakdown of 500 volts is approximately determined by shifting "a" to 500.

be 450 volts. The voltage drop between anode and cathode remains constant at 180 volts, regardless of current flow. Thus, the tube would continue glowing as long as the applied d-c. potential remained above 180 volts. Below this value, it would break off or cease glowing. By the d-c. break-off curve, it is seen that with a positive grid bias the break-off voltage is less than 180 volts as the positive potential to the grid decreased the potential drop between the cathode and grid.

The tube as used in this respect is capable of maintaining a constant potential between the limits of 0 to 180 volts. Its value as a "controllable" voltage regulator is not limited by any features of the tube which are objectionable.

Now, if an a-c. potential is applied to the cathode anode, the tube will glow when the voltage during the cycle that is negative to the cathode rises to that value which is necessary to break down the gas for the existing bias upon the grid, and will continue glowing during the alternation until the 180-volt point is reached. The R.M.S. voltage when operating on a-c. is the same for both breakdown and break-off, and the rectified waveform is well reproduced within the frequency limit above which the persistance of the positive shield of the ions about the anode between cycles affects the following cycle. With a d-c. bias of minus 100 volts to the grid, an a-c. potential having a peak value of 450 volts (318 R.M.S.) would break down the tube and the current would flow during that part of the alternation lying between the B.D. (breakdown) point and the 180-volt point.

If the grid bias voltage were to be maintained at a certain value, say, minus 300 volts, the value of the applied d-c. potential to produce breakdown would then be: zero bias breakdown (350 volts) + 300 volts = 650 volts, as the ratio of the existing bias to the potential above zero bias B.D. voltage required to produce breakdown is 1 to 1. For a given bias change, it is thus seen that the cathode potential necessary to maintain the tube just at the breakdown point is decreased or increased by the same amount, depending on whether the bias were made more positive or negative. Therefore, the amplification factor is 1.

The sensitivity of a tube individually considered is of different value, depending upon the Eg value for a given Ec. For, were Ec to be 500 with Eg minus 200, the bias would have to be increased by 50 volts in order for the tube to break down.

Now, were the grid free (for which the B. D. voltage is 800), and were a cathode potential to be applied, the tube would exist with an accumulated negative charge upon it effectively equivalent to a minus 450-volt bias. Now, the tube in order to break down at the 500 volts would have to have the effective value of the bias reduced to an equivalent value of a minus 150-volt bias. Were a 100-megohm resistor connected between the grid and anode so that 3 microamperes flowing from the grid through it produced the required 300-volt bias change, the tube would break down. Now, were there but 2.95 microamperes showing, the tube would be within 5 volts from breakdown, thus there would exist upon the grid a power quantity of

$$.05 \times 5 \times 10^{-6} = .25 \text{ micro watts,}$$

which when dissipated from the grid allows the tube to break down.

Characteristics of Tube

The sensitivity increases somewhat with increased cathode potential for higher value resistance paths for any leakage produces a greater effective IR drop. The sensitivity curve in Fig. 2 is taken at a cathode potential of 350 volts. It is seen that sensitivity increases as Eg nears O volts, being extremely high near breakdown.

The tubes are rated in accordance to their sensitivity. Some tubes, because of slight discrepancies in make, require less energy expenditure in the grid circuit to keep the tube just below breakdown. The sensitivity of an average tube is such that the applied potential can be adjusted so near the breakdown point that the energy existing in the grid circuit preventing tube breakdown, or rather, maintaining it just on the verge of breakdown, can be represented by the small quantity of 10^{-12} watts. This energy when dissipated from the grid in one of the many possible ways will allow tube breakdown.

Fig. 2 shows the a-c. and d-c. characteristics with d-c. bias to the grid. All biasing is in respect to the anode. Were the bias an a-c. voltage then the a-c. characteristic would form a 45-degree angle with the horizontal axis, and pass through the 250-watt point on the bias axis only when the cathode and the grid potential are in synchronism, which they will be normally if from the same source and no condition exists to produce a phase difference.

With an a-c. bias differing in frequency from the applied voltage, it is easily seen that the tube will glow intermittently at a frequency corresponding to the beat frequency of the two. This is true, however, only under the following condition: at some instant during the sequence of operation, the grid and the applied voltages will be maximum negative together, and at this instant the grid must be sufficiently negative to prevent the tube from breaking down; otherwise, the glow would be continuous. Then it is the frequency of the beat that determines the frequency of the intermittent periods of no tube glow, and the relative values of the grid and the cathode potentials that determine whether there is a period of no glow. In this respect the tube serves as a synchronism indicator. Synchronism is indicated by the tube ceasing to glow with the proper relative voltage values, for then the grid and the anode are of the same polarity at the same instant. In case the tube continues glowing, and the bias is not below the proper value, then the two voltages are of the same frequency but differ in phase by an amount near 90°, and near 180° if the breakdown drops below the zero bias value by an amount nearly equal to the grid potential, for then the grid is positive at the instant when the applied potential is maximum positive. After the frequencies have indicated themselves to be the same (which we are assuming them to be), the phase difference can accordingly be figured, providing, of

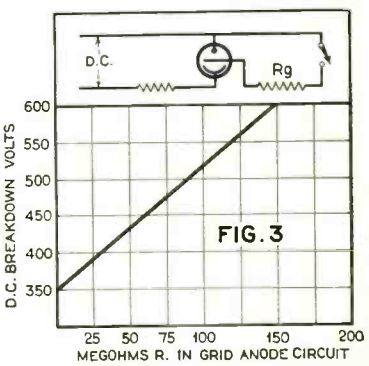


FIG. 3

Curve showing the breakdown voltage for values of the grid anode circuit resistance. Free grid resistance is approximately 350 megohms depending upon the design of the base and the socket in which used. This curve will vary somewhat for a given resistor as the circuit resistance may be of lower value than the resistor itself, because of leakage in the socket or wiring.

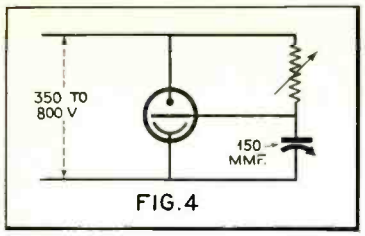


FIG. 4

This shows one of the many possible combinations of control. If control is to be obtained by a decrease of resistance in the grid anode circuit over a band of at least 10 to 15 megohms, the adjusting condenser is set to near tube breakdown. If breakdown is to be produced by a capacity change in the grid cathode circuit then a value of resistance is selected so that the tube is near breakdown, then any decreased capacity allows tube to operate relay. Or the tube may be normally glowing . . . then breakoff is produced by either a decrease of the resistance or an increase of the capacity.

course, that the two voltages have similar shaped sine waveforms.

For instance, as seen by the graph in Fig. 2, a potential having a peak value of 100 volts will require an applied potential having a peak of 450 volts to the cathode in order to maintain the tube just at the breakdown point with the two voltages in synchronism. Now, as the phase difference increases to 90°, the peak voltage that is necessary to maintain the voltage just at the breakdown point decreases to 350 volts. For, with a 90° phase difference, the grid is zero volts when the cathode potential is maximum negative. This initial value of 100 volts bias was selected in order to give a direct reading of the sine of the angle of phase difference, for as the phase difference shifts from 0° to 90°, the voltage maintaining the tube just at breakdown changes by (450 — 350), 100 volts.

The sine of the angle increases from 0 to 1 as the angle of phase difference increases from 0° to 90°. This difference in the voltage reading obtained, divided by 100, equals the sine of the angle of phase difference. Then, as the phase difference increases to 180° the grid becomes maximum positive when the anode is maximum positive, for which the voltage maintaining the tube just at the breakdown value is 250 volts, or 200 volts lower than for 0° phase difference. Now, the sine of the angle of 180° is ϕ. Thus, consideration must be given as to which quadrant the angle of phase difference might lie in.

Now from the above, using 100 volts as bias:

$$\frac{450 - x}{100} = \text{Sin. } \phi$$

in which x is the breakdown voltage obtained. Now, at 180° the above value of x would be 250 volts, making the sin. ϕ equal to 2, which is impossible. Thus the value 450 — x will determine the quadrant that the angle will lie in. Being in the first quadrant, if below 100, and in the second, if above 100.

Now as the angle increases above 90° the sine of the angle decreases from 1. Thus, when the angle of phase difference lies in the second quadrant, the difference in the voltage reading obtained must have subtracted from it twice the voltage that the difference is above 100 volts.

Thus, the above formula applies only to the first quadrant. That for the second quadrant is:

$$\frac{(450 - x) - 2\,(450 - x - 100)}{100} = \text{Sin. } \phi$$

or,

$$\frac{-250 + x}{100} = \text{Sin. } \phi$$

Current Averaging at Audible Frequencies

When a d-c. bias is applied to the grid, the persistance of the positive shield about the anode following each half cycle of glow tends to reduce the effective negative potential on the grid momentarily so that when high frequency is applied to the cathode, the rising E.M.F. during one alternation is at such speed that the tube will break down at an earlier point in the alternation, because of the momentarily decreased effective grid charge. This effect is proportional to the frequency increase. Thus, during that alternation there is more (quantity of current) rectified than during the preceding cycle. The increased quantity of current for that cycle allows a thicker positive field to form about the anode and the grid. Thus, the following cycle breaks gas down at a still lower potential. The quantity of current increases each preceding cycle to a maximum value, then likewise decreases each preceding cycle.

The high frequency current rectified in this way has an average increase and decrease in the quantity of electricity rectified each cycle. The frequency of the current averaging is dependent on the applied bias voltage which controls the degree to which the persistance of the positive shield affects each alternation and can be varied so that the averaging is controllable within the audible band. In this respect it is a generator of audible frequencies. Its use as such promises the introduction of a new form of modulation, as the audible note is not a modulation of the amplitude of the rectified wave. It is, instead, a modulation of the quantity of current flow for preceding rectified alternations.

Effect of Resistance and Capacitance in Grid Circuits

When the grid and the anode are in metallic connection externally, the grid cannot accumulate a negative charge as it is conducted away as fast as it is formed. The tube then functions as an ordinary two-element tube. This condition corresponds to a zero bias voltage for which the breakdown voltage is shown. With the grid free or disconnected and well insulated to prevent any leakage from it, the breakdown voltage is comparatively high—850 to 1,000 volts. The breakdown voltage is then also governed by the amount of leakage that takes place from the grid. This amount of leakage can be controlled by the proper resistance value placed in the grid-anode circuit. If it is assumed that all the leakage current from the grid passes through the resistor, the drop across the resistor acts as a bias to the grid, making it more negative in respect to the anode as the resistance value increases. Referring to the graph of Fig. 3, we see the voltage breakdown for values of grid-anode resistance. It shows that with a 25-megohm resistance value in the circuit, the breakdown voltage is 390. This is the same as the breakdown voltage for a 40-volt negative bias upon the grid. The current flow through the resistor is then in order of 1.5 x 10^{-6} amperes. Because of the instability of such high resistances, unless of special design, the predetermination of the breakdown voltage cannot be depended upon. However, in cases where the resistance of the external circuit is subject to change from, say, 15 megohms to 1 megohm, or vice versa, and it is desired to obtain relay operation as a result of the change, then operation is highly dependable. Such cases are unlimited. The change in the resistance of a flame will vary from approximately 40 megohms to less than 1 megohm as the temperature changes within appropriate limits.

In place of resistance control, capacitance control is much more desirable in that capacity is much easier to vary than resistance and is not subject to breakdown voltage. With a constant potential applied to the cathode and anode and a capacitance adjustment made so that the tube is

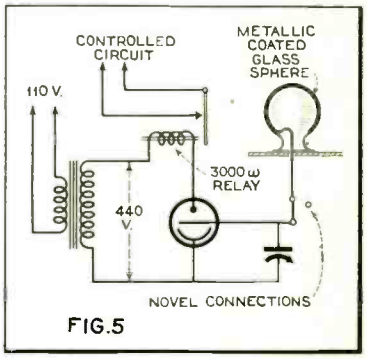


FIG. 5

This circuit is extremely sensitive to body capacity near the sphere. The hand near the sphere changes the capacity between the grid anode elements, as the anode is capacitively coupled to the ground through the capacity of the transformer windings, of which one side of the primary is grounded. Novel connections can be made by using the auxilliary terminal. By making connection to a large surface with precautions to prevent excessive leakage from the grid by the wiring, etc., and with proper condenser adjustment, the presence of the body within 2 to 3 feet from the surface is detectable.

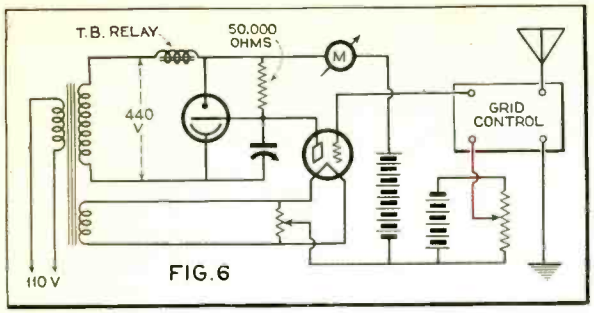


FIG.6

Circuit diagram of arrangement in which the tube is normally glowing, allowing relay operation to be obtained by breakoff, which is reproduced by any plate current increase from the vacuum tube.

near breakdown, any slight increase of capacity in the grid-anode circuit or any leakage from the grid allows the tube to break down.

In such cases where the desired control is not to be the function of another supply source, the breakdown and breakoff voltages can be controlled by a bias supplied to the grid through a resistance or a capacitance connected between the grid cathode, as shown in Fig. 4. The bias supplied to the grid by a condenser so connected is controllable within wide limits. In this circuit the tube can be adjusted for any desired value of breakdown between the zero bias value and near free grid value.

The sensitivity is a function of the relative values and the sum of the impedances of the grid cathode and the grid anode circuits. The ratio of the impedances, as can be reasoned from the earlier paragraph on sensitivity, will determine the quantity of energy that must be removed from the grid in order to produce breakdown, while it is the sum of the impedances that will determine the amount of IR drop that a given leakage from the grid will produce.

The value of the capacitance to give a desired breakdown voltage will depend upon the existing conditions for leakage from the grid. However, the values that give best control are 50 mmf. for the grid anode circuit, and 150 mmf. for the grid cathode circuit.

An example of the use of the tube by capacity change in the grid anode circuit to produce relay operation, as has recently been demonstrated on various occasions by passing the hand near a metallic surface which is connected to the grid, is shown in the circuit diagram, Fig. 5. This shows a small 1 to 4 ratio transformer with a secondary capacity of 10 ma. and connected to the cathode anode of the tube with a DFL relay in series. The grid of the tube makes contact with a metallic coating on the inside of the glass sphere, which is approximately 6 inches in diameter and is mounted on a well-insulated, high-grade panel. The variable condenser of 150 mmf. maximum capacity connected between the cathode grid is used as a means for supplying a negative bias to the grid, so that it can be adjusted to that value which just prevents the tube from breaking down, as indicated by the small initial halo or glow about the tip of the anode. This breakdown can be so nearly approached that the slightest leakage or capacity change in the grid circuit, such as passing the hand within 12 inches from the sphere, will allow the tube to glow, operating the relay. This circuit offers unlimited novelty advantages and shows the possibilities of the tri-element glow tube.

Use in Conjunction With the Vacuum Tube

The glow tube gives exceptional control advantages when used in conjunction with the vacuum tube amplifier.

An explanation of the circuit diagrams, Figs. 6 and 7, will show the principle which is used for relay operation with the thermionic tube. Fig. 6 obtains relay operation by tube breakoff, while Fig. 7 obtains relay operation by tube breakdown.

In Fig. 6 the circuit arrangement is such that an increased plate current flow through the resistor acts as a means for increasing the negative bias upon the grid of the tube allowing breakoff and giving relay operation.

The bias of the vacuum tube is adjusted to give nearly zero plate current through the resistor. In case the plate current is made zero, there is a possibility of over bias upon the vacuum tube, which would reduce the sensitivity of the circuit, as part of the incoming signal strength would be consumed in removing the surplus bias before effecting a plate current change.

With a plate current of .25 ma. maintained through the resistor, there is a voltage drop across it of 50,000 x .00025, or 12.5 volts which is negative to the grid. This bias is increased by the bias supplied to the grid through the adjusting condenser when near minimum position. Thus, a potential of nearly 440 volts is required to maintain the tube glowing. Then with the condenser adjusted so as to just maintain the tube at the breakoff, a very small increase of plate current flow in the order of .5 ma. gives an increased negative bias to the grid of the glow tube, of 25 volts, which is more than sufficient to extinguish the tube. While there is a reduction of the anode cathode current near breakoff, the current reduction at breakoff is quite sudden giving good relay action.

In the case of Fig. 7, the resistor is in the grid cathode circuit. Even though the resistor is of low value the resultant impedance is high, as the plate current of the vacuum tube flows through the resistor in a direction opposite to that furnishing a negative bias to the grid from the cathode. The control condenser in the grid anode circuit is thus very small, maintaining a high degree of sensitivity. With a normal plate current flow of .5 ma. through the resistor there will be a 25-volt drop which makes the grid at a potential 25 volts more negative than the cathode, which has the same effect as making it 25 volts positive in respect to the anode. The adjusting condenser must necessarily be small and its adjustment made near minimum capacity, so that the tube would just be near breakdown value as is indicated by the small halo or initial glow about the anode. Then an increase in the plate current of .25 ma. produces a 12.5-volt change in the bias making it more positive in respect to the anode, allowing the tube to break down, and remaining so until there is a decrease of the plate current.

In either circuit precautions must be taken to prevent excessive leakage from the grid of the glow tube, and in order to eliminate any external capacity, both the glow tube and vacuum tube must be in a shielded case.

These tubes are highly adaptable for use with photoelectric cells. Relay action is obtained either by tube breakdown or breakoff depending on whether the cell is used in the grid or the grid cathode circuits, respectively, and whether relay action is to be obtained by an increase or decrease of illumination upon the cell. In any case, the condenser should be used for the control adjustment.

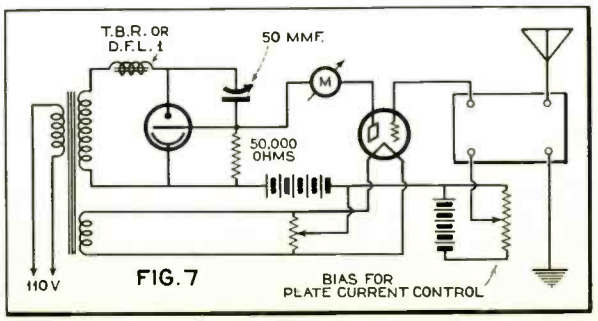


FIG. 7

In this circuit the tube does not normally glow. Relay operation is obtained by an increase in plate current through the resistor.

What About Servicing?

A Digest of the Results of a Survey of the Problems and Opinions of Leading Radio Manufacturers

By Austin C. Lescarboura
Mem. I.R.E. Mem. A.I.E.E.

BIG factories, high-powered sales forces, mass production, millions for advertising, highly paid engineers, the gift of gab, headline names and front-page concerns—all have gone into the making and selling of radios. Big men sit back and laugh. "We have the problem well in hand. The engineering end is down fine. Our advertising manager tells us that the billboards are plastered, the newspapers filled. Our sales manager tells us that so-and-so and what's-his-name, big shots in the public eye, are using our sets. Pictures in the papers of Al Smith listening in on the election returns over one of our sets. We can sell all we can make. The production manager reports that his department is stepping up every day. Great game, radio!"

Then a small voice asks: "How long will it last?" "Last?" says the big man, "why forever! This is a big industry. Millions invested. It's got to last. And anyway, what's to stop it?" The engineer seconds the motion. "We've got the engineering down cold. But there'll always be improvements, refinements, to make last year's set look old. People will keep turning them in and getting new ones. They're always after the latest." "Yes," from the advertising manager, "we'll make them feel like pikers if they haven't got the latest model." And the engineer, "The automobile manufacturers are able to do it. A few refinements in the engine and change the body styles. Like women's dresses!"

But the small voice continues: "How? Automobile repeat sales are due not only to quality in the product. There's something else. Service. 'Jim Jones takes care of me when anything goes wrong. My next car will be another Jumbo.' Or, 'Bill Smith wipes his hands of me as soon as he cashes my check. No more of these cars for me.'"

And there is the answer: SERVICE. One does not hear much about it. It lacks the bigness, the awe-inspiring quality of the large manufacturer—mass production, plants, chimneys, machines. It lacks the pep, flashiness, hard-boiledness of selling and advertising. It lacks the miraculous and magical element of engineering perfection. But it is the big factor in repeat sales. Oh, we know the radio industry will stay with us. Surely, new refinements will mean discarding the old, buying the new. But which new? To repeat or not to repeat—that is the question.

Formerly there were many makes of automobiles. They all made first sales. Any product can do that. But some of these makes have dropped out of the picture. No repeats. People took a chance. But not twice. Others got the trade on second cars, thirds, fourths. The situation is such that some dealers advertise the fact that such a per cent of purchasers repeat.

Radio is no different. Before long the saturation point will be reached. The radio industry will be dependent on the purchaser of new sets for old. Will they be repeat orders, or will the consumer change? When the manufacturer has sold, he is not through. He must hang on for a repeat. But how? Quality in the set, to be sure. Improvements in the new model, yes. But in the meantime, service the present set until the new comes out!

This problem of service will loom larger with the years. The serviceman can make or break the manufacturer. To the consumer, he is an expert. Manufacturer *A* makes it easy for him to service *A* sets. He services them well. Consumer *A* is satisfied, his set operates well, he will repeat on his next set. The serviceman is glad he can service *A* sets well. It means more money and a better reputation for him. He wishes all sets were *A's* and recommends them. His advice is taken. He is an expert and he ought to know. So far as the consumer is concerned, the serviceman has nothing to gain by recommending *A* sets. No prejudice. Not like a salesman. Perhaps manufacturer *B* does nothing to expedite the service of his sets. Servicemen do not know as much about his sets. How can they when he never sends information, charts, lessons, engineers? He dislikes to service *B* sets. Cannot do such a good job on them. Consumer *B* wonders. Is it the set or is the serviceman no good? The serviceman answers, "Oh, I'm all right. No better in the city. If you don't believe me, ask consumer *A*. Ask him about the job I did on his radio." "What kind was it?" asks the consumer. "An *A*. Real good set. These *B*'s aren't really worth fixing. Truly now, it gives me a bad name to fool around with these sets. They put out new models and don't tell us about it. We can't get any information about circuits, tools, or anything. Of course, I can find it out for myself, by experimenting with your set. But it takes time. And even so, when I find what is wrong, it is all I can do to get hold of parts. Nobody seems to handle them. Have to send to the factory. Sometimes have to send the whole set back."

Thus spake the serviceman. And since Service is becoming an ever-greater problem, we set out to get a summary of the radio servicing situation. We sent questionnaires to more than 100 of the leading radio manufacturers in the country, asking them eight pertinent questions about servicing. The replies were very interesting, and for the benefit of the industry at large we have compiled the answers of these manufacturers into what we believe to be the concensus of opinion among the radio manufacturers of America. Accordingly, here are the questions asked, and the concensus of opinion in the form of an answer to each:

(1). Is servicing, to your way of thinking, the greatest problem in the radio industry today? If so, why? If not, why not?

A few manufacturers answered the question in the negative, notably the service manager of a leading set manufacturing organization, who believes that, due to the more simplified radio design, more elaborate factory sets, better mass production methods and improved tube standards, the problem of servicing is diminishing. Since 90 per cent of service calls are for defective tubes, the improvement in their manufacture is greatly reducing the need of the serviceman. Moreover, the modern radio receiver is almost service free. The problem is not so much one of servicing as it is to eliminate the causes of servicing in design and manufacture.

The opposing view holds to the need for expert servicemen to repair the complex sets of today. The lack of good service men is causing friction between manufacturer and jobber, jobber and retailer, retailer and consumer. Any salesman can sell a set, but only a good serviceman can keep it sold. The manufacturer should co-operate with the dealer through the jobber, so that the dealer may become better acquainted with the product. Set owners are becoming more inclined to sit back and enjoy, and are less inclined to tinker; the more so since everything is enclosed, no extra wires are visible; all one sees is metal shielding around condensers, inductances and tubes, together with just the ground and antenna connections. Therefore, when anything goes wrong a serviceman is called. All the advertising and sales talk in the world goes for naught, unless the set is properly installed and maintained. Since radio is the most

involved branch of electrical technique, the best brains have gone into the manufacture, engineering and sales ends. The service has been left to the man around the corner. It is time for the situation to be corrected.

Much of the present servicing can be traced to faulty tubes. Thus the owner of a costly set will equip that set either willingly or through the selling efforts of the dealer, with "bargain" radio tubes of little known make. Such tubes are often the rejects in normal vacuum tube production—tubes of off-standard characteristics, or even tubes that are basically faulty. Obviously, with the critically balanced radio sets of today, which have no compensating means for taking care of off-standard tubes, the "bargain" tubes are apt to cause no end of trouble. Hence the starting point of any campaign to reduce servicing costs is to insist on the use of tubes of established quality. That is the foundation of all successful radio merchandising.

(2). Do you think that servicing is the manufacturer's, the jobber's, or the retailer's problem?

Some manufacturers regard servicing the retailer's problem. The manufacturer tests the merchandise and assures himself that it leaves the factory in perfect condition. The jobber acts merely as a clearing house. But the retailer receives the largest gross profit. He in turn, by rendering service where necessary, creates good will, which ultimately results in increased sales and profit. Furthermore, the dealer is acquainted with the peculiarities of each individual consumer better than the manufacturer or the jobber. Also, by maintaining an adequate service department, the dealer is often given service work on sets not originally sold by him, resulting in increased profits. Since the manufacturer cannot have engineers all over the country, it is his duty to choose retailers (direct or through jobbers) who can render service. He should train servicemen and desseminate information to the dealers through the jobber. The jobber should see to it that the retailer has good servicemen, that they are properly trained, and that they have the latest information concerning the sets. He is, in the last analysis, a clearing house for information. The retailer should do the actual servicing except in such cases as require more expert work or equipment, or are due to faulty construction, in which case the servicing responsibility lies with the manufacturer.

(3). Do you maintain a service department? If so, how extensive, and what does it do for the jobber, the retailer and the consumer?

Most of the manufacturers do. Perhaps a typical service department is that of the Radio-Victor Corporation, which maintains a service department whose principal functions are the preparation of service literature for distribution to jobbers and dealers; the maintenance and distribution of stocks of replacement parts for various models covered in its line; the handling of claims with the jobber and the claims adjusted by the jobber with the dealer in connection with initially defective merchandise; the testing and adjusting of alleged defective vacuum tubes; and educational work with jobbers and large dealers. The latter work is conducted from branch offices and competent factory-trained engineers are in charge. The servicemen of the American Bosch Magneto Corporation, operating from three sales branches, not only educate the distributors, but sometimes actually repair sets in the wholesaler's shop. The All-American Mohawk Corporation has servicemen in the field to instruct the jobbers, who in turn instruct the dealers. These men also check to see that the jobber and the dealer are equipped with facilities for service work, and make daily reports so that the factory can eliminate or correct those features in the sets that lead to the most trouble. Almost all the manufacturers are more than willing to train all the servicemen who come to the factory.

(4). Do you believe that defective equipment should be serviced out in the field, and if so, how?

The minority vote NO. The reasons, that it makes a bad impression to service sets in the field; that it is not as efficient as working in a shop; and that generally other people are standing about, bothering the mechanic with useless questions and disturbing him with their presence. The majority of manufacturers agree that servicing should be done in the field, since such procedure would save time, eliminate transportation costs and the risk of damage in transit. Some of the manufacturers interpreted this question to mean, "Should the servicing be done by the dealer, jobber or manufacturer," a repetition of question 2. They placed the work on the shoulders of the retailer, since he could service more cheaply than the others and had access to all necessary parts.

(5). What do you do to train jobbers' and retailers' men in the servicing of your products?

Most of the manufacturers distribute technical information on the various models, together with continuity tests, trouble charts, perspective wiring diagrams, catalogs of parts, and blueprints to jobbers and dealers. Service schools for jobbers are conducted by factory-trained field men, and traveling service engineers conduct dealer service classes in cooperation with local jobbers whenever new models are launched. In addition, some manufacturers keep service engineers on the road to consult jobbers and dealers on service problems. The Bremer-Tully Manufacturing Company, for instance, sends a serviceman to the jobber when the sets arrive. He goes over one of the sets with the jobber's serviceman, giving instructions on how to service that type of set. Finally, he works with the jobber's serviceman throughout his territory, helping with any special problems.

(6). Do you encourage jobbers and dealers to carry spare parts? Have you a spare parts catalog? Do you believe this practice is necessary?

The service policies of some of the manufacturers require jobbers and dealers to carry spare parts. Most of them issue catalogs, giving part numbers, prices, and short descriptions. Usually, traveling servicemen inspect the distributors' stocks and take orders for replacements. The concensus of opinion is that a wide distribution of spare parts is necessary, for unless replacement stocks are available throughout the country, it is impossible to make adequate repairs. Wide distribution means minimized complaints for consumers and dealers. A shortage of parts ties up the capital of dealers and jobbers in unsalable stock.

(7). Do you publish service notes or servicing literature?

Several years ago Stromberg-Carlson issued service data in mimeographed form and from time to time issued service notes on loose sheets. This plan was not satisfactory, and at present the organization issues a complete Engineering Data Book in bound form, one for every type of receiver made by the organization. This data book conforms to Radio Division NEMA Standard No. 324-611, covering size and perforation of service manual sheet. It is simple, clear, concise. It is complete, well illustrated, and contains assembly and wiring diagrams. Manufacturers considering this problem would do well to consult this data book.

The Radio-Victor Corporation, which also means the old Radiola sales division of the RCA, also gets out an excellent hand book for servicemen. It is arranged in loose-leaf form, with a fabrikoid binder to take the various bulletins of current sets.

The American Bosch Magneto Corporation distributes to dealers and jobbers a Radio Service Manual containing schematic and actual wiring diagrams, electrical values of all component parts, and an elaborate trouble chart.

The Jewell Electrical Instrument Company, specializing in equipment of a servicing nature, furnishes information as to its operation and application which is necessarily in the nature of service notes. With each of its radio testing sets is a booklet covering information as to its operation, together with data in 138 different receivers, a total of 38 different manufacturers. This data is in chart form and indicates what should be expected in the way of tube readings, and voltage and milliampere readings to be found in testing the various circuits.

The Weston Electrical Instrument Corporation and the Supreme Instruments Corporation also manufacture service test sets, and likewise publish elaborate service notes not only on their products but how to apply them in servicing the better known makes of radio sets in use.

(8). Do you supply any special equipment to servicemen?

Those who do not supply equipment to servicemen—and they are numerous—might use the Kolster Radio Corporation as spokesman of their views. That company announces that it has found it impractical to furnish field men with special equipment, as proper care is not given to it. And so far as the dealer is concerned, he usually carries several lines of radios and has his own tools. Besides, he usually has his own ideas as to kits and equipments. However, the Kolster men carry complete test equipment, which is their own property, being purchased for them by the concern, so that they may benefit by the trade price.

The All-American Mohawk Corporation, on the other hand, supplies its servicemen with set analysers when necessary, such as Jewell or Weston type oscillator and output meter. This company requires its distributors to have testing equipment, and is working on special equipment which the factory will furnish at cost.

The Fada factory service department uses numerous special instruments and equipment, designed and built in the Fada plant, to expedite service work. Fada field servicemen are equipped with standard kits without cost. Most of the manufacturers recommend but do not demand the use of definite equipment.

It is interesting to note that the radio test sets now available are so versatile that it is possible to test practically any standard type of radio circuit. Therefore, the burden of equipment can be neatly switched over to the dealer and the serviceman, who can go out on the open market and obtain the very best kind of servicing equipment for a wide variety of work. Furthermore, the test equipment manufacturers are constantly compiling data and service notes on the standard sets, so that, in a measure, they are doing to service detail work for radio set manufacturers. All in all, therefore, the radio set manufacturers are relieved of much of the responsibility of providing testing equipment. Theirs is more a matter of cooperating closely with test equipment manufacturers, to the end that the latter may be sure to include the proper tests for the sets in question.

In conclusion, it might be said that the decentralization of service facilities, in progress for the past several years, has brought service nearer to the customer, which is an excellent thing; however, it has caused the establishment of unnecessary service facilities, which in turn has had the effect of decreasing the quality of service rendered. There is not sufficient work to warrant every dealer to establish service facilities. Only by repetition and the handling of a fairly large volume of repair work can the necessary degree of efficiency and skill be developed in a service organization. The market researches indicate that the major portion of radio sales are made by a relatively small percentage of dealers. These large radio dealers should maintain first-class service stations. The small dealer should be discouraged from entering the service field, because in the past it has been his tendency to employ cheap help, with the result that his service is poor. He should be able to hand over his repair work to a larger organization, perhaps his distributor or jobber. Where the manufacturer is responsible for the defect, he should reimburse the distributor. If the fault is not the manufacturer's, the distributor might charge the dealer a reasonable fee for his service. But whatever the arrangement, the serviceman should not be neglected in matters of information, parts, instruction, literature, and other aids that can be given him by the manufacturer, the jobber and the dealer.

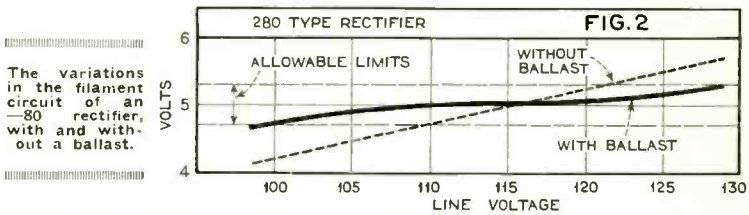
Why the Line Voltage Ballast?

An Analysis of the Actions of a Typical Broadcast Receiver Operating at Different Line Voltages

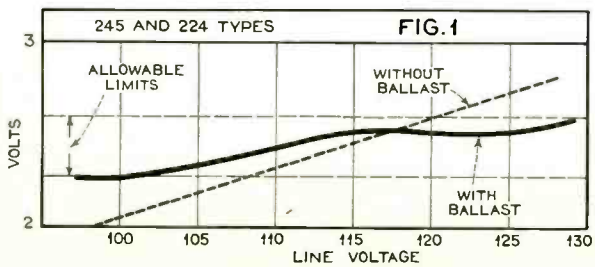
*By Charles Golenpaul**

SINCE its humble beginning the radio industry has always had a bone of contention to play with. The nature of this bone has varied from year to year, but it has never failed to arouse storms of criticism, abuse, enthusiasm, and promises from the engineers of the industry.

This year's outstanding bone of contention is the line ballast problem, or the intrinsic value of line voltage regulation. One hears many conflicting opinions, such as the fact that the line ballast is an absolute necessity; that it is no good and that any set will function just as well without it; that it is only a merchandising feature; and that it is absolutely useless as a selling point since the public is not familiar with it. In all this storm of assertions, pro and con, we have always maintained that the line ballast is indirectly a splendid merchandising feature for several reasons. To begin with, it is a genuine technical achievement based on the soundest engineering principles, and, in addition to this, its merchandising value cannot be overlooked since the very performance of 9 out of 10 receivers depends upon its proper use.



The variations in the filament circuit of an —80 rectifier, with and without a ballast.



Voltage variation in filament circuit with a variation in line voltage, with and without a ballast.

Vacuum tubes are designed to operate within very definite limits and there is not an engineer who will claim that a radio receiver will operate just as satisfactorily at 85 or 135 volts, as it will at the specified 110 volts. In addition to this, when it is considered that, despite the heroic claims made by power companies, line voltages do vary or fluctuate between these limits at times, it is evident that some sort of line voltage compensation must be incorporated if the receiver is to operate uniformly at all times.

The Tapped Transformer

The tapped transformer with a choice of two voltage ranges, while it is an

* *Clarostat Manufacturing Co.*

improvement, does not fill the bill, since it cannot compensate for fluctuations of voltage. Regulation must be automatic and it must be instantaneous for complete satisfaction. The actual ballast itself must incorporate a number of features developed in accordance with modern practice, if it is to overcome the bad impression created by a number of early attempts along this line. It must be absolutely safe, non-inductive, the wires must be non-oxidizing, free from sag or danger of shorting the turns, and, most important of all, heat dissipation must be allowed for.

One type of line ballast employs the automatic compensation idea. The principle of operation is that of a series resistor with a high temperature coefficient, so wound and ventilated that a change in line voltage is compensated for by a change in resistance. This system maintains a constant voltage on the transformer primary, even though the line voltage varies as much as 30 per cent. During this very wide voltage fluctuation, the actual primary voltage and resultant secondary voltages vary less than the plus or minus 5 per cent which tube manufacturers specify. If the average line voltage to be dealt with is 110 volts, then the primary of the transformer is designed for operation at 85 volts, and the difference in voltage is developed across the line ballast. Then, even though the line voltage changes within the limits of 100 and 135 volts, the actual primary voltages will remain constant within plus or minus 4 volts. The ballast and transformer combination may be made to allow for other ranges and is by no means limited to the figures of the example described.

Tests on Broadcast Receiver

In an effort to determine the actual voltages developed in a broadcast receiver, within a wide range of line voltage, as well as to check up the efficiency of a line ballast when operating at greatly increased and reduced loads, a number of curves of a popular make receiver were plotted, the receiver operating with and without line voltage regulation. The results of this investigation were extremely significant, inasmuch as they checked quite accurately with the statement of a prominent tube manufacturer, made some time ago. This manufacturer stated, in defence of his product, that the majority of tubes in use were operating at nearer 3 volts on the filament, than the specified 2½. This was found to be no exaggeration.

The following tubes were used during this test: four —24 types, one —27-type, two —45 types and an —80-type rectifier. The results at various line voltages were as follow:

RESULT ON 115-VOLT TAP WITHOUT BALLAST

Line Volts	Primary Volts	Ballast Volts	Primary Amperes	280 Fil.	245 Fil.	224 Fil.	D-C. Volts
99	99	None	.75	4.2	2.05	2.00	200
108	108	None	.79	4.7	2.20	2.20	200
120	120	None	.86	5.1	2.50	2.50	217
129	129	None	.95	5.5	2.75	2.75	270

The next test was made with the same set operating under the same conditions, with the exception of the voltage tap and the addition of a line ballast. The results were as follows:

RESULTS ON 84-VOLT TAP WITHOUT BALLAST

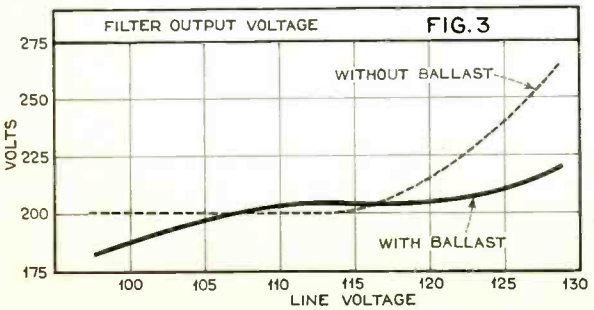
Line Volts	Primary Volts	Ballast Volts	Primary Amperes	280 Fil.	245 Fil.	224 Fil.	D-C. Volts
99	76	23	1.10	4.7	2.50	2.50	185
108	80	28	1.16	4.9	2.40	2.40	202
120	84	36	1.23	5.0	2.50	2.50	205
129	87	42	1.29	5.25	2.60	2.60	217

These results, secured with the line ballast, never exceeded the 5 per cent limit specified by manufacturers, whereas the results secured without the line ballast show that the tubes were operating abnormally about 50 per cent of the time. The evidence should answer the question as to the merchandising value of a ballast, whether the purchaser ever heard of it or not. A set without a ballast may function brilliantly during the store demonstration, but when it is moved to the purchaser's home in the suburbs, the volume may drop to a low level and stay there most of the time. On the other hand, the reverse may take place, in which case there will be a poor demonstration, with a subsequent loss of sale. If the prospect does select a set, he may enjoy brilliant operation of both set and tubes, for several months, following which there will be a complete and costly replacement of the tube equipment.

Comparative Curves

To give a clearer idea of actual comparison, the curves in Fig. 1 show the results obtained both with and without line ballast. It will be noticed that the —24 and —45 tubes are within the specified limits only when the line voltage is between 108 and 119 volts. Fig. 2 gives the same comparison for the —80 rectifier tube, while Fig. 3 gives a graphic picture of what happens to the filter output voltage.

It is well to mention that these ideal figures, obtained with the use of the line ballast, are possible only by having the ballast accurately matched to the transformer. To be thoroughly satisfactory, as well as adequate within a wide voltage range, the line ballast must be designed to balance with the particular transformer with which it will be used, in order to provide for the core saturation voltage and the input current.



Variations in filter output voltage with and without a line voltage ballast.

NEW MODEL PLANT

(*Continued from page* 29)

Vaults For Dies

These vaults provide dry, well-lighted, easily reached, protected filing space for dies when not in use. As the dies represent a considerable investment, both from the point of view of the Allied organization and that of their customers, every precaution is taken to keep them safe. Likewise, special storage vaults are provided for sample castings which have been approved by customers and also for those which have been supplied by the customer for the purpose of quotations.

Other instances of the Allied Die-Casting Corporation's efforts to make their plant the most efficient in the industry are—the counting mechanisms placed on all production equipment including the die casting machines, to check and re-check production and prevent errors in filling orders—and the cork-lined foundations which are set under every machine that has a tendency to vibrate, in order to minimize that vibration.

These instances are typical of the arrangement of the entire plant. Every effort has been made and the utmost in production engineering skill has been called upon to provide a plant that takes advantage of modern equipment to the fullest extent and combines with that—ease, efficiency and economy in operation.

Public-Address and Centralized Radio Systems

II. Fader Control Systems

By E. W. D'Arcy

THERE are several combinations for effective fading devices for fading from one circuit to the next. These devices range all the way from a simple potentiometer circuit up to a much more complex balanced fader control, and the efficiency and frequency response of this particular amplifier system can be affected a great deal by the fader characteristics.

A typical fader circuit is shown in Fig. 3. This scheme for fading from one circuit to the next is most universally used. Oftentimes the fader

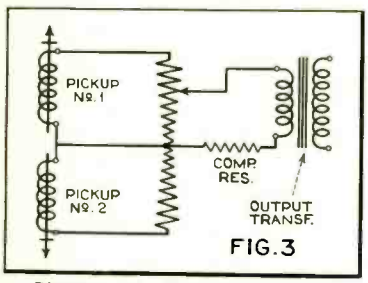


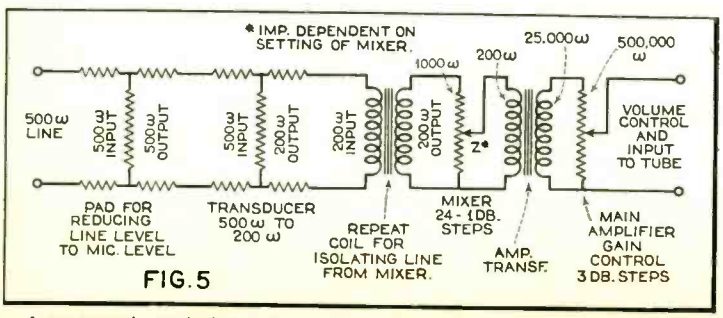
Diagram of "tapered potentiometer" employed as a fader in a simple circuit structure. This arrangement is the one generally used.

control is the only volume control used. This system of using a fader control for volume control is not very good due to the fact that the impedance presented to the primary of the input transformer varies considerably, and at high degrees of attenuation, the higher frequencies are greatly attenuated, resulting in a very drummy and barrely quality of reproduction. Undoubtedly, the chief reason for the popularity of this type has been due to its economy in manufacture. A very marked improvement can be obtained by a properly designed fader control circuit. This fader control is shown in Fig. 4 and can be used as the major volume control with no great difficulty.

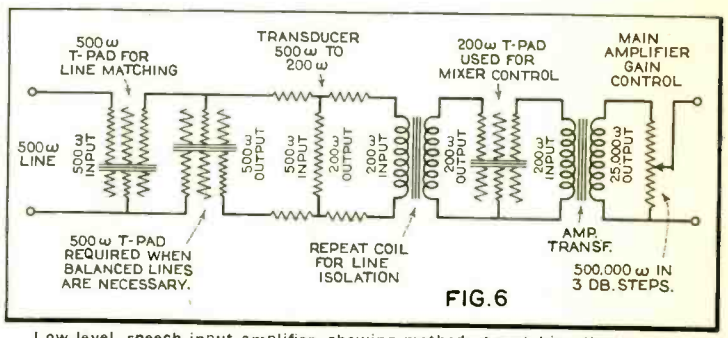
By a careful examination of the circuit here shown, it can easily be ascertained by a properly designed fader absorption resistance R-1, the compensation resistors R-2 and R-3, which are operated manually on the same control knob, maintain the impedance presented to both the pickup device and the input amplifier at substantially the same level. This system, therefore, allows a very fine degree of volume variation with a hitherto unknown superior quality of reproduction where fader volume controls are used. It is a little known system, and has recently been developed by the author. This particular type of control is now available.

Constant Impedance Input Volume Controls

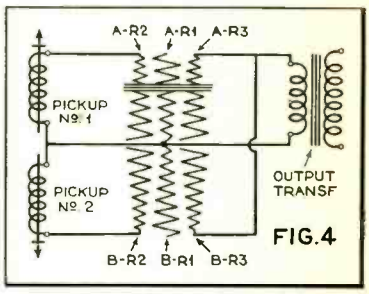
In the average broadcast or public-address system, a need is oftentimes felt to equalize the volume level from different lines coming into the central control panel. Ordinarily, this sort of thing is either accomplished by a pre-determined attenuation network, such as shown in Fig. 5. This type of pad is arranged to give a previously arranged degree of attenuation. It then becomes necessary to incorporate a finer degree of volume control, which has to be adjusted for the difference in line levels, as volume control No. 2. This control is quite necessary for satisfactory monitoring, although the system, if made sufficiently variable, is the most ideal system of input volume regulation.



Arrangement, employing pads or attenuation networks for reducing volume level to equal the levels in other lines; a system used extensively in speech input equipment.



Low level, speech input amplifier, showing method of matching line levels by means of T-type pads. Two T-pads are not required in cases where balanced lines are unnecessary. Pad arms may be joined to maintain balance.



The "constant impedance" fader, far superior to that of Fig. 3 as there is no attenuation of the higher frequencies.

It is quite easily recognizable that the balanced network, as shown in Fig. 5, would be difficult to produce mechanically at a price within reach of the average user. For this reason, a new type of volume control has been devised, shown in Fig. 6, making use of the familiar T-type attenuation pad. The controls in this system are instantaneously variable, and they move at the same time so that a very fair degree of compensation is reached, and the pad does not vary from its estimated impedance at all degrees of attenuation more than 5%. This variation is easily allowable, as a very small amount of reflection takes place

when the percent of error is held to this factor.

The typical public-address system, shown in Fig. 2 of the previous article gives one a very good idea of the placement of both the attenuation networks and the fader controls. Formulas are presented here (see Fig. 7 and Table 1) for the easy determination of the constants to be used in this filter pad. The constants are worked out for pads from 1 to 40 dbs. in attenuation. It is not figured in impedances, however, as these can be easily computed by multiplying the quantity designated under the heading as $Y^k(2Z)$. This formula is used for the Y-leg in this attenuation network. For a T-type pad, the formula and constants herein presented can be easily changed to the impedance used by merely multiplying X^k by the impedance which it works into and out of.

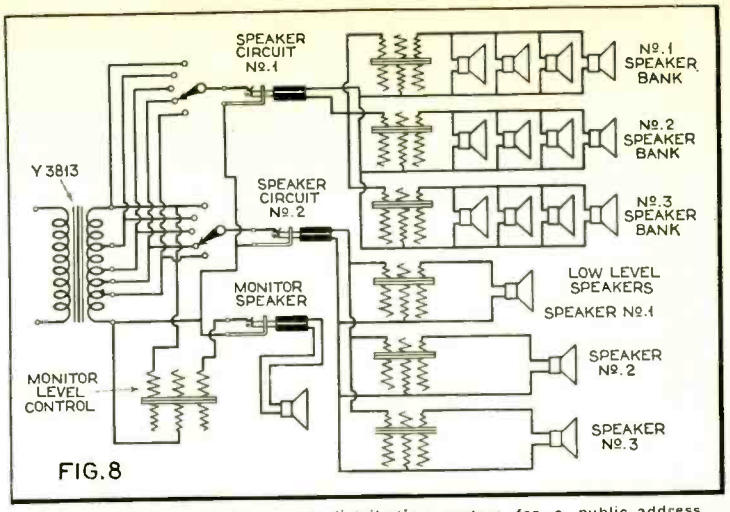


FIG.8

Schematic diagram of speaker distributing system for a public-address installation. Constant impedance volume controls are employed.

Constant Impedance Speaker Volume Control Systems

For variation of the volume output from the public-address amplifier, there oftentimes is required several different degrees of volume such as might be encountered where several banks of loudspeakers are operated simultaneously off the same transformer output. The matching of impedance in this circuit is very necessary for best reproduction, and it is quite easily recognizable that it is impossible to have a different input volume control with its associated amplifier for every degree of output volume required. There are no such devices on the market at the present time, but the author understands that one will soon be available for use in conjunction with amplifiers to fulfill the requirements herein mentioned. This volume control is the same as the input volume control herein described, with the exception that it is designed to fulfill the requirements of the individual user, that is, if he has a bank of four speakers connected in parallel (See Fig. 8), where the impedance of one individually might amount to say 4,000 ohms, the total impedance of this bank, therefore, would amount to 1,000 ohms. This condition requires the installation of the correctly designed attenuation pad. It is easily understandable that for this reason no great individual stock at any particular impedance will be available, but manufacturers or engineers installing equipment of this nature can make known their requirements and they can easily be fulfilled.

For the use of the average installation a transformer with several different output impedances is required. It is impossible to make any particular conjectures for the typical installation, other than to say that the transformer displayed in public-address installation pictured last month had an impedance range of the following: The first tap 210 ohms; the second tap, 280 ohms; the third tap, 420 ohms, and the last tap, 840 ohms. Then, any further variation in impedance required could be obtained by using the tips of the plugs to make connecting points with the switch arm itself, and further impedance variations could be obtained down to even the required impedance to match the voice coil of one dynamic speaker, which is equivalent to 6 ohms. A system of this range is really extremely necessary, unless the designer stipulates the use of constant impedance volume controls and the speaker banks into which they are to work.

DB.	$K=\frac{1^0}{1}$	Y^K	X^K	DB.	$K=\frac{1^0}{1}$	Y^K	X^K
1	1.122	4.48	.0566	24	15.85	.0636	.881
2	1.259	2.17	.15	25	17.75	.0565	.894
3	1.413	1.43	.17	26	19.95	.0505	.906
4	1.58	1.055	.225	27	22.40	.0448	.914
5	1.778	.829	.28	28	25.10	.04	.923
6	1.995	.667	.333	29	28.20	.0356	.93
7	2.24	.563	.3805	30	31.60	.0316	.939
8	2.51	.473	.43	31	35.50	.0282	.945
9	2.82	.407	.476	32	39.90	.0251	.951
10	3.16	.352	.52	33	44.60	.0225	.955
11	3.55	.308	.56	34	50.00	.0201	.96
12	3.98	.269	.598	35	56.20	.01785	.965
13	4.47	.235	.635	36	63.00	.0159	.968
14	5.01	.208	.667	37	70.80	.01415	.972
15	5.62	.184	.699	38	79.30	.0126	.975
16	6.31	.162	.726	39	88.10	.0125	.978
17	7.08	.1445	.753	40	100.00	.01	.98
18	7.95	.1282	.776	41	112.00	.00892	.982
19	8.91	.1144	.798	42	126.00	.00792	.984
20	10.00	.1011	.818	43	141.00	.00708	.9855
21	11.21	.09	.836	44	158.00	.00631	.9875
22	12.58	.08	.853	45	178.00	.00562	.989
23	14.12	.0711	.868	46	200.00	.005	.99

TABLE 1

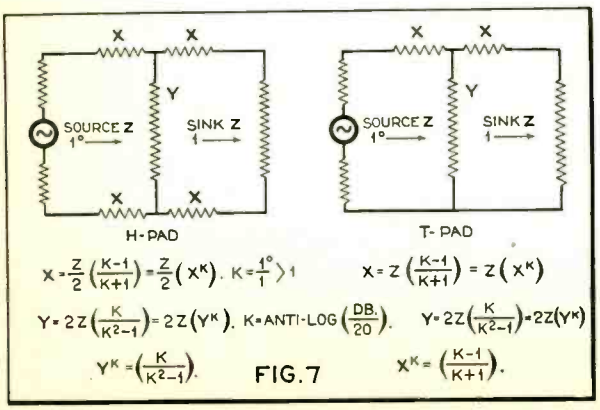


FIG.7

Complete design data for bilaterally symmetrical pads, or attenuation networks.

(*To be continued*)

RADIO BUSINESS BOOMING

THE radio industry is enjoying one of its biggest and most prosperous years and is now in the billion dollar class, according to Bond Geddes, executive vice-president of the Radio Manufacturers' Association. In an address at the Annual Convention of the National Association of Broadcasters, held at West Baden, Indiana, Mr. Geddes said that sound estimates of radio sales this year range from $750,000,000 to $1,000,000,000 and with no saturation points in sight. Broadcast chains and stations, he said, also are prosperous, together with radio distributors.

Among the leading commercial sponsors of broadcast programs are 25 manufacturers of all radio products sponsoring weekly broadcast programs, an increase of nearly 100 per cent over last year. According to a recent survey, radio manufacturers are placed first, the automotive industry second, and the drug industry third in radio sponsorship.

Vacuum Tube Design—and Production

The Methods of Seasoning Tubes and Some Practical Equipment

By Dr. Paul G. Weiller

Part III

THE operation called seasoning or aging has nothing in common with the aging of precious vintages. The writer does not know how the designation of aging was created.

Aging of receiving tubes consists of operating the tubes for a short period of time under a set of conditions differing materially from those of normal operation.

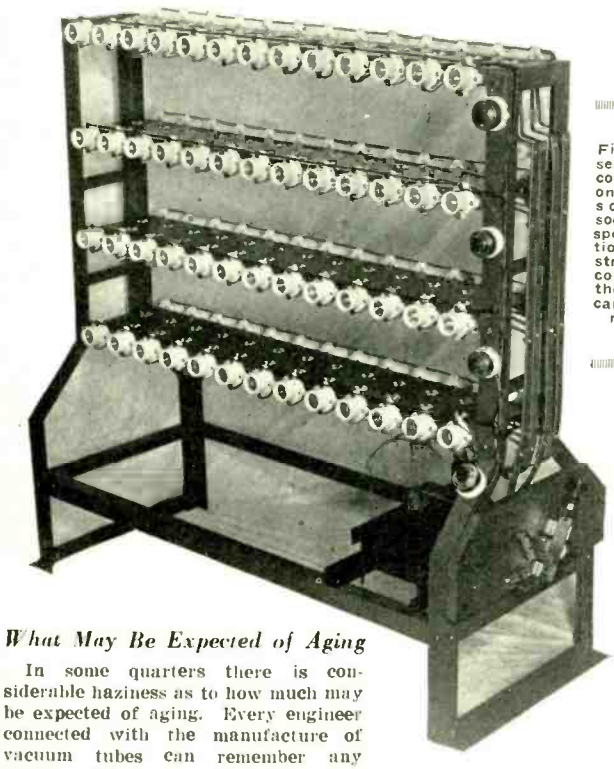


Fig. 1. A typical seasoning rack, containing over one hundred tube sockets. The sockets are of special construction, having very strong spring contacts. Note the bus bars for carrying the filament current.

What May Be Expected of Aging

In some quarters there is considerable haziness as to how much may be expected of aging. Every engineer connected with the manufacture of vacuum tubes can remember any number of instances where aging was blamed when things went wrong, or others when aging was called upon to make up for poor exhaust or improper preparation of parts. New aging schedules are frantically tried, mostly without result.

It may be said with no fear of contradiction that bad tubes cannot be made good by aging, and also that good tubes will never be ruined by any reasonable aging schedule. Aging should be considered an essential operation, but it should not be expected to correct deficiencies of exhaust.

Theory of Aging

In reference to aging, as to other tube making processes, our theory is a well-balanced combination of fact, and also of fancy where facts are scarce. While it seems difficult to account completely for all phenomena observed in aging tubes on the basis of well-established principles, we have, nevertheless, a good knowledge of the process.

Aging performs two distinct functions. One is the removal of the residual gas; the other is the bringing into being, or stabilizing of emission.

Exhausting, as it is carried on at present, either on trolleys or on automatic machines, does not produce a vacuum sufficiently high to make the tube operate properly. It has often been tried to flash the magnesium getter after the tube is sealed off, with the expectation of thereby obtaining a very high vacuum. Results were, however, very disappointing. While the magnesium flash is indispensable to proper exhaust, it does not do a sufficiently thorough job under average conditions. Only a limited quantity of gas is absorbed by the getter, and some types of gases are absorbed only incompletely. Furthermore, a considerable quantity of gas is evolved from the glass when it is heated during the basing of the tube.

The burden of creating a permanent high vacuum devolves on the seasoning process. Magnesium, at room temperature, will absorb no gas under ordinary conditions. It will, however, absorb avidly ionized oxygen and nitrogen. Its absorbing power for hydrogen is very limited, even though the latter be ionized.

We must, however, not forget that seasoning has its limitations. If good tubes are to be produced without undue shrinkage tubes must show no glow, or only a barely perceptible one, when put on the seasoning rack.

The ionized gas reacts not only with the magnesium, but unfortunately also with the active substance of the filament. This reaction tends to destroy the emission of both thoriated and oxide-coated filaments.

The Thoriated Filament

In the manufacture of thoriated filaments merallic tungsten powder is mixed with thoria (an oxide of thorium) and further processed until the finished wire results. After considerable discussion on this subject, the consensus of opinion seems to favor those who assert that thorium is present in thoriated wire as oxide, and not in metallic form.

The active principle in electron emission is, however, thorium metal. In small wire the reduction of some of the thoria to thorium may be accomplished by the graphite adhering to the wire during the drawing operations. At any rate, no special process is employed to introduce carbon into the filament.

The tube is not operative as it comes from exhaust. The —01-A tube, for instance, is operated on the seasoning rack first during about five minutes at 8½ volts, with from 150 to 180 volts on the plate, the grid floating. The high temperature generated by the over voltage evidently causes reduction of the thoria. Bombardment by plate current ionizes any gas present. The ionized gas is absorbed by the getter. The plate current is then switched off, and the filament voltage is raised to 16 volts for one minute, then reduced to 8 volts and kept constant for six minutes. This seasoning schedule may be varied considerably to suit prevailing conditions.

The Coated Filament

Oxide-coated filaments require a different treatment. According to the best available theory (Von Aspe), the

oxides themselves do not emit at low temperatures. If a platinum wire, coated with pure oxides is heated, little emission can be found at first. Under the influence of the plate voltage the emission builds up gradually, and comes to a maximum only after a period of approximately one hour. In the factory, however, conditions are somewhat different.

Coated filament tubes mostly come from the pumps with some emission. To bring the emission up to normal and stabilize it, the tubes are operated during two minutes at a filament voltage fifty per cent above normal with the plate voltage on. The filament voltage is then reduced to ten per cent above normal. The tubes are kept under these conditions until the gas is reduced to an amount within permissible limits, which takes from five to fifteen minutes.

Very gassy tubes can sometimes be salvaged by a longer seasoning schedule, but as a rule such a long treatment will considerably impair the emission.

The plate voltage for seasoning operations is most conveniently taken direct from a 220-volt a-c. line. The plate current is limited by insertion of a 110-volt lamp in each plate lead. For all small tubes a 10-watt lamp is a suitable size, as the lamp will admit sufficient current to strongly ionize the gas in the tube, but will prevent undue heating of plates and overloading of the filament. The advantage of the 10-watt lamp is that the condition of the tubes on the rack can be roughly told by the brilliancy of the lamp filament.

The treatment above described is sufficiently severe to ruin poorly exhausted tubes or tubes with a bad filament, thereby reducing the danger of sending out tubes which will be early failures.

It must be remembered that with the excellent pumps available at present it is quite possible to obtain a high vacuum in the bulb even when considerable amounts of gas are still occluded in the metal parts. Too mild a seasoning process will ionize the residual gas and fix it in the getter, but will not heat the plate sufficiently to drive out occluded gas. Such a tube would pass a gas test as perfect, but will develop gas when the plate becomes hot in regular service. The emission of such a tube will, of course, be destroyed very rapidly.

Larger tubes require more extended seasoning. As the filaments are larger and carry more coating more gas can be fixed by seasoning before the emission drops below the desired amount.

The carbonized plates of —45 and —50 tubes absorb a large amount of gas when exposed to the air. Hence the difficulty in exhausting these tubes. As a rule considerable quantities of gas remain to be seasoned out. The —45 tubes should be seasoned about one-half hour with 25-watt lamps in the plate lead. The —50's should be seasoned one hour with 450 or 500 volts on the plate and 50-watt, 220-volt lamps in the plate leads.

Other Seasoning Schedules

Complicated seasoning schedules are often talked of by the trade. The writer has seen many of them tried without being convinced of their usefulness. If any advantage is gained by any treatment differing materially from the one described above it is hardly sufficient to warrant the greater complication of processes and equipment. In trying out such a schedule one must be careful not to be misled. One or two trays of 50 tubes sent through according to a new schedule as an experiment do not prove very much. The writer remembers numerous cases where the average factory shrinkage was exceedingly high on some newly introduced type of tubes, yet quite often two consecutive trays would show only nominal shrinkage.

To prove the usefulness of any new schedule it is necessary to run it on about 200 tubes per day for several days, and to carefully tabulate results. If the statistics show a definite improvement over results previously obtained, one may be reasonably sure that the new treatment is of some value.

New seasoning schedules are mostly tried when things go awry in the tube section. Before experiments are sufficiently progressed to draw definite conclusions the difficulty will have disappeared and the experiments are dropped. Seasoning will never be a substitute for good exhaust. In spite of the writer's lack of faith in elaborate seasoning schedules we will discuss some of the more common ones.

Grid Bombarding

Some tube manufacturers are laying stress on grid bombarding. As a rule the grids of several tubes are connected to the 110- or 220-volt line through one lamp. Grid and plate seasoning are alternated through various periods of time. The effect is equivalent to heating the grids. If the grids are not sufficiently heated on exhaust grid, seasoning will drive off some gas from the grids. If the quantity of gas is small the getter will absorb it. If the quantity is considerable the emission will be impaired. The effect of this process depends, of course, on the size of the lamp in the grid circuit. Grid seasoning accomplished in this fashion, besides being of doubtful effectiveness has its drawbacks.

As the grids of several tubes are tied together, any tube that is gassy will take most of the grid current, while the others will not get enough for effective treatment. During the plate treating period the current is switched off from the grids. However, all the tubes grouped for each grid lamp remain interconnected. If one of the tubes is gassy a positive bias is applied to all grids, and all tubes will draw an undue amount of current, which is apt to ruin them. This can be avoided by connecting the grid bus to the filament during the plate treating period. If grid seasoning must be resorted to, better results are obtained if a small lamp is used in each grid lead. This method reduces the influence of one gassy tube on the others.

According to another method of grid treatment, plate and grid are tied together with a lamp in series with each tube. This method is the least advisable. If low voltages are used the cleanup is perfunctory. Tubes with considerable amounts of gas occluded in the plates will not be heated sufficiently for the gas to be liberated. They will pass the test and fail in the field. If higher voltages are used, the large current drawn by tubes with grid and plate connected is apt to impair the emission.

A-C. or D-C. For Seasoning?

There is some difference of opinion as to whether a-c. or d-c. should be used for seasoning. The logical answer is that if tubes are well exhausted, and the seasoning process is consequently short, a-c. is perfectly satisfactory. There is no excuse for going to the expense of motor generators to convert a-c. to d-c. For the salvage department which receives all tubes that do not pass the test d-c. is preferable.

If there is sufficient gas to show a considerable glow the filament will be quickly destroyed if a-c. is used for seasoning. With d-c. a certain proportion of such tubes can be saved. Yet, even d-c. is no cure-all. We can only state that out of a large number of very gassy tubes d-c. seasoning will save a higher percentage than a-c. seasoning. With properly exhausted tubes the difference is not noticeable.

Seasoning Equipment

Seasoning is carried out on a relatively simple piece of equipment called a "Seasoning Rack." In most plants such racks are home-made from commercial sockets, usually 100 to 300 sockets to a rack. Switches are pro-

(*Continued on page* 45)

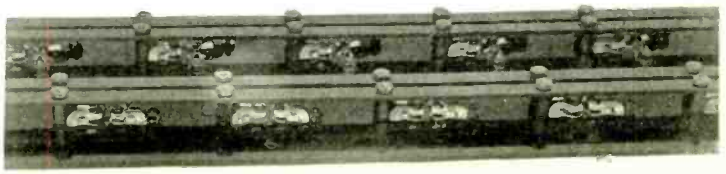


Fig. 2. Connections under the panel of a seasoning rack.

The Engineering Rise in Radio

By Donald McNicol

Fellow A.I.E.E., Fellow I.R.E., Past-President, Institute of Radio Engineers

Part XVIII

CHAPTER 14

Telephone Receivers and Loud-speakers

ALTHOUGH in Marconi's early experiments, and for a few years thereafter, in short-distance signaling, relay-operated tape registers were used in radio-receiving systems to translate the incoming signals. The employment of carbon-steel, and oxidized surface detectors as early as the year 1900 made it of advantage to use telephone receivers to read the incoming telegraph signals. The great sensitiveness of the telephone receiver, compared with any other known indicator of the presence of electrical variations, at once permitted signaling over longer distances. For radio telegraph purposes, therefore, the telephone receiver has up to the present continued to be employed as a dependable instrument.

The receivers at first used were those designed for land line telephone work, having a magnet winding resistance of about 70 ohms. For radio uses it was soon realized that by winding the magnets to have a largely increased number of ampere-turns, and by mounting two ear-pieces on a headband, weak signals could be read, which with the original type of telephone would remain inaudible.

Blondel, in France, in 1898 used a telephone receiver for wireless telegraph reception, and Marconi in his

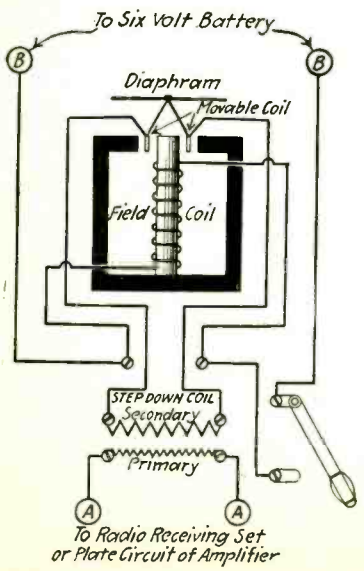


Fig. 51. Details of the Magnavox electrodynamic speaker of 1919.

THE Engineering Rise in Radio is brought to a close in this issue. Mr. McNicol's chronicle of the early struggles of workers in science, the march of radio from the days of Marconi into the field of industrialism, has been and will remain a source of inspiration to the radio engineering field.

The succeeding installments have brought us to the present stage of development, that stage which as yet is fraught with patent entanglements and too near at hand to be historically recorded with any degree of authenticity. We sincerely hope that Mr. McNicol will continue the chronicle when present events can be viewed with the necessary perspective that only time can provide.—EDITOR.

1901 trans-Atlantic experiments used a telephone receiver in connection with a coherer detector. With the coming of the improved detectors, the telephone was found to be particularly adaptable for signal reading. With the carborundum detector and the Fleming valve circuits, following in 1905, telephone receivers of about 8,000-ohms resistance were found to be suitable, while with the Marconi magnetic detector, telephone resistance of from 120 to 180 ohms were quite suitable. In several instances telephones of low resistance were employed when connected in the secondary of small transformers.

Throughout the years following, several ingenious telephone receivers were developed and were experimented with for radio purposes. Prof. G. W. Pierce invented a dynamometer telephone; Fessenden invented the heterodyne type of receiver; Berger, a monotone receiver, and in Europe receivers introduced by Ader and by Golounitsky were successfully used. In England, in 1899, S. G. Brown invented a type of telephone receiver employing a vibrating member comprising a steel reed and a light, conical, aluminum diaphragm, attached at its center through the reed and at a short distance from the core axis. The idea was to provide a tuned vibrating member, or set of members, which would respond to various periodicities as required.

In 1914-1915, just as the contact detectors were giving way to the tube receivers several attempts were made to amplify the signals rectified by the crystal detector by arranging so that the diaphragm of a connected telephone would in turn actuate a microphonic contact in a secondary circuit. The secondary circuit with local battery applied had sufficient energy to operate a horn type of telephone receiver, Devices of this type were proposed by Homer Vanderbilt and Stanley Hyde, in America and were at the same time experimented with by the engineers of the French radio telegraph service.

About 1917, C. A. Culver, in America, developed a new form of receiver particularly for radio reception, in which there was a tuned reed associated with an electromagnetic system, and having an external acoustic resonating chamber.

From the year 1885 on, investigations in the theory and efficiency of the telephone receiver were popular projects in college engineering laboratories, as well as in the laboratories of the telephone manufacturers. Engi-

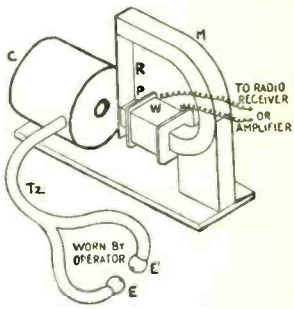


Fig. 52. The Culver telephone receiver of 1917.

neering data gathered in investigations carried out by Prof. A. G. Webster, beginning in 1890, and later by Professors George D. Shepardson and A. E. Kennelly, constituted an important part of the fundamental knowledge on this subject accessible to engineers entering the field at later dates.

What was perhaps the first headset telephone receiver designed and sold for radio purposes, was that made by W. C. Getz, in Philadelphia, in 1905 or 1906. The magnets were wound on a yoke so as to present both magnetic poles to the diaphragm; the spools wound with No. 40 silk-insulated wire, having a total of 2,000 ohms resistance in both receivers. The diaphragms were made of a compound of iron and a more ductile metal and were rolled very thin.

About the same time Brandes, in New York, began the manufacture of a line of receivers which were quite sensitive and served the purpose very well.

Prior to the revolutionizing events of 1912-1913, in the radio art, the energy available to operate the telephone receiver was so small that any type other than the ear-phone was of little use in practice. It was not until a way was discovered to amplify the antenna energy that there was a possibility of using loud-speaking telephone receivers which did not need to be held close to the ear.

Fig. 53. A horn-type loudspeaker marketed in 1922.

Loudspeakers of a rather inefficient type had since 1904 been used in railroad telephone service, on circuits used for train dispatching, but these required rather large operating currents and the small horn fixed to the receiver introduced such speech distortion that the instrument was tolerated only because there was nothing better to be had.

The idea of an efficient loudspeaker for radio uses occurred to Oliver Lodge[1] years before there was a likelihood of being able to use it successfully. He patented a speaker with a coil connected to a diaphragm, the coil "floating" in a strong magnetic field.

However, when the demand suddenly was created in 1922 for a satisfactory loudspeaker for radio broadcast reception there was none available. Excellent headphones produced by Brandes, Murdock, Baldwin and the Western Electric Company, were, fortunately, in production and were extensively used until such time as suitable loudspeakers could be developed.

Soon, ordinary phonograph quality was attained by attaching horns to telephone receivers, and for a time inventors were busily engaged in attempts to design horns which would effectively reproduce the faithful reception characteristic of the telephone receiver placed to the ear.

The evident demand for, and the market for loudspeakers at once attracted the attention of the large manufacturing companies as a result of which the task of designing loudspeakers came to the laboratories where trained engineers were at hand to do the work. Among the research engineers foremost in loudspeaker development in America from 1922 until 1928, were C. L. Farrand, C. R. Hanna, J. Slepian, E. W. Kellogg, Chester W. Rice, Dr. A. N. Goldsmith, Dr. J. P. Minton, A. Ringel, A. Nyman, W. H. Martin, I. B. Crandall, J. P. Maxfield, H. C. Harrison, I. Wolff, H. F. Kranz, R. L. Wegel, and Harvey Fletcher.

[1]*Br. pat. No.* 9,712 (1898).

Loudspeaker Development

As stated by Nyman,[2] essential features which pertain to loudspeakers are that they shall have uniform intensity of sound at all frequencies from 25 to 5,000 cycles; that there shall be absence of resonance points capable of responding at a frequency different from that applied or giving an excessive volume of sound when their own frequencies are applied; that they shall have the ability to reproduce a combination of frequencies with a volume of each frequency proportional to the input, and that there shall be absence of distorting harmonics at any individual frequency applied.

The reason for the range stated will be apparent from the fact that the frequency range of a pipe organ is from 16 to 4,138 vibrations per second; a piano from 27 to 4,096 per second. The practical range of musical sounds may be regarded as extending between 40 and 4,000 vibrations per second, although the whole auditory range extends roughly up to 40,000. There are to be considered also the harmonics.

Each tone is composed of its fundamental frequency and several harmonics of higher frequencies, and in the design of loudspeakers it has been less difficult to provide for faithful reproduction of the higher notes than of the lower tones. A loudspeaker which will not reproduce a frequency as low as 256 (middle C on the piano) if it registers the note is responding to harmonics of 256. A loudspeaker which gives out a "tinny" sound on the lower tones may in fact be responding only to the harmonics.

The problem of the loudspeaker was one which in its elements extended outside of the purview of the radio engineer. The solution of the problem was one which required on the part of the engineer a thorough knowledge of acoustics, of horns, of the propagation of sound waves, such as that applied by the designers of phonograph sound chambers.

[2]"*Electrical Loudspeakers*" *by A. Nyman, Journal of A.I.E.E., June,* 1923.

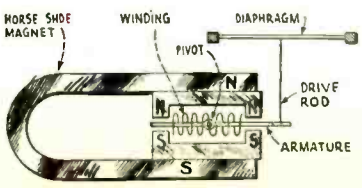


Fig. 54. Detailed sketch of one of the early balanced armature receivers.

The designers of loudspeakers at the start had the assurance that the voice and instrumental musical tones were reaching the diaphragm of the telephone receiver with a fair degree of faithfulness, as evidenced by the performance of the high-resistance earphone connected with a good radio receiver. The task was to preserve as nearly as possible this quality while enormously increasing the volume of sound set in motion by the diaphragm.

The design of improved types of sound-producing units of the general makeup of telephone receivers, with permanent magnet, electromagnet and diaphragm, has continued as a joint undertaking of radio engineers and telephone engineers, as a result of which many possibilities for improvement have been considered and investigated.

Early attempts to construct loudspeakers involved the association of a telephone receiver unit with a cone-shaped horn, but the volume obtainable was small owing to the close spacing between the diaphragm and the pole-pieces of the electromagnet; for the purposes of large sound volume, the diaphragm could not move freely and rapidly enough through a wide enough space.

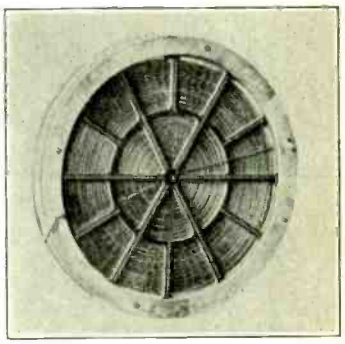


Fig. 55. The Hewlett Induction-type loudspeaker.

The Movable Coil Loudspeaker Unit

The movable coil type of receiver, such as that proposed in Lodge's early patent and used in the Magnavox loudspeaker, permitted a much wider movement of the diaphragm without risk of chattering against the pole-pieces of the electromagnet. The air-gap through which the movable coil travels has present a strong magnetic field excited by a field coil actuated by current from a direct-current source, while the moving coil attached to the diaphragm is actuated by the signal-producing current. The principle of this arrangement had been applied many years ago in submarine cable telegraphy in the design of the mirror galvanometer.

Balanced Type of Receiver

Another form of receiver which answered the requirements very well was that known as the "enclosed armature" type, or "balanced" type of receiver, employed successfully in the receivers due to Baldwin. In this assembly, a small iron armature is situated in the center of a magnet coil, suspended by two thin wires. In one form the coil is surrounded by two U-shaped pole-pieces forming two air-gaps, the magnetic flux in the gaps being supplied by a permanent magnet. The current in the coil causes opposite pole-pieces to become magnetic simultaneously, causing the armature to rock, which motion is in turn communicated to the diaphragm by means of a light connecting rod. Receivers of this type respond to frequencies up to and beyond 10,000 per second.

Relay Type Receiver

A receiver similar to the balanced type, designed somewhat along the lines of an ordinary polar relay as used in duplex telegraphy has a thin armature situated between the four pole-pieces, each of which serves also as the core of an electromagnet. The pole-pieces are magnetized by a permanent magnet, the coils on the extremities being so connected that diametrically opposite pole-pieces exert attraction simultaneously. The motions of the armature are communicated to a corrugated aluminum diaphragm by way of a connecting rod. In those receivers where the motion of an armature is transmitted to the diaphragm by way of a connecting rod it is not necessary that the diaphragm be made of iron or other magnetic material, in which case mica, parchment, balsa wood, aluminum, or other light materials may be used.

The Hewlett Loudspeaker

A loudspeaker of somewhat spectacular performance, which has been used for radio reproduction in large auditoriums is that due to Dr. C. W. Hewlett, and known as the induction type of speaker.

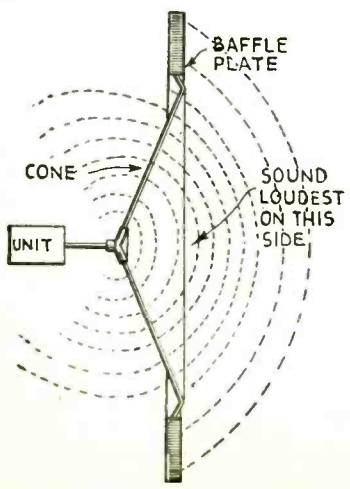


Fig. 56. Baffle plate around periphery of cone.

In this instrument the diaphragm is a thin sheet of aluminum rather loosely supported between two flat coils, the turns of wire being so spaced that there is sufficient freedom for the air waves produced by the diaphragm. Current from a direct-current source passes through the coil windings in such direction that a radial field is set up in the region of the diaphragm. The radio receiver output circuit is connected to the coils of the speaker in such a manner that both coils serve as primaries to induce currents in the diaphragm. This was a distinct departure in loudspeaker design as, other than the action of the diaphragm, there are no moving parts in the instrument.

Modern Cone Loudspeakers

In the complete radio receivers, as developed up to 1923, it was apparent that the low tones either were not reaching the diaphragm of the speaker, or the speaker was not properly radiating the low tones. Forthwith engineers investigated the characteristics of audio-frequency transformers used in audio-frequency stages of amplification, and more efficient transformers were designed and produced; transformers which passed on to the telephone receiver the low tones in faithful outline. Improvements were made in the low-capacity condensers, impedance and resistance units were employed in other forms of amplification. With the benefits of these improvements demonstrated, it was evident that where in the final reproduction the low notes failed to appear, the loss occurred in the loudspeaker.

Departure from wire telephone practice occurred when it was discovered that for radio loudspeaker requirements larger diaphragms could be used to advantage. Laboratory investigations carried out by Farrand, Rice, the Western Electric Company's engineers, and others mentioned herein, resulted in the modern cone type of loudspeaker represented by the Farrand speaker, Pathé, and Western Electric 540-AW speakers.

The questions of diameter, thickness, shape and material of diaphragm naturally were all important. Theoretically it would appear that the movement of the diaphragm should be that of a true piston; that is, it should remain perfectly flat while vibrating in response to the actuating electric currents. It should have a maximum of rigidity commensurate with light weight. The original diaphragms of two inches diameter were replaced by diaphragms ranging from two to thirty-six inches, and larger. In the Hewlett speaker of 1921, a diaphragm twenty-four inches in diameter was employed. With diaphragms of the larger sizes, vibration amplitudes as great as 1/32 inch took place.

Fig. 57. Radiophone receiver of 1923, employing a loop antenna.

In the Gaumont loudspeaker, used in France, the diaphragm was in the form of a cone and was made up of thin silk on which was cemented a single layer coil of fine aluminum wire. Here was an extremely light and sensitive diaphragm and one free from resonance effects. In this speaker element the reaction of the voice currents in the aluminum coil with the radial component of the magnetic field produced the driving force.

Chester W. Rice designed a loudspeaker on the Gaumont principle, improving the performance of the instrument greatly by providing a more flexible support for the rim of the diaphragm, as a result of which the low tones were reproduced more effectively. Rice introduced a diaphragm made up of a single layer of copper wire embedded in rubber, which was four inches in diameter and weighed eleven grams.

It was discovered that the absence of the low tones in a loudspeaker was due in part to the circulation of air between the space in front and back of the diaphragm. Rice corrected this difficulty by employing a flat "baffle board," providing that both sides of the diaphragm should produce sound radiation. With this construction the total power radiated for a given amplitude of diaphragm was nearly four times that where the diaphragm is inclosed. A baffle thirty inches in diameter was employed in the first speakers of this type.

In the loudspeaker investigations of Rice and Kellogg, it was determined that a simple 45-degree cone of 0.007-inch to 0.010-inch paper, about six inches in diameter, with flexible support for the rim consisting of a layer of very thin rubber ¼ inch wide and under slight tension made a satisfactory sound radiator. Fig. 57 shows one form of baffle board, or plate, around the periphery of a cone speaker.

With the rigidity possible with the light materials used in constructing "cone" loudspeakers, it was early apparent that in the larger diameters all of the sounding surface does not vibrate with every note the speaker gives out. Notes in the higher sound frequencies are produced by the center portion of the diaphragm while the low-frequency notes are produced by the area extending from the center to the rim. That is, as the voice or instrumental frequency increases, the outer area of the cone will tend to remain stationary, the active (vibrating) area of the cone decreasing as the frequency increases. Conversely, the lower the note, the greater the area of the cone set in vibration.

C. L. Farrand, in America, should be credited with important pioneer work in the development of cone loudspeakers. Improvement in the design, construction and performance of loudspeakers had a wide and important bearing on the popularization of radio for entertainment purposes.

The design and construction of loudspeakers for use in radio reception are quite certain to undergo further improvements as time goes on and what is accomplished will be the result of the joint efforts of the radio engineer and the engineer of acoustics.

CHAPTER 15

Correlation

IN this story of the engineering rise in radio, the author has endeavored to adhere to the plan of reporting the scientific discoveries made from time to time which contributed toward the building up of the science of radio, and the invention of circuits, devices, systems and machines which have been used throughout the evolution of radio from a novelty of physics to a world-wide social service and commercial utility. In confining the work to a story of the technical rise of radio; a seriatim account of the discoveries and inventions which contributed in a large way or in a small way to the upbuilding of this great art, there is the lack that nothing may consistently be recorded about the work of the executives who pioneered the organization of the large operating companies, among whom stand out prominently Edward J. Nally, John Bottomley, George S. Davis and Charles J. Pannill, in America; Godfrey C. Isaacs and H. W. Allen, in England; E. T. Fisk, in Australia; E. Girardeau, in France, and Arthur H. Morse and G. H. Pearson, in Canada. Also, a separate subject from that here undertaken, is that of radio telephotography, as well as that of television. In their radio applications thus far these by-products have been advanced gradually through the genius of A. Korn and Ernest Ruhmer, in Germany; M. J. Martin, T. Thorne Baker and J. L. Baird, in England, and C. Francis Jenkins and R. H. Ranger, in America.

Undoubtedly the time is approaching when it will be impracticable to set down a history of radio which would be complete unless extended to several volumes. Even now there are several divisions of the subject which have contributed so much to the general advance; to design and manufacture of equipment, and to investigations into the nature of radio phenomena, that each soon will be worthy of a history of its own.

For instance, the very important work of an educational nature carried on for many years past by the American Radio Relay League, under the direction of Hiram Percy Maxim and through the intelligent efforts of K. B. Warner, F. H. Schnell, Charles H. Stewart, Arthur A. Hebert, Robert S. Kruse, John M. Clayton, F. E. Handy, C. M. Jansky, Dr. L. J. Dunn and A. H. K. Russell, has been of such vast benefit to radio in all of its applications, that a history of that organization's activities would in fact be a history of radio engineering progress, particularly in connection with short-wave (high-frequency) radio telegraphy over long distances.

Stephen Gray, pensioner of the Grey Friar's School, tinkering with pewter plates, iron balls, tea kettle, paint pots, fishing poles and glass rods, in 1729, demonstrated that electrical effects may be observed at a distance from the source, provided a path, made of certain substances (conductors), is laid down.

Could the Charterhouse brother return to life, what a marvel it would appear to him to observe an English youth seated before a row of two or three glowing bulbs, a small cage-like coil, and a tapping key, carrying on a conversation with another youth away off in the Americas, space only serving as the conducting path! To him electron, audion, heterodyne, space charge, counterpoise and grid leak would be meaningless words. But, as Gray's labors started the train of discoveries and inventions recorded somewhat chronologically in this work, by recalling in our closing lines the elementary nature of his discovery, we are enabled to sense the measure of progress which has taken place in the intervening two hundred years.

(*The End*)

VACUUM TUBE DESIGN

(*Continued from page* 41)

vided to supply the desired voltages. If we analyze the design of such a rack we come, however, to some difficulties. It is, of course, important that definite voltages should be applied to the filaments during the different stages of the seasoning process. If we have, for instance, 100 type-80 tubes on the seasoning rack the total current drawn by the filament will be close to 300 amperes during the application of 7½ volts to the filaments. When such high currents are used at low voltages, very large cross sections must be used for the buses, and connections to individual sockets must be made very carefully, as even a drop of one-half or one volt will materially affect the seasoning process.

Fig. 1 shows the general layout of a seasoning rack. Fig. 2 shows the connections under the panel. In this design the sockets are integral with the panel, and the filament current is admitted through heavy copper strips which are bolted directly to the socket prongs. Twelve or thirteen sockets are connected to one set of bus bars. All bus bars come out at the side of the rack, where they are connected with still heavier bars to the transformer. The latter is hung in the frame under the rack. A swivel switch is used to apply the proper voltages.

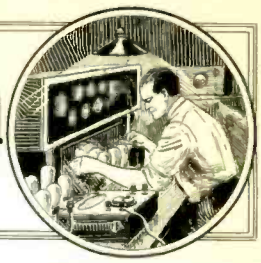
It is sometimes convenient to use a standard transformer for all or most of the tubes manufactured in a given plant. It is, however, advisable to arrange this transformer so that the operator cannot easily use the wrong voltage. This can be done in quite a practical fashion by using a special transformer. The secondary of the transformer should have three taps, one giving full voltage the second seventy-five per cent of full voltage, and the third fifty-five per cent of full voltage. The primary of the transformer should have one tap, corresponding to the voltages for each type of tube for which the transformer is to be used. The taps in the primary are changed only when the type of tube to be seasoned on the rack is being changed. All the voltages necessary for the seasoning of any single type of tube are obtained by switching the secondary through a three-way snap switch. In this way there is very little chance for the operator to apply wrong voltages.

It may be desirable to apply automatic operation to seasoning. This not only effects a saving in labor, but gives the assurance that all tubes would be seasoned uniformly, which is not the case if switching is left to the operator. In the most elaborate automatic seasoning installations the tubes are inserted by the operator in a rotating disk, or drum. As the drum or disk turns, the tubes are switched to the required voltages. Such an outfit is rather elaborate, and the expense is not entirely in keeping with the saving. It is quite possible to provide automatic switching for a stationary seasoning rack by a so-called program machine, which is less expensive and more reliable than the rotating rack.

A fully automatic seasoning machine can be built on a continuous belt, which carries the tubes over contacts with the required voltages, and ultimately also over the testing equipment. Of course, such automatic machines are not economical unless a very large number of tubes of one kind are produced during a long period of time.

The Trend of Invention

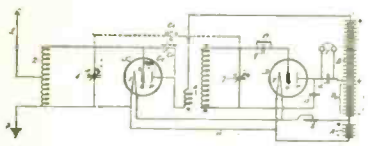
By RICHARDS & GEIER
PATENT AND TRADE MARK ATTORNEYS 274 MADISON AVE NEW YORK CITY



Balanced Radioreceiver

Joseph David Roth Freed, of Woodmere, New York assignor to Freed-Eisemann Radio Corporation, of Brooklyn, New York, a Corporation of New York. U. S. Patent No. 1,727,103. *(Issued September* 3, 1929.)

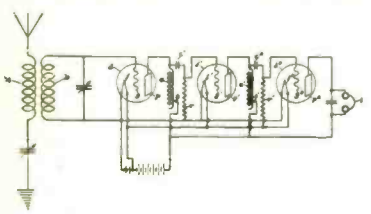
THE present invention relates to an improved method and circuit arrangement by which this inherent capacity between plate and grid electrodes is used to balance the inherent capacity between their associated circuits so that when the circuit is used under conditions which avoid electro-magnetic coupling below the point at which it is capable of causing the generation of oscillations, the various circuits can be tuned to resonance for the purpose of employing, for example, radio-frequency amplification in the most efficient manner.



Amplifier

John M. Miller, of Washington, District of Columbia. U. S. Patent No. 1,724,498. *(Issued August* 13, 1929.)

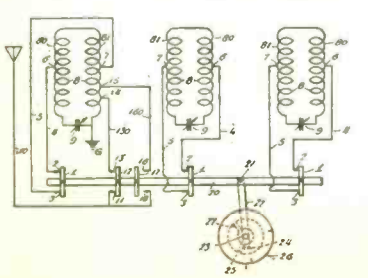
This invention relates generally to an amplifier, particularly one using three element vacuum tubes which serve to amplify alternating currents or voltages of the higher frequencies of those used in radio signaling, and particularly to a means for obtaining and passing on an amplified voltage from one stage to another in a radio-frequency amplifier.



Frequency-Range Extension Switch

Alfred Henry Grebe, of Hollis, New York, U. S. Patent No. 1,727,641. *(Issued September* 10, 1929.)

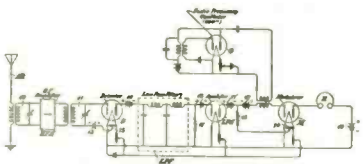
This invention relates to range extension switches and has for its principal object the extension of the range of frequencies over which a radio tuning system is capable of operating efficiently.



Radio Receiving Set

Allan Weaver and Fay Harold Chase, of Brooklyn, New York, Assignors to American Telephone and Telegraph Company, a Corporation of New York. U. S. Patent No. 1,724,057. *(Issued August* 13, 1929.)

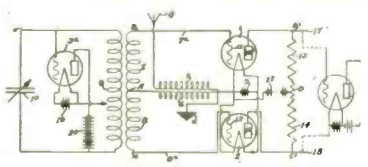
One of the objects of the present invention is to provide a receiving circuit for continuous waves which will produce audible tones in the receiver without depending upon the heterodyne principle and which will be highly discriminative against interfering stations.



Method and Apparatus for Elimination of Static Disturbances

Frederick W. Kranz, of Geneva, Illinois, assignor to B. Cumming, Trustee. U. S. Patent No. 1,728,617. *(Issued September* 17, 1929.)

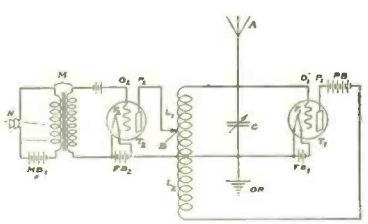
It is an object of this invention to provide a method and apparatus whereby electrical disturbances known as static may be eliminated or greatly minimized in the reception of radio messages.



System of Modulation

James E. Parker, of Washington, District of Columbia. U. S. Patent No. 1,724,960. *(Issued August* 20, 1929.)

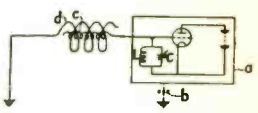
The purpose of the present invention is to cause a high percentage variation or modulation in the amplitude of the oscillations in the oscillatory circuit, in response to feeble oscillations applied to said circuit.



Wireless Signaling System

Quentin Charles Alexander Craufurd of Lyda, and Cyril Charles James Frost of Windsor, England. U. S. Patent No. 1,727,536. *(Issued September* 10, 1929.)

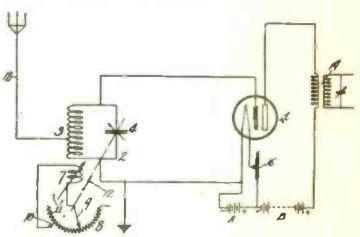
This invention relates to wireless signaling systems and has for its object to provide a new or improved method of and means for transmitting and receiving electric radiations which are propagated through a conductive medium, such as earth or sea. The invention may also be applied to wireless signaling apparatus disposed on or within a conducting body such as the hull of an airship, which may be surrounded by a dielectric medium.



Radio Receiving Circuit

Dimmitt Ross Lovejoy, of New York, N. Y., Assignor to Lovejoy Development Corporation, of New York, N. Y., a Corporation of New York. U. S. Patent No. 1,725,360. *(Issued August* 20, 1929.)

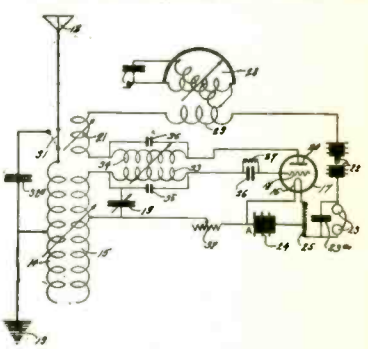
The present invention relates to radio receiving circuits in which regeneration occurs either intentionally or unintentionally, and in which absorption and dissipation of a portion of the energy is employed to control the amount of regeneration.



Process and Apparatus for Increasing the Strength of Radiosignals

Chauncey C. Chapin, deceased, late of Sterling, Colorado, by the Colorado National Bank, Executor, of Denver, Colorado, U. S. Patent No. 1,726,806. *(Issued September* 3, 1929.)

The object of the invention is to provide a process for increasing the strength of radio signals by superposing a harmonic vibration or frequency on the signal wave of the grid circuit and means for controlling the amplitude of the superposed harmonic frequency, said means comprising adjustable induction coils arranged in operative relation in the grid and plate circuits respectively, and by-pass condensers for shunting said coils so that radio-frequency waves can pass through the grid and plate circuits without having to pass through said coil.



The New Hammarlund HiQ-30 A-C. Receiver

A Screen-Grid Receiver with a Band Selector Circuit and a –45 Push-Pull Amplifier

By Lewis Winner

IT is acknowledged that with screen-grid tubes, amplification heretofore unknown can be obtained, and with exceptional circuit stability. But this tremendous amplification cannot be harnessed, without sacrificing selectivity or destroying the radio-frequency signal, unless a special system is used.

Let us see why. Suppose we used a radio frequency amplifier which permitted the utilization of the maximum amplification of the screen-grid tube. We would then be unable to tune in any distant signals or even local stations operating on a frequency near to that of the station being tuned in, for they would be blanketed out. Then suppose we introduced selectivity to prevent this. Distortion due to sideband cutting would result.

It is, therefore, very evident that a special tuning system which will permit the use of all of the screen-grid tube's amplification, but still maintain selectivity and no band cutting, is necessary.

With what is known as a "band filter unit," this type of tuning is possible.

Note that all the units are completely shielded. The large tube on the left is a voltage regulator.

Such a unit is incorporated in the latest Hammarlund HiQ creation, the HiQ-30. This unit precedes the first radio-frequency tube. The radio signal wanted is, therefore, first pre-selected and then fed into the radio amplifier for strengthening. In this way we can use the maximum amplification of the tube, and yet maintain 10-kilocycle separation without any sideband cutting. In other words, flat top tuning is provided. The radio signal characteristic required for perfect tone is thus preserved, and yet with sharp tuning.

And now let us see how this selectivity is maintained and the fidelity of the signal is kept in the radio and audio amplification systems in this new HiQ.

The Receiver

This new model, a 9-tuber, uses completely assembled and wired units. The utmost in efficiency is thus assured because of the correctly wired and matched units, afforded by the use of specially designed laboratory instruments, not readily obtainable by the fan. Rapid assembly and wiring is thus also affected.

The matching with these laboratory devices affords ganging of all the condensers, (six are used) resulting in real one dial control. There are three in a pre-selector unit, and three in the high gain radio-frequency amplifying unit.

In this receiver, which is the a-c model (there also being a battery model which is fundamentally the same) 24-type tubes are used in the screen-grid r. f. unit, a -27 tube in the super sensitive detector circuit and a –27 tube in the first stage of transformer-coupled audio. This is followed by a pair of –45 tubes in a stage of push-pull audio.

The three-stage band filter unit contains a three-gang .0005 mf. matched condenser, housed in an aluminum shield. Each of these condensers shunt a portion of special radio-frequency coils which are coupled by a new conductive and inductive method. Each coil is enclosed in a copper can.

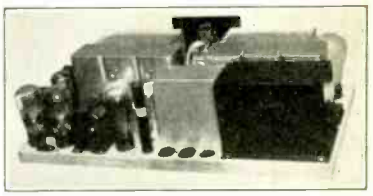
Incidentally, all background noises, which so often interfere with distant reception, are also reduced to a minimum with this unit. The advantages of this type of tuning are especially valuable in congested localities, where there are many local stations, or in the locality of interference producing electrical apparatus.

The Screen-Grid Amplifier

The signal is fed from this unit into the first screen-grid tube, and then, of course, into the other screen-grid tubes and into the detector tube, all by way of a high gain screen-grid, radio-frequency amplifier.

This unit also contains a matched three-gang .0005 mf. condenser. It is housed in an aluminum can with partitions shielding each condenser. These condensers shunt the secondaries of special radio-frequency coils, each enclosed in a copper can. In each of these plate circuits, a newly developed radio-frequency choke, one which is polarized, is connected. This choke is also housed in an aluminum shell. It has a high impedance to all frequencies in the broadcast range. This, coupled with its low distributed capacity, total absence of a natural resonance period within the broadcast band, and the polarization effect, prevents feedback and consequent receiver instability. A polarized choke is also used in the detector output circuits.

The special shielding of these units has been carried out to an extent found only in experimental laboratory receivers. This further insures peak amplification at all frequencies in the broadcast spectrum, without the slightest trace of instability or regenerative distortion.



A rear view, showing the audio-frequency amplifier units and power-supply units.

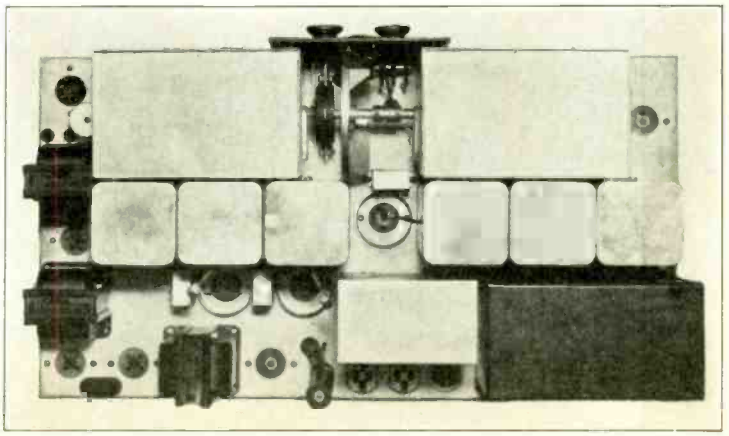
The screen-grid amplifier has a sensitivity well under ½ microvolt per meter. This extreme sensitivity permits the use of a small copper screen mounted on the rear of a console as an antenna with great satisfaction.

The detected signal is fed into an audio transformer, having a ratio of 1½ to 1. From here it passes into the push-pull stage, where a transformer having a ratio of 2 to 1 on each side is used.

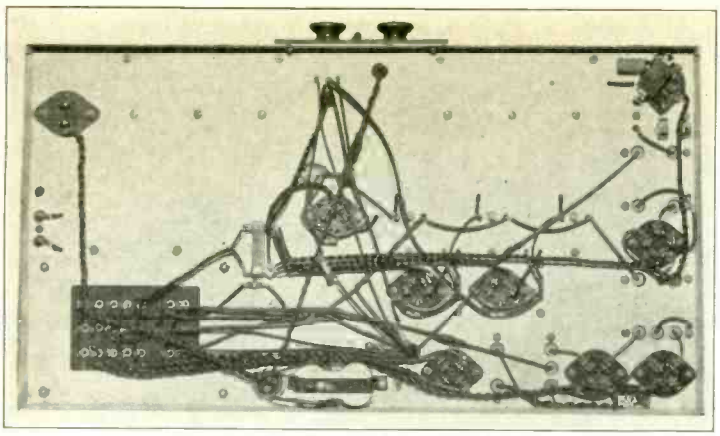
Uniform Amplification

The primaries of both transformers are unusually large. This, coupled with the use of treated laminations grouped into large cores, permits the superb reproduction of every shade and overtone of voice and instrument affording that depth and richness so desired.

Either a magnetic or dynamic speaker can be used, a special output transformer being provided for in each case. In the case of the dynamic speaker, the transformer is designed to work directly into the moving coil, thus taking the place of the input transformer usually supplied with these speakers. Larger cores of treated laminations are also incorporated in these transformers, preventing current saturation and allowing true energy transfer.



Looking down on the chassis. Note the position of the three screen-grid tube sockets.



The wiring underneath the metal chassis.

To supply filament voltage, a special transformer with a tapped input primary at 80 volts for use with a voltage regulator is used. Two 30-henry chokes constituting a part of the filter supply are also housed in the same case with the transformer.

The filter condenser block which is one of the other parts of the filter unit, contains seven condenser sections. It consists of a 2 mf. condenser rated at 600 volts, a 4 mf. condenser rated at 500 volts, a 2 mf. condenser rated at 400 volts, a 1 mf. condenser rated at 300 volts, a 1 mf. condenser rated at 400 volts, and a pair of 1 mf. condensers each rated at 200 volts. These are liberal voltage ratings and will take care of extreme peak voltages.

Another component of the filter supply is the voltage divider, with which the proper plate and grid voltages are obtained. This is a specially designed enameled wire-wound resistor, conservatively rated at 30 watts. The wire is wound on a vitreous tube, ¾-in. in diameter and 5 inches long.

This power filter supply which is designed for an -80 type tube, is conventional and time tried. This with the use of parts of decided excellence permits an unusually smooth direct-current output.

Overheating is prevented with the use of large cores of treated laminations and heavy wire.

To further insure the full advantage of the amplifying qualities of the screen-grid tubes, the tubes are housed in aluminum shields. These shields completely surround the tubes, even as to the bases. Soft rubber grommet protect the control grid outlet. It prevents vibrations as well as accidental shorts.

The Automatic Voltage Regulator

To preserve the tube efficiency and aid in maintaining uniform volume level, an automatic voltage regulator is used.

A strong cadmium plated chassis is used to mount the parts. The parts, by the way, are supplied with pigtail leads for sub-panel connection. The sub-panel wiring, unit construction, and factory assembly, wiring and testing of the filter and amplifier units, make the construction a very simple operation requiring only two or three hours of time. The standard size of the chassis (7 in. x 12¾ in. x 24 in.) allows an unrestricted choice of cabinets. The walnut panel and control knobs with the statuary bronze dial escutcheon make the panel arrangement exceptionally pleasing and compact.

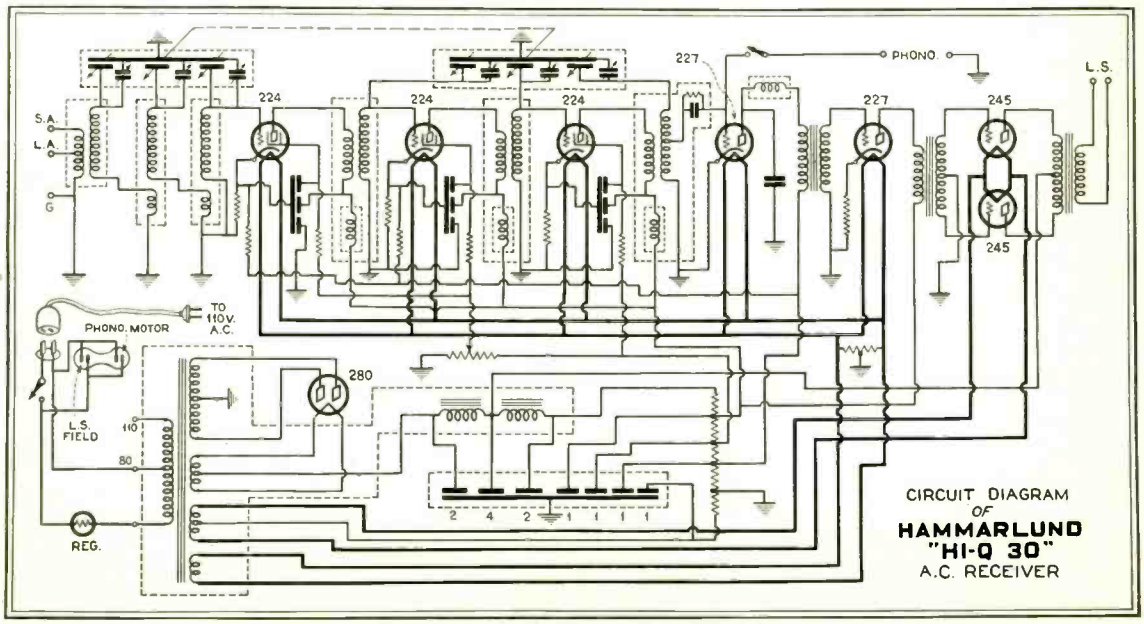
So that recorded music may be reproduced through the audio end, a toggle switch arrangement is incorporated. This switch is mounted on the front panel atop the alternating-current switch. A snap of this switch connects the phonograph or radio.

Provision is also made for connecting in the motor of a phonograph via a plug mounted next to a plug which takes the field of the dynamic speaker.

LIST OF PARTS REQUIRED

One Hammerlund "HiQ-30" Foundation Unit, QFU-30.
One Hammarlund Three Stage Band Filter Unit, BS-3.
One Hammarlund Three Stage Screen-Grid Amplifier Unit, RF-3.
One Hammarlund Knob Control Drum Dial, SD.
One Hammarlund Shielded Polarized R-F. Choke, SPC.
One Hammarlund First Stage Audio Transformer, AF-2.
One Hammarlund Push-Pull Input Audio Transformer, AF-4.
One Hammarlund Push-Pull Output Audio Transformer, AF-M or AF-D (AF-M is for magnetic speakers, while AF-D is for dynamic speakers without transformer).
One Hammarlund Power-Supply Unit for Push-Pull '45s, PS-45.
Three Hammarlund Screen-Grid Tube Shields, TS.
*One Aerovox Filter Condenser Block, CHQ-30.
*Three Aerovox Triple By-Pass Condensers, BP-3.
One Yaxley Center Tapped 10-ohm Fixed Resistor, No. 810-C.
One Pair Yaxley Insulated Phone Tip Jacks, No. 422.
One Yaxley Speaker Twin Tip Jack, No. 401-S.
*One Electrad Voltage Divider, RHQ-30.
*One Electrad 1500-ohm Flexible Grid Resistor, No. 3.
*Three Electrad 400-ohm Flexible Grid Resistors, No. 3.
*Three Electrad 5000-ohm Flexible Filter Resistors, No. 3.
*One Electrad 25,000-ohm special Taper Royalty Volume Control Potentiometer.
*One Eby Two-Prong Tube Socket marked "Amperite," No. 6-11 (Voltage Regulator).
*One Eby Four-Prong Tube Socket marked 245, No. 6-11.
*Two Eby Four-Prong Tube Sockets marked 280, No. 6-11.
*Two Eby Five-Prong Sockets marked 227, No. 6-11.
*Three Eby Five-Prong Sockets marked 224, No. 6-11.
*One Eby Triple Binding Post Strip.
*One Hart and Hegeman Phons-Toggle Switch, No. 20510.
*One Hart and Hegeman Line Toggle Switch, No. 20510.
*One Sangamo .001 mf. "Illini" Mica Fixed Condenser.
*One Beaver-Arrow Handle Cap, Cord Connector and Silk Cord.
One Beaver Duplex Receptacle, No. L-14.
One Arrow Plug Type Midget Receptacle, No. 8339.

** Specially designed for the "HiQ-30." These parts are not stocked by radio distributors and are available only on special order.*



Complete schematic diagram of the "Hi-Q 30"

NEWS OF THE INDUSTRY

KOLSTER ANNOUNCES ELECTION OF L. T. BRECK TO SUCCEED FROST

Announcement is made by the Kolster Radio Corporation that L. T. Breck, who has been sales manager of the organization for the past year, has been elected vice-president in charge of the merchandising division to succeed Major Herbert H. Frost, who has recently resigned. Mr. Breck will assume his new duties at once.

During the year he has been with Kolster, Mr. Breck has been very active in the field, continually attending distributor and dealer meetings all over the country and studying the problems of each section. This has resulted in a closer contact than ever before between the Kolster Radio Corporation and its dealers. His progress in improving the Kolster merchandising organization and in speeding up action on all matters relating to dealer and distributor problems has been so outstanding that the promotion has resulted.

W. A. BROOKS JOINS TEMPLE

Mr. W. A. Brooks who for the last seven years has been connected with the Timken Roller Bearing Co., Canton, Ohio, as assistant secretary-treasurer, has just been appointed assistant to Alfred Marchev, president and general manager of the Temple Corporation, local radio manufacturing concern, and in that capacity will take over part of the heavy work and responsibility now on Mr. Marchev's shoulders.

Mr. Brooks is a graduate of the University of Pennsylvania. In addition to his work with the Timken Co., Mr. Brooks was connected for several years with an affiliated General Motors Co., Detroit, as secretary-treasurer and with the E. I. Du Pont de Nemours Co., Wilmington, Delaware and Philadelphia.

W. D. POWERS MERCHANDISE MANAGER OF CECO

W. D. Powers is a new official up Providence way, having joined the rapidly expanding organization of CeCo Manufacturing Company, Inc.

As Merchandise Manager, Mr. Powers will take up some of the heavy load that has been carried by the advertising and sales executives.

The production department has the plant running 23 hours daily, but it is manned by several shifts. In the office, however, the executives have been working nights as well as days.

Mr. Powers comes into the radio field from the automotive world. He was sales manager of the Providence Buick Company until the CeCo folk persuaded him to join them.

Incidentally, like so many of his CeCo confreres, he is an athlete. Not so many years ago he played professional baseball.

ELECTRAD ELECTS NEW OFFICERS

At a meeting of the Board of Directors of Electrad, Inc., held on October 15, 1929, Mr. Henry G. Richter was elected Vice-President in charge of Engineering, and Mr. Edward Metzger, Vice-President and General Manager in charge of Credits, General Office and Factory Supervision, according to an announcement by Arthur Moss, President of Electrad.

ROBERT ARNOLD JOINS SENTINEL RADIO

Robert Arnold, who has been prominent for a number of years as a radio engineer, has recently joined Sentinel Mfg. Co., Chicago.

Mr. Arnold has been a consultant for one of the largest radio development organizations in the world, and his addition to the Sentinel staff in a permanent capacity speaks well for the aggressiveness of this company in furthering the perfection of its products.

F. J. BULLIVANT HEADS TRAV-LER RADIO SALES

Harold J. Wrape, president, Trav-Ler Manufacturing Corporation, has announced the appointment of F. J. Bullivant as sales manager of the company. Mr. Bullivant in assuming his new duties will retain active charge of the sales department of the B-L Electric Manufacturing Company, builders of rectifying devices.

The new sales head of the Trav-Ler organization has been actively identified with the radio industry for the past eight years, joining the B-L and Trav-Ler organizations after being for eight

F. J. BULLIVANT
Sales Manager, Trav-Ler Mfg.

years with the Valley Electric Company.

Prior to his connection with the Valley company he was with the Wagner Electric Company also of St. Louis, holding positions in both the sales and engineering departments. It was during the fourteen years while with this manufacturer of automotive ignition and generating equipment that Mr. Bullivant built up a wide acquaintance in the automotive field among manufacturers, distributors and dealers.

NEW WESTERN SALES MANAGER FOR SPEED

Speed tube sales for the Western District will be in the hands of C. M. McIntosh, it has been announced from the offices of Cable Radio Tube Corporation, at 84-90 N. Ninth St., Brooklyn, N. Y.

Mr. McIntosh, widely-known throughout the radio industry, will make his headquarters in Los Anges, but both he and others of his firm, will be in constant touch with representatives and distributors throughout the territory.

Mr. A. D. Strathy, national sales manager for Speed tubes, has just returned from a three months' trip in which he has built up and strengthened the entire distributing organization from coast to coast.

In the southern California territory, Mr. Barrie C. Bloeden of 1321 Maple Ave., Los Angeles, has been appointed. His company will operate under the name of Speed Sales Company. In northern California, the Monarch Sales Company, 1268 Mission St., San Francisco, has been named Speed representatives. For Washington, Oregon and Idaho, Mr. Strathy selected the A. S. Detsch Company, Security Bldg., Portland, who will cover that territory, from headquarters in Portland and from their branch office in the Terminal Sales Bldg., Seattle, the latter in charge of G. McNicholds.

All these sales organizations now are directly under the supervision of Mr. McIntosh, as well as the Denver representatives, the C. M. McIntosh Co.

NEMA ELECTS NEW OFFICERS

Following the recent annual meeting held at Washington, the National Electrical Manufacturers Association announces the election of Clarence L. Collens of Cleveland as president, and the appointment of A. W. Berresford as Managing Director, succeeding Alfred E. Waller, resigned.

Mr. Collens, who is president of the Reliance Electric and Engineering Company, served as Vice-President of the Policies Division of NEMA since the Association's organization three years ago.

Mr. Berresford, the new Managing Director of NEMA, is President of the American Engineering Council and has been prominently identified with the electrical manufacturing industry for many years.

Five vice-presidents were also elected for 1929-30. They are S. L. Nicholson, Westinghouse Electric & Manufacturing Company, New York; C. H. Strawbridge, Goodman Manufacturing Company, Chicago; W. E. Sprackling, Anaconda Wire & Cable Company, New York; D. R. Buller, General Electric Company, Schenectady, N. Y.; Louis B. F. Raycroft, Electric Storage Battery Company, Philadelphia.

HOLMES RESIGNS FROM DEFOREST COMPANY

Harry C. Holmes, well-known in the radio trade for his activities in the marchandising of radio tubes, has resigned as Director of Sales of the DeForest Radio Company, effective Monday, October 14th. It will be recalled that this genial sales executive went with DeForest at the time of its reorganization in June, 1928. When interviewed at his headquarters in the Elks Club of Newark, N. J., Harry had no announcement to make regarding his future plans, except to state that he was taking a few weeks off to look the radio field over with a view to applying his vacuum tube merchandising experience wherever it might be needed.

J. W. A. HENDERSON ELECTED PRESIDENT OF N.R.T.A.

The Northwest Radio Trade Association, at its annual election of officers and banquet held recently in connection with the Northwest Radio Show in Minneapolis, chose by a unanimous vote, Mr. J. W. A. Henderson as its president for the coming year.

Mr. Henderson is manager of the Minneapolis Branch of the Edison Distributing Corporation and directs the distribution of Edison Radios, Phonographs and Records in the northwestern section. He has been actively engaged in the work of the Northwest Radio Trade Association for many years, serving on its Membership Committee and Board of Directors.

News of the RMA.

Manufacturers Studying Merchandising Problems

AN ANALYSIS of the advertising methods and practices of radio manufacturers is being made by the Radio Manufacturers' Association, it was disclosed at a recent meeting of the RMA Merchandising Committee.

The purpose of the survey, according to Major Herbert H. Frost, Chairman of the Merchandising Committee, is twofold. First, to give radio manufacturers information as to industry practices in advertising, and second, to protect the public from exaggerated and misleading claims in radio advertising.

The preparation of radio industry statistics on past production and sales of radio apparatus was another subject discussed at the meeting, held jointly with the Statistics Committee of the RMA of which Mr. George C. Furness, of New York, is Chairman. Definite steps were taken to set up machinery to compile and disseminate authentic information on sales and production so far this year.

Non-Standard Voltages Hinder Widest Use of Modern Radio

It is not generally known that there are many sections of the United States using non-standard electric current and voltages. One of the major undertakings of the RMA will be a campaign to bring about uniform current and voltage throughout the country.

Two types of current are used in this country, the announcement said—alternating and direct, with the voltages ranging from 100 volts to 225 volts.

The fact that the most up-to-date radio receiving sets, which operate on 110-volt, 60-cycle alternating current, are useless in those sections of the United States which are served with other current and voltages, prompted the RMA to attempt to bring about uniformity in this respect so that the public in all parts of the nation may have full benefit of modern a-c. sets which are considered the highest perfection of the radio art to date.

The preliminary plans for this important standardization job are being formulated under the direction of Major Herbert H. Frost, Chairman of the RMA Merchandising Committee, and William Alley, Merchandising Manager of the radio association.

Standards of Radio Advertising Being Raised

Constant efforts and much progress are being made to raise the standards of radio advertising, according to Mr. Morris Metcalf of Springfield, Chairman of the Fair Trades Practice Committee. In cooperation with Better Business Bureaus and other organizations, Mr. Metcalf, outlining the goal of the RMA for the best ethics in radio advertising, believes that real progress is being made not only in this endeavor, but in bettering general trade practices in the selling of radio and also in adjustments of disputes between members and other interests.

"It is estimated that between $20,000,000 and $25,000,000 is spent annually by radio manufacturers in advertising channels," said Mr. Metcalf. "In the hectic and unstable days of the industry in its early years advertising excesses crept in, as in other new industries. This condition has largely become changed. There is room for improvement, of course, and it is the constant effort of the Fair Trade Practice Committee to insure the highest standards of truth and fair dealing with the public, as well as ethical practices between members engaged in the manufacture and selling of radio products.

"The Fair Trade Practice Committee of the Radio Manufacturers Association endeavors to right such business wrongs, as are contrary to the ethics of good business practice, as may be brought to its attention. In cooperation with Better Business Bureaus and other organizations, it attempts to eliminate false and misleading statements in advertising, and to prevent as far as possible the deception of the public in radio matters."

Many hundreds of thousands of dollars are being saved annually to national radio manufacturers, frauds are unearthed and collection of accounts insured by cooperative service of the Radio Manufacturers Association, according to Leslie F. Muter of Chicago, Chairman of the Credit Committee.

The Association's credit and collection service, Mr. Muter announced, is to be expanded further in an effort to reduce still more the credit losses of national radio manufacturers who are members of the national association. These losses amount to several million dollars annually, according to information compiled by Chairman Muter and his Committee.

As the "watch dog of the treasury" of the RMA, Chairman Muter and his Committee, which comprises eastern, central and western divisions covering all parts of the country, have an extensive credit information and also collection services in force. The credit information service, under the plans of expansion, approved by the Board of Directors of the RMA, will make available to manufacturer members complete information on almost anything connected with the radio industry. Accounts aggregating many hundreds of thousands of dollars are collected annually through the collection service.

Constructive work preventing bankruptcies also is another important feature of the Credit Committee's service. Claims of RMA members are pooled and adjustments made which often save valuable industrial units from bankruptcy through the operation of a Creditors Committee composed of RMA members.

Vigorous joint action, unified to secure more efficient results, are also taken when credit frauds are unearthed. Several recent prosecutions for fraud have effected large savings to members of the Association.

In its credit information service, the radio manufacturers operate in conjunction with the National Credit Office of Cleveland, Ohio. The collection service is operated with the New York Credit Clearing House Adjustment Corporation, with offices in six principal cities.

Radio Changes Coming Slowly

No radical change in the construction of radio receiving sets this year is in prospect and television still is some years off, according to President H. B. Richmond of the RMA at the Association's large national radio exposition at the Coliseum and the incident gathering of radio industry leaders. The large and sustained sales of all radio products, the large attendance at the Coliseum show and also at the recent Radio World's Fair at Madison Square Garden in New York, are among the many ample evidences, Mr. Richmond said, of stability for the industry and satisfactory service to the radio public.

"Fortunately for the radio public, as well as the industry," said President Richmond, "there are no radical changes in construction of receiving sets in sight this year and probably for some time to come, although there are great advancements in manufacturing refinements, especially in beauty of design. Cabinets and consoles especially have had great development.

"Fortunately for the average pocketbook, radio receiver design has reached a point where today's set does not make obsolete yesterday's.

"Television and home radio talkies are coming, but as separate units and not as supplementary adjuncts to the home receiving set. We shall see some fair television demonstrations this winter. They will not, however, affect the regular radio receiver. Television is an added service. When it is ready it will be in addition to your receiver, or more probably, because of electrical and mechanical complications, an entirely separate unit. Except for the experienced experimenter, television may be dismissed for the present. Home radio talkie-movies are just another complication of television. They are bound to come—inevitable and costly, both of them."

Industry Statistics to be Compiled

Estimates as to the number of receiving sets that will be manufactured in 1929 show a wide fluctuation. They range from a low of 3,500,000 to a maximum of 8,000,000. Actual sales, however, are estimated at 2,500,000 to 4,000,000. Accurate figures, so far, have not been obtainable in either case.

The same uncertainty exists as to the actual 1928 figures on production and sales of receivers. Estimates of last year's record of sales range from 2,500,000 to 3,500,000. Here, again, the actual numbers are beclouded by a large variety of wild guesses.

To secure accurate and authentic figures as to sales and production in both 1928 and 1929 the RMA will make a comprehensive survey of production and sales of radio receivers for the pas ttwo years.

Field Investigation of Radio Will be Undertaken

The first nationwide field investigation of trade conditions in every section of the country will be undertaken by the RMA, it was announced recently by Major Herbert H. Frost, Chairman of the Merchandising Division.

Trade conditions and practises in all parts of the country will be studied with particular reference to radio, Major Frost declared.

This unusual merchandising study of the United States will be undertaken by William Alley, Merchandising Manager of the RMA, and is expected to consume the better part of a year before the trip is completed.

Mr. Alley's itinerary will take him into every State, from the East Coast to the West Coast and from Canada to Mexico. He will work in cooperation with RMA members and their distributing and retail organizations all over the United States, so that an authentic first hand picture of merchandising conditions and customs section by section throughout the country may be secured.

R.M.A. to Compile Number of Wired Homes by Counties

According to figures issued by the Department of Commerce, there are approximately 28,000,000 homes in the United States, of which some 18,500,000 are wired for electricity.

These have been broken down into the number of wired homes in each State, but, so far, no accurate knowledge is available of the number of wired homes by counties.

To insure the public the fullest possible benefits of the most modern a-c. radio receivers, the Merchandising Department is embarking upon an investigation to ascertain the number of wired homes in each county in every State in the Union.

This information, it is expected, will prove of immense value not only to radio set manufacturers in the distribution of the latest electric radio receivers, but also to local municipal authorities, who, themselves, do not know accurately the number of homes wired for electricity in their respective territories.

The results of the survey, when completed, will be made available to the trade and public, according to Major Herbert H. Frost, Chairman of the RMA Merchandising Committee, under whose direction the survey will be made.

FEDERATED RADIO TRADE ASSOCIATION CHANGES NAME

At a meeting of the Board of Directors held Wednesday, October 23rd, at the Congress Hotel in Chicago, the Board of Directors of the Federated Radio Trade Association changed the name to the National Federation of Radio Associations. This is in order that the name will be more truly representative of that portion of the industry the association represents.

"The National Federation of Radio Associations is strictly as its name implies, a national group or federation of local, state and territorial radio associations throughout the United States. It is the purpose of the National Federation of Radio Associations to watch legislation and to direct association activities in such manner as to be to the best interests of the radio public and the radio industry in general," as stated President Michael Ert of Milwaukee, Wisconsin, in an interview recently.

Plans being promoted for the examination and registration of radio servicemen in every locality will, upon their completion, materially benefit every owner of a radio set in providing him with an adequately trained and competent radio serviceman.

Preliminary plans were discussed for the 4th annual Convention of the National Federation of Radio Associations. The Ohio Radio Trade Association, official hosts for the Convention, are preparing a program of unusual interest and import-

ance for the Convention which will be held in Cleveland, Ohio, on February 10-11, 1930. This convention will be given over entirely to the study of the problems between the radio industry and the consuming public, and will be of importance to the welfare of distributors and dealers everywhere.

RADIO WHOLESALERS SECURE FREIGHT RATE REDUCTION

The Traffic Committee of the Radio Wholesalers Association in cooperation with the Traffic Department of the Radio Manufacturers Association have effected a freight rate reduction on radio products which will aggregate well over $1,500,000 annually. The new rate schedule effecting this enormous savings in the annual freight bills of the radio industry will go into effect approximately January 1st, 1930. Radio receiving sets, console and table models, combinations and loudspeakers will be affected by this new rate. This huge savings will probably be reflected in part to the radio public.

F. E. Stern, Chairman of the Traffic Committee, Hartford, Conn. has represented the association for over a year with the Traffic Committee of the Radio Manufacturers Association in the conferences held with the Consolidated Classifications Committee.

The new freight rates will effect a savings of approximately 10% on all console receiving sets shipped in carloads. This is chiefly due to a reduction in the minimum carloading of from 20,000 lbs. to 18,000 lbs. A saving averaging between 20-24% on table models and mixed carloads which includes radio receiving sets, console or box type, combination talking machines and radio sets, talking machines, electrically amplified or otherwise, talking machine records or record blanks etc. at a minimum weight of 24,000 lbs. at 3rd class rate instead of 20,000 lbs. second class rate.

LEUTZ MOVES TO ALTOONA, PA.

After eight years in Long Island City, C. R. Leutz, Inc., of transoceanic reception renown, has moved to Altoona, Pa., where the organization is now housed in a modern steel and concrete building with some 30,000 square feet of floor space.

The new Leutz factory was originally planned and built by the Altoona Chamber of Commerce as an "ideal factory building." It incorporates offices, experimental laboratory, test room, stock room, shipping room and demonstration salon, as well as the manufacturing plant proper. The demonstration salon has been completely sound-proofed from the rest of the factory, and is furnished as an attractive drawing room.

The factory this year will be used exclusively for the production of the Silver Ghost, Phantom Special, Seven Seas Console, Seven Seas Phonograph Combination, and the latest developments in short-wave receivers.

REPORT ON R-V. C. A.

General James G. Harbord, President of the Radio Corporation of America, Mr. Gerard Swope, President of the General Electric Company, and Mr. Frank A. Merrick, President of the Westinghouse Electric & Manufacturing Company, made the following announcement to their respective organizations:

"Carrying forward the cooperative plans begun ten years ago with the creation of the Radio Corporation of America, General Electric and Westinghouse, with the Radio Corporation of America, will form the RCA Victor Corporation. Beginning with January 1, 1930, the new company will carry on research activities as well as all the engineering, manufacturing and selling activities in connection with radio sets, talking machines, records and other devices in the home entertainment field now sold by the Radio-Victor Corporation and manufactured by the General Electric and Westinghouse companies.

"Since the purchase of Victor Talking Machine Company, plans for manufacturing concentration have been under way and have now developed to the point where consolidation of facilities, with the Camden plant as the nucleus, is desirable.

"Of major importance is the unification of the radio research and engineering facilities of General Electric, Westinghouse, RCA and Victor so that the same staffs which have produced so many of the major contributions to science and engineering in radio and the entire home entertainment field, will not only cooperate in the future but will actually be consolidated under single and unified direction. The new company will continue, however, to get full benefit in its field of the broad research facilities of the General Electric and Westinghouse companies.

"The President of the RCA Victor Corporation will be Mr. E. E. Shumaker, President of Victor Talking Machine Company.

"Mr. J. L. Ray, Vice President of the Radio Corporation of America, and head the present selling organization for both Victor and RCA, will continue in charge of sales, as Vice President of the new company.

"Mr. H. C. Grubbs, at present Vice President in charge of Victor Talking Machine Division, will continue in that capacity.

"The unification involves no change in present distribution facilities.

"Mr. Alfred Weiland, formerly Vice-President in Charge of Production of the Victor Talking Machine Company, will be Vice-President in charge of all manufacturing activities of the new company.

"Executive and sales headquarters of the new company will be in New York."

DE FOREST REPORTS INCREASING PRODUCTION AND SALES

During the twelve months since it has been completely reorganized and refinanced, the DeForest Radio Company of Jersey City, N. J., has made steady progress in radio tube production and sales, according to its President, James W. Garside. The graph shows a steadily climbing production curve, dollar sales curve and tube sales curve, with the two last-mentioned curves gaining and by now exceeding the production curve to an estimated extent of at least 1,000,000 more audions than will be produced by December, 1929.

The De Forest Radio Company is now operating two huge radio tube plants at Jersey City and Passaic, N. J., with a total of 150,000 square feet of floor space. It carries over 2,000 employees on its payroll. The daily production of tubes passed for shipment exceeds 25,000, and is growing steadily with the installation of special automatic production units.

In addition to receiving tubes, the DeForest Radio Company, taking advantage of its unique patent rights, is building up a production of transmitting tubes, for which there is a growing demand already far exceeding the supply. The transmitting tube business will tend to raise the sales curve during that portion of the year when receiving tube sales drop off, it is said.

EARLY RADIO SEASON

Predictions made early in the season by the Department of Commerce that this would be radio's greatest year are being realized as shown in the results of a national survey just completed by Gordon C. Sleeper, vice-president and sales manager of the Temple Corporation.

Having covered thirty-four cities throughout the United States in the last two months Mr. Sleeper found the same story at every turn—that the radio season opened earlier and that each phase of distribution from factory to distributor, distributor to dealer and dealer to consumer has reached a volume and momentum that is about sixty days in advance of any previous year.

PIONEER BROADCAST MOVES

Ted Nelson, president of Pioneer Broadcast Service, Inc., has announced the removal of his company to its new quarters in the General Motors Building, 1775 Broadway, Manhattan.

The company, which has been engaged for the past two years in the building of radio programmes which are later electrically transcribed over broadcasting stations throughout the country, has also added to its studio facilities in order to care for increased orders placed by a number of leading national advertisers.

At the present time Mr. Nelson, formerly director of a number of eastern stations and pioneer radio authority, stated that his company's programmes are now being broadcast over approximately fifty stations in the United States and three in Canada.

STEINITE INCREASES FACTORY FORCE

A payroll numbering 3,000 employees now is the Steinite Radio Company's contribution to the Fort Wayne, Indiana, manufacturing wealth.

The factory force has been increased by the addition of 500 weekly for the last three weeks, according to an announcement by Lester Abelson, general production manager.

"Unusually heavy production schedules have made this increase necessary," said Mr. Abelson. "and we are planning to put on a night shift very soon to care for the heavy demand for our receiving sets which is coming from all parts of the country."

GULBRANSEN APPOINTS NEW JOBBERS

The radio division of the Gulbransen Company of Chicago announces the appointment of the following new jobbers in seven of the larger distribution centers of the country; Braiterman Felder Company, Baltimore; George Byers & Sons Co., Columbus, Ohio; Colonial Electric Supply Co., Philadelphia; North Coast Electric Company of Portland, Oregon, and Seattle and Tacoma, Washington, and Smith-Hassler-Sturm Co., Indianapolis.

NOTT-ATWATER NEW STEINITE DISTRIBUTORS

Announcement is made by the Steinite Radio Company of Fort Wayne, Indiana, that the Nott-Atwater Company of Spokane, Wash., have become local Steinite distributors in that territory.

This was brought about through the recent purchase by the Nott-Atwater Company of the M. F. Bruning Company, formerly Steinite distributors for the Inland Empire.

Nott-Atwater is one of the pioneer wholesale houses of Spokane. J. B. Simons, formerly manager of the M. F. Bruning Company, will continue as manager of the radio department for Nott-Atwater.

MARVIN COMPLETING WORLD-WIDE DISTRIBUTION CHAIN

The Marvin Radio Tube Corporation of Irvington, N. J., announces the practical completion of a world-wide distribution system.

According to F. A. LaBaw, General Sales Manager, there are now 70 distributors appointed here in the United States. These cover every sales district and represent the capable handling of about 4,000,000 tubes a year. By December of this year, there will be 125 Marvin distributors in this country, accounting for about 6,000,000 tubes a year, it is said.

In addition to the distributing organization for the domestic market, live-wire representatives are working in the following countries: England, Belgium, France, Portugal, Spain, Italy, Switzerland, Germany, Japan, China, Australia and the Philippines.

H. M. TOWER CORPORATION TAKES OVER WESTERN NEW ENGLAND TERRITORY

Announcement was made on October 10th at a luncheon at the Hotel Kimball by President Arthur T. Murray of the American Bosch Magneto Corporation, of the appointment of the H. M. Tower Corporation, of Boston and New Haven as wholesale distributors of Bosch Radio in Vermont and Western Massachusetts.

The H. M. Tower Corporation, represented at the luncheon by President W. G. Miller, Treasurer George Raymond and others, was welcomed into the Springfield territory by Percy Dorr, President of the Springfield Chamber of Commerce.

NEW MINNEAPOLIS DISTRIBUTOR FOR BOSCH

Charles J. Parker, formerly General Manager of Western Motor Supply Company at Minneapolis, Minnesota, has resigned from that position to open a wholesale distributing house in the same city under the name of Charles J. Parker Company. He takes the distributorship of Bosch Radio with him, according to an announcement by the American Bosch Magneto Corp.

CROSLEY REPRESENTATIVE APPOINTED

The Crosley Radio Corporation announces the appointment of L. E. Peterson as factory representative for the Nebraska-Western Iowa territory. Mr. Peterson is well known in the northwestern radio

PAM music in Peruvian park

In the Zoological Gardens at Lima, Peru (pictured above), and all over the world, you will find PAM Amplified entertainment enhancing the beauties of nature.

PAM'S crystal clear voice can be suited to blend with forest sounds or increased to be easily heard above the roar of motors at air meets.

All around you are opportunities of a similar nature.

These opportunities are found in hotels, clubs, excursion steamers, schools, hospitals, parks, theatres, auditoriums, dance halls, skating rinks and swimming pools, air ports, athletic fields, boat races, outdoor services, etc.

To the pioneer dealer who first sees and grasps this opportunity in his locality comes the greater volume and profit.

A new 16-page bulletin giving mechanical and electrical characteristics, representative installations and many new PAM Amplifiers will be sent upon receipt of 10 cents in stamps to cover postage. When writing ask for Bulletin No. RE6.

Main Office: **Canton, Mass.**

Samson Electric Co.

MANUFACTURERS SINCE 1882

MEMBER R·M·A

Factories: **Canton and Watertown, Mass.**

field, having previously been connected with a distributing organization in Milwaukee. He will make his headquarters in Omaha.

NEW GROSS-BRENNAN TERRITORY

The states of Maine and New Hampshire have been added to the territory covered by Gross-Brennan, Inc., Eastern District Distributors of Stromberg-Carlson receivers and the activities for the development of this new territory are under way.

The territory now covered by Gross-Brennan, Inc., takes in Metropolitan New York, New Jersey and all of New England with the exception of Vermont.

ISSUES LEAFLET ON THE GRID-GLOW DEMONSTRATION SET

The Grid-Glow Demonstration Set is the title of Leaflet 20437, just released by the Westinghouse Electric & Manufacturing Company. This four-page folder describes the novel demonstration set involving the grid-glow tube, which can be used to operate almost any type of display or exhibit that can be conceived. A wave of the hand over the grid-glow tube operates the relay which controls the operation of the apparatus being displayed. Some of the many applications of this advertising medium are starting electric fans, lighting electric lights, sounding electric bells, turning on radio receiving sets, and controlling show window lights and mechanical displays.

Illustrations of several of the applications of the grid-glow set are shown in the leaflet together with a wiring diagram of a typical installation. An explanation of the equipment and a table of weights and dimensions of the parts are included.

EUROPE'S GREATEST RADIO SHOW

The great "Deutsche Funkausstellung" or German Radio Exposition, has again been Europe's most important show of its kind this year.

All the radio manufacturing concerns in Germany without exception were represented at this, the fifth exposition of its kind, and many of Europe's leading radio experts and inventors were in attendance.

There were in all 320 exhibitors. This is about 30 less than last year, but the area devoted to the exposition has been increased by some 4,000 square yards to a total of more than 17,300 square yards. A new hall had to be added to those already on hand for last year's exposition, and another has had to be built this year. Its walls and half of its roof are of glass. Moreover, a second new hall is under construction. These buildings represent the beginning of preparation for the "Great German Building Exposition," which will be opened in 1931 and last until 1936.

At this year's exposition, extraordinarily noteworthy improvements were found everywhere. The whole tendency in new receiving instruments is to dispense with batteries. The instruments that can be plugged directly in to the light circuit dominate the field. However, there are still plenty of instruments with batteries, and the factories manufacturing them have made further steps in the last year toward perfecting them. The manufacturers of batteries are also keeping pace, for many radio subscribers still operate with batteries. Among these, one of particular interest is an anode battery with dry acid which here takes the form of a firm gelatine, preventing any danger of a leak and also making transport easier.

Another tendency observed is the increasing employment of so-called umbrella frame tubes. Through this it has become possible to reduce the total number of tubes from 7 and 8 to 4 or 5 even in the highest grade instruments.

Most gratifying is the great progress made by all manufacturers in increasing the selectivity. This is found even in low-priced apparatus. Further progress has been made by the constructors in simplifying operation. One sees instruments with which one can receive all wavelengths from 200 up to 2,000 meters without changing inductances. Other apparatus have a scope reaching from 10 to 2,000 meters by changing tubes. Almost all instruments now have but one control, and many have also an appliance for reproducing phonograph music.

The electrodynamic system now takes its place alongside the electromagnetic in the loudspeakers. While it is somewhat more expensive in operation, since it requires stronger currents, it has the advantage over the magnetic system of giving a purer tone. At this year's exposition, loudspeakers were permitted to be demonstrated only in sound-proof cabinets.

Television the Sensation

The real sensation this year was television, which was demonstrated by the German Postal Department at a large, tastefully constructed stand. This exhibit naturally attracted the most attention among the spectators, for it was the first time that television has been practically shown to the public. Four different systems were seen—those of Baird, Karolus, Mihaly, and one developed by the German Post Office Department.

TRIAD APPOINTMENTS

The Triad Tube Company, of Pawtucket, Rhode Island, announces the appointment of Raymond Ackmen as factory representative for the entire state of Utah.

Harry Gebhard, well known to New England radio dealers, will represent the Triad Tube factory for the entire state of Massachusetts. He will have two assistants covering the territory with him.

The Spencer Company, of Memphis, Tennessee, has been appointed factory representative for Triad tubes, covering the entire southern territory.

PORTER APPOINTED VICE-PRESIDENT OF R. C. A. C.

The appointment of G. Harold Porter as vice-president of R. C. A. Communications, Inc., and of the Radiomarine Corporation of America, in charge of the Pacific division activities of these corporations, was announced by General J. G. Harbord, president of the Radio Corporation of America.

Mr. Porter began his radio career in 1913 with the Marconi Wireless Telegraph Company, and one of his first assignments was the task of purchasing the entire equipment for the erection of high-power radio stations in California, Alaska, Hawaii, Massachusetts and New Jersey. His marked ability in this work led to his appointment as purchasing agent. Three years later Mr. Porter was made assistant commercial manager.

With the formation of the Radio Corporation of America, which absorbed the Marconi Company in 1921, Mr. Porter was made general superintendent of the marine division. As the business of the Corporation rapidly increased on the Pacific Coast, Mr. Porter was chosen to assume the duties of manager of the Pacific Coast division, with headquarters in San Francisco. Mr. Porter will continue to act in this capacity for the Radio Corporation in addition to his duties as vice-president of the two communications companies.

INSULINE APPOINTS NEW SALES MANAGER

The Insuline Corporation of America, 70-80 Cortlandt Street, New York, N. Y., has just announced the appointment of Mr. S. Dimond, as sales manager for the eastern portion of the country.

Mr. Dimond, who formerly held the position of assistant sales manager, has been associated with the Insuline Corporation for the past four years. He has been connected with the radio industry since the start of broadcasting and before that time held important sales positions with several large electrical and utility organizations.

Mr. Howard H. Meyer has been appointed in Mr. Dimond's place as assistant sales manager. Mr. Meyer has had varied experience in radio, having spent considerable time in production work, in radio servicing and in experimentation with short-wave receivers and television apparatus. In addition, he has had considerable sales experience with a large radio jobbing concern.

R-V. C. A. INCREASES TUBE PRICES

A slight increase in the list price of seven types of vacuum tubes used in battery operated receivers was announced by the Radiotron Division of the Radio Victor Corporation of America. Effective September 3d, the WD-11 was increased to $3.00, the WX-12 $3.00, the UV-199 $2.75, the UX-199 $2.50 the UX-120 $3.00 the UX-200-A $4.00, and the UX-240 $3.00.

APPOINT EASTERN SALES REPRESENTATIVES

Transcontinental Coil, Inc., of Newark, N. J., announce the appointment of Friedman-Snyder Company of 15 Park Place, New York City, as Eastern Sales Representatives.

Both Adolph Friedman and Milton C. Snyder are well-known radio salesmen in the Metropolitan district, and their present association with Transcontinental Coil, Inc., will be welcome news to their many friends in the trade.

G. M. LATHAM JOINS TEMPLE

Gene M. Latham, of New York City, has been appointed district sales manager of the Temple Corporation. He comes to the Temple organization from Atwater Kent and will have charge of the New York-New Jersey territory. Mr. Latham was connected with the Victor Talking Machine Company for a number of years and is widely known in radio and music circles of the eastern metropolis.

NEW RATING FOR SX-280

The Sylvania Products Company of Emporium, Pa., announce a new rating for the SX-280 Rectifier Tube.

This tube may be operated with as much as 400 volts a-c. applied to each plate of the tube, providing the current drain does not exceed 110 milliamperes. This will allow considerably higher d-c. voltages to be obtained for operation of power tubes.

This change has been made possible because most receivers do not require the maximum output current of the tube which is 125 milliamperes. If more than 110 milliamperes is required, it is best to limit the applied a-c. voltage to 350 volts per plate if satisfactory life is desired.

Extensive life tests have been conducted for several months before this new rating has been approved.

H. W. SAMS JOINS S-M

Howard W. Sams has just been appointed director of territorial sales for Silver-Marshall, Inc., Chicago. He resigned as New York District Sales Manager of E. T. Cunningham, Inc., to accept the new position, which makes him McMurdo Silver's personal sales representative throughout the United States. He will make his headquarters in Chicago.

Mr. Sams, a native of Chicago, has spent eight years in the radio field, going to Cunningham in 1926, after five years with the Universal Battery Company. He was Chicago district sales manager for Cunningham before going to New York in the same capacity.

NEW ALLEN-BRADLEY REPRESENTATIVE

Mr. F. L. Reynolds has been appointed District Representative for the Allen-Bradley Company, of Milwaukee, Wis. Mr. Reynolds will look after the Western Michigan territory and will have his headquarters at 4143 Ellsworth Avenue, Grand Rapids, Michigan.

SYNTHANE REPRESENTATIVE

J. K. Johnson is now the Philadelphia District Sales Representative for Synthane Corporation, manufacturer of laminated bakelite products, situated at Oaks, Pennsylvania. Other representatives are J. B. Rittenhouse, Chicago; H. G. Blauvelt, New York City; C. E. White & Company, Cleveland.

COMPLETES FOURTH ANNUAL SERVICEMEN'S COURSE

The Williams Hardware Company, Crosley-Amrad Distributors of Streator, Illinois, realizing the very urgent need for trained and efficient servicemen, have just completed their fourth annual Servicemen's Training Course.

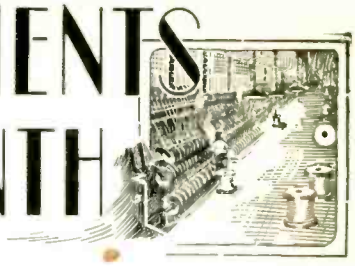
An unusually large and attentive group marked the success of the course which was prepared and given under the direction of H. M. Light, service manager for the company.

McELROY APPOINTED GULBRANSEN DISTRICT SALES MANAGER

The Gulbransen Company, of Chicago, announces the appointment of Capt. William R. McElroy of the Wm. R. McElroy Company, 604 Chamber of Commerce, Pittsburgh, Pa., as district sales manager in the radio division. Capt. McElroy's territory will include western Pennsylvania, northeastern Ohio, and northern West Virginia.

Capt. McElroy's radio merchandising experience dates back to 1922, three years having been spent in the merchandising department of the Radio Corporation of America.

NEW DEVELOPMENTS OF THE MONTH



NEW LINE OF PILOT TUBES

A new line of radio tubes bearing the trade name "Pilotron," and including all the standard types has been brought out by the Pilot Radio & Tube Corporation, of Brooklyn, N. Y. These tubes are now being produced in the company's factories in Brooklyn and Detroit.

The series comprises seven tubes. The a-c. types are described as follows: the P-224, screen-grid amplifier; the P-226 radio- and audio-frequency amplifier; the P-227, general-purpose detector, radio- and audio-frequency amplifier, with special features to permit its use in short-wave receivers; the P-245, power audio amplifier; the P-280 full-wave rectifier; and the P-171A, semi-power audio amplifier for both a-c. and battery receivers. The seventh tube is the P-201A, which is intended for the many old-style battery sets still in active use.

NEW ELECTRO-ACOUSTIC SUPER-POWER AMPLIFIER

The Electro-Acoustic Products Company, 55 E. Wacker Drive, Chicago, have introduced a new portable resistance-coupled amplifier for public-address and other uses. This amplifier has several distinctive features which are highly desirable in public-address and theatre sound projection work.

The amplifier consists of three stages of resistance coupling, working into two -50 tubes which are in push-pull. Two -81 rectifier tubes supply the direct current to the plates of the tube as well as the microphone current. The amplifier is completely a-c.-operated in every detail, and is entirely free from hum. It is completely self-contained, it being only necessary to connect the input wires and two output wires for operation.

Among the new features is a switch-type gain control calibrated in steps of three db. loss, a variable scratch filter with which can be eliminated surface noise when it is objectionable, and a variable output impedance. The output impedance is variable from 500 to 4000 ohms.

The amplifiers can also be provided with special output impedance as low as 6 ohms. The advantage of having the output impedance variable is obvious to most engineers and technicians interested in amplifier installations. It obviates the series-parallel connections which are always necessary when connected to an amplifier having a fixed output impedance. In this case all the speakers may be connected in parallel and the output impedance of the amplifier adjusted to meet the load conditions. The switching arrangement permits a rapid changeover from microphone to phonograph pickup or radio set.

The unit is in a steel carrying case of very rigid construction, 27" long, 15" wide and 16" high. The weight is about 125 lbs. It is finished in a beautiful black hard rubber.

The Electro-Acoustic portable public-address amplifier.

A NEW DEAL FOR THE HEATER TYPE A-C. TUBE

An entirely new design for the familiar heater type a-c. tube is announced by the Marvin Radio Tube Corporation of Irvington, N. J., in its Marvin MY-227 tube. The characteristics of this new tube are identical with the conventional types of -27 tube, but in construction and performance it is quite different. To begin with, the elements have the general appearance of a miniature -24 or screen grid a-c. tube, being much shorter than the usual -27 and about twice as large in diameter. The heater filament is of the coil-spring design, and is dipped in liquid ceramic, so that the usual bulky insulator is eliminated. The cathode sleeve, grid and plate, are widely spaced, and the peculiar construction of the tube insures accurate and positive spacing at all times. The elements positively cannot shift unless the tube is actually smashed, it is stated.

The most unusual feature of the new Marvin MY-227 tube, however, is a mica disk insulator at the top of the elements, a trifle smaller than a silver half-dollar, in diameter. In addition to serving as a top spacer in preserving the relative positions of the elements, this disk has a marked effect upon the direction of the electron flow in the tube. It checks "massing" or saturation and subsequent discharge, in the operation of the tube, and makes the tube practically humless. Crackle is entirely absent. The tube has a flat heating time of five seconds, as originally featured by the Marvin heater type a-c. tubes.

The new tube undergoes a pumping cycle of over four minutes, and enjoys an unusually long life as the result of the high vacuum.

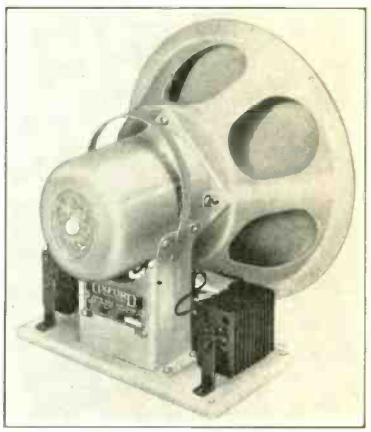
THE DUBILIER DISTURBO-DUCON

In order to provide a simple solution of the inductive interference problem, in place of condensers, chokes and resistances heretofore employed by radio servicemen or lighting company experts with questionable success, there is now available on the market a complete, self-contained device which plugs into the usual socket or outlet, and provides an interference-proof connection for radio set or electrical appliance. The device, known as the Disturbo-Ducon, is a product of the Dubilier Condenser Corporation of New York City, which has long specialized in inductive interference problems. Briefly, the device comprises a complete and efficient filter circuit, contained in a metal case provided with attachment cord and plug, a receptacle for plugging in radio set or electric appliance, and a ground binding post.

There are two main uses for the Disturbo-Ducon; first, it may be plugged into the usual socket or convenience outlet, and the electric appliance connected to the receptacle, thereby placing an efficient filter circuit between the appliance and the line so as to prevent propagation of disturbances; secondly, it may be connected between the socket-power radio set and the line, so as to filter out inductive interferences coming over the lighting system.

NEW OXFORD AUDITORIUM SPEAKER

An interesting contribution to public-address work is the new Auditorium model dynamic speaker announced by the Oxford Radio Corp. of Chicago, Ill. This speaker is especially designed for theatre installations or wherever great volume is desired.



The New Oxford Auditorium Speaker.

The Auditorium model boasts a 12½" cone made of metallized fabric to protect it from moisture and for certain acoustic reasons. The voice coil has an average impedance of 11 ohms. Rugged construction of all parts of the speaker allow it to handle the full output of two type -50 tubes operating in push-pull.

Model 71-AC, pictured herewith, operates from 110 volts a-c. A full-wave Kuprox rectifier unit of generous proportions insures adequate field strength. This particular style retails for $70.

The Auditorium speaker also is obtainable with other forms of field supply coils. Another 110 volt a-c. model operates from a type 280 full-wave rectifier tube. Both 6 and 110-volt d-c. fields are made.

In all the above styles, field consumption is approximately 14 watts.

NEW TEMPLETONE D-C. RECEIVER

Due to the urgent demand from various sections of the country that are not supplied with a-c. the Temple Corporation has just placed in production two new models of Templetone receivers, a d-c. receiver that operates with batteries.

The all-electric d-c. set now being made at the Temple plant has ten tubes, six —12-A tubes and four —71-A tubes. The sensitivity of this receiver is equivalent to that of any standard —27 receiver. The audio-frequency consists of a transformer coupling the same as used in the a-c. receivers, using —12-A for the first audio and four —71-A tubes in the last stage, used in push-pull parallel to increase the power output of the receiver.

A special 14-inch Temple electrodynamic speaker, specially designed for this receiver is used.

A small 22½-volt C battery is used for the C bias, the reason being to keep the maximum plate voltage of 110 volts on the power tubes. If the C bias were taken from the supply the effective plate voltage would be reduced equal to the amount of C bias which is about 16 volts.

Engineering Facts Have A Utility Value

SET EFFICIENCY AND TUBES

by

GEORGE LEWIS

Vice President, Arcturus Radio Tube Company

TUBES of poor design and hasty construction, more than any other factor, contribute to the failure of any radio receiver, regardless of its efficiency.

Hum is the enemy of the A-C set. To reduce hum to the minimum, it is necessary, with most tubes, to connect the cathode to the exact electrical center of the heater. This point is variable in tubes of the same make, presenting difficulties in this operation. Arcturus design makes this delicate adjustment unnecessary, thus contributing to clearer, unmarred tone in any set. In addition, the Arcturus filament is so constructed that its magnetic fields are balanced out. With no possibility of this A-C magnetic field affecting the electron flow, another common cause of hum is eliminated.

To insure uniformity, Arcturus Tubes are rigidly tested to very precise limits. Critical engineers, recognizing this vital property of efficiency, demand Arcturus tubes for rigid factory tests and for experimental purposes.

Buyers Directory of Materials and Apparatus

Readers interested in products not listed in these columns are invited to tell us of their wants, and we will inform the proper manufacturers. Address Readers' Information Bureau.

Addresses of companies listed below, can be found in their advertisement—see index on page 78

ADAPTERS:
Lynch, Arthur H., Inc.

ALUMINUM:
Aluminum Co. of America
National-Harris Wire Co.

AMMETERS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

AMPLIFIERS, POWER:
Ferranti, Inc.
G. M. Laboratories, Inc.
General Amplifier Co.
General Radio Co.
National Co., Inc.
Radio Receptor Co., Inc.
Samson Elec. Co.

ANTENNAE, LAMP SOCKET:
Dubilier Condenser Mfg. Co.
Electrad, Inc.

ARRESTERS, LIGHTNING:
Jewell Elec. Inst. Co.

BASES, VACUUM TUBE:
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.

BAFFLES:
Wright-DeCoster, Inc.

BATTERY COMPOUNDS:
Mitchell Rand Mfg. Co.

BEARINGS, RADIAL:
Chicago Gear Works

BENCHES, STEEL WORK:
Standard Pressed Steel Co.

BINDING POSTS:
General Radio Co.

BRACKETS, ANGLE:
Electrad, Inc.
Scovill Mfg. Co.

BRASS:
Baltimore Brass Co.
National-Harris Wire Co.
Scovill Mfg. Co.

BROADCAST STATION EQUIPT:
Cardwell, Allen D., Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jenkins & Adair, Inc.

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America

CELLS, PHOTOELECTRIC:
Burt, Robert C.
G. M. Laboratories, Inc.
National Carbon Co., Inc.

CEMENT, LOUD SPEAKER:
Maas & Waldstein Co.

CENTRALIZED RADIO SYSTEMS:
Ferranti, Inc.
Samson Elec. Co.

CHARGERS:
Elkon Co.

CHASSES
Aluminum Co. of America
United Scientific Laboratories, Inc.

CHOKES, AUDIO FREQUENCY:
American Transformer Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Thordarson Elec. Mfg. Co.
Transformer Co. of Amer.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co., Inc.
Samson Elec. Co.

CHOKES, B ELIMINATOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Polymet Mfg. Corp.
Transformer Co. of Amer.

CLAMPS, GROUND:
Fahnestock Elec. Co.
Scovill Mfg. Co.

CLIPS, SPRING:
Electrad, Inc.
Fahnestock Elec. Co.
Scovill Mfg. Co.

COIL FORMS:
General Radio Co.

COIL WINDING:
Acme Wire Co.
Dudlo Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, CHOKE:
Acme Wire Co.
Dudlo Mfg. Co.
Ferranti, Inc.
General Mfg. Co.
Jefferson Electric Co.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, IMPEDANCE:
Acme Wire Co.
Dudlo Mfg. Co.
Ferranti, Inc.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, INDUCTANCE:
Acme Wire Co.
Cardwell, Allen, D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.
Rome Wire Co.

COILS, MAGNET:
Acme Wire Co.
Dudlo Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, RADIO FREQUENCY:
General Mfg. Co.

COILS, RETARD:
Hammarlund Mfg. Co.

COILS, SCREEN GRID:
General Mfg. Co.

COILS, SHORT WAVE:
General Radio Co.
Hammarlund Mfg. Co.

COILS, TRANSFORMER:
Acme Wire Co.
Dudlo Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

CONDENSER PARTS:
Aluminum Co. of America
Ferranti, Inc.
Scovill Mfg. Co.

CONDENSERS, BY-PASS:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Electrad, Inc.
Fast, John E. & Co.
Ferranti, Inc.
Flechtheim Co.
Leslie F. Muter Co.
Polymet Mfg. Corp.
Potter Co., The
Powrad, Inc.
Wireless Specialty Apparatus Co.

CONDENSERS, EQUALIZING:
Hammarlund Mfg. Co., Inc.

CONDENSERS, FILTER:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Flechtheim Co.
Leslie F. Muter Co.
Polymet Mfg. Corp.
Potter Co., The
Powrad, Inc.
Wireless Specialty Apparatus Co.

CONDENSERS, FIXED:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Electrad, Inc.
Electro-Motive Eng. Co.
Fast, John E., & Co.
Flechtheim Co.
Leslie F. Muter Co.
Polymet Mfg. Corp.
Potter Co., The
Powrad, Inc.
Wireless Specialty Apparatus Co.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

CONDENSERS, NEUTRALIZING:
Hammarlund Mfg. Co., Inc.
Polymet Mfg. Corp.

CONDENSERS TRANSMITTING:
Dubilier Condenser Mfg. Co.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.

CONDENSERS, VARIABLE:
Cardwell, Allen D. Mfg. Co.
DeJur-Amsco Co.
Frost, Herbert H., Inc.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

CONNECTORS:
Scovill Mfg. Co.

CONTROLS, CURRENT:
Allen Bradley Co.
Central Radio Laboratories
DeJur-Amsco Corp.
Polymet Mfg. Corp.
Shallcross Mfg. Co.

CONTROLS, ILLUMINATED:
Hammarlund Mfg. Co.

CONTROLS, VOLUME:
Allen Bradley Co.
Central Radio Laboratories
Clarostat Co.
Electrad, Inc.
Ferranti, Inc.
Polymet Mfg. Corp.
Radio Receptor Co., Inc.

CONVERTERS:
Cardwell, Allen D., Co.
Electric Specialty Co.

CONVERTERS, ROTARY:
Electric Specialty Co.
Janette Mfg. Co.

COPPER:
Baltimore Brass Co.
Scovill Mfg. Co.

CORD CONNECTORS:
Rodale Mfg. Co.

CORDS, EXTENSION:
Acme Wire Co.
Rodale Mfg. Co.

COUPLINGS, FLEXIBLE:
Chicago Gear Works
Hammarlund Mfg. Co., Inc.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

CUSHIONS, SPEAKERS:
Western Felt Co.

DIALS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

DIALS, DRUM:
Hammarlund Mfg. Co.
National Co., Inc.
United Scientific Laboratories

DIE-CASTINGS:
Allied Die-Casting Corp.

DIES:
Willor Mfg. Corp.

DYNAMOTORS:
Electric Specialty Co.

ENGINEERS, CONSULTING:
Allied Engineering Institute

ESCUTCHEONS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Scovill Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FELT, ACOUSTICAL:
Western Felt Co.

FELT, PACKING:
Western Felt Co.

FILAMENTS:
Callite Products Co., Inc.
Fansteel Products Co., Inc.
Gilby Wire Co.
National-Harris Wire Co.
Radio Prod. Corp.

FILAMENT CONTROLS, AUTOMATIC:
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.
Radiall Co.

FOIL, ALUMINUM:
Aluminum Co. of America

FOIL, ZINC:
Lehmaier, Schwartz & Co.

FRICTION TAPES:
Mitchell Rand Mfg. Co.

GALVANOMETERS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.

GEARS:
Chicago Gear Works

GENERATORS:
Electric Specialty Co.
Janette Mfg. Co.

GETTER MATERIAL:
Gilby Wire Co.
National-Harris Wire Co.
Radio Products Corp.

GRID LEAKS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
DeJur-Amsco Co.
Electrad, Inc.
Electro Motive Eng. Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
C. E. Mountford
Polymet Mfg. Corp.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.

HEADPHONES:
Amplion Co. of Amer.

HINGES:
Scovill Mfg. Co.

HORNS:
Amplion Co. of Amer.
Best Mfg. Co.
Magnavox Co.
Miles Mfg. Corp.
Oxford Radio Corp.

INDUCTANCES, TRANSMITTING:
General Radio Co.

INSTRUMENTS, ELECTRICAL:
Ferranti, Inc.
General Electric Co.
Jewell Elec. Inst. Co.

INSULATION LAMINATED
Formica Insulation Co.
General Electric Co.
National Vulcanized Fibre Co.
Synthane Corp.

INSULATION, MOULDED:
Bakelite Corp.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.

INSULATION, VARNISHED:
Acme Wire Co.
Mitchell Rand Mfg. Co.

JACKS:
Carter Radio Co.
Electrad, Inc.
General Radio Co.

JACKS, TIP:
Carter Radio Co.

KITS, BROADCAST:
Hammarlund Mfg. Co., Inc.

KITS, SHORT WAVE:
Hammarlund Mfg. Co., Inc.
Lynch Mfg. Co., Inc.

KITS, TELEVISION:
Lynch Mfg. Co., Inc.

KITS, TESTING:
(See Testing Kits)
General Radio Co.
Jewell Elec. Inst. Co.

LABORATORIES, TESTING:
Electrical Testing Labs.
Wireless Egert Engineering, Inc.

LABORATORIES, ENGINEERING:
Allied Engineering Institute

LACQUER, WOOD:
Maas & Waldstein Co.
Zapon Co., The

LACQUER, METAL:
Maas & Waldstein Co.
Zapon Co., The

LACQUER, ENAMEL:
Maas & Waldstein Co.
Zapon Co., The

LAMINATIONS:
Lamination Stamping Co.
Willor Mfg. Corp.

LAMPS, MINIATURE:
National Carbon Co., Inc.

LAMPS, PANEL:
National Carbon Co., Inc.

LAMPS, SOUND RECORDING:
G. M. Laboratories, Inc.

LEAD-INS:
Electrad, Inc.

LOCK WASHERS:
Shakeproof Lock Washer Co.

LUGS:
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

MACHINERY, COIL WINDING:
American Safety Table Co.

MACHINERY, TUBE:
American Transformer Co.
Arrow Mfg. & Machine Co., Inc.
Engineering Co., The
Central Scientific Labs.
Eisler Eng. Co.
Int'l Machinery Works, Inc.
Lepel High Frequency Labs.
Manhattan Electric Bargain House, Inc.
Radio Products Corp.

MACHINES, SPECIAL
Willor Mfg. Corp.

MAGNESIUM:
Aluminum Co. of America.

MAGNETS:
Thomas & Skinner Co.

METALS, RARE:
Fansteel Products Co., Inc.
American Electro Metal Corp.

MERCURY SWITCHES:
(See Switches)

METERS:
Ferranti, Inc.
General Electric Co.
Jewell Elec. Inst. Co
Weston Elec. Instr. Co.

MICROPHONES:
Amplion Co. of America
Electro-Acoustic Prod. Co.
Jenkins & Adair, Inc.
Radio Receptor Co., Inc.
Universal Microphone Co.

MOLDING MATERIALS
Bakelite Corp.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.

MOTORS:
Electric Specialty Co.

MOTOR-GENERATORS:
Electric Specialty Co.

MOUNTINGS, RESISTANCE:
DeJur-Amsco Co.
Electrad, Inc.
Lynch Mfg. Co., Inc.
Polymet Mfg. Corp.

NAMEPLATES:
Crowe Nameplate & Mfg. Co.
Scovill Mfg. Co.

NICKLE SILVER:
National-Harris Wire Co.
Riverside Metal Co., The

NUTS:
Shakeproof Lock Washer Co.

OHMMETERS:
General Radio Co.
Weston Elec. Instru. Co.

OSCILLOGRAPH:
The Beltone Corp, Ltd.
General Radio Co.

OSCILLOSCOPE:
The Beltone Corp., Ltd.

PACKING PADS, CABINET:
Western Felt Co.

PANELS, COMPOSITION:
Formica Insulation Co.
Synthane Corp.

PANELS, METAL:
Aluminum Co. of America
Radio Receptor Co., Inc.
Scovill Mfg. Co.

PAPER, CONDENSER:
Dexter, C. H. & Sons, Inc.

PAPER, CONE SPEAKER:
Seymour Co.

PARTS, SCREW MACHINE:
Standard Pressed Steel Co.

PARTS, TUBE:
American Electro Metal Corp.
Callite Products Co., Inc.
Engineering Co., The
Fansteel Products Co., Inc.
Gilby Wire Co.
Lepel High Freq. Labs.
Nat'l.-Harris Wire Co.
Radio Products Corp.

PHONOGRAPH MOTORS:
(See Motors)

PHOSPHOR BRONZE:
Baltimore Brass Co.
National-Harris Wire Co.
Riverside Metal Co.

PHOTOELECTRIC CELLS:
(See Cells)

PICK-UPS, PHONOGRAPH:
Amplion Co. of Amer.
Electro-Acoustic Prod. Co.
Hardwick, Hindle, Inc.
Jensen Co.
Magnavox Co.
Wright DeCoster

PLATES, OUTLET:
Carter Radio Co

PLUGS, ATTACHMENT:
Carter Radio Co.
General Radio Co
Polymet Mfg. Corp.
Rodale Mfg. Co.

POTENTIOMETERS:
Allen-Bradley Co.
Central Radio Laboratories
DeJur-Amsco Co.
Electrad, Inc.
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories

POWER UNITS, A-:
Elkon, Inc.
Jefferson Electric Co.
Kodel Radio Corp.
Radio Receptor Co., Inc.

POWER UNITS, B-:
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Thordarson Electric Mfg. Co
Webster Co.

POWER UNITS, A-B-C:
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Thordarson Electric Mfg. Co.

POWER UNITS, PARTS FOR:
Acme Wire Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Kodel Radio Corp.

Kodel Radio Corp.
Lynch, Arthur H., Inc.
National Co., Inc.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Powrad, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of Amer.

PRESSINGS:
Scovill Mfg. Co.

PUBLIC ADDRESS SYSTEMS:
Radio Receptor Co., Inc.
Samson Elec. Co.

PULLEYS:
Chicago Gear Works

PUMPS, HIGH VACUUM:
Arrow Mfg. & Machine Co., Inc.
Central Scientific Co.
Eisler Engineering
Int'l Machine Works, Inc.

PUNCHINGS:
Aluminum Co. of America
Scovill Mfg. Co.

RECEPTACLES, WALL:
Carter Radio Co.
Rodale Mfg. Co.

RECORD CHANGERS:
Krasberg Tool & Mfg. Co.

RECTIFIERS, DRY:
Elkon, Inc.
Kodel Elec. & Mfg. Co.

REGULATORS, VOLTAGE:
Central Radio Laboratories
Clarostat Co.
DeJur-Amsco Co.
Polymet Mfg. Corp.
Radialt Co.
Ward Leonard Elec. Co.

RELAYS:
Cardwell, Allen D., Mfg. Co.
Leach Relay Co.

REPRODUCERS, TALKING MOTION PICTURES:
The Beltone Corp., Ltd.

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Central Radio Laboratories
Clarostat Mfg. Co.
DeJur-Amsco Co.
Electrad, Inc.
Electro-Motive Co.
Ferranti, Inc.
Frost, Herbert H.
General Electric Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.
Ward Leonard Elec. Co.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
Central Radio Laboratories
Clarostat Mfg. Co.
Electrad, Inc.
Electro-Motive Co.
Frost, Herbert H.
General Electric Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
C. E. Mountford
Polymet Mfg. Corp.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.

RHEOSTATS:
Allen-Bradley Co.
Central Radio Laboratories
DeJur-Amsco Co.
Electrad, Inc.
Electro-Motive Co.
Frost, Herbert H.
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories

SCREW MACHINE PRODUCTS:
Aluminum Co. of America
National Vulcanized Fibre Co.
Scovill Mfg. Co.
Standard Pressed Steel Co.
Synthane Corp.

SEALING COMPOUNDS:
Candy & Co.
Mitchell Rand Mfg. Co.

SHIELDING, METAL:
Aluminum Co. of America
Hammarlund Mfg. Co., Inc.

SHIELDS, TUBE:
Carter Radio Co
Radio Products Corp.

SHORT WAVE APPARATUS:
Cardwell, Allen D., Co.
General Radio Co.
Hammarlund Mfg. Co., Inc.
Lynch, Arthur H., Inc.

SOCKETS, TUBE:
Frost, Herbert H.
General Radio Co.
Lynch, Arthur H., Inc.
Leslie F. Muter Co.

SOLDER:
Chicago Solder Co.

SOUND CHAMBERS:
Amplion Corp. of Amer.
Jensen Radio Mfg. Co.
Miles Mfg. Corp.
Oxford Radio Corp.
Rola Co., The

SOUND RECORDING LAMPS
(See Lamps)

SPAGHETTI:
(See Wire, Spaghetti).

SPEAKERS:
Amplion Corp. of Amer.
Electro-Acoustic Prod. Co.
Best Mfg. Co.
Jensen Radio Mfg. Co.
Magnavox Co.
Miles Mfg. Corp.
Leslie F. Muter Co.
Oxford Radio Corp.
Potter Co., The
Rola Co., The
Transformer Co. of Amer.
Wright-DeCoster, Inc.

SPROCKETS:
Chicago Gear Works

STAMPINGS, METAL:
Aluminum Co. of America
Radio Products Corp.
Scovill Mfg. Co.

STEEL, MAGNETIC:
See *(Iron Magnetic.)*

SUBPANELS:
Formica Ins. Co.
General Radio Co.
National Vulcanized Fibre Co.

SWITCHES:
Electrad, Inc.
Ferranti, Inc.
Rodale Mfg. Co.

SWITCHES, MERCURY:
G. M. Laboratories, Inc.

TABLES, STEEL WORK:
Standard Pressed Steel Co.

TANTALUM:
Fansteel Products Co., Inc.

TAPES, FRICTION:
Mitchell Rand Mfg. Co.

TAPPERS
Eastern Tube and Tool Co.

TELEVISION PARTS:
Allen-Bradley Co.
Clarostat Co., Inc.
Lynch, Arthur H., Inc.
Shallcross Mfg. Co.

TESTERS, B-ELIMINATOR:
General Radio Co.
Jewell Electrical Inst. Co.

TESTERS, TUBE:
Ferranti, Inc.
General Radio Co.
Jewell Elec. Inst. Co
Weston Elec. Inst. Co.

TESTING INSTRUMENTS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

TESTING KITS:
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Inst. Co.

TESTING LABORATORIES:
Electrical Testing Labs.

TIN COATED METAL:
Baltimore Brass Co.

TOOL STANDS:
Standard Pressed Steel Co.

TOOLS:
Eastern Tube and Tool Co.
Willor Mfg. Corp.

TRANSFORMERS, AUDIO:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Radio Receptor Co., Inc.
Samson Elec. Co.
Sangamo Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America
Webster Co.

TRANSFORMERS, B-POWER UNIT:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America
Webster Co.

TRANSFORMERS, BROADCAST STATION:
Ferranti, Inc.
Radio Receptor Co., Inc.
Samson Electric Co.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
Thordarson Electric Mfg. Co.

TRANSFORMERS, OUTPUT:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Sangamo Elec. Co.
Thordarson Electric Mfg. Co.

TRANSFORMERS, POWER:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Polymet Mfg. Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co.
Webster Co.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co., Inc.

TRANSFORMERS, STEP-DOWN:
Amplion Corp. of Amer.
Radio Receptor Co., Inc.

TUBE CONTAINERS:
Holed-Tite Packing, Inc.

TUBE MACHINERY:
See (Machinery, Tube.)

TUBE PARTS:
(See Parts, Tube.)

TUBE TESTERS:
(See Testers, Tube)

TUBES, A.C.:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Radio Tube Co.
De Forest Radio Co.
Dilco Radio Corp.
Duovac Radio Tube Co.
Gibraltar Radio Supply Co.
Hyvac Radio Tube Co.
Marvin Radio Tube Corp.
National Carbon Co., Inc.
Nat'l Union Radio Corp.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.
Triad Mfg. Co.

TUBES, RECTIFIER:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Radio Tube Co.
De Forest Radio Co.
Dilco Radio Corp.
Duovac Radio Tube Co.
Gibraltar Radio Supply Co.
Hyvac Radio Tube Co.
National Carbon Co., Inc.
Nat'l Union Radio Corp.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.
Triad Mfg. Co.

TUBES, SCREEN GRID:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Radio Tube Co.
De Forest Radio Co.
Dilco Radio Corp.
Duovac Radio Tube Co.
Gibraltar Radio Supply Co.
Hyvac Radio Tube Co.
National Carbon Co., Inc.
Nat'l Union Radio Corp.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.
Triad Mfg. Co.

TUBES, TELEVISION
See *(Cells, Photoelectric.)*

TUBING, NICKEL:
National-Harris Wire Co.

TUBING, REFRACTORY:
Stupakoff Labs. Inc.

TUBING, VARNISHED:
Alpha Wire Corp.
Mitchell Rand Mfg. Co.

UNITS, SPEAKER:
Amplion Corp.
Best Mfg. Co.
Jensen Radio Mfg. Co.
Rola Co.
Temple, Inc.
Wright DeCoster, Inc.

UNIVERSAL JOINTS:
Chicago Gear Works

VARNISH:
Maas & Waldstein Co.
Mitchell Rand Mfg. Co.
Zapon Co., The.

VOLTAGE REGULATORS:
(See Regulators)

VOLTMETERS, A. C.:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

VOLTMETERS, D. C.:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

WASHERS:
Aluminum Co. of America
Scovill Mfg. Co.
Shakeproof Lock Washer Co.
Synthane Corp.

WAXES, IMPREGNATING:
Candy and Co.
Mitchell Rand Mfg. Co.

WAXES, INSULATING:
Candy and Co.
Mitchell Rand Mfg. Co.

WAXES, SEALING:
Candy and Co.
Mitchell Rand Mfg. Co.

WIRE, ANTENNA:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Corp.
National Vulcanized Fibre Co.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE BALLAST:
National-Harris Wire Co.
Radio Wire Corp.

WIRE, BARE COPPER:
Alpha Wire Corp.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, COTTON COVERED:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, ENAMELED COPPER:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Corp.
Polymet Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, FILAMENT:
American Electro Metal Corp.
Callite Products Co., Inc.
Fansteel Products Co., Inc.
Gilby Wire Co.
National-Harris Wire Co.
Radio Products Corp.

WIRE, HOOK-UP:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Co.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, LITZENDRAHT:
Dudlo Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, MAGNET:
Acme Wire Co.
Dudlo Mfg. Corp.
Rome Wire Co.

WIRE, MOLYBDENUM:
American Electro Metal Corp.
Callite Products Co., Inc.
Fansteel Products Co., Inc.

WIRE, PIGTAIL:
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, RESISTANCE
Gilby Wire Co.
National-Harris Wire Co.

WIRE, SILK COVERED:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, SPAGHETTI:
Acme Wire Co.
Alpha Wire Corp.
Mitchell Rand Mfg. Co.
Rome Wire Co.

WIRE, TINNED COPPER:
Alpha Wire Corp.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.

Majestic Replacement Condenser Blocks

by the foremost manufacturer of radio condensers

Built to give TEN YEARS of service.
Without exception, the best ever made.

For Majestic B-Eliminators

Super-B & Master-B Models
PL-1223
List Price $8.00

Special Master-B Model
PL-1737
List Price $10.00

For Majestic A-Eliminators

PL-1778 LIST PRICE $9.00

For Power-Packs in Majestic Sets

Year	Tube Used	Cat. No.	List Price
1928-29	171	PL-1309	$10.00
"	250	PL-1765	10.00
1929	245	PL-1766	12.00

For Majestic Power-Packs in Stewart-Warner and Mohawk Sets

PL-1761 List Price $11.00

The New Dubilier Light Socket Aerial

New solid internal design.
Better than ever. Going bigger.
Increased sensitivity of sets contributes to radio-buyers a saving against outdoor antennas.
Manufacturers, jobbers, and dealers are using the light socket aerial as a sales-expedient to make sets sell at less than competition.

Advantages of the Light Socket Aerial:—

1. **Cost:** Far below that of an antenna of any other character.
2. **Convenience:** Simply plugged into the house-current outlet.
3. **Time-saving:** Installed in a few minutes as against several hours.
4. **Neatness:** Saves unsightly roof-mountings and lead-in wiring, or cumbersome indoor loops.
5. **Safety:** Avoids dangerous roof-erecting work.
6. **Protection:** Avoids lightning hazards and anxiety during storms.
7. **Flexibility:** Affords long antenna or short antenna results without putting up antennae to determine best size.
8. **Durability:** Requires no maintenance attention—no damages by weather and storms to be repaired.
9. **Serviceability:** Efficiency does not impair with age, as in outdoor antennas, where insulation encrusted with soot functions poorly.
10. **Efficiency:** Maximum signal strength in all directions.
11. **Correctness:** Avoids all the pitfalls of the average antenna erector, as described in leaflet No. 163.
12. **Clarity:** Insures first-class antenna conditions, with good signal pick-up, low interference pick-up, avoidance of aerial defect noises, etc.

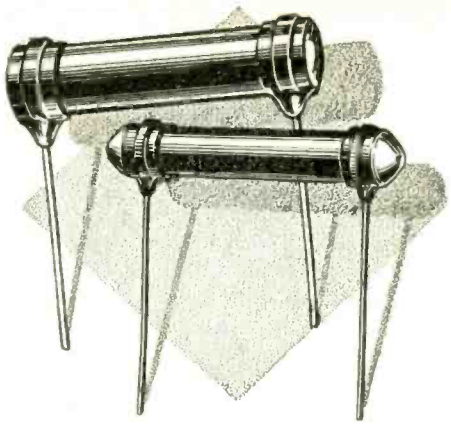
The Light Socket Aerial is appropriate to any and all receiving sets, AC or DC.
Uses the house wiring system as an antenna.
Couples to the system only, consumes no current.
Needs no attention.

Full exclusive rights are now Dubilier's under Patents 1,526,624, Feb., 1925; 1,716,001, June, 1929, and 1,717,701, June, 1929.

Dubilier

CONDENSER CORPORATION

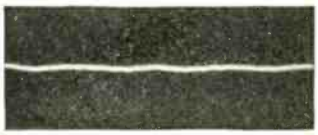
342 Madison Avenue *New York City*



Bradleyunit Fixed Resistors

are noiseless in operation

THAT'S why they are the choice of leading set manufacturers for grid leak and plate coupling resistors. The oscillograms of units picked at random clearly illustrate the superior quietness of the Bradleyunit. Constant resistance and permanent quietness, regardless of age and climate are reasons why you, too, should investigate Bradleyunit Solid-Moulded Resistors.



Oscillogram showing noiseless performance of Bradleyunit Resistors.

Oscillogram showing noisy performance of other types of resistors.

Furnished in ratings from 500 ohms to 10 megohms, with or without leads. Color coded for quick identification.

Write today, giving specifications

ALLEN-BRADLEY CO.
279 Greenfield Avenue Milwaukee, Wis.

Allen-Bradley
PERFECT RADIO A-B RESISTORS.

INDEX OF ADVERTISERS

Volume Control INSURANCE!

Switch Type

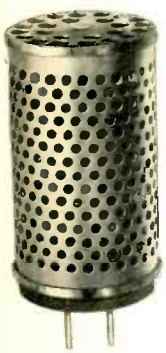
YES, the NEW CLAROSTAT VOLUME CONTROL is just that—***volume control insurance,*** because, when you include this device in your assembly, you can promptly forget all volume control troubles. You are positively insured against any and all of them.

And if you are from Missouri, all the better. Just ask to be shown. Let us send you a sample. Examine it for yourself. Try it out for smooth operation. Try it out for noise, using the most critical grid circuit test. Try it out for wear and tear. Try it out for resistance variation, either straight or tapered resistance, in any value up to 50,000 ohms. Try it in your radio assembly. And then make up your own mind.

Of course the NEW CLAROSTAT VOLUME CONTROL is a 100% wire-wound job, with the wire itself supplying the resistance. No carbonized paper. No carbon paint. No uncertain contact to cause noise or rapid wear. Instead, this device comprises a neat bakelite case with metal end plate, containing a wire-wound bakelite strip and unique form of contact. The wire turns are firmly held on the bakelite strip. They cannot slip or short-circuit. The winding and mechanism are free from dust, dirt or moisture. One-hole mounting. Handy soldering tabs. Compact. Neat. Positively handsome.

Duo Type

And you can have the NEW CLAROSTAT VOLUME CONTROL to fit any requirements. It is available to any resistance range up to 50,000 ohms, with straight line or tapered resistance. Furnished with or without 110 volt switch attached. Also available in the *duo type* for controlling two circuits simultaneously.



½ Actual Size

and don't forget the LINE BALLAST CLAROSTAT

In addition to a good volume control, you might as well secure complete insurance coverage by including the LINE BALLAST CLAROSTAT — the handy all-metal cartridge which automatically regulates the applied line voltage, making for uniform and perfect operation of any socket-power radio set. This device is now standard in all leading radio chassis. Maintains tube voltages within specified 5% plus or minus. Unique design and construction, with special resistance wire wound on mica and metal framework. Turns cannot sag or short-circuit. Prompt regulation. Nothing to break. Nothing to wear out. Nothing to service. Ideal for all socket-power radio sets in meeting wide variations of line voltage.

DESIGNERS AND MANUFACTURERS

WRITE *for samples of NEW VOLUME CONTROL CLAROSTAT, as well as complete data. Also ask us about the LINE BALLAST CLAROSTAT and how it can be applied to your radio set, power amplifier or other socket-power assembly. Are you on our technical bulletin mailing list?*

Clarostat Manufacturing Company, Inc.

Specialists in Radio Aids

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Remember- there's a* CLAROSTAT *for Every Purpose

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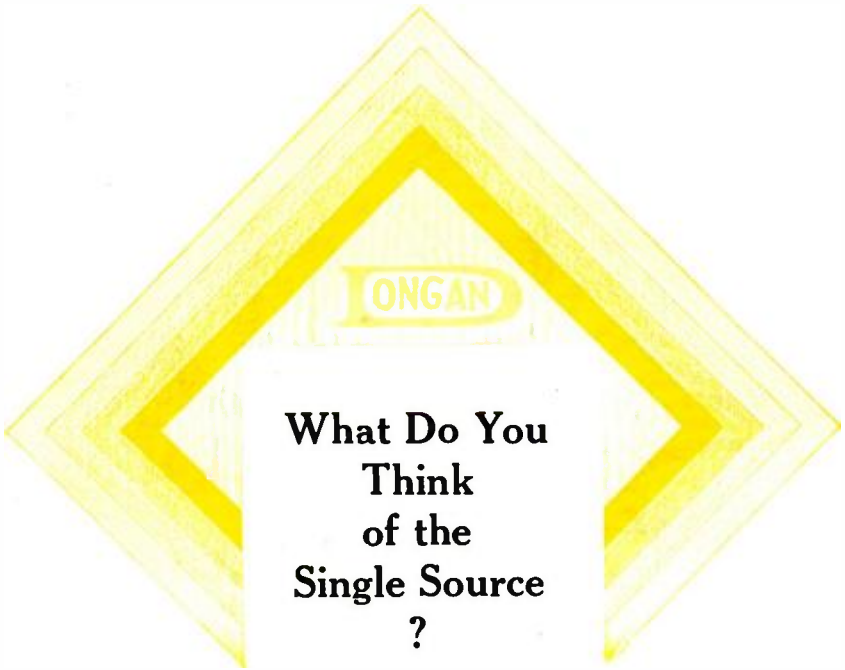

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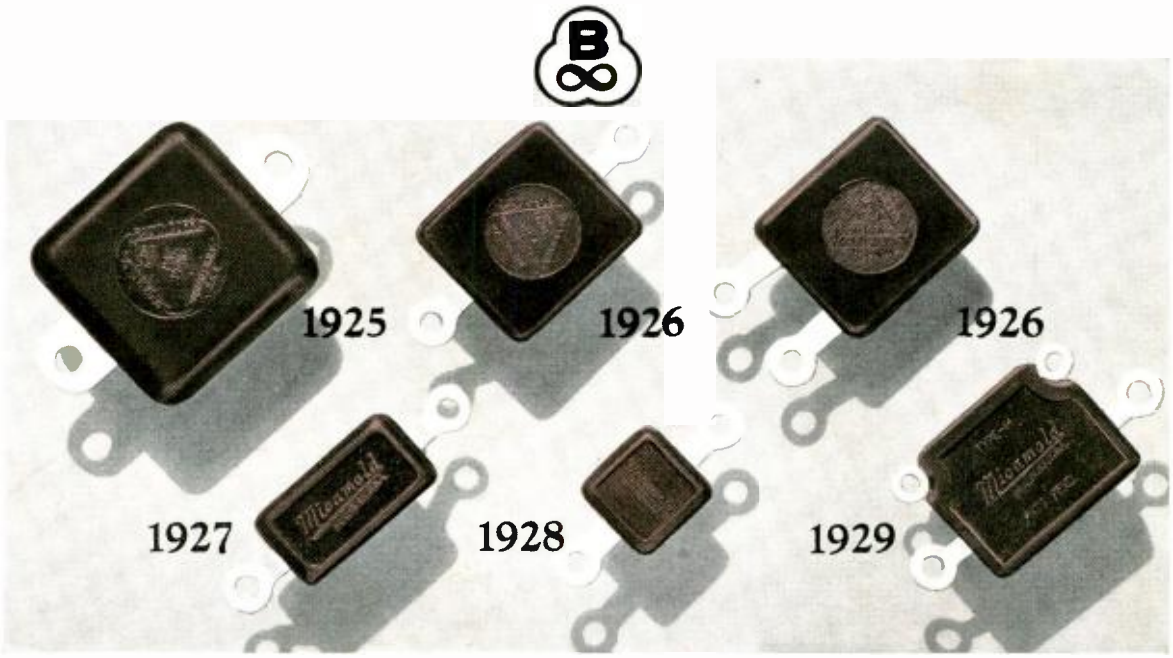

Changes in form of Micamold, Bakelite Molded Condensers between 1925 and 1929. All made by Micamold Radio Corp., Brooklyn, N. Y.

Keeping pace with ever changing trend made possible by Bakelite Molded

WITHIN the short period of four years, there have been radical changes in radio receiver design. Manufacturers of radio parts have had to be constantly on the alert to keep pace with the ever changing demand.

Fixed condensers provide an example. In 1925 Micamold brought out a Bakelite Molded condenser in a wide range of capacities. In 1926, smaller condensers of equal capacities were demanded. In 1927, different sizes were required for different capacities. All chance of error when soldering condensers in place was avoided. By 1929, the wide adoption of metal panels required the production of a condenser which could be rivetted to a metal base. With each change in the size and form of condensers, Micamold found Bakelite Molded equal to every requirement. In fact they say that "without Bakelite Molded it would have been practically impossible to accomplish these results."

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