EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. VIII | MARCH 1928 | Number 3

IN THIS ISSUE

Sold Only by Subscription | $2.00 per Year

The TECHNICAL MAGAZINE of the RADIO INDUSTRY

*F*RANK *T*ALKS *W*ITH *R*ADIO *E*NGINEERS

BY A. T. HAUGH

Vice-President United Radio Corporation, Rochester, New York

The *Peerless* "GOTHIC"

Even The Best Must Be Sold

NO matter how good a radio set you may build, it STILL HAS TO BE SOLD! Some of the greatest "flops" on record flopped because the engineer was *too far ahead of his public.*

So, I say—no matter how good your radio, you need to "keep your ear to the ground." You must know what the public wants. And you must give it to them.

In radio speakers, for instance, *the public prefer Peerless Reproducer.*

I say they *prefer* it, because they bought and paid for more *Peerless* Reproducers this last season than any other independent speaker on the market.

The public prefers *Peerless*—just as they prefer Timken Bearings, or Fisher Bodies—because the product has performed satisfactorily, day and night, month in and month out—in the hands of the inexpert user.

Our replacement requests due to defects have been less than one-tenth of one per cent. We *must* have "something on the ball" to make a record like that.

Now, if the public prefers *Peerless* Reproducer, they will still prefer it in your new radio models. Equipped with a built-in *Peerless* Reproducer, the radio buyer will have confidence in your set—for the same reason that Timken axles give you confidence in a car.

BUILT-IN

Peerless

REPRODUCER

This Peerless Reproducer Unit comes in a compact square cabinet as shown in the illustration. It is only 9¼ in. wide, by 9¼ in high, by 6 in. deep. Self-contained all ready to install in the radio.

Peerless Reproducer gives good engineering a chance, too. For it gets the lows and the highs, takes a lot of volume and stands the gaff!

Of course, your purchasing agent may be a price-buyer and that may cut you off the *Peerless* list. For this is not a "cheap" radio reproducer. You can't get *Peerless* performance unless you build it in with *Peerless* Quality. And *quality* always costs a little more than "shoddy."

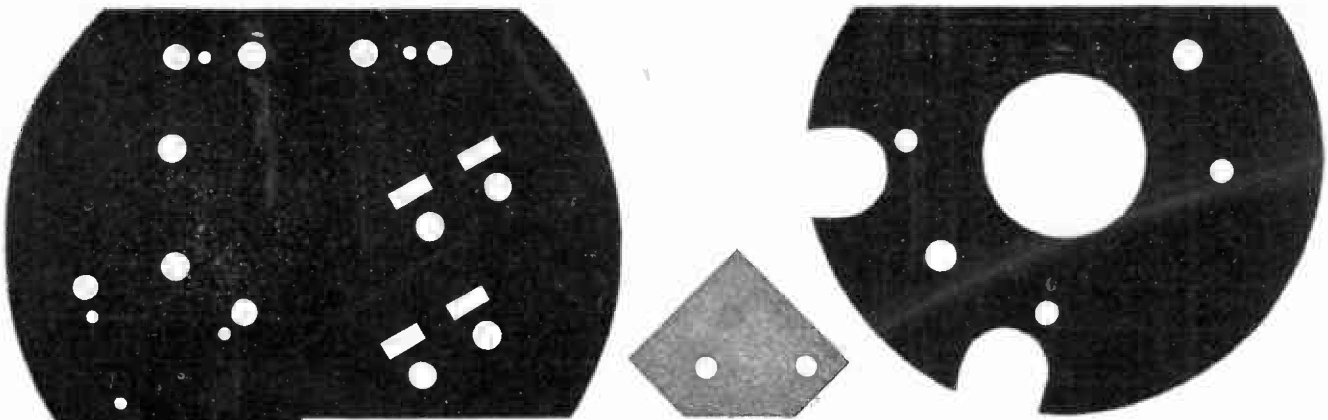
Note these things: *Peerless* Reproducer builds into small space. It gives maximum results with minimum size.

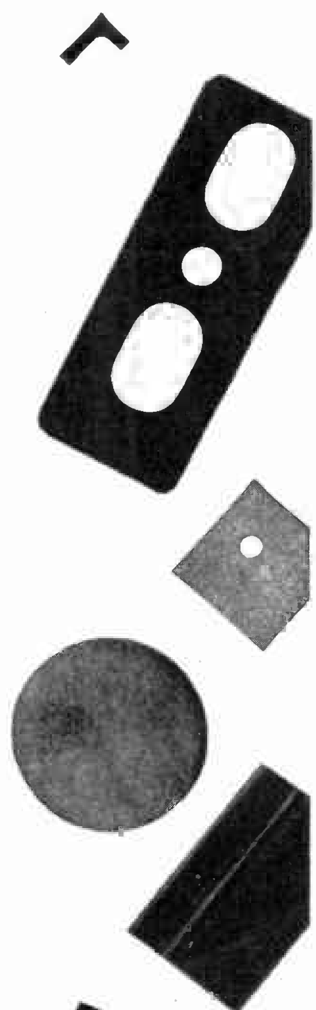
Mechanically it's a marvel. No speaker will stand equal punishment. It almost never requires service. And that means a lot to you—for when a speaker goes bad, they blame the radio—not the speaker.

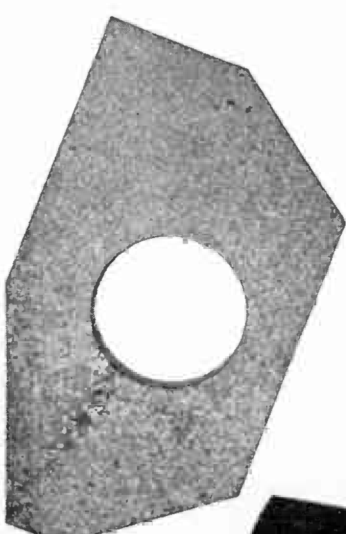
And it reproduces a wide range with high efficiency, fine quality—and genuine distortionless fidelity.

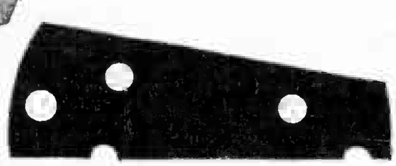
If I were a Radio Engineer, building a fine radio, I would demand that *Peerless* Reproducer be used in justice to my radio design. I would write the *Peerless* people now for details of the *Peerless* 7B Built-In Reproducer.

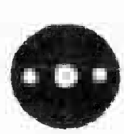
UNITED RADIO CORPORATION, 15 CLARISSA STREET, ROCHESTER, N. Y.











RADIO ENGINEERING

for MARCH 1928

Edited by M. L. Muhleman

52 Vanderbilt Avenue
New York, N. Y.

VOLUME VIII NUMBER 3

Editorial

THE introduction of the electric receiver has instituted throughout the entire radio industry a new and dynamic selling power. Radio sets have automatically taken their place in the same merchandising classification as the washing machine, the vacuum cleaner and sundry other home electrical appliances.

The fact that most of these receivers are sold complete makes them as *easy* to buy as an electric iron, a toaster or any other simple electric device. Simplicity of design has reduced manufacturing problems to a minimum; quantity production is within the reach of even the small manufacturer.

The important point is that for the first time in the history of the radio industry competitive products have been met in their own field.

The electric receiver is a remarkable selling proposition as already demonstrated by the unparalleled success gained by a number of set manufacturers. The success of the electric receiver as a merchandising proposition is bound to exert a definite influence on other branches of the radio industry. Radio sales in general will be stimulated by its pioneering.

Rumor has it that three automobile manufacturers, a maker of a famous vacuum cleaner and a number of other large industrial organizations are contemplating the manufacture of electric receivers. These organizations have unquestionably come to the realization that now, if never before, the radio field has a wealth of undeveloped possibilities.

There are approximately 33,000,000 families in the United States. Only a small percentage of them own radio sets. All of them are potential buyers of new sets or parts for sets. They may spend their surplus cash on automobiles, phonographs, vacuum cleaners, portable motion picture outfits or any of the many other luxuries which work under the skin and become necessities. We venture the guess that these 33,000,000 families will spend a large portion of this surplus on radio if they are properly handled.

The population of the United States is far from being "radio minded." It is interesting to observe that infinitely more bananas are consumed today than in the past because the Fruit Growers Association educated the whole country into eating more of them, principally through the abolition of a few false conceptions the public entertained regarding the food value and physiological effect of bananas.

The time is ripe for group educational advertising in the radio field. This form of publicity will do more towards creating a large radio market than any other means.

Once educate half of the people to radio and the other half will swing into line.

By necessity alone, broadcast programs will improve and the control of broadcasting will be safe in the hands of an immense radio audience representing a force too great and likewise too important to meddle with.

Once convert the public through constructive educational missionary work and you will have permanently tapped the cash surplus of the Nation's families. Accomplish this and "Wired Wireless" will automatically have lost its value as a commodity.

M. L. MUHLEMAN,
Editor.

Contents

Departments

Published Monthly by
RADIO ENGINEERING MAGAZINE, INC.

Bryan S. Davis, *President* Harold H. Keefe, *Secretary*
James J. Walker, *Asst. Secretary*

Main Editorial and Business Offices, 52 Vanderbilt Ave., New York, N. Y. Midwest office, A. G. Rudolph, 500 No. Dearborn St., Chicago, Ill. Publication Office, Lyon Block, Albany, N. Y. Printed in U. S. A. Yearly subscription $2.00 in U. S. and Canada; $2.50 in foreign countries. Entered as second class matter at the postoffice at Albany, New York, January 9, 1925, under the act of March 3, 1879.

Announcing the TABLE TYPE CLAROSTAT

Reg. U. S. Pat. Office

And now you can have micrometric resistance in the form of a convenient accessory. No longer must the volume control Clarostat be incorporated in the radio assembly as an integral part.

There are many applications for the TABLE TYPE CLAROSTAT. Among the first to suggest themselves to the radio engineer and the radio set builder, are:

An ideal form of remote control for loud-speaker volume, in fitting the radio rendition to conditions and programs.

Volume control for the A-C tube harness, which may be conveniently placed without disturbing existing set wiring.

A handy and neat form of volume control for electrical pick-ups that give new life to the old phonograph.

Convenient variable resistance for use in experimental work and in laboratory practice.

The TABLE TYPE CLAROSTAT is a handsome addition to any radio set. Finished in statuary bronze and nickel, with attractive Bakelite knob. Bottom provided with felt to protect surface of fine furniture. Two connection cords and tip connection block permit of insertion in any circuit, in the case of the standard model, but other connection means may be employed to meet particular requirements. Available in any resistance range to meet special needs. Resistance range covered in several turns of knob, providing razor-sharp adjustment or micrometric resistance. Noiseless in operation. Holds resistance setting. Foolproof. Durable. In brief, a *genuine* Clarostat in a new dress.

Your latest radio offering will be all the better for the addition of this convenient form of reliable resistor. Look into the matter!

And There's a CLAROSTAT for Every Purpose

THE VOLUME CONTROL CLAROSTAT *for controlling volume, tone, plate voltage, oscillation, stabilization and other functions in radio receivers. (7-watt rating.)*

THE STANDARD CLAROSTAT *for controlling voltage taps in the usual B-power unit, electrified receiver, and power amplifier. Also extreme resistance range in radio reception. (20-watt rating.)*

THE HEAVY-DUTY CLAROSTAT *for line-voltage control in small and moderate-sized radio power units, as well as other resistance requirements requiring greater capacity than Standard type. (25-watt rating.)*

THE POWER CLAROSTAT, *the giant variable resistor, for handling resistance problems usually considered the exclusive field of wire-wound units, particularly in the electrified receiver, A-B-C power unit, power amplifier, and for line-voltage control. (40-watt rating.)*

Let us co-operate with you in your resistance problems. Aside from the Table Type, don't forget the Volume Control, Standard, Heavy-duty and Power Clarostats. Write for samples and engineering data on your firm letterhead.

RADIO MANUFACTURERS ASSOCIATION RMA MEMBER

AMERICAN MECHANICAL LABORATORIES, INC.

Specialists in Variable Resistors

285-7 North Sixth St. :: :: :: Brooklyn, N. Y.

CLAROSTAT

A REPORT

which may be of interest to our readers and advertisers

1.—In six months the paid circulation of RADIO ENGINEERING has more than doubled.

2.—In January and February of this year the readers of RADIO ENGINEERING spent $977.50 in the purchase of Radio Books thru RADIO ENGINEERING.

3.—The amount spent for advertising in RADIO ENGINEERING in January and February of this year exceeded the amount spent in the same months of 1927 by *over* 50%.

4.—In February, 1927, RADIO ENGINEERING stood *last* among the eight leading radio monthly magazines in *volume* of advertising carried. In February, 1928, RADIO ENGINEERING stands *fourth* among these eight publications — (trade, fan and technical magazines inclusive).

5.—Twenty-two advertisers who used space in RADIO ENGINEERING regularly during the past four months *used space in no other radio magazine.*

Typical communications, recently received are quoted below:

"Radio Engineering Magazine, Inc.
52 Vanderbilt Ave., New York, N. Y.

Gentlemen:
We were greatly surprised at the QUALITY drawing power of an advertisement in Radio Engineering, bringing responses from such firms as American Telephone and Telegraph, Crosley Radio Corp'n, Dooley Electric Co., Stewart Battery Company and others.
Replies were received from Mexico, Canada and one from Czecho-Slovakia.

Cordially yours,
....
........................."

"Radio Engineering Magazine, Inc.
New York City.
Gentlemen:
.... I have had considerable comment from the field .... and can assure you that your circulation must be quite extensive.

Yours very sincerely,
..........................."

Every Dudlo coil is individually inspected and tested for specified requirements by highly trained employees before packing.

Every material must pass a laboratory test before it is approved for Dudlo magnet wire and coils.

The thorough system of testing and inspection employed in every department of the Dudlo factories safeguards the quality of *your* product as well as our own.

No industry is more exacting in its requirements than radio. Every coil must be perfect in every respect—or your receiving set, your power unit, your transformer, may be defective and you and your dealers will have to pay the penalty by standing the grief of returned goods, replacements, repairs, loss of reputation and shrinking sales.

DUDLO

Why take a chance? Why not play safe by following the lead of the most successful radio manufacturers by making Dudlo a department of your business? Use our engineering and manufacturing facilities freely—they are dependable.

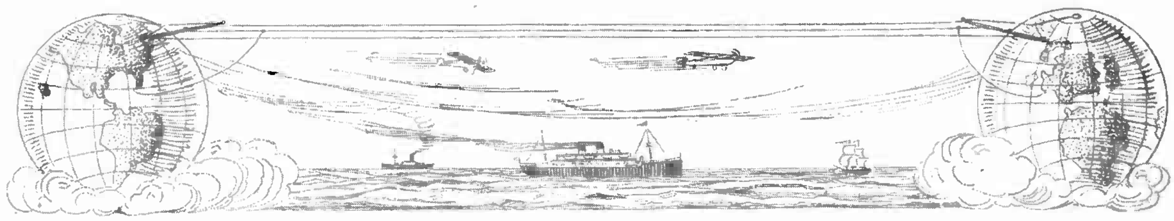
DUDLO

Magnet Wire and Windings

DUDLO MANUFACTURING COMPANY, FORT WAYNE, INDIANA

Division of THE GENERAL CABLE CORPORATION

160 NORTH LA SALLE STREET CHICAGO, ILL. | 56 EARL STREET NEWARK, N. J. | 4153 BINGHAM AVE. ST. LOUIS, MO. | 274 BRANNAN ST. SAN FRANCISCO, CALIFORNIA



Theory and Construction of Quartz Crystal High Frequency Oscillators

A Discussion on the Properties of Quartz and Practical Data on Cutting, Twinning and Grinding

By Jennings B. Dow, Lieutenant, U. S. Navy

QUARTZ crystals for use as frequency stabilizers in short wave radio transmitters have received much well merited attention during the past year but the number of experimenters who have availed themselves of the benefits of these important devices is few. Several causes no doubt are responsible for this condition but the most important one is believed to lie in the limited circulation of definite information on the subject of their operation and construction. It is hoped that the present article will be at least a small contribution in the right direction.

The various steps in the production of a crystal for the purpose here considered are shown in Fig. 1. The details of cutting and grinding will be explained fully in later paragraphs. Fig. 2 shows the designation of axes with respect to the rough crystal. It should be understood here that twenty or more finished high frequency crystals can be made from one rough crystal depending upon the size and quality of the latter. The rough crystals vary in weight from a small fraction of a pound to as much as a hundred or more pounds.

It is useful to designate reference axes in the following manner. The O or optical axis of the rough crystal is its longitudinal axis. Pass a plane through the O axis and any one of the six prismatic edges of the rough crystal. Any element of this plane perpendicular to the O axis is an E or electric axis. Pass another plane through the O axis perpendicular to the first plane. Any element of the new plane perpendicular to the O axis is a B axis. Any line in the finished crystal which is parallel to these axes is similarly designated.

Now, take the finished crystal out of the rough one of Fig. 2, and put it between two brass plates which will hereafter be called the *electrodes*. If experiments are performed with this combination and suitable measuring apparatus, it is possible to prove experimentally the following laws.

First Law: *Compression along the electric axis results in charging the electrodes with equal and opposite charges of electricity. Stretching the crystal along the B axis produces charges on the electrodes having signs corresponding to those of compression along the electric axis. Stretching the crystal along the electric axis also produces equal and opposite charges on the electrodes but the signs of these charges are opposite to those produced by compression. Compressing the crystal along the B axis produces charges having the same signs as those resulting from stretching the crystal along the E axis. The electrical effects of compression or extension along the optical axis are negligible.*[1]

Second Law: *If the electrodes are charged by connecting a battery to them and the charges have signs similar to those produced by compression along the electric axis, the crystal will contract along the electric axis and expand along the B axis and will be neutral along the optical axis. If the applied charges are opposite to those mentioned above, a converse effect results along the E and B axes.*

The value of a quartz crystal for the control of a vacuum tube oscillator may readily be inferred from a consideration of the two laws and the fact that such a body may be made to vibrate mechanically along any one dimension at a frequency uniquely determined by that dimension. In the present case interest is confined to the longitudinal vibration along the electric axis and the crystal can be thought of as a rod having length which is small compared to its other dimensions. If a rod is struck on its end with a hammer, its natural frequency of vibration is that one which makes the rod one half a wave length in length. This is fortunate because the maximum elongation and contraction are produced by such a vibration —and since the piezo electric charge is a function of the strain in the crystal, the maximum potential variation is produced at the electrodes.

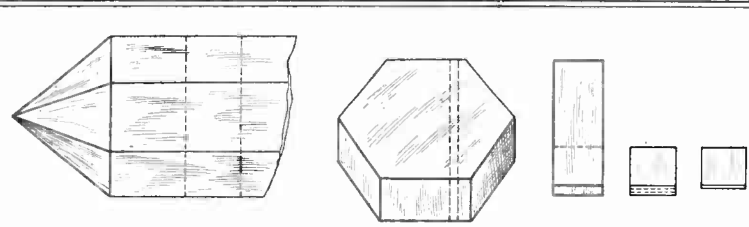


FIG. 1

Successive steps in the cutting and grinding of quartz crystals for piezo-electric use in the control of high frequency transmitters. Dotted lines indicate positions of succeeding cuts.

If the finished crystal is placed in the grid-filament circuit of a vacuum tube and mechanical vibrations are started, piezo electric potentials sufficient to control the plate current are produced. If sufficient energy is fed back to the crystal from the plate circuit during each half cycle, the mechanical vibrations will not die out but will become sustained and the tube will continue to oscillate. In practice this feed back of energy is accomplished through the plate-grid capacity of the tube.

A rigid mathematical discussion of a vibrating crystal in the grid circuit

1 It is *now* quite well understood that the crystal is not entirely neutral along the optical axis. Absence of the neutral conditions is believed due to actual deformation along the E and B axis even though the external force is applied along the optical axis. Consult works on the *Strength of Materials.*

of a tube has not been developed to date and indeed presents a very complex problem owing to the fact that the crystal is not uniformly elastic in all its dimensions. Moreover this difficulty is accentuated by the fact that the dielectric "constant" varies throughout the vibration and in a manner which is not well understood.

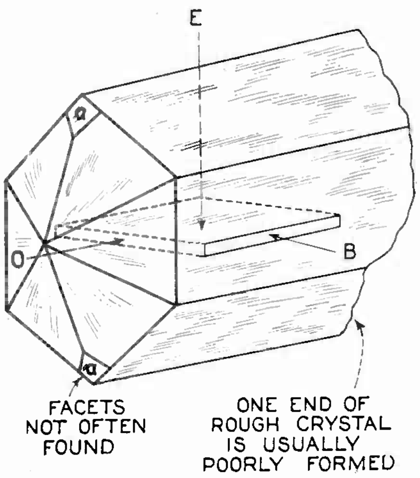


FIG. 2

Orientation of axes of finished crystal with respect to rough crystal.

Curie has proved experimentally in his resarches upon piezo crystals the existance of the following static laws

$$q' = K_p A \qquad (1)$$

where, q'=piezo electric charge developed on each electrode (ESU).
p=externally applied pressure (dynes/sq. cm.).
A=area of one face (sq. cm.).
K=a constant (6.32 X along the electric axis of quartz).

$$x = KV \qquad (2)$$

where, x=increase or decrease in the dimension along the electric axis due to the applied voltage V. (cm.).
V=externally applied voltage. (ESU).

Having the above two fundamental equations, it is useful for practical purposes to write them in terms of the undisturbed dimensions along the electric axis. This latter dimension will be designated as y and to substitute it, use is made of the familiar elastic equation,

$$p = e\frac{x}{y} \qquad (3)$$

where, $e = 6.78 \times 10^{11}$ dynes/sq. cm. along E.

This equation states that the pressure required to change the length of an elastic rod, say, is the product of Youngs Modulus of Elasticity of the material by the ratio of the change in length to the original length.

Substituting (3) in (1) and (2) we arrive at

$$q' = eKA\frac{x}{y} \qquad (4)$$

$$p' = eK\frac{V}{y} \qquad (5)$$

where p'=piezo pressure resulting from V.

We can further simplify (4) and (5) by letting

$$eK = g \qquad (6)$$

where, g is a constant including both e and K.

Performing the substitution, there results the more simple expressions,

$$q' = gA\frac{x}{y} \qquad (7)$$

$$p' = g\frac{V}{y} \qquad (8)$$

For those who are interested in the physics of quartz crystals it is interesting to compare the equations (7) and (8) with those obtained by a simple theoretical study of a *charged* condenser having glass or any other insulator for its dielectric. This interesting study was pointed out by Pierce in his Harvard Lectures.

For simplicity a condenser having two plates separated by the dielectric will be considered. Let

$-Q$ and $+Q$=charge on the condenser plates (ESU).
V=potential difference between plates (ESU).
W=energy of the system (Ergs).
y=undisturbed thickness of the dielectric (cm.).
F=force of attraction between the plates (dynes).
A=area of one plate of the condenser. (sq. cm.).
ϵ=dielectric constant.
P=pressure on dielectric of condenser (dynes/sq. cm.).

The energy of the system is

$$W = \tfrac{1}{2}CV^2 \qquad (9)$$

Since the capacity of a condenser is

$$C = \frac{A\epsilon}{4\pi y} \qquad (10)$$

it follows from (9) that,

$$W = \frac{1}{2}\left[\frac{A\epsilon}{4\pi y}\right]V^2 \qquad (11)$$

Since,

$$F = \frac{\delta w}{\delta y} \qquad (12)$$

it follows that (11) becomes

$$F = \frac{A\epsilon V^2}{8\pi y^2} \qquad (13)$$

Now we know that pressure is force per unit area and in terms of pressure, (13) becomes

$$P = \frac{\epsilon V^2}{8\pi y^2} \qquad (14)$$

In the differentiation required by (12) we have kept V constant. If Q is held constant the same result as given by (14) would be obtained.

Next, let us determine the change in P which we shall call p resulting from an increase in V by a small amount v. From (14),

$$P + p = \frac{\varepsilon(V+v)^2}{8\pi y^2} = \frac{\varepsilon(V^2 + \varepsilon Vv + v^2)}{8\pi y^2} \qquad (15)$$

Since v is of small magnitude comparcel to V we can consider the v^2 term in (15) as negligible compared to the others. Therefore

$$P + p = \frac{\varepsilon V^2}{8\pi y^2} + \left[\frac{\varepsilon V}{4\pi y}\right]\frac{v}{y} \qquad (16)$$

In view of (14) the first term on each side of the equality (16) cancels giving,

$$p = \left[\frac{\varepsilon V}{4\pi y}\right]\frac{v}{y} \qquad (17)$$

Equation (17) gives the increase in pressure tending to compress the dielectric. that results from an increase in V by an amount v. Note the similarity of the result (17) with the piezo equation (8). The bracketed term in (17) is a constant like g in (8).

Now let us determine the increase in V caused by a decrease x in the thickness y. The charge on any condenser is

$$Q = CV \qquad (18)$$

hence from (10)

$$Q = \frac{\varepsilon AV}{4\pi y}$$

$$= \frac{\varepsilon A(V+v)}{4\pi(y-x)} \qquad (19)$$

$$= \frac{\varepsilon A\,(V+v)}{4\pi y\left(1-\frac{x}{y}\right)} \qquad (20)$$

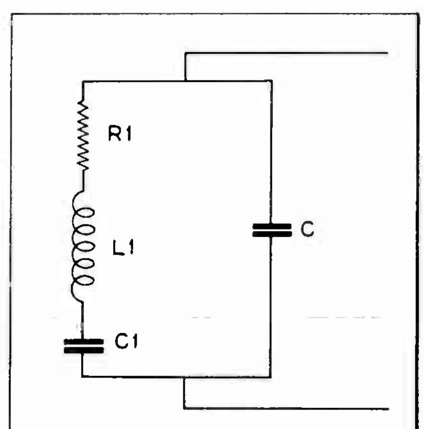


FIG. 3

Equivalent circuit of vibrating crystal.

Since we are compressing the y dimension by an amount x without removing any of the charge Q it is permissible to write from (19) and (20),

$$\frac{\varepsilon A V}{4\pi y} = \frac{\varepsilon A(V+v)}{4\pi y\left(1-\frac{x}{y}\right)} \qquad (21)$$

Performing the cancellation suggested by (21) one gets,

$$V = \frac{V+v}{1-\frac{x}{y}} \qquad (22)$$

and further simplification of (22) gives

$$v = -V\frac{x}{y} \qquad (23)$$

That is, decreasing y by an amount x develops a potential v given by (23).

Next determine the charge q′ which can be withdrawn from the condenser and still leave the potential V as before. We have

$$q' = Cv \qquad (24)$$

Substituting for v its value given by (23) and the value of C from (10).

$$q^1 = \left[\frac{A\varepsilon}{4\pi y}\right]\left[-V\frac{x}{y}\right] = \left[-\frac{\varepsilon V}{4\pi y}\right]\left[A\frac{x}{y}\right] \qquad (25)$$

Note the similarity of (25) to the piezo equation (7). The left bracket in (25) is a constant for the charged condenser and corresponds to the constant, g, in (7).

It is possible to treat the vibration case of a *very thin* crystal with a fair degree of accuracy by considering only one of the elastic constants. This can be done after the method of Pierce but the treatment is too involved to include here. The results of such a treatment are of interest.

The vibrating crystal is equivalent electrically to the circuit shown in Fig. 3. in which R, L, and C, are due to the vibration and C is the non-vibrating capacity of the condenser formed by the crystal and its electrodes. R is the equivalent resistance introduced into the circuit by heat and sound energy losses during the crystal vibration. R is small. L is a very large inductance and C is a small capacity probably not exceeding a value equal to 0.002 C. To gain an idea of the size of L, Pierce has shown that in one case its value was approximately 500 times the inductance which would resonate C to the natural mechanical frequency of vibration of the crystal.

Constructing the Finished Crystals

There are various sources of rough quartz crystals suitable for our purposes. The more important ones are in order of importance as to quality. Brazil, Madagascar, domestic, and Japan. As a rule it is possible to obtain the rough crystals through mineral supply houses or through other advertisers in the many technical journals. It is to be regretted that more advertising in this line does not appear in the radio literature. In recent months many of the optical supply houses have taken to the cutting of crystals for experimental purposes and at least one company has been advertising finished crystals of excellent quality.

For best results rough crystals should be selected with the following points in mind.

1. One end of the rough crystal should have the typical quartz crystal configuration shown in Fig. 2, at least should possess as much of this detail as possible. The facets "a" of Fig. 2. are usually not to be found owing to the rough handling which the crystals receive at the mines.

THE SCRAMBLE FOR SHORT-WAVE CHANNELS

Developments in short-wave communication have introduced a decidedly interesting and likewise delicate situation in Washington. These high frequency communication channels are now in strong demand and may form the basis of innumerable political difficulties.

The insistent clamor for channel assignments on the part of a myriad of commerical organizations suggests that caution should be exercised in making channel assignments. For obvious reasons the action of the Federal Radio Commission in this direction is of prime importance to everyone associated with the radio industry.

Mr. Donald McNicol has prepared a special article for RADIO ENGINEERING which presents the facts of the situation as they now stand. This article will appear in the April issue.

2. As many as possible of the six prismatic edges should by intact.

3. The crystal should be as regular (faces and edges parallel) as possible.

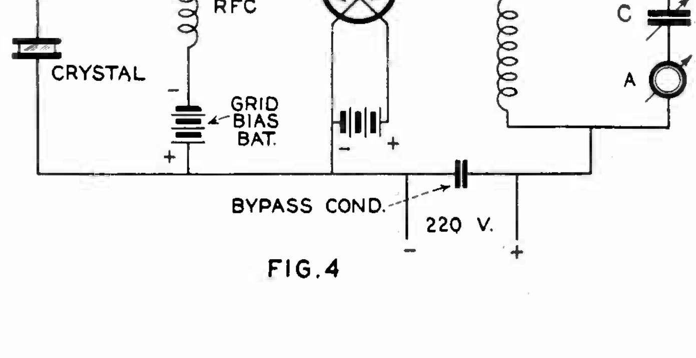
4. There should be as much freedom from interior flaws and cloudy structure as possible. If it is difficult to examine the interior owing to unpolished surfaces, the application of a generous coating of almost any clear oil will greatly assist in this examination. Only the clear portion of any rough crystal can be used.

Cutting and Twinning

After the rough crystal has been selected, the optical axis should be located. This axis may be considered for practical purposes to be along the centers of all right sections of the crystal. The first cutting should consist in dividing the rough crystal up into sections one inch thick. These cuts should be made perpendicular to the optical axis. To accomplish the cutting which is a long time consuming process, the rough crystal may be mounted in a power driven hack saw. A blade of mild unhardened steel without teeth and about the dimensions of a large hack saw blade should be used. During the motion of this blade across the crystal, an ample supply of carborundum grain (number 60) should be fed with water to the contact line between the saw and crystal. care being taken to insure that the grain is fed via both sides of the blade to make the cut as straight as possible. The carborundum grain may be collected and used over and over during the cutting. After the crystal has been cut up into slabs in this way an examination for *twinning* should be made. This examination is most important.

During the growth of a quartz crystal, changes in temperature and pressure are manifested by changes in the crystal structure. Changes in structure result in shifting the previously designated axes, i. e., portions of other smaller crystals appear to grow until the temperature and pressure conditions again become normal when the main crystal structure continues its growth over these smaller twins. Any twinned region of a crystal is unfit for use. The previously cut slabs may be examined for twinning by sending polarized light through the slabs along the optical axis and observing the transmitted light with a *Nicol* prism.

Apparatus for this purpose is usually available in any scientific laboratory where crystal structure or light phenomenon is observed. Most university laboratories have an instrument known as a polariscope for this purpose. When examining a slab of quartz in this way the twinned section will show up as one in which irregular or jagged regions of colored light will be seen. Again oil can be used to facilitate interior examination. In some cases, particularly close to the edges of the slab, regions of multi-colored light will be seen due to natural reflection phenomena. If this particular region of light is not jagged but quite regular the phenomenon is probably not due to twinning.



Oscillator circuit, using a 210 tube or equivalent, suitable for testing well made quartz crystals.

FIG. 4

The crystal should be turned slowly about the optical axis during the examination. The region in which twinning has not taken place will show no colors or only very soft shades of any color. The clear or untwinned portions of each slab should be marked out for use. In this connection it might well be mentioned that a whole crystal may be so completely filled with twins as to be unfit for piezo-electric purposes.

Direction of Electric Axis

The next part of the operation consists in choosing the direction of the electric axis. We have already fixed the optical axis as the center line. Should it be possible to locate one of the two facets which exist in a perfect crystal use a prismatic edge of the crystal terminating at one of these facets, and the optical axis to determine the plane of electric axes. Pass such a plane and mark its intersection across each slab. In case the facets cannot be found, pass the plane through the optical axis and the prismatic edge of each slab which makes the plane most nearly parallel to the two longest sides of the polygonal top. Next, mount a slab in the power saw and cut out strips of quartz such as are shown in Fig. 1, making the cuts perpendicular to the electric axis. The strips of quartz obtained in this manner should be about one-eighth inch in thickness or thinner if practicable since the finished crystals will require grinding to probably not over 0.035 inch (assuming a 4000 kilocycle fundamental).

The strips of quartz should now be cut into one inch lengths as shown in Fig. 1. For this cutting, either the modified power hack saw or a circular saw may be used. A circular saw for this purpose may be made by cutting out a disc of 0.020 inch mild unhardened steel sheet and mounting it on a motor driven spindle. Water and carborundum grain may most conveniently be used in the cutting. Such a disc six inches in diameter and revolving at 400 to 800 R.P.M. makes an excellent saw when used with carborundum abrasive and an ample supply of water. With a saw of this kind it is possible to cut through a one inch square section of quartz in about one-half hour.

For the rough grinding operation. a circular grey iron plate (6 to 12 inches in diameter) mounted with its upper surface horizontal upon a motor driven spindle is most useful. The speed of this plate should be 200 to 400 R.P.M. Rough grinding is accomplished by keeping the plate well supplied with water and corborundum grain (Number 90) and holding the crystal on the plate with the fingers. Micrometer calipers must be used frequently during all grinding operations to insure that after the operation the crystal is of uniform thickness. When the thickness of the crystal is within 0.020 inch of the finished dimension, the edges should be squared up by grinding.

An intermediate grinding operation using a fine abrasive (carborundum grain number 220 is recommended), should be made next, and for this operation a separate wheel like the first is recommended. In case an additional wheel is not available the former may be used after careful washing to remove all traces of the coarse abrasive. This operation should carry the grinding to within 0.005 inch of the finished dimension along the electric axis and particular care should be taken to see that the plane surfaces of the crystal are parallel to within 0.001 inch at this point. The edges should again be squared up.

The final grinding operations can now begin and for this purpose two stationary grey iron plates are required. These plates should be machined flat and smooth. The first of the final operations is made by moving the crystal around on the plate with the fingers applying water and a fine abrasive (number 302 emery grain is recommended). One plate should be reserved for this abrasive and one for the second of the final operations to follow. It might well be mentioned here that *the plane surfaces of the finished crystal must be parallel to within 0.0001 inch* and success in obtaining this essential accuracy depends greatly upon using the correct amount of abrasive. If too much is used the tendency will be to make the crystal thinner near the edges than it is in the center.

Final Smoothing Operations

As in the previous operations the edges should be smoothed up again at this point. All traces of scratches and nicking of the edges of the crystal which have been carried along from the rough grinding should be removed. After carefully washing the crystal the second of the final operations should be made using a still finer abrasive and the remaining disc (number 303 emery grain is recommended). The first part of this operation should carry the grinding to within 0.001 inch of the final dimension along the electric axis and at this point the plane surfaces of the crystal should be parallel to within 0.0001 inch. *Bevel all edges very slightly* at an angle of about 45 degrees, thoroughly wash and test the crystal in a small tube circuit. The diagram for such a circuit is shown in Fig. 4. If the oscillating circuit is of fairly "low loss" construction the ammeter (A) will indicate from 1 to 2.5 amperes when the condenser (C) is tuned into the resonance region.

If the crystal does not oscillate it may be due to any of the following possible causes in order of probability.

1. Plane surfaces of crystal not parallel to required accuracy.

2. Slight nicks in edges. Crystal contains scratches or flaws.

3. Crystal not clean. Finger prints will frequently prevent oscillation.

4. Crystal ground from twinned section of rough crystal. A thorough examination of the original slabs should have prevented this.

5. Poor quality of quartz used.

6. Axes not well determined. The selection of a well preserved rough crystal is important in determining the axes.

After investigating the above possibilities and rectifying the deficiencies if any exist, and the crystal is found to oscillate, a wavemeter may be employed to advantage. As the crystal is 0.001 inch over the final dimension the wave length of the resulting oscillation will be in excess of that desired and further grinding will be necessary. By additional grinding and measurement the crystal can be worked down to the desired wave length. It frequently happens that after a crystal has been made to oscillate, it will cease to work after further grinding. This trouble can usually be traced to a lack of parallelism of the faces resulting from the last grinding.

Grinding a small amount of the B dimension will sometimes improve the output of an apparently feeble crystal.

Patent Exchange Plan Is Near Completion

AT Buffalo, on February 6, the RMA patent interchange draft was perfected by its special patent committee. The successful patent pools of the automotive and aeronautical industries are being followed in part.

Broadening of radio patent cross-licensing to include future developments, such as television, is provided for in the RMA plan. Also it is proposed to include the new devices for reproduction of programs and pictures via electric light and telephone wires. Although it is not probable that television and other developments, now in the experimental stage, will be available soon to the public commercially, the RMA patent pool is being broadened to take in the radio future as five years' trial of the patent cross-license plan is contemplated under the RMA draft, with automatic extension thereafter, if successful.

As now being completed by the RMA Patent Committee, it is believed that the patent cross-licensing system proposed will be acceptable to the necessary majority of eligible manufacturers when it is presented to the RMA membership meeting next June. Immediate complete cross-licensing of all radio manufacturers is not expected to ensue, but gradual growth of the patent interchange operations is the aim of its sponsors.

Filter Circuits for Filament Type Rectifiers

The Effect of Filter Design on the Operating Characteristics of the CX-380 Rectifier Tube

By R. M. Wise*

IN a recent article, RADIO ENGINEERING, December 1927, the effect of filter constants on rectifier tube performance was discussed. It was shown that the omission of the input capacity across the filter (the tube feeding into an inductor instead) resulted in much better tube operating conditions, higher efficiency, and improved voltage regulation. Additional tests have been made to determine the tube losses with each type of circuit and the effect of the filter circuit on the ripple voltage at the output terminals.

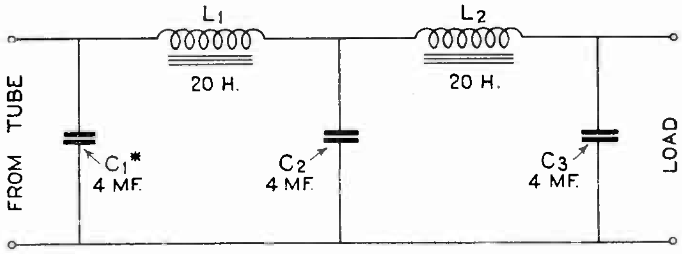
The filter circuit used in determining the distribution of tube losses is shown in Fig. 1. The inductors used, L_1 and L_2, were larger in physical dimensions, although about the same in inductance values as the types ordinarily used in B power units. The D.C. resistance was only 75 ohms, thus reducing the IR drop across them to a negligible value. The self inductance of these units varied only slightly with changes in D.C. load current, as shown in Fig. 2.

The size of the inductor L_1 has little effect upon the power dissipated in the tube due to the flow of rectified current, as long as the capacity across the input (C_1) remains large. As the capacity of C_1 is reduced the self inductance of L_2 begins to affect the wave form of the current through the tube, and therefore the losses in the tube.

Alteration of Wave Form

The wave form of the current through the tube, shown in the oscillograph record in the earlier article for the condition in which C_1 was 4 mfd. and with C_1 omitted: is reprinted for reference. With C_1 connected as usual, (Fig. 3), the current flows through the conducting anode only

The output filter circuit employed to determine the distribution of tube losses.



* C_1 OMITTED WITH CHOKE INPUT

FIG. 1

during about one-half of each alternation, and with a load current of 125 m.a., reaches the high peak value of 310 m.a. On the other hand, with the condenser omitted (Fig. 4), the current flowed through one anode or the other during the entire cycle, and the variation in current is quite small, the minimum value being 110 m.a., the maximum 140 m.a., with the same load current as before, 125 m.a.

Since, if the internal resistance of the tube is assumed constant, the losses in the tube are proportional to the square of the current through it, the high peak current occuring with condenser input causes an increase in power losses in the tube under the condition of Fig. 3. The internal resistance decreases to some extent with increase in load currents, so that the increase is not quite proportional to the square of the current, but this effect is rather small.

The reduction in tube internal losses under the conditions of Fig. 4 is 35%, as compared with Fig. 3, and while the output voltage is also reduced 20%, this latter reduction is not the result of a power loss, being due to the reactance of inductor L_1. The transformer voltage may be increased 20% to compensate for this reactance drop and yet it will be found that the power consumed is lower than before, due to the saving effected by lower tube losses. This condition, together with the decreased peak current through the tube results in improved operating conditions for the tube, and therefore in improved life.

Improved Regulation

It is obvious that when the first filter condenser is omitted, the variations in tube current will depend upon

* Chief Engineer, E. T. Cunningham, Inc.

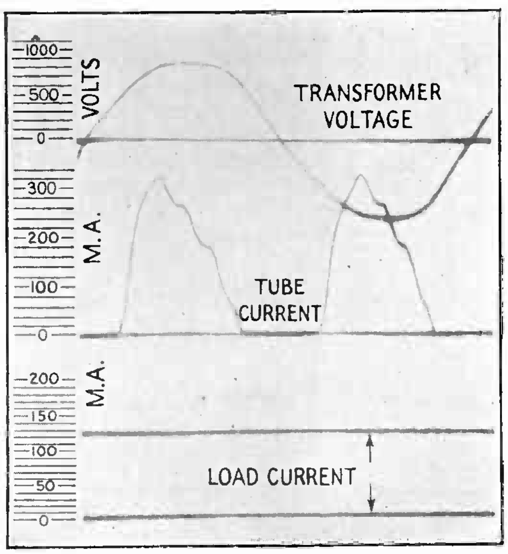
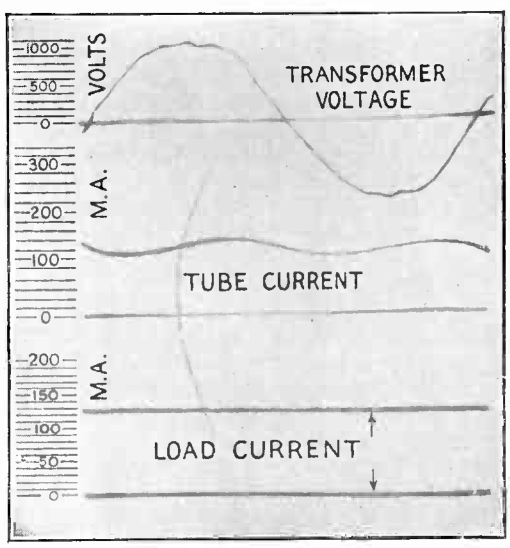


Fig. 3. Left: Oscillograph record of the output of a CX-380 full wave rectifier tube when using a standard current filter circuit with condenser input. Note the high peak current.

Fig. 4. Right: Oscillograph record of the output of a CX-380 tube when using a filter circuit with reactance input. Note the substantial reduction in the peak current. The reduction in voltage is easily compensated.



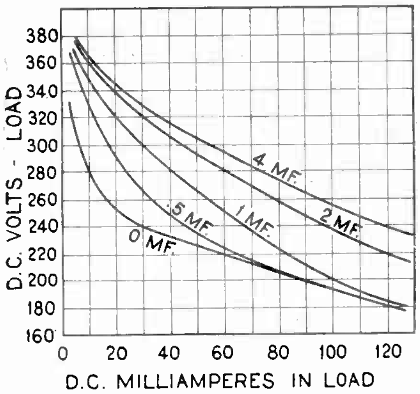


FIG. 5

Regulation curves of CX-380 with input capacities from zero to 4 mfd. Impressed potential 300 vots R.M.S. per anode.

the value of the self inductance of the inductor L_1. If this inductor is made very large the current through the tube will approach direct current, while if it is quite small the pulsations will again become large and the conditions will approach that of condenser input. A somewhat similar condition occurs when the capacity of C_1 is varied, and a series of measurements were made in which C_1 was varied from zero to 4 mfd. The regulation curves under the various load conditions are shown in Fig. 5, in which the improved regulation, when the first filter condenser is omitted, is quite evident. The reduction in output voltage is also shown.

The power dissipated in the tube for each condition shown in Fig. 5 is given in Fig. 6, where the favorable operating conditions with choke input are evident. There was very little difference between 2 and 4 mfd, the loss for each of these conditions being 11 watts with full load current of 125 m.a. flowing. With a reduction of input capacity to 1 mfd, the power loss was decreased to 9.2 watts. With .5 mfd. the loss was 7.5 watts, and with the condenser omitted was 6.9 watts, a saving of 4.1 watts, or 37%. The temperature of the bulb was measured after a run under the extreme conditions shown in Fig 6, that is with a capacity of 4 mfd., and with the condenser omitted. The bulb was several degress cooler in the latter case. This is a factor of importance at times as it is often difficult to secure good ventilation of rectifier tubes included in the cabinet of a radio receiver.

Effect of Filter Constants

The effect of the filter constants and connections upon the efficiency of the arrangement from the standpoint of filtering action secured, was next investigated. It was necessary to use A.C. from a motor generator set in the building as D.C. power only was available. It was found that a low frequency pulsation occurred in the power from this source, this pulsation affecting the readings of ripple voltage obtained, although the readings could be repeated at any time without change in the relative values. To obtain a comparable value four commercial B power devices were supplied with power from this source, and the ripple measured in terms of the r.m.s. value of the alternating component present in the output circuit. The values found were as follows:

Make	D.C. Load Current	Load Resistance	Load Volts	Ripple Millivolts
A	46	4260	196	55
B	46	3100	143	25
C	46	3580	165	63
D	46	4420	203	71
Average				55

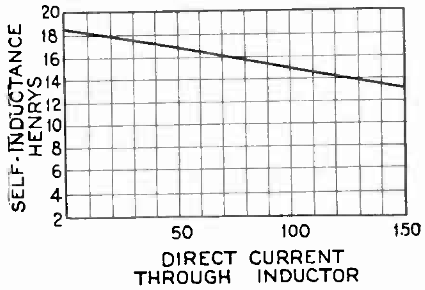


Fig. 2

As indicated, the self-inductance of the chokes L_1 and L_2 in Fig. 1 varies only slightly with an increasing current.

The measurements of ripple voltage with various filter arrangements were next made. In the tabulated results the notations refer to circuit constants as indicated in the diagram, Fig. 7. The load resistance, R, was held constant at 3000 ohms, and the transformer voltage adjusted to give the same output voltage regardless of the filter connection used. The load current was 45 m.a., and the self inductance of the inductors used was measured with this current flowing.

Tabulated values for each arrangement tested follows, the blank spaces indicating that the corresponding filter elements were omitted in that test:

L_1	C_1	L_2	C_2	L_3	C_3	Ripple Millivolts
			4	13.5	4	400
			8	13.5	4	74
		11.5	4	13.5	4	52
		11.5	4	13.5	8	44

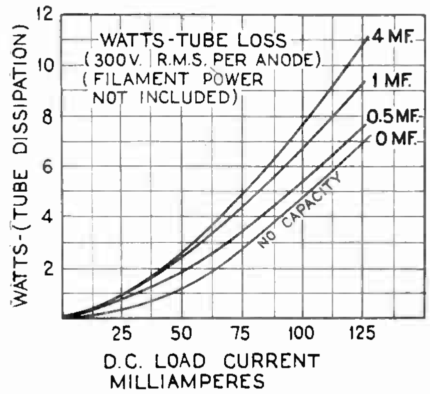


FIG. 6

Curves indicating watts dissipated by a CX-380 tube under various input conditions.

L_1	C_1	L_2	C_2	L_3	C_3	Ripple Millivolts
	2	11.5	4	13.5	4	48
	2	11.5	2	13.5	4	48
17.5	4	11.5	4	13.5	4	33
7.0	4	11.5	4	13.5	4	45

The above results indicate that little change in ripple output (hum) is involved when the input condenser is omitted. The lowest values in the table would have been reduced to a greater extent than the higher values had it been possible to eliminate the pulsation in the supply voltage source. It is evident that they are well within the values encountered in practice, comparing favorably with the values in the previous tabulation.

The advantages obtained by omission of the first filter condenser may be completely summarized as follows:

(1) Improved voltage regulation, (2) Improved efficiency, (3) Reduced emission demand on tube filament, (4) Reduced heating of tube, (5) Improved tube life (very marked), (6) Lower filter cost for equal filtering efficiency.

The original suggestion of the desirable features of this circuit were received from Mr. J. C. Warner of the Research Laboratory of the General Electric Company, and the investigation was undertaken in connection with performance tests of the CX-380 rectifier tube in the Cunningham Laboratory. Mr. J. M. Stinchfield assisted the author in making the measurements and compiling the results of the tests.

Filter circuit employed for making tabulations of ripple voltage given in this article.

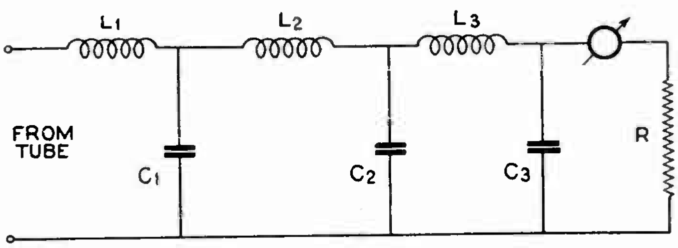


FIG. 7

The Problem of Radio Set Power Supply

Covering the Design of Socket Power Circuits

*By George B. Crouse**

PART III

As explained in the preceding article of this series, the current wave passed through the rectifier is exceedingly complex and has the general shape shown in Fig. 1 when the valve rectifies both halves of the wave. Since the two paths through the rectifier are rarely exactly equal, the two halves of the output wave are usually not identical, so that a small amplitude component will be present having the same frequency as the supply. Obviously, the largest component present in the rectifier output will be twice the supply frequency, and careful analysis shows that the next largest amplitude will be at a frequency of six times the supply. In addition, there will be small but important even harmonics of the line frequency as high as the twentieth.

It is the function of the filter to remove substantially all of these alternating components leaving only smooth direct current to be passed on to the filaments or plates of the tubes in the radio set.

The design of the filter is dictated very largely by the direct current output specifications. For instance, it will be found that a filter principle which can be satisfactorily converted into material for supplying two or three amperes at 6 or 7 volts, will not work out satisfactorily when 50 or 60 milliamperes at 200 or 300 volts are required. For this reason we have grouped the descriptions in the following under three heads:

1. "B" Socket Power Circuits,
2. Parallel "A" Socket Power Circuits,
3. Series Set Socket Power Circuits.

Method of Analyzing Filter Circuits

Unfortunately, it is not possible, except in the simplest cases, to give a satisfactory explanation of the theory of operation of any filter circuit in purely physical terms, and it is necessary to resort to mathematics. While complete and rigorous proof of the following is somewhat involved, the method may be applied with a knowledge of ordinary engineering mathematics[1].

For the purpose of illustrating the method, there is shown in Fig. 2 a simple rectifier and filter circuit such as is commonly employed in B Socket Powers. In this figure, 1 is the iron core of a power transformer having a primary 2 and a tapped secondary 3. 4 is a full-wave rectifier. The filter comprises the iron core chokes 5 and 6 in series between the rectifier and the load 7, and the three condensers 8, 9 and 10.

In order to bring the analysis into a sufficiently simple form for ordinary engineering application certain assumptions and simplifications must be made. In the first place, the mathematical difficulties are enormously increased, if any impedance elements are introduced into the circuit which are not constants. The rectifier 4 is such an element, its internal impedance being a complex function of the current flowing through it. Not only is it necessary to replace the rectifier system, comprising the rectifier and the transformer, with some other equivalent element, from mathematical considerations, but we would find that even when the laborious analysis had been made, we would have no satisfactory means of determining the necessary coefficients relating to the rectifier system. We have found, by empirical methods, that this system may be replaced by a generator of zero impedance and to which we can assign the various frequencies which are known to be present in a given rectifier output.

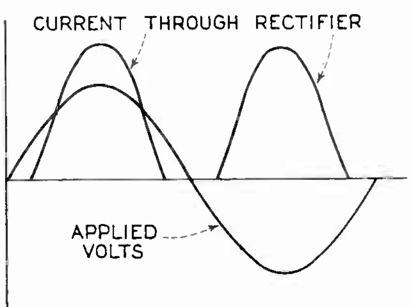


FIG. 1

General shape of current wave passed through a rectifier.

Generalized Delineation

In Fig. 3, the diagram of Fig. 2 is redrawn with the just mentioned substitution and the inductive and capacitative elements of the mesh and the resistive element of the load have been represented as generalized impedances. The capacity 8 of Fig. 2 has now become impedance Z_1 of Fig. 3. inductance 5 of Fig. 2 has become impedance Z_2 of Fig. 3, etc.

We now proceed to break the complex mesh up into a number of simple coupled circuits. Circuit I includes the generator in series with the impedance Z_1. Circuit II comprises impedances Z_1, Z_2 and Z_3. Circuit III comprises impedances Z_3, Z_4 and Z_5, Circuit IV includes Z_5 and the load Z_6. It will be obvious that any current flowing in Z_1 by virtue of the potential generated by the source will set up a potential across this impedance which will cause current to flow in circuit II. In other words, circuit I and circut II are coupled by the impedance element Z_1. In a similar manner, circuits II and III are coupled through the impedance Z_3, and circuits III and IV through impedance Z_5.

We assume that the generator is producing a potential E at some frequency at which we wish to investigate the properties of the mesh, and the problem is to find the current which will flow through the impedance Z_6. This is accomplished as follows:

The current flowing in circuit I is represented by I_1 and is the combined result of the potential of the generator and the potential across Z_1 due to

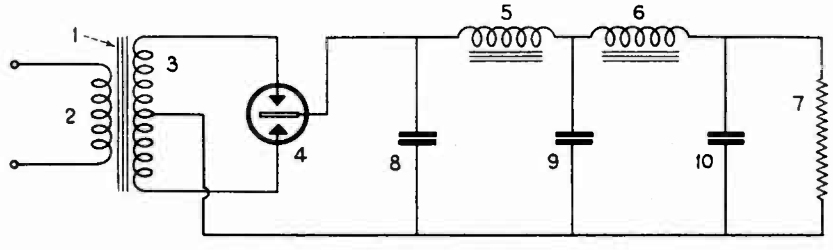


FIG. 2

Common form of rectifier and filter circuit used for B supply.

1 For complete proof see Steinmetz "Transient Electric Phenomena and Oscillations" and G. W. Pierce "Electric Oscillations and Electric Waves."

* *Vice-president and Chief Engineer, Conner-Crouse Corporation.*

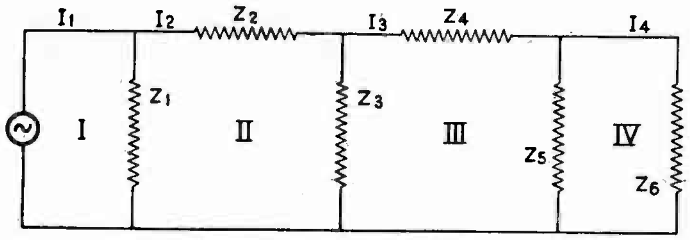


FIG. 3

The circuit of Fig. 2 in its basic form wherein the elements are represented as generalized impedances.

current circulating in circuit II represented by I_2 and is equal to

$$I_1 = \frac{E - Z_1 I_2}{Z_1} \qquad (1)$$

In similar manner it may be shown that the current in circuit II is the combined result of the currents in circuit I and III, and is given by

$$I_2 = \frac{Z_1 I_1 - Z_3 I_3}{Z_1 + Z_2 + Z_3} \qquad (2)$$

and similarly

$$I_3 = \frac{Z_3 I_2 - Z_5 I_4}{Z_5 + Z_3 + Z_4} \qquad (3)$$

$$I_4 = \frac{Z_5 I_3}{Z_5 + Z_6} \qquad (4)$$

Since the impedances are all constant and the value of E may be arbitrarily assumed, these three equations may be solved by ordinary algebra as simultaneous, for any of the currents. Since we are interested in I_4, the current flowing through impedance Z_6 we solve for this quantity giving

$$I_4 = \frac{E Z_1 Z_3 Z_5}{[Z_6 + Z_7]\,[Z_1 Z_2 (Z_3 + Z_4) + Z_3 Z_4 Z_1] + Z_5 Z_6 Z_1 (Z_2 + Z_3)} \qquad (5)$$

The impedances in this equation are of course generalized and must be converted into specific types before numerical values can be assigned, and the actual vector amplitude of the current I_3 found. Going back to Fig. 2 and comparing with Fig. 3 we see that Z_1 is capacitative (the resistance of the reactive elements of the mesh may ordinarily be neglected) and its value is defined by

$$Z_1 = -\frac{1}{j\omega C_1} \qquad (6)$$

in which ω is equal to $2\pi\times$ the frequency, C_1 is the capacity of the condenser 8 in farads, and $j = \sqrt{-1}$. Similarly Z_2 has a value defined by

$$Z_2 = j\omega L_1 \qquad (7)$$

As a final step, the complex quantities are converted into ordinary algebraic quantities, by collecting the reals and imaginaries, and taking the square roots of the sum of the two squares.

By assigning various values to ω, the frequency factor, we may determine the action of the filter mesh at any frequency, and knowing the frequencies which will be present in the rectifier output we can determine the suitability of any mesh for any particular problem.

It may be shown that any mesh, no matter how complex, may be broken up into elementary coupled circuits and its characteristics determined by ordinary algebraic methods as outlined above.

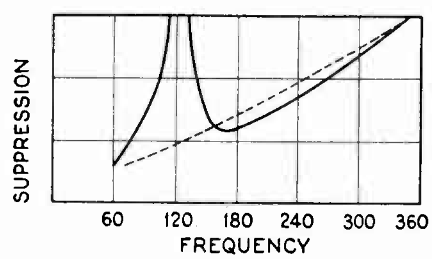


FIG. 4

Ideal suppression curve for a filter network. Infinite impedance is present in the close vicinity of 120 cycles.

In the actual application of the method it is necessary to know the approximate input voltage at the output terminals of the rectifier and also the allowable ripple output voltage of the mesh for a given radio set or amplifier. Both of these are susceptible of measurement with a fair degree of accuracy by modern laboratory methods.

"B" Socket Powers

The most common form of filter for this class of service has just been described and its analysis given. It is a simple circuit to build but if a high degree of suppression is required it will work out to large and bulky apparatus. It was pointed out above that by far the largest alternating component in the rectifier output was of a frequency of twice the supply frequency. Since the bulk of alternating current outlets are 60 cycles, this predominant frequency will be 120 cycles, and with modern amplifiers this is well within the amplified range. Unfortunately, the circuit of Fig. 2 will be found to have its greatest suppression at the very high frequencies, which are ordinarily not present in large quantities at the filter input.

It will, therefore, be seen at the outset that it is extremely desirable that the filter should exert the maximum suppression at some particular frequency, and usually at 120 cycles. An ideal suppression curve for most cases is shown in the full line in Fig. 4, and for comparison, in dotted lines, the suppression characteristics of the circuit of Fig. 2. This ideal suppression curve may be obtained in a variety of ways.

For instance, in Fig. 5 is shown one method applicable to "B" circuits in which we have all the elements of Fig. 2 identically numbered, plus a capacity 11 connected in shunt to the inductance 5. If we are dealing with 60 cycle circuits the relative values of the inductance and capacity should be so designed that the equivalent quantity Z_2 will be infinite at 120 cycles. Since this quantity appears in the denominator of equation (5), the quantity I_3 will vanish at this frequency whereas at other frequencies the mesh will behave very similarly to the original simple mesh. The infinite suppression characteristic of the mesh of Fig. 5 will of course be apparent from physical considerations, since it is well known that a parallel resonant circuit, such as that formed by inductance 5 and capacity 11, has an infinite impedance at one frequency, and being connected between the source and the load will not pass this frequency through the load.

Another method suitable for "B" Socket Powers, and which has the advantage of not requiring any additional structure over the simple mesh is shown in Fig. 6 where again identical parts are identically numbered with Fig. 2. This mesh differs from that of Fig. 2 by the addition of the coil 12 wound on the same core with inductance 5 and connected to an intermediate point of that inductance, as shown.

By introducing the proper quantities into equation (5) it will be found this combination may be made equivalent to a series resonant circuit in place of the simple capacity 9 of Fig. 2, and again the quantity I_3 may be made to vanish.

Filter circuit with first inductor 5 shunted by a capacity 11 to provide infinite impedance at 120 cycles (See Fig. 4).

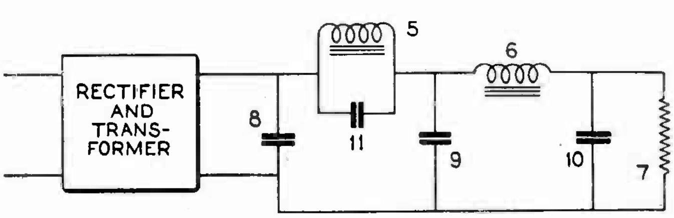


FIG. 5

Certain precautions must be observed in the design of these circuits employing resonance in any form, since the resonance effect is greatly reduced by resistance, iron losses, or other losses. They will be found to be most effective where the original value of the alternating component is relatively small.

Another method whereby desirable suppression characteristics may be obtained is by the use of the bridge circuit in various forms. Since circuits of this type will be described under all three headings it will be desirable to digress for a moment to consider the general properties of the bridge. A bridge circuit formed of generalized impedances is shown in Fig. 7, in which the generator represents, as before, an effect equivalent to the rectifier. In this circuit four arms are represented by the impedances Z_{10}, Z_{20}, Z_{30}, and Z_{40}. The load is included in the impedance Z_{50} and may constitute the whole of this impedance or any part of it. It should be pointed out that while the four balancing arms Z_{10}, etc., may be of any type it is necessary that at least two opposite arms be capable of passing direct current and at the same time the bridge must be strongly unbalanced for the direct current. In order to make the case general an impedance Z_{60} is shown in series with the generator. This might represent a series inductance or an entire filter mesh introduced between the generator and the bridge.

In the case of a bridge circuit the elementary circuit may be variously selected. In any case there will be three circuits. For instance, circuit I would include the generator, and impedances Z_{60}, Z_{10} and Z_{30}. Circuit II would include impedances Z_{10}, Z_{20} and Z_{50}. Circuit III would include Z_{30}, Z_{40} and Z_{50}. We are, of course, interested in the current I_{50} flowing in the load branch Z_{50} and this current will be found to be given by

$$I_{50} = \frac{E\,[Z_{20}Z_{30} - Z_{10}Z_{40}]}{(Z_{10}+Z_{20})(Z_{30}Z_{40}+Z_{50}Z_{20}) + (Z_{30}+Z_{40})(Z_{10}Z_{20}+Z_{50}Z_{60}) + (Z_{50}+Z_{60})(Z_{10}Z_{40}+Z_{20}Z_{30}) + Z_{50}(Z_{10}Z_{30}+Z_{20}Z_{40}) + Z_{60}(Z_{10}Z_{20}+Z_{30}Z_{40})} \quad (8)$$

One embodiment of a bridge type mesh is shown in Fig. 8. In this figure there is no impedance between the bridge and the rectifier system so that Z_{60} is zero. The bridge arm Z_{10} is formed by the inductance 20 and the capacity 21. Z_{30} is formed by the inductance 22. 20 and 22 are both mounted on the same iron core 23. The arms Z_{20} and Z_{40} are formed respectively by the pure resistances 24 and 25. If we are considering the filtering for the detector circuit the impedance Z_{50} will comprise the series resistances 26, 27 and 28, together with the complex impedance formed by the capacity 29 and the plate resistance of the detector tube. By so proportioning the four arms of the bridge that the following equation is satisfied

$$Z_{20},\ Z_{30} = Z_{10},\ Z_{40} \quad (9)$$

the numerator of equation 8 may be made to vanish at the frequency for which equation 9 is true and at this frequency no alternating current will be passed through the load. By making the reactance of the capacity 21 small in comparision with the reactance of the coil 20, the numerator of equation 8 will remain small for all higher frequencies and a substantial suppression will be exerted on them.

Turning now to the direct current characteristics of such a mesh it will be seen that no direct current can pass through the arm containing the condenser. Further, since in order to balance the bridge for an alternating component it is only a ratio of the arms which is required, we may make the upper arms as small as we please and therefore waste very little direct current through the resistance 25. The resistances 26, 27 and 28 serve as a potentiometer for taking off intermediate voltages and the capacities 30 and 31 perform the usual by-passing function for signal currents. Since any ripple introduced into the last tube in the audio amplifier is not further amplified only a moderate degree of filtering is needed for this stage. The potential for this tube is therefore taken off at the upper terminal of the capacity 21, as shown.

The circuit just described has the advantage of requiring only one inductive element and is extremely flexible in its design possibilities so that it may be adapted to a wide variety of output specifications.

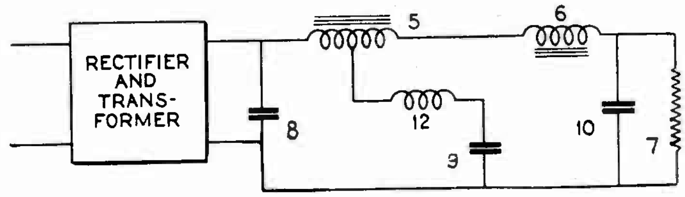


FIG. 6

The addition of inductor 12, wound on the same core as Inductor 5, will introduce a resonance effect in the filter circuit.

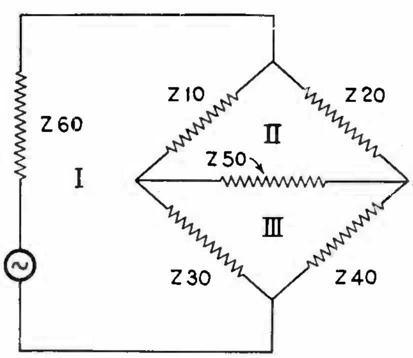


FIG. 7

A bridge circuit arrangement, composed of generalized impedances which will provide the desirable suppression characteristics.

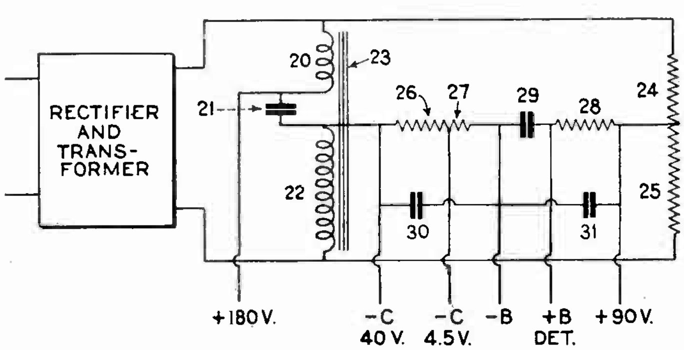


FIG. 8

A filter circuit of the bridge type, represented in generalized form in Fig. 7.

Radio Jobbers Form National Organization

ONE of the most outstanding features the Bi-Annual Convention of the Federated Radio Trade Association in Milwaukee was the foundation of a national organization of radio jobbers. This organization to take in individual jobber members throughout the entire country and to become a part of the Federated Radio Trade Association. The Jobber's Section will act individually and of its own accord and will build a strong foundation for the Federated. They will work on their own individual problems for the good of the entire industry but will not attempt to dominate the sections of the Federated as a group.

On admission for membership:—A jobber shall become eligible for membership in the Jobbers Section of the Federated Radio Trade Association if he does business on a substantial wholesale basis and does pass the requirements of the Membership Committee.

Many wholesale radio houses throughout the entire country have signified their intentions of joining this national movement and its success is already assured.

The Problem of the Battery Set

Methods and Circuits for A.C. Conversion

By Victor Greiff, E.E.*

PART II

THE object of all A.C. conversion methods is to make of the battery set an A.C. set of the usual type of which the circuits are all very similar, in so far as power supply is concerned. Therefore, an analysis of these circuits is in order.

The elements of such a circuit, as shown (Fig. 1) are, one or more transformers, for filament and plate supply, rectifying tube (or tubes), filter circuit, control and bias resistors, and a few sundry condensers. This is all in addition to the usual circuits of the D.C. radio set. The circuits of

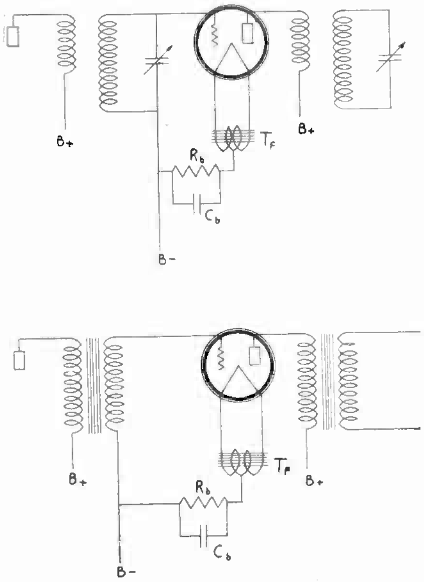


Fig. 1. R.F. and A.F. circuits for A.C. tubes of the '26 type.

R.F. and A.F. amplifying tubes are identical. The filament is heated by a transformer winding T_F tapped at its center point for plate and grid return. The resistor R_b is the bias resistor, which sets up by $I_B R_b$ the proper negative potential at the grid. The condenser C_b holds down the back coupling of the signal fluctuation into the grid circuit, which would be in a negative or preventive direction.

A.C. Circuits

The usual detector stage, consisting of a heater type tube, usually with leak and condenser detection, is only slightly different (see Fig. 2). The grid is biased by the leak to the cathode; the tuned circuit may be conductively anchored at its low end, or merely by a comparatively large capacity (in the order of IM.F.) at C_x. An interesting feature is the connection between the cathode and the center tap of the heater winding. This is similar to the standard biasing hookup; but in polarity and amount offers wide latitude.

Variation seems principally to control the sensitivity of the tube. The manufacturer's recommendations vary from —45 volts to —9 volts on the heater with respect to the cathode.

The only other element in the electric set is the output tube circuit. This, however, is very similar to the audio stage of Fig. 1, but with different constants, as a 171 or, in the better models, a 210 or similar, would be used in this stage.

The cases in A.C. electrification of sets may be classified with respect to condition of equipment and results to be attained:

1. Set is equipped with a B-eliminator capable of giving over 180 volts, preferably 210 volts or over.

2. B-eliminator for set must be furnished—best tone results not essential (171 output tube satisfactory).

3. B-eliminator for set must be furnished; best outfit desired, 210 tube.

In case 1, there is usually a 171 in the last stage with a separate bias for it, and an output transformer, if needed, with the speaker used.

Such a set, for battery operation, may have connections as shown in Fig. 3. Here are four groups of grid returns; the detector, to A.F.; the R.F. stages to A.; the 1st A.F. stage to —C1, usually 4½ volts, and —C2, usually 27½ volts or more. Of course, some of these are often combined.

The —B sources may be as varied as shown, or may likewise be combined, usually the R.F. and the A.F.

In converting this set, the B-eliminator may be retained. It will be seen that the voltage supplied to the 171 will be robbed of an amount equal to the C bias. This is obvious, since this grid bias resistor is directly in series with the plate-filament circuit of the tube.

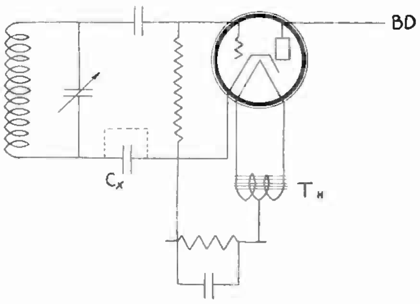


Fig. 2. Detector circuit for A.C. tube of the '27 type with heater element.

Most important, it will be seen that connecting the old A— and the C— in no way limits the bias of the 171 or the 226's. The transformer windings are raised to different negative potentials (D.C.).

Tying the —C1 to these others does limit all the 226's to the same bias. This is found best and, in fact, they are usually all operated at the same plate voltage also.

The cathode of the 227 is shown connected, via the A— lead directly to the heater transformer, without the intervention of any biasing element. However, the 226 bias may be used in either direction, or a part of the 171, or a separate bias developed, according to the practice selected.

The simplicity of this connection makes it interesting (see Fig. 4). The unit with the necessary A.C. windings

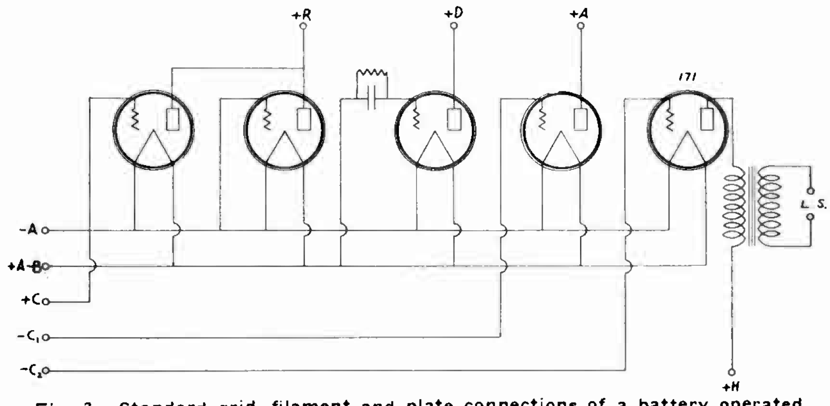


Fig. 3. Standard grid, filament and plate connections of a battery operated receiver illustrated for the purpose of indicating the steps in converting a set to A.C. operation.

* Chief Engineer, Radio Receptor Co., Inc.

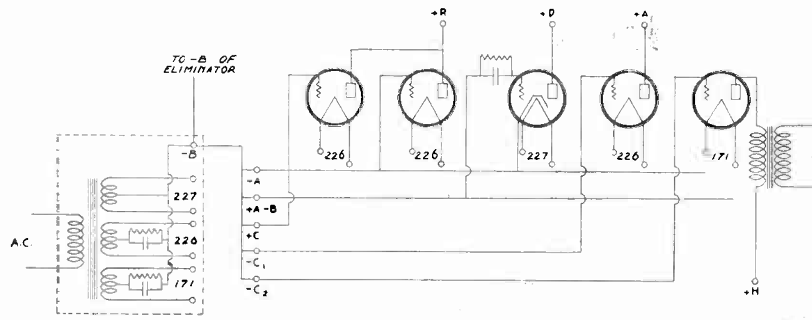


Fig. 4. The circuit of Fig. 3 converted to A.C. operation. The unit at the left is a standard filament heating transformer. This supplies filament current to the three 226 tubes, the 227 and the 171 through separate windings. Note the grid connections.

and biasing circuits and terminals for simplest connection, should be quite popular. There is required with it a six wire harness with adapters. These adapters must maintain the grid and plate connections as with battery tubes, but make no connection with the old filament springs in the sockets, except in the case of the detector, where a connection for the cathode is desired.

Of course, it should not be forgotten that the set can be rewired for the new tubes. It will be seen that if all the set connections are maintained intact, except to detach them from the filament springs of the sockets, the altered set will operate O. K.

The same thing may be accomplished by bending back the filament springs and feeding the A.C. to the filaments by a tangent connection or adapter.

In this application of the 226 tubes, as in others, it may be found necessary to cut down the signal energy to the grids of the tubes in the R.F. stages by the insertion of grid resistors. This is not a universal remedy for oscillation, but some battery sets use as high as 1600 ohms, though the writer suspects that there are bad oscillatory couplings in such sets. This value of resistance is about the maximum required to stop oscillation of a 226 under any normal condition, and a few hundred ohms in each R.F. grid circuit generally suffices.

Volume Control

The matter of control is not to be forgotten. Control of the filaments of 226 tubes is almost impractical, for the following reasons:

1. Time lag.
2. A very sharp cut-off at very low voltage.
3. Necessity for balanced A.C. voltage (neutral).
4. Distrubance of tube working conditions for control purposes may introduce hum.

Investigation has shown that it is most desirable to permit the tubes to operate at full power and cut down the "gain" somewhere before the detector.

The most convenient and accessible point of the circuit is, of course, the antenna, and the most generally desirable connection is a potentiometer of high enough resistance not to drain too much of the antenna energy at the full position (25,000 ohms has been found very satisfactory) connected, as shown in Fig. 5, sometimes characterized as the "constant output impedance" connection.

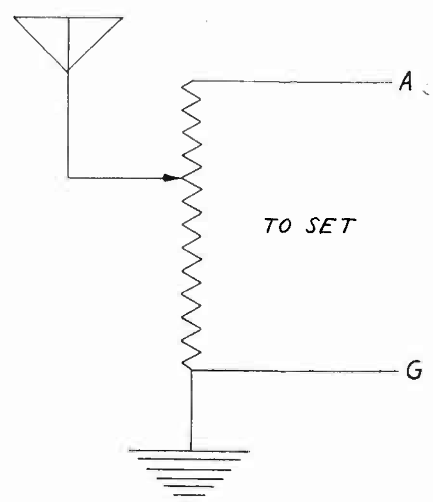


Fig. 5. A high resistance potentiometer connected in the antenna circuit as shown makes an excellent volume control for A.C. sets.

The use of the existing B-eliminator, as described, is never quite as desirable as the use of a properly designed combination unit, comprising B-eliminator, filament windings, and a complete B-bridge across the potential circuit, giving stability, freedom from tube intercoupling, and wide adaptability to different sets. The circuit of a unit of this sort is shown in Fig. 6.

This type of unit using the 171 tube can give any set the power plant of the less expensive electric sets. It cannot, however, promise any considerable improvement in tone, if a 171 with good voltage has been used with the set previously.

Unfortunately, these units are being thrown on the market by simply packing a cheap form of the previously described addition unit, consisting of filament transformer, bias resistors, etc. into unsaleable B-eliminators.

If the plate source circuit were sufficiently high in voltage and stability, this would give an equally good unit; but no job, except perhaps some amateur packs, has this range. Stability should be obtained by having low resistances throughout, so that the cross drain through the B-bridge is as high as 50 mils. on open circuit.

The harness and adapter problem on such a job is the same as the previous one. The tubes must be furnished with filament and heater current through the harness, and with signal connections to the set. This may be accomplished:

A. By rewiring the set. This is sometimes quite easy.

B. By tubes with side connections. A temporary expedient.

C. By standard A.C. tubes with adapters of either. *(a) the prong type, as furnished with powerized harness; *(b) the flat shelf type, for UX base tubes and where filament springs of the socket may be bent back or cut off.

* *Pats. Pending.*

(To be continued)

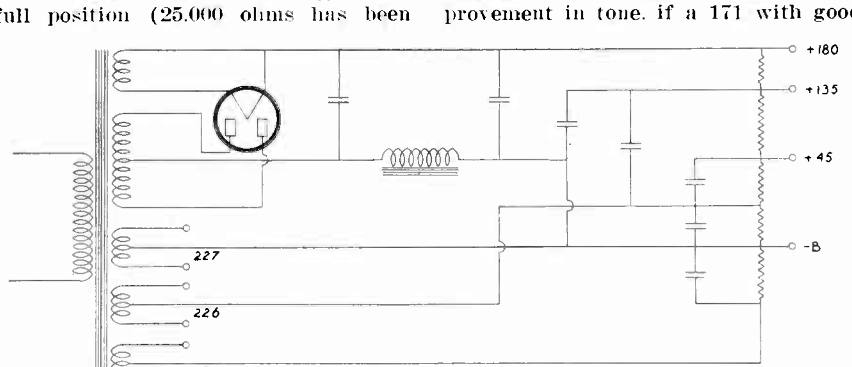


Fig. 6. Circuit diagram of a complete A-B-C unit for A.C. receivers. Three filament heating windings are included on the core of the power transformer for supplying current to the A.C. tubes and the power tube.

Corrections

Second solution of parallel resistances shown on Page 41 of Part 3 of "The Mathematics of Radio" reads as follows:

$$R = \frac{1}{3.25} \text{ or } 3.07 \text{ ohms}$$

it should be

$$R = \frac{1}{.325} \text{ or } 3.07 \text{ ohms}$$

Solution of parallel resistances in second column on Page 40 reads as follows:

$$R\ 2 = \frac{E x R1}{R \text{ plus } R1}$$

it should be

$$R\ 2 = \frac{R x R1}{R \text{ plus } R1}$$

Small Power Transformers for "A" and "B" Units

Design Calculations Relative to the Construction of Small Power Transformers

*By P. McK. Deely**

UP to the time that B-eliminators and similar devices came into almost universal use, the design of small power transformers has had a field of interest limited to such uses as that of ringing bells, operating various electrical toys and some special purpose applications. With the present day demand for complete electrification of radio receivers, the more general use of power amplifier equipment as applied to use in connection with both radio receivers and electrical reproducing phonographs, the small power transformer has assumed a position of vital importance and has become of interest to all.

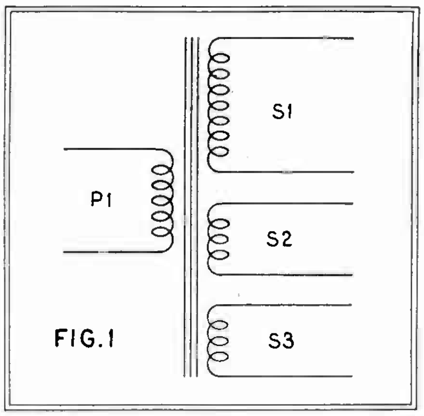
A careful analysis of large numbers of transformers used in present day radio receiver power equipment shows definitely that many manufacturers of transformers, in an attempt to cut down the cost of manufacture of such articles, are disregarding the fundamental design equations to the extent of turning out transformers that are operating continuously at the verge of burning up, have poor regulation, efficiencies of as low as 60% and last but surely not least cost much more to produce for the efficiencies obtained. It may be true that the ultimate consumer may not care at all what current his power supply relatively consumes. It is also quite probable that the buying public is not in the least interested in the engineering problems of transformer efficiency, but it is also true that many radio manufacturers are expending large sums of money for copper because they think they are exercising economy by using cheap grades of transformer iron. A more economical method would be to buy lines of force instead.

For any given wattage in a transformer a definite sum total amount of iron and copper must be used for any given efficiency. The separate amounts of both of these elements may be varied over comparatively wide ranges without seriously affecting the efficiency. This being the case, it becomes apparent that as iron costs a fractional part of the value of copper, a minimum amount of copper should be used. Incidentally, the less copper used the better the regulation. To get the best possible combinations of iron and copper though is not only the result of calculation but of years of experience in transformer building. Also it must not be forgotten that it is the total flux density or number of lines of force that is important. If cheap grades of iron are used instead of the high silicon sheet steels there certainly must be more of the former used or more copper.

The purpose of this article is to show how reasonable design figures can be determined. Like the insignia of a certain fraternal organization, a transformer consists of "three links": the primary, the secondary and the core.

Transformer Losses

Before attempting the design of a transformer it is important to thoroughly understand the different losses in a transformer and their mutual relations. As a transformer consists of three links there must be three classes of losses. Primary loss, secondary loss and core loss.



General arrangement of windings on the power transformer.. S_1 is the high voltage winding. S_2 and S_3 are filament supply windings.

The primary loss is a true I^2R loss, expressed in watts and is the ohmic resistance of the primary winding in ohms multiplied by the current in amperes squared, that is flowing in this winding. Likewise, the secondary losses are expressed in watts and determined in the same manner as the losses in the primary. If the primary is connected to the supply line but the secondary is disconnected, the secondary loss will be zero but the primary has a small current flowing, therefore a small power loss.

The core loss consists of two separate forms of power loss. First the eddy current loss and second the hysteresis loss. *Both* these losses are expressed in watts. Any conductor placed in a magnetic field of changing flux has an electric current induced into it, likewise an electric current is induced in the iron of the core. These currents are undesirable because they represent power drawn from the supply source which is not available for use. Also this power is wasted in the form of heat which heats the copper in both primary and secondary windings increasing their resistance thereby causing still further losses in these windings.

Eddy current losses may be kept small by using thin sheets of steel or iron and insulating one sheet from the other by coatings of insulating varnish or in case of the high silicon steels the natural oxide or scale. This insulating coating must be kept very thin or the total core section will be greatly increased. In design practice it must always be remembered that allowance must be made for this insulating coating in determining core cross section area.

Eddy current losses are expressed as a rule by the following equation:

$$W_e = \frac{16.38}{10^{16}} b^2 f^2 B^2$$

W_e is loss in watts per cubic inch, b the thickness of a lamination in thousandths of an inch (mils), f the frequency and B the flux density in lines of force per square centimeter of core cross section (Gauss).

The hysteresis loss in an iron core can be explained by picturing the following: When a piece of iron is magnetized for the first time and the magnetizing force removed a portion of the magnetic flux remains in the iron. To remove this portion completely it is necessary to magnetize the iron in the opposite direction. Obviously energy must be used to demagnetize the iron, and for each single reversal of the magnetizing force there is a definite amount of energy expended. As the primary current of a transformer is constantly changing in both value and direction naturally the magnetizing force is likewise changing, therefore the total hysteresis loss per second is a function primarily of frequency.

Hysteresis is a Greek word meaning "to lag." As magnetization is a molecular arrangement of the iron molecules, hysteresis can be defined in this sense as a molecular lag resulting in molecular friction which manifests itself in heat.

* *Chief Engineer, Electrical Research Laboratories.*

Hysteresis loss is expressed by the following equation:

$$W_h = \frac{16.38}{10^7} k f B^{1.6}$$

Wh is the loss in watts per cubic inch of iron, k is a constant called the hysteresis co-efficient and is determined by the class of iron or steel used. B is the flux density in gausses, or lines of force per square centimeter of cross section of the core, f denotes frequency.

The total core loss in a transformer is the sum of both eddy current loss and hysteresis loss and is expressed by the equation:

$$W_c W_e + W_h = \frac{16.38}{10.16} b^2 f^2 B^2 + \frac{16.38}{10^7} k f B^{1.6}$$

Power Efficiency of Transformer

Having defined more or less roughly the losses in a transformer the next consideration is efficiency and regardless of the fact that so many designers of transformers for use in connection with radio receivers make the claim that high efficiency is not only unnecessary but undesirable from an economical manufacturing viewpoint, it is necessary for the fundamentals of efficiency to be understood to design any transformer.

The power efficiency of a transformer is expressed as the ratio of the useful power output to the total power input. If this fraction is multiplied by 100 the efficiency will then be expressed in per cent. The useful output is obviously the total power input less the sum of all three losses.

$$\eta = \frac{W_t - W_e - W_h - (I^2R)_p - (I^2R)_s}{W_t}$$

The power efficiency could also be expressed as the secondary load in watts as obtained by the product of voltage times current divided by the sum of the secondary wattage plus the wattage of both copper losses in primary and secondary windings plus total core loss, more readily expressed as follows:

$$\eta = \frac{E_s I_s}{E_s I_s + I_p^2 R_p + I_s^2 R_s + W_c}$$

This is an assumption which holds true only when the power factor is assumed to be unity or in other words the secondary load is non-inductive as is the case with the application of transformers to their uses with radio receivers. Since the copper losses in both primary and secondary windings vary as the square of the current in these windings the efficiency of a transformer is a variable factor and transformers should be designed to have maximum efficiency at normal load. The core loss can be assumed to be constant and this has an important bearing on design of large constant duty transformers but need not be mentioned here.

All losses in transformers are heat losses. This is important to bear in mind, especially so since the advent of the completely electrified receiver. The user of a radio receiver since its complete electrification shows a marked tendency to turn on the receiver and let it run for indefinite periods of time. This is only natural as there is no fear of run down batteries or limited service. At the same time this tendency is playing havoc with some power apparatus in which transformer efficiency and heat generation and dissipation have been given little consideration.

The ratio of transformation should next be considered, and this is described as the ratio of secondary voltage to primary voltage.

$$\text{Ratio} = \frac{E_s}{E_p}$$

Transformer regulation is indicated by the proportionate change in secondary voltage from open circuit load to full load. This can only be determined by actual measurement. The calculation of core losses can be eliminated and core size and volume may be determined directly by a shorter method. The manufacturers of high silicon sheets guarantee a minimum total core loss in watts per pound. By assuming a certain total core loss as determined by size of proposed transformer the total volume of core can be readily ascertained, and this will be fully covered a little later.

Example of Transformer Design

To make this article more practical and useful, complete design of a transformer will be carried out step by step.

Design of power transformer to supply filament current to one type 281 rectifier tube and one 210 power tube; also to supply plate current of .065 amperes at 550 volts. (See Fig. 1.)

First determine total useful output. Supply current to be 110 volts, 60 cycle alternating current.

$E_{s1} = 550$ volts
$E_{s2} = 9$ volts
$E_{s3} = 9$ volts

$I_{s1} = .065$ amperes
$I_{s2} = 1.25$ amperes
$I_{s3} = 1.25$ amperes

Total useful output=
$(550 \times .065) + (9 \times 1.25) + (9 \times 1.25) = 58.25$ watts.

Assume an efficiency of 90%:

$$\text{Input} = \frac{58.25}{90} \times 100 = 64.72 \text{ watts.}$$

Total input to primary at normal load is 64.72 watts.

Assume the use of high silicon sheet such as Apollo Special or Armco Transformer Special and No. 29 gauge (.014") B = 5,000.

Total losses = 64.72 — 58.25 = 6.47 watts.

Also in this type of transformer it is usual procedure to assume that copper losses are equal to the core losses. This is an easy illustration, however, of the design problem, as are most of the assumptions in this article.

$$\text{Core losses} = \frac{6.47}{2} = 3.235 \text{ watts}$$

$$\text{Copper losses} = \frac{6.47}{2} = 3.235 \text{ watts}$$

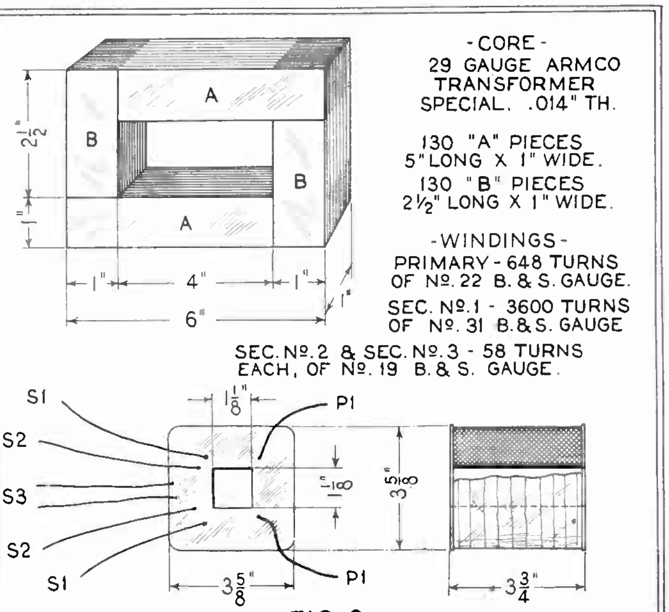
It is also customary to assume that the secondary losses are two-thirds of the total copper losses therefore:

Primary loss=1.078 watts
Secondary loss = 2.156 watts

Determinations of volume of core:

$$W_c = \frac{16.38}{10^7} \times \left(\frac{b^2 f^2 B^2}{10^9} + 0.0021 f B^{1.6}\right)$$

b=.014 or 14 mils which corresponds to No. 29 gauge.



Details of the power transformer the design of which is worked out, step by step, in this article. All dimensions, etc., are the result of mathematical calculations explained in the text.

FIG. 2

$$W_c = \frac{16.38}{10^7} \times \left[\frac{14^2 \times 60^2 \times 5000^2}{10^9} + (0.0021 \times 60 \times 5000^{1.6}) \right]$$

$$W_c = \frac{16.38}{10^7} \times \left[\frac{196 \times 3600 \times 25,000,000}{1,000,000,000} + (.0021 \times 60 \times 5000^{1.6}) \right]$$

$5000^{1.6}$ is not obtained logarithmetically as follows:

$\log 5000^{1.6} = \log 5000 \times 1.6$

$\log 5000^{1.6} = 3.698987 \times 1.6 = 5.918352$

With the use of a table of logarithims the number corresponding to this logarithim is found to be 828,600.

To continue:

$$W_c \frac{16.38}{10,000,000} \times \left[\frac{196 \times 3600 \times 25,000,000}{1,000,000,000} + (0.0021 \times 60 \times 828600) \right]$$

$$= \frac{16.38}{10.000.000} \times 122043.6$$

$= .000001638 \times 122043.6$

$= .1999$ watts per cubic inch.

In the beginning of this design problem total core losses were assumed to be 3.235 watts and as the core loss is 0.1999 watts per cubic inch then the total volume of the magnetic circuit must be:

$$\frac{3.235}{.1999} = 16.1 \text{ cubic inches.}$$

It is apparent that the mean length of the core (l) multiplied by the cross-sectional area (A) is equal to the volume in cubic inches.

$A \times l = 16$ cubic inches.

Right here we must assume another numerical value and this is the cross-sectional area. For convenience in coil winding this is generally made square. Also, we must add 10% to the total core volume to allow for space occupied by the oxide, scale or other insulation laminations otherwise we would have only 90% of actual core material in a given space.

$$\frac{16}{90} \times 100 = 17.7 \text{ cubic inches.}$$

Assume $A = 1^2$ or 1 square inch

$$l = \frac{17.7}{1} = 17.7 \text{ inches}$$

one-half the mean length =

$$\frac{17.7}{2} = 8.8 \text{ inches.}$$

Now it must be decided whether the "shell type" core or so called "core type" transformer is to be used. This is governed by space available, coil winding facilities and insulation factors. For use in connection with radio receiving power equipment the shell type is in more or less common use. To facilitate illustration, this particular design will be completed on the assumption of use of core type as this is the easiest construction for the average builder.

If the shorter leg of the core is assumed to be one-third that of the longer, then the long laminations will be 5.86 inches × 1 inch and the shorter 2.93 inches.

Rapid Calculation of Core Dimensions

Now before going ahead with the design of the primary and secondary windings it is advisable to discuss briefly the shorter method of arriving at the size of core dimensions without going through the more or less tedious mathematical calculations just illustrated and for the additional reason that advantage may be taken of the better grades of high silicon transformer sheets now available.

Such silicon sheets as Apollo Special or Armco Transformer Special have guaranteed maximum core loss for No. 29 gauge at 60 cycles and 10,000 gausses of approximately 0.8 watts per pound.

Assumed total core loss was 3.235 watts.

$$\frac{3.235}{.8} = 4.04 \text{ pounds.}$$

As such steel weighs approximately .27 pounds per cubic inch

$$\frac{4.04}{.27} = 14.9 \text{ cubic inches.}$$

Much simpler and shorter, no?

Now comes the design of the primary winding. The fundamental transformer design equation is:

$$E_p = \frac{\sqrt{2} \times A \times N_p \times \pi f \times B}{10^8}$$

E_p = primary supply current voltage.

$\sqrt{2} = 1.414$ or conversion factor of peak voltage to root mean square (R.M.S.) voltage.

A = cross sectional area of core in square centimeters, because B is in gausses or lines of force per square centimeter.

N_p = number of turns in primary winding.

$\pi = 3.1416$.

f = frequency of supply current.

B = magnetic density in gausses or lines of force per square centimeter of cross sectional area.

We have assumed A to be 1 square inch and B to be 5000 in our core calculations. One square inch = 6.45 square centimeters

$f = 60$ cycles

$E_p = 110$ volts

$$110 = \frac{1.414 \times 6.45 \times N_p \times 3.1416 \times 60 \times 5000}{10^8}$$

$$110 = \frac{8,707,500 \, N_p}{10^8}$$

$N_p = 1263$ turns

It might be well to say right here that it may seem satisfactory to the reader that in a 60 or 70 watt transformer 1263 primary turns will be the right amount, but stop and consider for a moment. Such a large number of turns in the primary means relatively that many more in the secondary, especially so when a step-up secondary ratio is desired. The increased length of secondary windings means increased ohmic resistance with consequent loss of voltage and poor regulation. It is apparent that in the equation for primary turns the values of B and A must be increased if the copper content is to be kept low. The increase in A is a relative factor because although an increase in the numerical value of A decreases the required number of turns it increases the mean length of each turn. It is common modern practice to operate the high silicon sheets at from 60000 to 80000 lines per square inch or 10.000 to 12.-000 gausses. Assuming a B of 10.000 gausses the number of primary turns becomes 648 turns. This reduces the copper content of the design by almost half. Also the use of the high silicon steel enables the total cubic content in this particular design to be reduced approximately 3 cubic inches.

The designed becomes more specific now.

$$l = \frac{15}{1} = 15 \text{ inches}$$

$$\frac{15}{2} = 7.5 \text{ inches}$$

$$\frac{7.5}{3} \times 2 = 5 \text{ inches.}$$

Size and Length of Primary Wire

There are two methods of determining this. First assume, as is also standard practice by the manufacturers of better grade transformers, 1000 circular mils per ampere of current at normal full load and let it go at that, and second by the following method:

Length of wire: Core section is 1 inch square then it must be 4 inches around it. If the primary is wound next to the core, as is common practice, a mean turn must be more than 4 inches, say 5 inches. As there are 648 turns then

$$\frac{648 \times 5}{12} = 270 \text{ feet.}$$

Size of wire: The primary copper loss was assumed to be 1.078 watts.

$$I_p^2 \, R_p = 1.078$$

Primary voltage 110 volts

$$\text{Primary current } \frac{64.72}{110} = .588 \text{ amperes}$$

$$I_p^2 = .588^2 = 345744$$

Resistance of primary, using former calculations:

$$.345744R = 1.078$$

$$R = \frac{1.078}{.345744} = 3.1 \text{ ohms.}$$

By consulting the wire table the size of wire which is nearest to that corresponding to the desired resistance is found to be No. 20 B & S gauge.

$$\frac{3.1 \text{ ohms}}{270 \text{ feet}} = .0114 \text{ ohms per foot.}$$

Now the circular mil area of No. 20 is 1022 circular mils, and that of No. 22 is 642 circular mils. Based on the previous shorter method of allowing 1000 circular mils per ampere No. 22 would be perfectly satisfactory. The weight of the primary wire can easily be obtained by referring to the tables.

Secondary Windings

The optional methods of determining size and length of primary wire having been discussed, it is not necessary to repeat same for the secondary, so the design of the transformer will be completed by the shorter and more convenient method.

$$\text{Transformation ratio} = \frac{E_s}{E_p}$$

$E_{s_1} = 550$ volts
$E_{s_2} = 9$ volts
$E_{s_3} = 9$ volts

Assumed efficiency of transformer was 90%, therefore ratio of transformation is also only 90%.

$$\frac{E_{s_1}}{E_p} = \frac{550}{110} = 5$$

$$5 \times \frac{648}{90} \times 100 = 3600 \text{ turns in secondary No. 1}$$

Current in secondary No. 1 is .065 amperes; size of wire required is 65 circular mils or No. 31 B & S gauge.

$$\frac{E_{s_2}}{E_p} = \frac{9}{110} = .081$$

$$.081 \times \frac{648}{90} \times 100 = 58 \text{ turns}$$

Current in $S_2 = 125$ amperes; 1250 circular mils required which is equivalent to No. 19 B & S gauge wire S_3 is a duplicate of S_2.

This completes the design. The design specifications as calculated are given in Fig. 2.

Conclusion

The object of this article is to show only the fundamental design problems of transformer design and the actual application of the various equations. In doing this a number of roundabout methods have been applied for the sole reason of illustration. The actual ability to rapidly and efficiently design good transformers is the result of experience and the use of good common sense and judgment in the application of the fundamental design equations.

No mention has been made of insulation problems, heat dissipation, core mounting, coil assembly or coil treatment. All these phases are naturally equally important with the others but are governed by the particular use and conditions to which the transformer is to be subjected.

Pointers on the Use of the Screen-Grid Tube

Perfect Shielding of Leads and Circuits Required

THE widespread interest in the new CX-322 screen-grid tube has caused many fans to build sets using these tubes. In some cases both engineers and fans have not properly investigated the operating characteristics and peculiarities of these tubes, with the result that the receivers they have designed and built have not proved entirely satisfactory.

Proper Use Produces Results

It must be remembered in dealing with this tube that certain precautions must be followed if the extraordinary possibilities of the tube are to be realized. The Cunningham CX-322 is not a "tricky" tube to use, but it is different than the standard 301A type of tube and therefore requires special attention.

Careful Shielding Important

In using this tube there are two very important factors which must be given careful consideration before maximum efficiency can be attained through its use.

The first is that of careful and complete shielding of each R.F. stage and the second is that of proper design of the R.F. transformers or coupling transformers.

There is nothing about the new tube that will eliminate undesirable interstage coupling in electromagnetic and electrostatic forms, and therefore shielding in a two stage screen-grid amplifier must receive approximately the same amount of attention as would the shielding in a four-stage radio frequency amplifier.

With adequate shielding, it is entirely practicable to employ even three stages of R.F. amplification, using CX-322 tubes without any trouble from oscillation. Incidentally, such an amplifier will provide a voltage amplification of from 10,000 to 15,000 as compared with around 125 for a similar number of stages in the average receiver and about 1,000 for an exceptionally efficient R.F. amplifier using 301A type tubes.

To be at all effective, shielding must include not only the metallic shielding usually used to isolate each R.F. stage but also means for preventing coupling through the battery or eliminator circuits.

Copper Shielding Best

The former can best be attained by the use of suitable completely interlocking shields. For that purpose, copper shields with soldered corner joints and slip-over tops, are best, but where such joints are not practical, comparatively heavy aluminum with overlapping joints may be used. Very thin shields are practically useless. Aluminum used for the purpose should be at least about .08 inch thick. Copper may be thinner but should not be less than about .05 inch thick. Individual shielding "cans" for the tubes are recommended though not absolutely necessary. For best results even the lead which connects the plate from one tube to the coil of the next stage should be shielded by means of a small grounded metal covering.

To eliminate battery coupling it is necessary to employ radio frequency chokes and by-pass condensers in the plate circuits. In a three-stage amplifier it is advisable to also include chokes in the screen-grid leads of each stage, although in a two-stage unit, chokes in the plate leads alone will usually prove adequate.

Special R.F. Transformers

The standard types of R.F. transformers used to couple R.F. stages using 301A type tubes cannot be used in circuits employing the CX-322 screen-grid tubes, because they do not provide a sufficiently high primary impedance to obtain the high degree of amplification possible with these tubes. The old standard type of transformer with a small primary winding may be used as an antenna coupler, but not as a coupler between the R.F. stages. Transformers for the CX-322 tubes should have primaries having approximately the same inductance as the secondaries. Impedance coupling, using a single coil common to both the plate circuit of one tube and the grid circuit of the succeeding tube may be used, but this method does not permit of the selectivity obtained by the transformer method.

The use of the close coupling obtained by having a transformer with equal primary and secondary winding does not broaden tuning to any appreciable extent if proper care is taken in the design of the transformers and circuits.

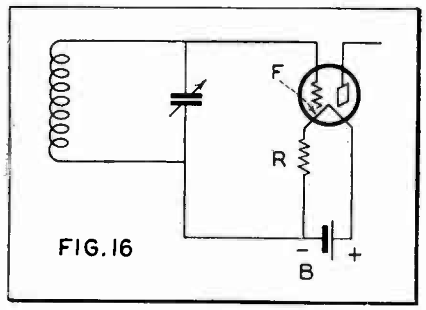
The Mathematics of Radio

Determination of Resistance Values for Filament Circuits and the Calculation of Condenser Capacities

By John F. Rider, Associate Editor

PART IV

NOW we can consider the general application of resistances. Variable or fixed, carbon or wire wound, the calculation and general application is the same. By same I do not mean that they will function in a like manner in all circuits, that is to say, their operation will be the same. As a resistance they all will cause a predetermined voltage drop, but in some instances the value of resistance changes with age, use and the temperature of operation.



The voltage of battery B is reduced by the resistance R to exactly meet the voltage requirement of filament F.

Calculating Values of Filament Resistances

The use of a resistance in the filament circuit for the purpose of causing a definite voltage drop, and the application of a predetermined voltage upon the filament of the tube in question, is very familiar to all. Therefore, the calculation of this resistance is of more importance than a description of its function.

Resistance calculations have been covered in several paragraphs, but it might be well to actually show the method employed for the calculation of resistances utilized in actual filament circuits. Let us segregate filament circuits into A.C. and D.C. arrangements, although the process of calculation is the same in both. Picture the filament circuit shown in Fig. 16. We have the tube filament F, the resistance R and the battery B. Let us assume that this battery is the regular storage battery rated at 6 volts. With the trend towards A.C. filament operation, discussion of D.C. circuits seems out of order, but the contrary is true because the method of procedure is applicable to other combinations.

We know, having examined the tube carton, that the filament voltage to be applied to a 201-A is 5 volts and that the tube consumes .25 of an ampere. What resistance R is required to reduce the voltage from the battery, so that it is 5 volts at the filament terminals. If the battery has a potential of 6 volts and we requre a potential of 5 volts, we must cause a drop of 1 volt. According to formula 5 resistance is equal to voltage divided by current, hence

$$R = \frac{1}{.25} \text{ or}$$

$$R = 4 \text{ ohms}$$

Therefore, a resistance of 4 ohms will cause a voltage drop of 1 volt and the application of 5 volts to the filament from the 6 volt battery.

Let us now imagine the same filament circuit, the same battery but a different tube. Suppose that the tube requires 3 volts and consumes only .06 of an ampere. In this instance we must dissipate 3 volts hence the problem will be

$$R = \frac{3}{.06} \text{ or}$$

$$R = 50 \text{ ohms}$$

Suppose that this tube were used in a 4.5 volt battery. What resistance would be required to reduce the voltage to the proper figure? Now we must dissipate 1.5 volts. According to the formula

$$R = \frac{1.5}{.06} \text{ or}$$

$$R = 25 \text{ ohms}$$

Note that with the current constant, the resistance is proportional to the voltage. If the voltage is increased, the resistance must be increased. If the voltage is decreased, the resistance must be decreased. The actual calculation is independent of the source of potential. In our discussion we have used a battery (storage) as the source of potential, but the same method is utilized if the source is the 110 volt D.C. house mains. The same applies to the number of tubes used. So far we have been considering just one tube. Let us picture a receiver utilizing 6 tubes, connected in parallel, as shown in Fig. 17. All the tubes are of like design, consume equal amount of current and operate at like values of filament potential. Assuming standard type tubes, the potential remains at 5 volts because tubes connected in parallel change only the value of current consumed, the current varying in proportion to the number of tubes used. When like tubes are connected in series, the voltage varies as the number of tubes used and the current remains equal to that of one tube filament. Hence the current drain of the six tubes in parallel is 1.5 amperes or 5 volts.

What value of resistance R must be used in the circuit to reduce the line voltage to the correct value, which in this instance is 5 volts? According to the formula

$$R = \frac{105}{1.5} \text{ or}$$

$$R = 70 \text{ ohms}$$

(110 volt house mains are used in the above problem). Let us now consider a frequently used arrangement for operating single tube oscillators. Try and overlook the generator part of this circuit, and also the means of obtaining plate voltage; consider only the source of filament potential and the means of obtaining the correct potential at the tube filament terminals. See Fig. 18. Here we have a single tube oscillator, whose filament supply is being obtained from the 110 volt D.C. mains, in conjunction with the plate voltage from the same source. If the tube is of the 112 type, it requires 5 volts at .5 ampere. What must be the value of R? Solving we have

$$R = \frac{105}{.5} \text{ or}$$

$$R = 210 \text{ ohms}$$

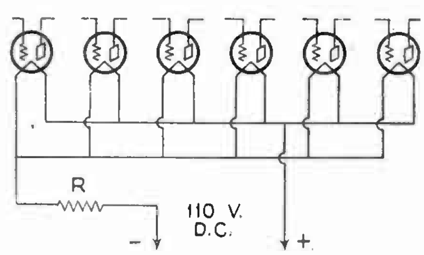
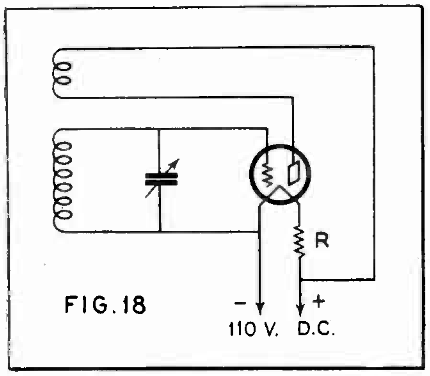


FIG. 17

A parallel filament connection. The tube filaments are operated from the 110 volt D.C. line. Resistance R is the controlling factor.

Now, mention has been made in a previous paragraph that watts is equal to volts times amperes, and since the regular lighting bulb used in every electrically equipped home is nothing more than a resistance, despite the fact that it gives off light, when the resistance is made incandescent, we can utilize a bulb of this type as the controlling resistance R. We have found that we require a 210 ohm resistance. We know that the tube consumes .5 of an ampere. What bulb would be suitable for use as a resistance? When used it would replace resistance R in Fig. 18.

Since our requirements call for a current flow of .5 an ampere let us see



An oscillator circuit. Both the "A" and "B" voltages are obtained from the 110 volt D.C. line. Resistance R reduces the voltage for the filament.

which bulb will pass a half an ampere, or rather which bulb consumes a half ampere when operating. Since watts equals E×I and since in this case E=110 and I=.5 the products of E×I will be 55 or approximately a 50 watt bulb. Let us now solve for the resistance of this bulb. If it consumes .5 ampere and the voltage is 110 the resistance will be equal to

$$R = \frac{110}{.5} \text{ or}$$

$$R = 220 \text{ ohms}$$

Therefore, this bulb is satisfactory for use as the resistance. By the same token other bulbs are satisfactory as resistances by virtue of their inherent resistance. Such bulbs are exceptionally suitable for use in chargers operated from the 100 or 220 volt house mains. A simple way of deciding what bulb is required, is to consider the current drain and then to determine which bulb (wattage) will pass the required amount of current. For example a 100 watt bulb will pass approximately 1 ampere; a 200 watt bulb will pass approximately 2 amperes, etc. It is of course necessary to give some consideration to the resistance of the system to be fed, but at low voltages and high values of current, this resistance is negligible. That is to say, if the system to be fed requires 5 volts and two amperes, the resistance of this system is negligible in comparison with that of the bulb. At 5 volts and 2 amperes, the resistance is only 2.5 ohms.

A.C. Filament Supply

Now for the A.C. circuits. find a problem daily increasing in importance, which fact can be vouched for by the many users of type 226 and 227 tubes. Operating as we do, and with the voltage fluctuations encountered in house lighting mains, it is necessary that some sort of current control be used in the filament circuits of the tubes used in the receiver. That is, if the tube filament is sensitive to overloading, with respect to operating life. At this point, some will say that such resistances are unnecessary, that the line voltage never increases to an extent which would cause excessive filament voltage, when the source of potential is the filament transformer. Let me correct this impression. I have made measurements upon various transformers operating under various conditions. The voltage output of the 1.5 volts winding very often reaches 1.8 volts and the voltage output of the 2.5 volt winding often reaches 2.9 volts. This increase in voltage is not the fault of manufacturer, even if the output voltage is slightly in excess of the tube filament voltage when the line voltage is 110 volts. The manufacturer of the transformer must accord some thought to voltage drop in the receiver wiring, and if he is to limit his transformer output to the exact voltage, any small amount of resistance in the receiver filament circuit will cause a drop great enough to impair reception by insufficient filament voltage.

The calculation of the correct resistance required in A.C. filament circuits involves the process described before, but in addition, necessitates the determination of the transformer output voltage. After this information is obtained, the correct resistance is easily determined.

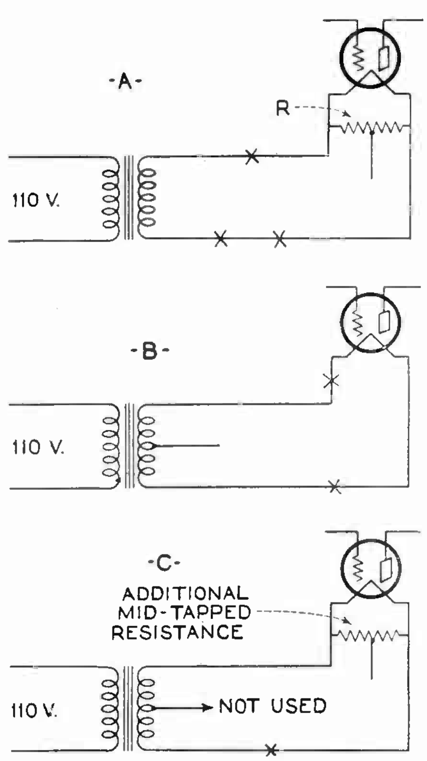
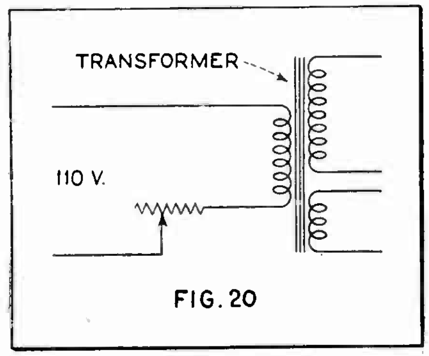


FIG. 19

Arrangements used to obtain a point of zero potential.

The position of these resistances is an important subject in A.C. filament circuits. Because of the center balance employed, these resistances can be placed only at certain points in the circuit. If the tube in question is equipped with a center tap resistance such as R in Fig. 19-A, the resistance



A variable power resistor employed with a power transformer to compensate for variations in line voltage.

for reducing the filament voltage can be placed at any of the points designated by X. But if the filament circuit is tapped at the transformer, the placement of a voltage reducing resistance at any of the points marked X in Fig. 19-B, will mar the electrical balance of the circuit and cause a "hum." The use of a voltage reducing resistance in a filament circuit utilizing a tapped filament winding necessitates the use of another midtapped resistance as shown in Fig. 19-C. In this case the regular midtap on the transformer is not used, as indicated.

The value of the midtapped resistance commonly used in A.C. filament circuits is governed by the resistance of the tube filament. Manufacturers of such resistances have as yet remained undecided as to the correct resistance, all values being manufactured. Since the resistance of the average A.C. tube (other than the 15 volt tube) is within the 1 to 1.5 ohm range, practically any resistance greater than 20 ohms will be satisfactory.

Mention must be made while discussing resistances, that the resistances utilized in A.C. circuits for the reduction of voltage, should not be inductive. The D.C. resistance of a choke will reduce the voltage in the D.C. circuit a predetermined amount, but the action of this winding will manifest a different effect in A.C. circuits. This will be considered later.

Voltage Control

A very popular theme is the use of a variable resistance in the primary circuit of the average power transformer utilized in A and B eliminators. The function of this primary circuit resistance is to reduce the input voltage, thereby reducing the output voltage and functioning as a volume control, although some claim that this unit will even control voltage fluctuations. As a means of controlling voltage fluctuations a fixed or manually variable resistance is useless as a line voltage fluctuation control. Such control can be accomplished only with an automatically operating current limiting device which will govern the amount of current fed into the transformer primary winding. The position of a variable primary circuit resistance is shown in Fig. 20. The exact calculation of this resistance for A.C. circuits will be considered in a later part of this series, because it involves data not discussed thus far. However, if a volume control unit is desired, or a resistance for reducing the line voltage is desired, one rated at 50 watts and with a range from 25 to 500 ohms, will be found satisfactory. So much for resistances.

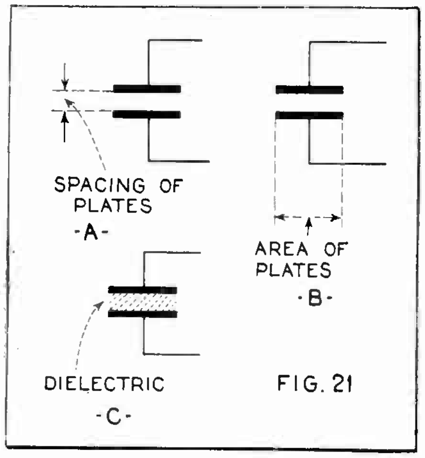


FIG. 21

Illustrating the three factors governing the capacity of any condenser.

Capacity and Its Use in Everyday Radio Practice

In the discussion of capacity and other items associated with A.C. circuits, radio frequency circuits and audio frequency circuits we will deliberately omit extensive definitions of what the term denotes. The actual definition of the term capacity is of no use to the man who is desirous of calculating the capacity of a condenser required to resonate a certain coil to 356 meters. And as far as the actual calculation is concerned this same man can determine the proper capacity without ever knowing anything about what takes place within the condenser. This paper is not intended as a treatise of the theoretical facts pertaining to radio, but rather as a treatise on simplified design. Under the circumstances, the reader is considered as sufficiently versed in just what constitutes a condenser and, therefore, more interested in the design details pertaining thereto.

Assuming that the reader is familiar with the definition of a condenser, let us proceed with some technical details pertaining to its calculation. The capacity of any condenser varies with the distance between the plates, be they two or twenty-two in number. In addition the capacity of a condenser can be made to vary by altering the area of the effective surfaces. A third means is to vary the substance separating the effective plates of the condenser; that is to say, to change the dielectric. These three methods are shown in Fig. 21, A, B and C. Condensers consisting of two plates only, are shown, but the same facts apply to condensers comprising a greater number of plates.

If we assume a condenser consisting of two plates, separated a certain distance and of a certain area, we will find that the capacity of this condenser will be a certain value, when air separates the two plates. But if we fill up the space between the two plates with some material, such as glass, paraffin, hard rubber, bakelite or mica, and re-measure the capacity of the condenser, it will be found to be greater than before. The capacity of the condenser has been increased by replacing the air dielectric with some other substance. We say increased because air is considered as a dielectric with a constant of 1. All other materials have greater values, which values are known as the "dielectric constant" or "K" of that material and denote the ratio between the capacity of the condenser when this dielectric material is used, to that of the same condenser when air is used as the dielectric. The dielectric constant is therefore

$$K = \frac{Cx}{Ca} \text{ where} \qquad (7)$$

Cx is the condenser with the dielectric in question and Ca is the condenser with the air dielectric. As an example of the above let us assume a condenser with a capacity of .0012 mfd. This condenser has air dielectric. We fill the space between the plates with shellac by immersing the condenser in a container of this substance. The condenser while in the shellac is again measured and the capacity is found to be .0039 mfd. What is the dielectric constant of the shellac? According to the formula

$$K = \frac{.0039}{.0012}$$

$$K = 3.25$$

If we know the dielectric constant of any substance, its use in a condenser to replace the air dielectric will cause an increase in capacity equivalent to

$$C = Cx - Ca \text{ where}$$

$$Cx = K \times Ca \text{ and}$$

K is the dielectric constant and Ca is the capacity of the condenser with air dielectric.

As an example of the method of predetermining increase in capacity when a known dielectric is substituted for air we have the following:

$C = Cx - Ca$

$Cx = K \times Ca$

$Ca = .005$ mfd

$K = 4.7$

therefore $Cx = .005 \times 4.7$ or

$Cx = .0235$ mfd (capacity of condenser with castor oil dielectric)

$C = .0235 - .005$ mfd or

$C = .0185$ mfd (increase in capacity)

Table of Dielectric Constants

Substances	Values of dielectric constant (K)
Air	1.0
Glass	4 to 10
Mica	4 to 8
Hard Rubber	2 to 4
Paraffin	2 to 3
Paper, dry	1.5 to 3.0
Paper (treated, as used in cables)	2.5 to 4.0
Porcelain, unglazed	5 to 7
Sulphur	3.0 to 4.2
Marble	9 to 12
Shellac	3.0 to 3.7
Beeswax	3.2
Silk	4.6
Celluloid	7 to 10
Wood, maple, dry	3.0 to 4.5
Wood, oak, dry	3.0 to 6.0
Molded insulating material, shellac base	4 to 7
Molded insulating material, phenolic base ("bakelite")	5.0 to 7.5
Vulcanized Fibre	5 to 8
Castor Oil	4.7
Transformer Oil	2.5
Water, distilled	81.0
Cottonseed Oil	3.1

(*Bureau of Standards, Circular No.* 40)

The accompanying table shows various values of dielectric constant for various substances. These values, however, are not definite in actual practice, that is, not constant under all conditions. In the first place, the kind of voltage applied to charge the condenser manifest an influence and effect upon the value of the dielectric constant. If the charging voltage is D. C. the dielectric constant of the dielectric will vary with the period of charging. Another difference is found if the charging potential is A. C. The differences, however, are not great enough under ordinary operating conditions to cause effects which will completely nullify calculations of capacity when the most commonly used dielectrics are utilized. In actual practice the most frequently used dielectrics are linen paper and mica for fixed condensers and air for variable condensers. In some cases oil dielectric condensers are encountered, but this is very seldom the case in everybody radio practice. Data pertaining to electrolytic condensers will be discussed in a subsequent paragraph.

Calculating Condenser Capacity

The factors governing the capacity of a condenser have been mentioned. Let us now consider the general formula for 2 plate condensers. Three formulae are used, although the sum and substance of all three are alike. They follow:

$$C = .0885 \times 10^{-6} \times \frac{KS}{t} \qquad (8)$$

$$C1 = \frac{KS}{12.556 \times t} \qquad (9)$$

$$C2 = .0885 \times \frac{KS}{t} \qquad (10)$$

C is in microfarads
C1 is capacity in esu (1 esu= 1.1124 micromicrofarads)
C2 is in micromicrofarads
K is dielectric constant
S is area of one plate in centimeters squared
t is thickness of dielectric in centimeters squared.

Another formula for such condensers when the capacity is expressed in micromicrofarads is

$$C = 8.85 \times .001 \times \frac{KS}{t} \qquad (11)$$

Suppose we solve one or two problems. We have two sheets of tinfoil 2″ wide and 20″ long. The dielectric is linen paper with a dielectric constant 3, and .005″ thick. Since 2.54 centimeters equals 1 inch, .005″ is equal to .0127 centimeters. According to formula (10).

$$C \text{ in micromicrofarads} = .0885 \times \frac{3 \times 10{,}322}{.0161}$$

(the 10,322 is equal to the square inches of surface area x the centimeter constant squared)

Carrying this through to its conclusion:

C=169.253 mmfds or
C=.169253 mfds

We have two sheets of metal 10″ square immersed in oil with a dielectric constant of 4.7. The plates are .1 of an inch apart. What is the capacity? Using formula (9) we have

$$C = \frac{4.7 \times 254^2}{12.56 \times .254^2}$$

$$C = \frac{303{,}255}{8.03} \text{ (approx)}$$

C=37875 esu
C=37875x1.1124=42132 mmfds
C=.042132 mfds

Condensers in Parallel Connection

Just as resistances are connected in series and in parallel to obtain certain values, capacities are interconnected in the same manner but with contrary results. When condensers are connected in parallel, the final capacity is greater than that of any of the condensers used in the combination, and when condensers are connected in series, the final capacity is always less than that of the smallest used in the combination. Fig. 22-A shows two condensers connected in parallel. The type of condensers used is immaterial, the calculation remains the same, and the increase in capacity varies in like manner. (We will discuss the calculations of multi-plate condensers such as the standard variable tuning condensers in a subsequent paragraph).

With a steady source of potential at E in Fig. 22-A, charging the condensers C and C1, the same difference of potential exists across the two condensers. Now if the charge applied to each condenser is equal to

$$Q = C \times E \qquad (12)$$

the total charge will be equal to Q plus Q1 and be equivalent to (C plus C1) multiplied by the voltage or

Qx=(C plus C1)xE

and since the capacity is equal to the charge divided by the voltage the resultant capacity is equal to

Cx=C plus C1

If we set the value of C in Fig. 22-B as .002 mfd and that of C1 as .003 mfd the total capacity will be equal to

Cx=.002 plus .003 or
Cx=.005 mfd

By the same token the total capacity of the combination shown as Fig. 22-C is .042 mfd.

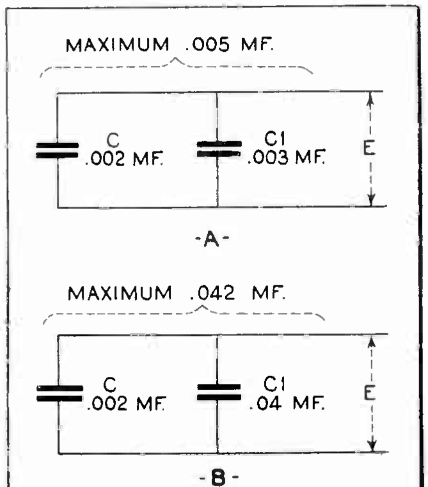


FIG. 22

Illustrating the result of connecting condensers in parellel. It will be noted that the capacities are additive.

The calculation of parallel capacities is carried out along the same line regardless of the number of capacities in parallel, be they 2, 3, 5, or 55. Mind you, we are not speaking about the ability of withstanding certain potentials. This will be taken care of later. At the present we are concerned solely with parallel capacities. The application of such parallel capacities in actual practice is shown in Fig. 23, A and B. In A we find the condenser used in the plate circuit of the detector tube. The condenser recommended for this point is a .001 mfd. Let us imagine that the condenser already in the circuit C is one of .0005 mfd capacity. To augment the capacity at this point until it reaches the proper value, we connect another condenser C1 in parallel with the first. If the first one has a value of .0005 mfd, the second must have a like value, so that the total should be .001 mfd. In Fig. 23-B we show a stage of tuned double impedance audio amplification. C is the coupling condenser within the unit. Let us assume that it is a .04 mfd condenser. We desire to raise this value above 1 mfd. To do so we connect in parallel with C another condenser C1 of at least .96 mfd. We can more easily solve the problem by making C1 a 1 mfd unit. Two parallel condensers are shown connected across the B supply feeding this audio stage.

(To be continued)

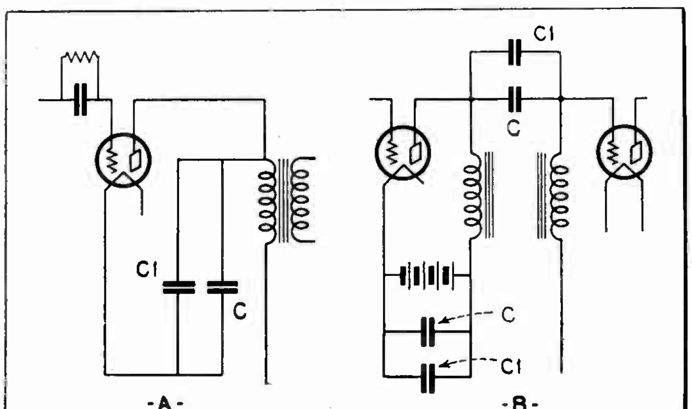


FIG. 23

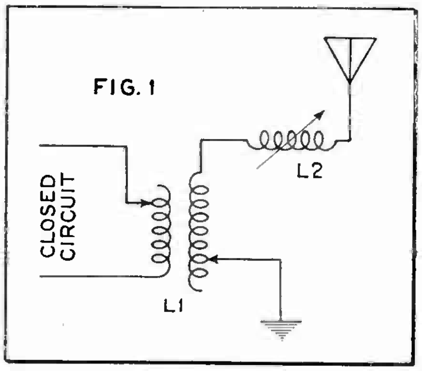
Showing how the capacity of a condenser can be increased by any amount by connecting another condenser in parallel with it. The calculation is merely a matter of simple addition.

Tuning the Broadcast Transmitter Aerial

Tuning the Antenna Circuit With a Parallel Condenser Arrangement

By H. R. Rawson*

FIGURES 1 and 2 show two methods commonly employed for tuning the aerial circuit to resonance. In most cases, coarse tuning is accomplished by the use of a tapped inductance and with series condensers. The very fine tuning is then done with either a continuously variable inductance, such as the variometer or the sliding contact form of inductance, or the variable condenser.



Antenna circuit tuned by means of a tapped inductance and a variometer.

Tapped Inductance and Variometer

In Fig. 1 we have the antenna or open circuit coupling inductance variable with taps for the coarse tuning of this circuit. The variable inductance, L_2 takes care of the fine tuning. The variometer makes a very good form of variable inductance, but in high power transmission, such an instrument must be large and very bulky, as well as difficult to construct. A method more commonly employed is the sliding contact form, in which an arm controlled from the front of the transmitter forces a contact to slide over a certain number of turns of the inductance.

This form is much easier to construct, and does give the desired fine tuning. But a sliding contact must make a comparatively light connection and thus is not always positive, often developing a high resistance in this important circuit. I have known parts of the inductance to become corroded, and when being varied, the circuit will even break at certain points.

Tapped Inductance and Variable Air Condenser

Another common form employed for tuning in this circuit is the series variable air condenser. This gives everything one could ask in fine tuning. For the short waves where large capacities are not required, it offers the ideal system. But in broadcast transmission between 200 and 550 meters, a series capacity under .0005 mfd. is seldom employed, and more commonly this is not under .001 mfd. A variable air condenser variable to .001 mfd, that could be employed in a transmitter of over 1000 watts, would indeed be a bulky and costly instrument. It would likely be 6 feet high and 4 feet in diameter.

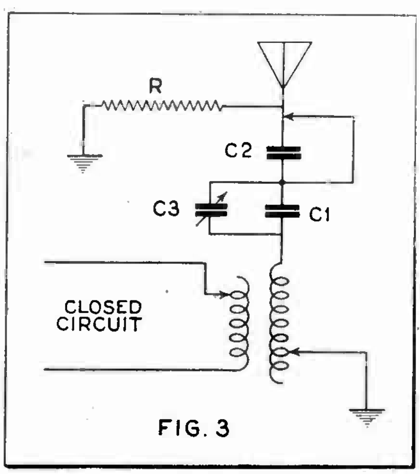
Parallel Condenser Arrangement

While trying to develop a method of fine tuning, easily available, I found the system illustrated in Fig. 3 to be most satisfactory, as well as convenient and low in cost.

In this circuit C_1 is a fixed mica condenser of proper power rating, not under .001 mfd. Across this condenser, I placed a small variable air condenser of 100 m-mfd. capacity, maximum. The condenser contains 23 plates, and the actual spacing between the stationary and rotating plates is 0.18 inch.

At first thought it would not seem possible that such a small condenser would stand up in high powered work. True, it will not if employed independently of C_1. But in this case it shows no signs of weakness at 1000 watts on 710 K.C. But one of the first lessons we learn either from the electrical primer, or by experience, is that electrical current follows the path of least resistance. Now capacitive reactance,

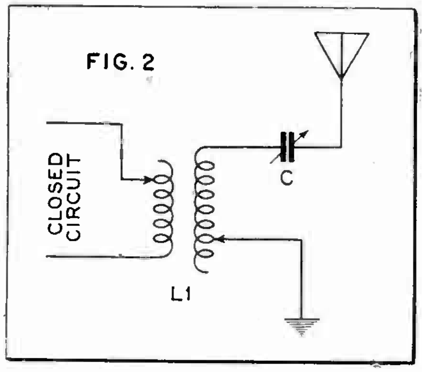
$$X_c = \frac{1}{2\pi f C}$$



A splendid tuning system utilizing a parallel condenser arrangement.

and a bit of figuring shows that at 710 K.C the reactance of C_3 is about 100 times that of C_1.

According to this, this condenser should easily handle the fine tuning of a 5000 watt station. To give it a further test, I inserted at C_3 a condenser having 43 plates, spaced 3/16 inch, or only 0.08 inch between stationary and rotating plates. The capacity of this condenser was 440 m-mfd. maximum.



Antenna system tuned by means of a tapped inductance and a variable air condenser.

This condenser showed absolutely no ill effect at 800 watts output, with maximum capacity in, and tuned to 710 K.C.

But the first condenser spaced ⅜ inch seems the ideal condenser. It gives full 10 kilocycle variation near the 710 K.C. band. It is small, and can be mounted easily and conveniently. It is readily obtainable and is also very moderate in price.

At R in Fig. 3, I have a 180,000 ohm resistance to take care of static charges that might otherwise damage or jump the condenser. The variable condenser should be operated by an insulated extension shaft to eliminate body capacity when tuning. I have also enclosed the condenser in a copper box.

If C_1 and C_2 are placed in the circuit to reduce the capacity, C_3 should parallel but one of the condensers. I do not believe the condenser should be used across a fixed condenser of less than .001 mfd capacity in the broadcast range. It can be used across larger capacities, however.

This system works well for me and saved much delay and expense in installation Were I using a sliding contact form of variable inductance with a fixed antenna series capacity, I would surely substitute this method for fine adjustments because of its positive action and ease of control.

* Chief Engineer, Station WOS.

The Synchronometer

A Synchronized Automatic Contactor for the Laboratory

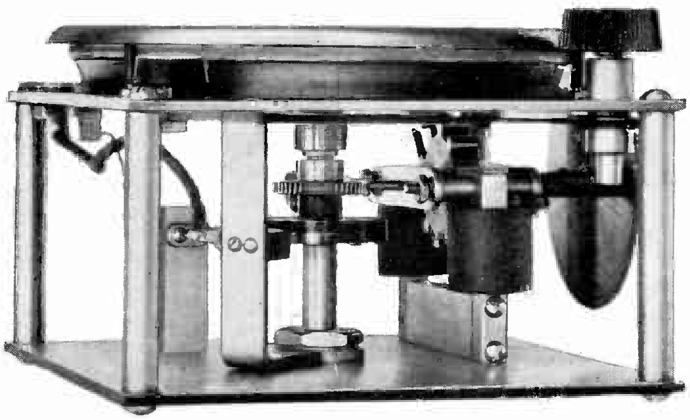
*By H. W. Lamson**

THE Synchronometer is nothing more than an accurately timed automatic transmitting key which, in the model shown in the illustrations, is designed to close a pair of electrical contacts for a brief interval once in every five seconds. It has, however, a special feature in that, while the duration of contact can be adjusted at will to any value between .05 seconds and .50 seconds, the beginning of the contact interval, or in other words, the "nose" of the signal, always occurs exactly at the zero point on the scale.

The complete outfit comprises two instruments; the Synchronometer proper and the synchronous driving fork.

The Synchronometer carries a black bakelite dial the circumference of which is graduated into one-second intervals, each second being, in turn, subdivided into twenty spaces. A clock hand, painted white for clear visability, sweeps over this dial, keeping exact time when the proper adjustments have been made. The shaft carrying this hand is driven at a uniform speed by a small synchronous motor coupled to the shaft through a 50:1 reduction worm drive. The interior view shows the motor and the driving mechanism. The motor has two poles and a ten-tooth rotor, and hence a synchronous speed of 600 revolutions per minute when driven by 100 pulses of current per second. The extremeties of the two field coils terminate in a pair of jacks on the upper panel of the instrument.

An insulating disc bearing an annular metallic segment is mounted upon the vertical shaft carrying the clock arm. Two spring contacts press radically against this segment. One of these is mounted in a fixed position which determines the "nose" of the signal. The second brush is mounted upon an arm which may be swung a certain angular distance around the shaft as a center. This brush determines the instant at which the circuit between both brushes through the revolving segment is interrupted and, hence, the duration of the interval of contact. In the front left hand corner of the upper panel will be seen a thumb screw for swinging this arm and clamping it in any desired position. The two brushes are connected to a second pair of jacks mounted upon the top panel whereby this time interval key may be connected into any desired circuit.



A view of the small synchronous motor and the 50 to 1 worm drive reduction gear. The motor operates at a speed of 600 R.P.M.

A second identical clock hand, known as the index hand, is mounted directly beneath the motor-driven hand. This index hand, which is normally stationary, is carried by a hollow shaft upon which is mounted, directly beneath the panel, a large grooved pulley. In the front right hand corner of the panel is located a hand knob which carries a small pulley beneath the panel. A belt of twine joins these two pulleys. Thus, by manipulating this knob, the index hand may be set at any desired position on the scale.

The purpose of the index hand is as follows: Suppose that the automatic signal, transmitted at zero time on the scale, sets in motion a train of mechanisms which, at some later time, produces a second signal, preferably audible in nature. The operator, by setting the index hand under the position of the revolving hand at the instant of the retarded signal, can obviously determine the time required for the operation of the mechanism. If this operation can be repeated a few times at five second intervals, a close determination of the elapsed time may be made. Various applications of a device of this sort will suggest themselves to the experimenter. Obviously a slight change in the design of the instrument will permit considerable variation in the time interval between signals.

The interrupted direct current of

The complete Synchronometer, including, in the large case the batteries, meters and the tuning fork and in the small case the special synchronous motor.

* *Engineering Dept., General Radio Co.*

100 pulses per second necessary for driving the synchronous motor is supplied by a 100-cycle electrically driven tuning fork. This is mounted in a separate cabinet which carries also ten No. 6 dry cells furnishing six volts for energizing the magnet of the fork, and nine volts for operating the motor. Milliammeters are provided for measuring these two currents and a rheostat for controlling the current to the fork magnet. The fork draws about 20 milliamperes and the motor about 200 milliamperes. An adjustable contact is provided upon each tine of the fork, one for interrupting the magnet current to maintain the fork vibrations and the other for controlling the motor current. Both circuits may be opened or closed by a single battery switch. A twin conductor cord fitted with a plug on the Synchronometer end joins the two instruments.

The accuracy of the time interval of the Synchronometer is, of course, determined directly by the precision with which the frequency of the fork is adjusted to 100 cycles per second. Small changes in fork frequency can be made by manipulating the rheostat in the driving circuit, while greater changes are accomplished by the adjustment of two counterweights mounted near the outer extremities of the fork tines. A check upon this timing can, of course, be made by comparing the Synchonometer with a stop watch. However, if accurately regulated 60 cycle lighting current is available the following procedure is simpler and more rapid. The shaft of the motor protrudes through the right hand side of the cabinet and carries a disc painted black with 12 narrow white segments uniformly spaced around it. When this disc is illuminated by a lighting source supplied with 60 cycle alternating current the spoked pattern will appear stationary if the speed of the motor is exactly 600 R. P. M. If the pattern, on the other hand, appears to advance in the direction of the disc rotation, the speed of the motor, and hence the frequency of the fork, is too high and vice versa.

A small knurled handle is attached outside of this disc. This is twirled between the thumb and forefinger to start the motor, which may readily be brought up to synchronous speed by observing the disc pattern in 60-cycle light or by watching the pulses of the needle on the milliammeter reading the motor current.

A Slide-Wire Bridge for the Laboratory

Can Be Used for Measuring Resistance, Inductance and Capacity

By W. A. Dickson

ONE of the most useful instruments in the experimenter's laboratory is the well-known Wheatstone Bridge. In addition to measuring resistance, this device may readily be adapted to the measurement of inductance and capacity; by combining actual results with simple mathematics the wave-length range of coils and condensers may be found accurately, the impedance of audio frequency transformers checked and many other useful experiments performed. By employing care in the details of construction of the bridge itself and the standards, reasonable accuracy may be assured.

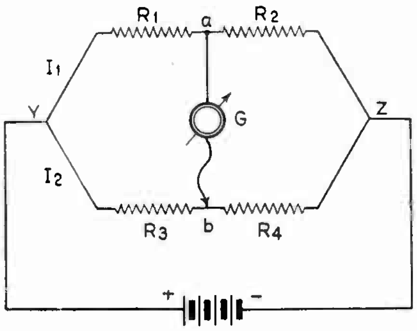


FIG. 1

The schematic diagram of the slide-wire bridge described in this article.

Theory of Operation

The Wheatstone Bridge described here is known as the Slide-Wire type due probably to the fact that a slide wire is stretched over a meter scale and employed as the variable arm of the instrument. Before we proceed with the details of construction let us stop and consider the simple theory of operation. The circuit of the Wheatstone Bridge is primarily a branched, or divided circuit as shown in Fig. 1 and the principle of operation depends upon the fact that the voltage drop from *y* to *z* must be the same over the path *yaz* as it is over the path *ybz*. It then follows that for any point, *a*, which may be chosen on the upper circuit *yaz*, there must be some point, *b*, on the lower branch *ybz* such that there will be no potential difference between it and the point *a*. If I_1 is the current flowing through the top branch and I_2 the current flowing through the bottom branch, then the voltage drop between *y* and *a* is $R_1 I_1$, and is equal to $R_3 I_2$ which is the voltage drop between *y* and *b*. From this relationship it will be seen that

$$R_1 I_1 = R_3 I_2 \text{ or } \frac{R_1}{R_3} = \frac{I_2}{I_1}$$

And also that

$$R_2 I_1 = R_4 I_2 \text{ or } \frac{R_2}{R_4} = \frac{I_2}{I_1}$$

From which it is clearly seen that

$$\frac{R_1}{R_3} = \frac{R_2}{R_4}$$

Or

$$R_4 = R_3 \frac{R_2}{R_1}$$

If three of the resistances are known the fourth can easily be calculated from the above formula. In the slide-wire bridge the branch *ybz* is made from a long piece of resistance wire and it is not necessary to know its resistance value. The ratio of the two segments of the wire will be the same as the ratio of the resistance.

A schematic diagram of the slide-wire bridge is shown in Fig. 2. Here *yz* is the slide-wire, R is the known resistance, X the resistance to be measured and r_1 and r_2 are two resistances which may be inserted at each end of the bridge wire for reasons explained later. An ordinary telephone receiver T, is employed to determine the point of balance; this point is obtained by sliding a contact along the wire until a minimum sound is heard

General layout and connections of the completed slide-wire bridge.

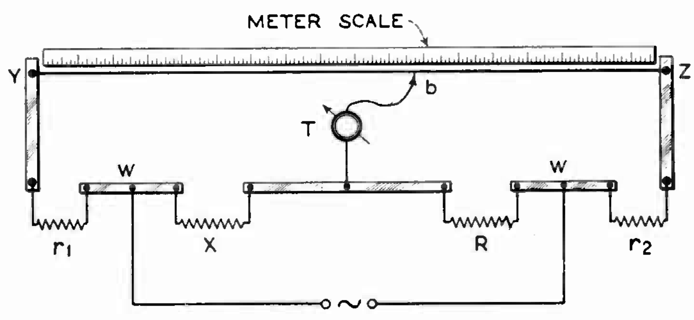


FIG. 2

in the receiver, thus indicating an absence of potential difference. The terminals W are connected to a source of alternating current which may be either a 1000 cycle audio frequency oscillator or a high-frequency buzzer and transformer. The latter method for providing an A. C. tone is shown clearly in Fig. 3. If yz is the length of wire and b is a point on the wire where a balance is obtained, and r_1 and r_2 are two resistances determined in

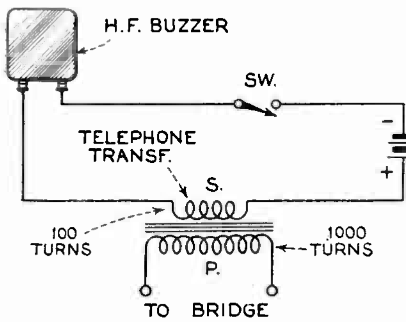


FIG. 3

Circuit connections for the high frequency buzzer.

equivalent millimeters of bridge wire, a balance is obtained when

$$\frac{R}{X} = \frac{r_1 + yb}{r_2 + bz}$$

Or

$$X = R\left(\frac{r_2 + bz}{r_1 + yb}\right)$$

If r_1 and r_2 are equal both may be called r and as yz is 1000 millimeters in length, the equation now becomes

$$X = R\left(\frac{r + 1000 - yb}{r + yb}\right)$$

The value which may be given to r will depend upon how nearly it is possible to choose the resistance R to be like X. Since the greatest value yb can have is 1000 and a balance still be obtained on the wire, we can assume yb to have this value and solve the previous equation for r

$$r = \frac{1000\,X}{R - X}$$

Which is the maximum value r can have. If it were possible to always choose R so that X would never be greater than R/2 then

$$r = \frac{1000\,\frac{R}{2}}{R - \frac{R}{2}} = 1000$$

In other words r could equal 1000 millimeters of bridge wire. Using then this value of r the equation solving for X becomes

$$X = R\left(\frac{2000 - yb}{1000 + yb}\right)$$

The use of the two resistances designated by r is theoretically to make the bridge wire three times as long. It is obvious, however, that the range of the bridge will be limited when these two resistances are inserted, but greater precision obtained than without them.

Construction of Bridge

As the slide-wire bridge must be long enough to comfortably mount a meter scale, 45 inches should be allowed for the length of the base; as for width, 8 inches will be sufficient. Practically all of the connections between the various components of the bridge are made on top of the base by means of strap brass, ½ inch wide and ¼ inch thick, shown in Fig. 5. The holes for the terminals are tapped the correct size which allows a minimum amount of resistance between them and the strap. The bridge wire may be any high grade resistance alloy and although Manganin is to be preferred, Nichrome or others may be substituted satisfactorily; number 24 or 28 gauge is the most convenient size to work with. The wire is stretched taut and securely fastened to the brass straps at each end of the bridge. The meter scale is mounted directly beneath the wire, its ends fitting snugly between the two pieces of strap to which the wire is fastened. The slide-wire should be mounted so that it is about 1-16 inch above the meter scale. A stylus for making contact with the bridge wire may be made from a piece of ⅛ inch brass rod about three inches long and provided with a bakelite or hard rubber handle. The point of the stylus should be ground to rather a sharp edge in order to obtain an accurate reading on the scale.

Operation of Bridge

The operation of the slide-wire bridge is exceedingly simple and requires very little calculation to arrive at the result. In the case of resistance measurement, a standard unit (which is chosen as near to the value of the unknown resistance as possible) is connected to the R terminals. The resistance to be measured is connected to the X terminals. The current is switched on in the A.C. arrangement and the stylus moved along the wire until a point is reached where a minimum of sound is heard in the telephone receiver. The resistance of X is then calculated from the formula given previously. For example; if R is 100 ohms and a balance obtained at the point 400 on the scale then we find that

$$X = 100\left(\frac{2000 - 600}{1000 + 600}\right)$$

$$= 100\left(\frac{1400}{1600}\right) = 87.5 \text{ ohms.}$$

In which we have assumed r to be equal to 1000 millimeters of bridge wire.

The measurement of inductance is made with the two resistances, designated by r, removed and replaced by copper links. The standard inductance L is connected to the R terminals and the coil to be measured connected to those marked X. A balance is obtained and X calculated from

$$X = L\left(\frac{1000 - yb}{yb}\right)$$

In determining the capacity of an unknown condenser the same process is

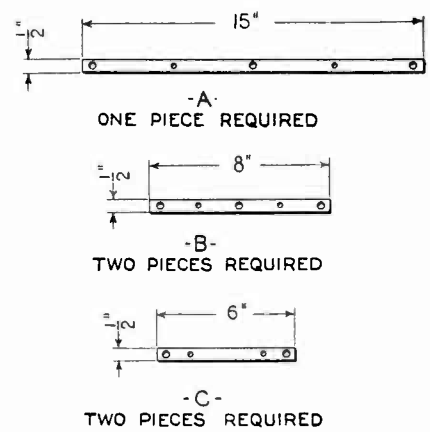


FIG. 5

Dimensions of the brass pieces used in the construction of the bridge.

employed with the exception of the formula which becomes

$$X = C\left(\frac{1000 - bz}{bz}\right)$$

The impedance of an audio frequency transformer winding may be easily determined by the use of the slide-wire bridge. First, it is necessary to know the resistance of the winding which can be obtained in the foregoing manner. Second, the inductance must be measured which is also done with the aid of the bridge. Assuming the measurement of inductance to have been

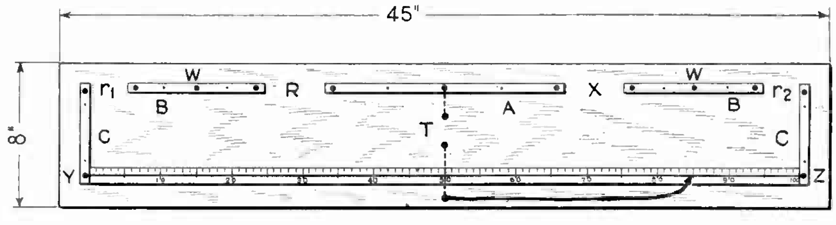


FIG. 4

Details of the base board for the slide-wire bridge on which the brass pieces and scale are mounted.

accomplished at approximately 1000 cycles the reactance of the transformer winding under test may be calculated from the formula

$$X = 2 \pi f L$$

In which f is the frequency (in this case 1000 cycles)

L is the inductance as measured by the bridge.

$\pi = 3.1416$

Now, knowing the resistance and the reactance the impedance is calculated from the formula

$$Z = \sqrt{R^2 + X^2}$$

In which Z is the impedance in ohms.

R is the resistance as measured.

X is the reactance.

The standards for use with the slide-wire bridge may be either purchased from one of the manufacturers specializing in these products or made by the experimenter himself. The resistance standards must be accurate in their value of resistance, possess a low temperature coefficient and be practically non-inductive. The inductance and capacity standards must also be accurate and capable of holding their values of inductance and capacity respectively over an indefinite period. For resistance standards several of each of the following units will be necessary: 1, 10, 100, and 1000 ohms. Insulated resistance wire is available in various sizes which may be wound on bobbins to give, as near as one can calculate, the resistance desired. Half of each coil must be wound in one direction and the other half in the opposite direction in order to minimize self inductance. After they are wound and impregnated with wax they may be taken or sent to a commercial laboratory and their actual values of resistance determined and carefully noted. The writer has found that the resistance units used for commercial purposes as manufactured by several of the large electrical companies have a fairly low temperature coefficient and are practically non-inductive as far as the average experimenter is concerned. These, of course, are actually within only about 10 per cent. of their rated values but if they are carefully checked when purchased and their actual value noted, will act as excellent standards. The most satisfactory arrangement for an inductance standard is probably a well constructed variometer. This may be mounted with a vernier dial and when calibrated with a curve plotted showing the inductance at any dial setting, will serve for most radio measurements. A 1000 micro-microfarad variable air condenser of good construction and low dielectric losses, calibrated as in the case of the variometer, will provide an ideal standard of capacity.

Where greater precision is desired as in the case of a commercial laboratory, the slide-wire bridge is usually calibrated before being put into service. In deducing the formula for the bridge, it was assumed that the bridge wire was divided into 1000 parts of equal resistance and that the readings obtained from the scale correspond to these divisions. To make sure that the scale readings do thus correspond to the bridge wire it is necessary to calibrate the wire. Two well-adjusted resistance boxes are inserted in the R and X arms of the bridge and the instrument operated in the usual manner. Supposing 500 ohms are put in each box, then the balance point theoretically should fall on the point marked 500 on the scale. If it does not, but falls a distance, e, below 500, then e is the correction which must be added to the reading observed in order to obtain the true reading. In the same way the true location of the points for 100, 200, 300, 400, 500, 600, 700, 800 and 900 may be found. The combined value of the two boxes is usually kept at 1000 ohms. With a curve plotted for these values the correction for any point on the scale may be read directly from the curve. The corrected readings are expressed in thousandths of the bridge wire including the resistance of the connecting straps.

From Out the Dust

The Story of the Processes Involved in Vacuum Tube Socket Manufacture

*By F. C. Trimble**

TO all appearances the vacuum tube socket is a lowly product. One buys it and installs it in a radio receiver without giving it a second thought. Yet if we analyze the socket, its constituency, its construction, its electrical design, yes, even the contact springs used, this commonplace article is replete with romance and interest.

Let us consider its birth. In Fig. 1, we see the finished product, but what about its origin. "From out the dust" is an appropriate appellation, since the socket is originally a powder. But wait a moment, we have advanced too rapidly. The socket is made of bakelite, hence the first question is "what is bakelite"? We have heard much about its properties, but what is it? The principal ingredients are carbolic acid and formaldehyde, the former being also known as phenol. Readers who have had occasion to encounter the odor of these chemicals, never promise much for their use, since they are odoriferous to the fullest extent of the word. But if the two are combined, mind you two smelly substances, the new product is odorless and tasteless and in the form of a resinous solid. The resulting material is an entirely new substance, possessing altogether new and different chemical and physical characteristics.

In this primary state, bakelite phenol resin does not possess the marvelous properties accredited to the finished product. Moderate heat will soften it and solvents such as actone and alcohol will dissolve it. A short period of exposure to greater heat than is originally required to slightly soften it, will result in the creation of certain chemical actions which will so harden the material, that never again can it be softened, and the solvents which were previously effective are now powerless to act upon it. This bakelite resin is the binding substance used in all bakelite molding materials. This is a definite chemical with distinctive and unwavering properties.

Illustration of a molded vacuum tube socket shell.

The molding material used for making vacuum tube sockets is located under the "wood flour materials" classification. The exact selection of the material is governed by the characteristics desired, and the suitability of the materials for the purpose in mind. One of these characteristics is the coefficient of expansion or the power of contraction when the material is cooled. This property is of paramount importance, particularly when the tube prong holes are molded. If the material contracts more than a predetermined value, the spacing between the holes will be less than is

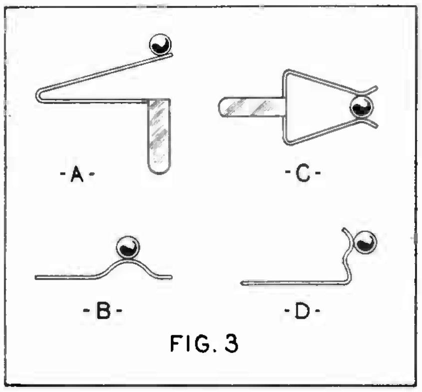
* Engineering Dept., H. H. Eby Mfg. Co., Inc.

required and the socket will be unfit for use. The coefficient of expansion of the materials used for the socket shell illustrated is .00003 per degree Centrigrade, standard temperature being normal room temperature, 68 degree F. or 20 degrees C. The dielectric strength varies from 300 to 500 volts per mil. and the dielectric constant is approximately 4.5.

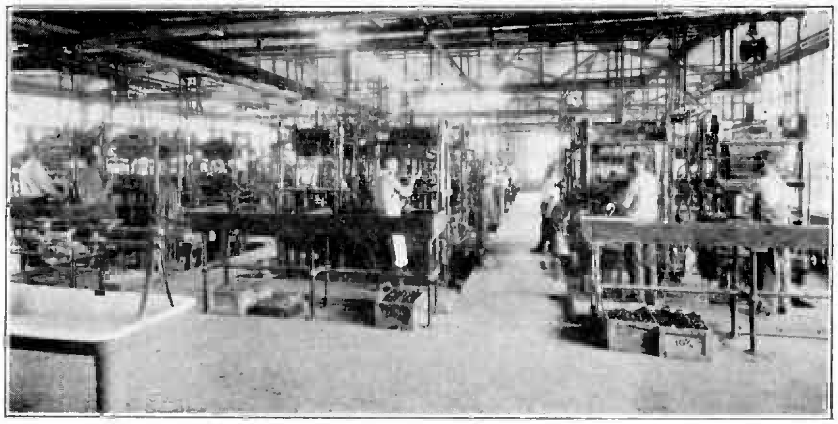
Forming the "Biscuit"

The socket in its original state is a copper colored powder. A predetermined amount of this powder is placed into what is known as a "preforming" machine. This machine compresses the "charge" to form a "biscuit" or "tablet." The shape of this "biscuit" usually is governed by the shape of the finished product. The biscuit has an average volume of 1.5 times that of the finished product. The powder placed into the preforming machine is cold and is compressed cold under a pressure varying between 8.000 and 10.000 pounds per square inch. A photograph of the "biscuit" making machine is shown in Fig. 2.

The biscuit is then placed into the mold, which is heated to a temperature of approximately 356 degrees F. by means of steam, which is fed to the molds through heavy asbestos covered pipes. The steam is caused to circulate around the mold, thus heating it to the correct temperature. After the heat has been applied for the correct length of time, the steam is turned off, and cold water is caused to circulate around the mold, chilling it to the proper temperature. This process of molding affords a more accurate method of controlling the contraction of the molded subject, because it is within the mold during the contracting process. By utilizing this type of manufacturing machinery, standard uniformity of the manufactured product is obtained. After the mold is sufficiently chilled the flow of water ceases, the mold is opened and the socket shells are removed. Each socket shell is then tested with a gauge and a tolerance of .002 plus or minus is allowed on all dimensions.



Various forms of spring metal contacts for vacuum tube sockets.



A view of the molding department in the plant of a vacuum tube socket manufacturer.

Automatic Control of Operations

The human factor encountered in the operation of the molding machinery, plays a very minor part. The flow of steam and the flow of water are automatically controlled, as to temperature and quantity. The possibility of overheating or underheating the molds is completely eliminated. Gauges are used to indicate the temperature and the pressure, which usually averages about 2,000 pounds per square inch of horizontal surface of the mold.

The socket when it is first removed from the mold, is devoid of all metal substances, but is in a state ready for the clips, contact springs, bushings or whatever metal units are associated with it. The mounting holes, tube prong holes and contact spring cavaties are all molded in one operation.

Contact Springs

This brings up the subject of contact springs. The engineering department of this organization expended a great deal of time experimenting with various types of contact springs prior to the selection of the type used, hence a short discussion of this phase of socket manufacturer will not be amiss. It will bring to light why certain types of springs fail after a certain period of operation.

Prior to the selection of the contact spring shown in Fig. 3-A, a great number of experiments were conducted with contacts of the type shown in Fig. 3-B, -C and -D. Every one of the last three developed a weakness after a certain period of operation. The faults were due to cumulative effects. In some cases the tube prong when in place was acting against the spring action at the spring point, as in Fig. 3-B. In 3-C the contact between the socket contact spring and the tube prong is limited to one very small point and in 3-D the spring action of the contact spring against the tube prong is very weak. The contact selected, Fig. 3-A, affords excellent advantages. First it permits full length side wiping contact between the tube prong and the socket contact spring. Second, being of spring phosphor bronze and with a long leverage action, the pressure of the tube prong does not weaken the spring tension.

The physical design of the socket is of interest, particularly so with respect to what must be done to the molds to produce certain effects upon the finished product. Whatever markings are to be produced upon the finished socket must be engraved upon the mold. If any one portion of the socket is smooth and with a polish, the associated part of the mold must be highly polished.

By molding the designated symbols associated with the contacts, on top and bottom of the socket flange, the unit is adaptable with equal facility for baseboard and subpanel mounting.

Half-Billion Dollar Radio Business in 1927

RADIO business during 1927 approximated a half-billion dollars according to a statement by R. A. Klock, Chairman of the Statistical Committee, Radio Division, National Electrical Manufacturers Association.

This and other estimates are based on information compiled from a survey of the radio stocks in the hands of dealers throughout the country. The information was gathered by direction of Marshall T. Jones, Chief of the Electrical Equipment Division, Bureau of Foreign and Domestic Commerce in cooperation with the NEMA Radio Division. The average radio dealer did a business of $11,000 in 1927, according to the interpretation of the returns.

Loud-speaker, socket power units and "A-C" tubes and sets showed a slight increase in this survey, as of January, 1928, in comparison with October, 1927. A slight decrease is to be noted in battery operated receivers, dry cells, and direct current types of radio tubes, according to Mr. Klock.

Radio sets in use today are estimated to be eight million, of which the NEMA committee figures that at least one million are "A-C" tube sets.

A Universal Tester

A Test Meter Which Will Perform Most of the Tests That Are Required in Conjunction With a Radio Receiver

*By Leon L. Adelman**

THERE are at the present time an endless assortment of various types of meters used for test purposes in conjunction with radio receivers and allied apparatus. Each has been designed for a specific function and no doubt fulfills its duty with entire satisfaction. Often, it is possible to use an instrument in a number of different tests, but often, too, it is not possible to use it further, for more complex and intricate tests.

Working on the assumption that one single meter can do as much as three or more, the author, in collaboration with Mr. A. R. Marcy, Chief Engineer of Station WSYR, evolved a circuit which more than exceeded all expectations. In other words, owing to the flexibility of the device regarding the numerous tests that can be made with it, there can be no question but that it will appeal at once to every set builder, service man and radio technician.

What the Meter Will Do

The instrument, in its well-finished cabinet presents a very neat appearance, and since it is small and compact, allows of ready portability, to be carried from place to place without fear of damage or injury to its vital parts.

There are three distinct functions which are performed by the device and these are:

1—Voltage tester: for "A", "B", "C" batteries and for "A", "B", "C" eliminators and trickle chargers.

2—Tube tests: measures the direct plate current consumption of the tube when it oscillates at radio frequency, and thus gives the actual efficiency of the tube in a relative way.

3—Circuit tester: for open, shorted and grounded circuits on coils condensers, transformers, choke coils, rheostats, loud speakers, etc.

The large number of trouble-shooting cases in which the meter will find endless use, is really surprising, for though the subject of trouble shooting is a rather large one, it is quite possible to give an accurate outline of the most general cases.

Then again, the testing procedure involved in obtaining the characteristics of vacuum tubes in order to ascertain the particular use for which the tubes are best suited has been boiled down to a very simple method which has been found to be infallible.

* *Chief Engineer, A. M. Flechtheim & Co.*

Of course, where the laboratory requirements are exacting and severe, it is advisable to use the 'round-about method of finding the amplification constant, the plate impedance. the mutual conductance and other important characteristics. In other words, the meter described in the following paragraphs gives only the information which would be required by the practician and not by the laboratory engineer who is anxious to find out the number of electrons which leave the

Top view of the completed Universal Tester.

filament every second, or to learn the extent of electrolysis taking place in the glass bulb when the tube is operating at definite voltages and frequencies. What it does do, it answers the purpose very nicely, in that it gives in abstract terms—2, 3, 4, 5 or more, the exact relative value of the tube and denotes its particular use as an amplifier for radio or audio frequencies, or as detector.

Any type of tube can be tested—the '99 type, the '01A, the '12, the '71. Herewith is the list of parts required for its construction:

LIST OF PARTS REQUIRED

1—Panel 7¾" x 6 7/16" x ⅛".
1—Combination Meter—0—6 Volts.
0—120 Volts.
0—6 Milliamperes.
1—Voltage Multiplier for Meter.
1—Jack Switch.
1—85 m. h. R. F. Choke.
1—R. F. Transformer.
1—Jack.
1—Standard Socket.
1—50-ohm Rheostat.
1—Filament Resistor, ½ Amp.
1—Cabinet 8½ x 7 x 7⅜.
4—All-Metal Binding Posts.
2—Pearl-head push buttons, ⅝ diameter.
1—Roll of Hookup Wire.
1—Fiber Strip 2½ x 1".
1—Brass Angle "L" 1 x ½ x ½.
1—Brass Strip "L" 3" x ½ ½".
1—Phone Plug.
3—Single Flexible 6' Phone Cords (Spade tips at one end and plug tips at the other).
1—By-pass condenser, 1 mfd.
1—Small Knob for Rheostat.

Construction

The panel is laid out according to the constructional drawing of Fig. 1.

The large holes are cut either with an extension bit or else with a small scroll or coping saw. This task too, must be done with pains-taking care, else the mistakes will prove costly.

The meter is fastened in place by three small machine screws and nuts. The push buttons are forced into their holes, fitting snugly. The binding posts are locked tightly and the rheostat, the phone jack and the cam switch are mounted in the single-hole mounting manner. Two machine screws hold the socket in place.

What parts are not mounted on the top of the panel, are fastened to it on the under side. In a word, all the parts are placed together in one single unit, making the device very compact and adaptable for quick check-up.

When the instruments have been placed on the top of the panel, the radio frequency inductance coil, the radio frequency choke coil and the 1 mfd. by-pass condenser are mounted by means of the fiber strip and brass strip respectively. The filament resistance unit is attached to the under side of the panel by means of a small machine screw.

It will be noted from the illustration of Fig. 3 that the multiplier for the meter is held in position by means of the connecting wires which pass through its central core. Thus, all strain is taken off the coil connections and accidental breakage of the fine wire leads from the multiplier resistance, is prevented.

Soldering lugs have been provided for every terminal, so that all connections and joints can be properly soldered. No mechanical means of making an electrical connection should be made, for continued handling may loosen these connections and give cause for trouble.

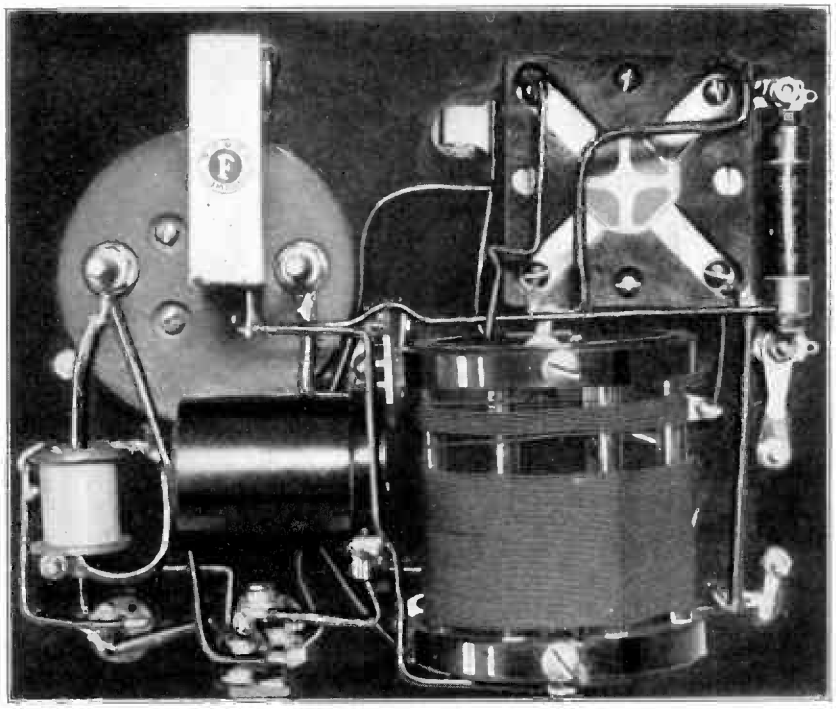
The parts have been arranged so as to provide the shortest leads consistent with proper disposition. The finished instrument is illustrated in Fig. 2.

Precautions

Before the instrument is placed into service the wiring should be checked and as a final precaution, rechecked. This will avoid needless spilling of tears when the meter is accidentally burned out by a nice fresh "B" battery because the multiplier had been left out of the proper circuit, or else by the loss of a seemingly perfect tube due to some incorrect connection.

As the instrument is wired, it is impossible to do any damage to it or to any instrument connected with it, if the proper procedure is followed. Only familiarity with the circuit will prevent accidents to expensive parts.

The panel has been engraved with the letters "A" and "B." These denote the "A" and "B" battery connections. Since the meter range is 6 volts for the "A" battery and up to 120 volts for the "B" battery, never use more than these potentials connected to their respective binding posts. Otherwise, the inevitable happens and you are the only one to be held accountable. If in doubt as to the output voltage of a "B" eliminator, test it step by step, that is, by measuring the detector voltage, then, the amplifier and finally the power amplifier voltage, if you believe it safe. Otherwise, test the voltage output between terminals and add them together to obtain the total. This is really the better test, and since the meter is a rather sensitive one, any fluctuations in the supply can be noted quite readily.



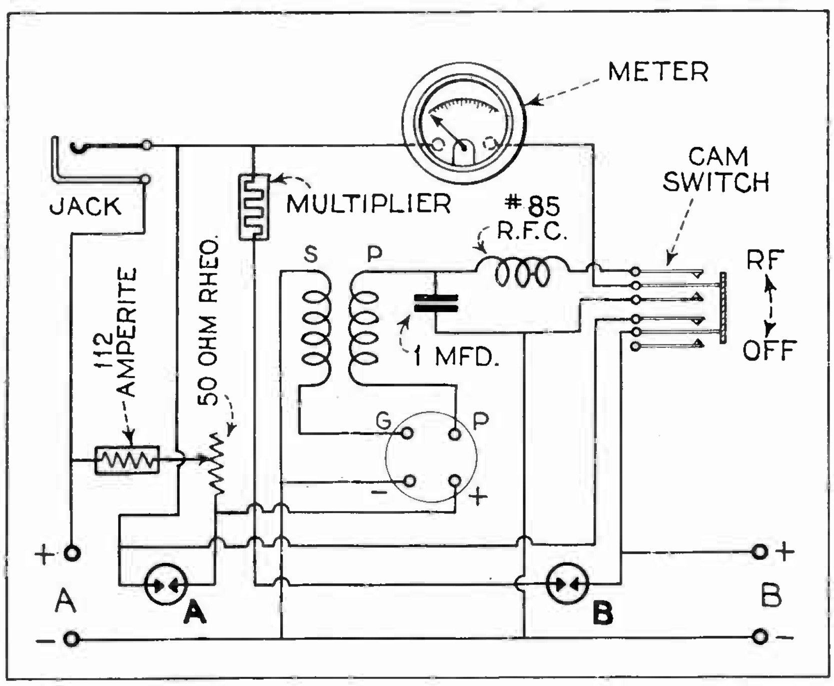
Interior view of the Universal Tester showing the special coil, the R.F. choke, the automatic filament control, the voltage multiplier, etc.

In this manner, "A", "B" and "C" voltages from batteries or eliminators can be ascertained with accuracy. However, make sure that you do not reverse the polarities of the voltage supply leads to the terminals. The author finds that the needle pointer develops a powerful kick which results in a badly bent pointer. The marked leads of the telephone cords plainly show the polarity and should not be disregarded or forgotten when making connections.

Since the meter has full scale deflection of 6 volts and 6 milliamperes, it is easy to understand that at 6 volts, the meter consumes 6 milliamperes and thus the resistance of the meter must be 1000 ohms.

Following the same line of thought, the resistance of the multiplier, in order that the full scale reading of the meter be 120 volts, is 19,000 ohms.

It will be seen, therefore, that the meter consumes very little current and is thus capable of giving a very accurate measure of the voltage output of an eliminator or trickle charger.



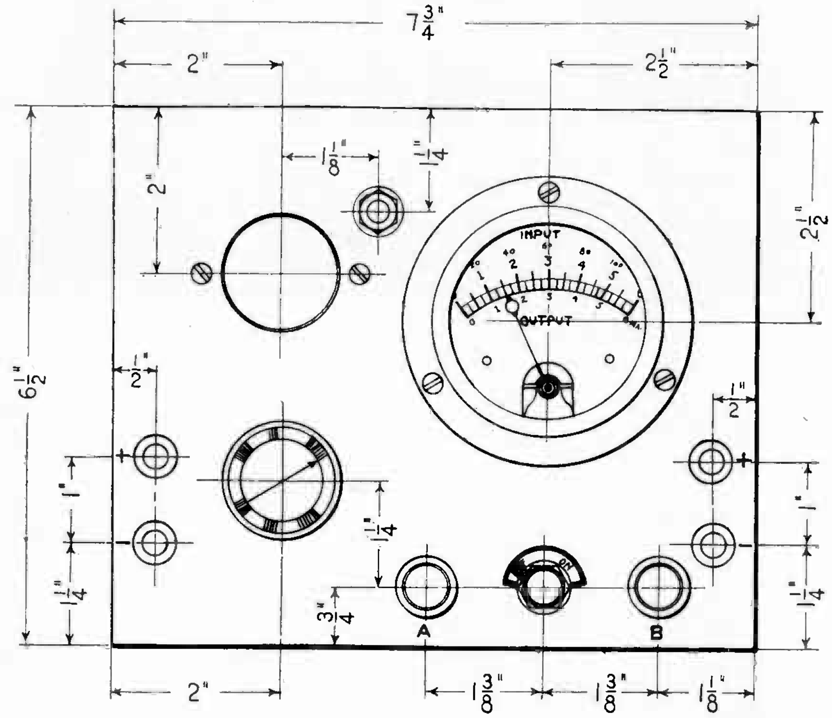
Schematic diagram of the Universal Tester. Note that a voltage multiplier is used in connection with the combination voltmeter and milliammeter.

Testing Tubes

Tubes can be tested quickly, accurately and safely. Let us first consider the type '99. First connect a source of filament supply to the "A" terminals on the tester. Either 4 or 6 volts can be used. However, be sure that the rheostat is in the "off" position.

Keep in mind to use 45 volts on the plate of the tubes when testing them. If a higher potential is employed, say 90 volts, the tube may be found to be so exceptionally good, when tested for radio frequency oscillations, that the needle of the meter may go off the scale. Besides, the curves plotted for tubes with 45 volts on the plate will, of course, be different from those using 90 volts.

Therefore, connect 45 volts of "B" battery potential to the "B" terminals. Place the tube in the socket. (Use an adapter, if it is the old type.) Then turn on the rheostat slowly, keeping your finger pressed down on the "A" push button and with your eyes on the pointer of the meter. You will notice the needle start to move very slowly at first and then accelerate with every small increment in filament voltage. Stop turning the rheostat when the needle points to 3.5 volts, for that is the correct filament operating potential for '99 type tubes. Then take your finger off the "A" push button and press the "B" push button, merely to ascertain the proper plate voltage for the tube. When the upper scale of the meter has been read and found to be 45 volts, the direct current input characteristics of the tube have been met with. The grid return of the tube has been made to the negative side of the "A" battery, making the circuit more difficult of oscillation and putting the tube to a harder test than if the grid return



Construction details for the panel of the Universal Tester. All necessary dimensions are given.

were made to the positive side of the "A" battery.

It will be noticed too, that no grid leak and grid condenser are used, nor even a condenser across the secondary of the radio frequency inductance.

These conditions have a tendency to enhance the severity of the test, so that if the tube oscillates under these conditions, it certainly will work properly when placed in a regular radio circuit, be it the radio frequency amplifier, audio frequency amplifier or detector circuit. Just where, or in what position the tube will function best, will be taken up shortly.

Now, when it has been ascertained that the tube is properly fed with the required voltages, do not touch anything else, but turn the cam switch to its "on" position. Note the meter reading. It should be anywhere from 1.5 to 2.5 milliamperes.

If the reading is very low, the tube is evidently a poor one and should not be used as radio frequency amplifier or detector. Even as an audio frequency amplifier it may not function with much success, but if it must be used, it should be placed in the audio frequency amplifier circuit, preferably the first stage.

However, the low reading may be due to the fact that the tube is not oscillating. This condition may result from an improper connection of the plate coil in the oscillatory circuit. Try reversing the leads to the plate coil and then take the R. F. reading. Whether the tube is oscillating can quickly be determined by placing a finger on the grid terminal of the inductance coil or socket. The meter reading should fall off appreciably when the finger is placed on the high potential post. If it doesn't, then one can be reasonably sure that the tube is not oscillating.

One thing must be kept in mind, and that is—it is possible to increase the R. F. reading by increasing slightly the filament potential. Yet, it must also be remembered that an increase of ten per cent in filament potential results in a marked decrease in the life of a tube. Thus, if the filament potential is adjusted to 5.5 volts for a type 01-A tube, it may be found that the plate current may be increased to half again or more, than when operating the tube at 5 volts.

If, therefore, it is desired to use the tube in a radio receiver, to obtain the best results, it will be necessary to turn up the filament rheostat. Unless the tube is controlled by a separate rheostat, the other tubes may suffer because of the overloaded condition under which they are forced to operate. This results in a distinct loss, for the tubes soon lose their efficiency and the reproduction from the receiver is affected.

When, of course, the tube is controlled by an automatic filament device sufficient volume or amplification cannot be obtained because the emission from the filament is too low. Hence, the best place for such a tube is in the first stage of audio amplification, after which a stage of power amplification can be used.

The radio frequency choke coil and by-pass condenser augment the chances for self-oscillation in the circuit and keep the radio frequency currents out of the meter and batteries. This insures accurate tube characteristic readings.

The wave-length at which the tube is made to oscillate is approximately 130 meters. The inductance of the secondary winding together with its self or distributed capacity which is extremely low, because of the exceptionally fine construction and design of the inductance, afford the high frequency conditions (about 2,300,000 cycles) at which the tube responds. As this value of oscillation is far greater than that at which the tube will be called upon for any broadcast range reception, the tube is tested in a manner that is positive and thoroughly definite in every respect.

Since the meter range is but 6 mils, and since the type '12 tube makes a very good detector tube when operated at the proper characteristics, do not connect 90 volts of plate current to test the tube, because the needle pointer of the meter may run off the scale too far and get badly bent. Rest assured that if the tube proves to be a good detector, it certainly will operate very efficiently as an audio amplifier.

Here is a chart which gives all the information concerning the tubes most generally used and what should be expected from them when tested by the meter, using a plate potential of 45 volts.

	Milliamperes			Input Characteristics Filament	
Type	Poor	Good	Very Good	Volts	Amps.
199	1.5	2.0	2.5	3.5	.06
200-A	1.0	1.5	1.7	5.0	.25
201-A	3.5	4.0	4.5	5.0	.25
112	5.0	5.7	6.0	5.0	.50
*171	3.0	3.2	3.5	5.0	.50

* *Only 22.5 volts on plate.*

It will be noted that 45 volts of "B" battery potential has been used for testing all the tubes, even though some require more and others less. However, the values of the R. F. readings as given in the above chart have taken this into consideration and represent the results of averaging together the readings found during the testing of a large number of the various types of tubes. Thus, one has the means of ascertaining the actual value of a tube and for what purpose it should be used in a radio receiver circuit.

Samson DeLuxe Power Amplifier

By Perry S. Graffam

INTELLIGENT forecasters of radio development last year predicted that this year would be a power year as far as audio amplification is concerned. Events to date would prove that they are right for the -10 type of tube has come into its own. No one starts to talk about real quality reproduction with any sort of volume unless they are speaking of a high voltage power job.

The new feature of power work this year, however, is the utilization of the push-pull idea using these excellent tubes. In other words, since the equipment for high voltage was being purchased, could we not get the utmost out of it and use a push-pull combination? The amplifier we are about to describe has been designed as an answer to this question and after listening to it the reader, we feel sure, will agree it is an effective answer.

This unit has been developed to a point where it is extremely flexible permitting its use in a number of ways. For instance, it can be used with an electro-magnetic phonograph pickup which will give remarkable reproduction of the new electrically cut phonograph records, equalling the results obtained with talking machines selling at $500 and above.

The completed Samson De Luxe Power Amplifier which employs a 210 push-pull unit as the output stage.

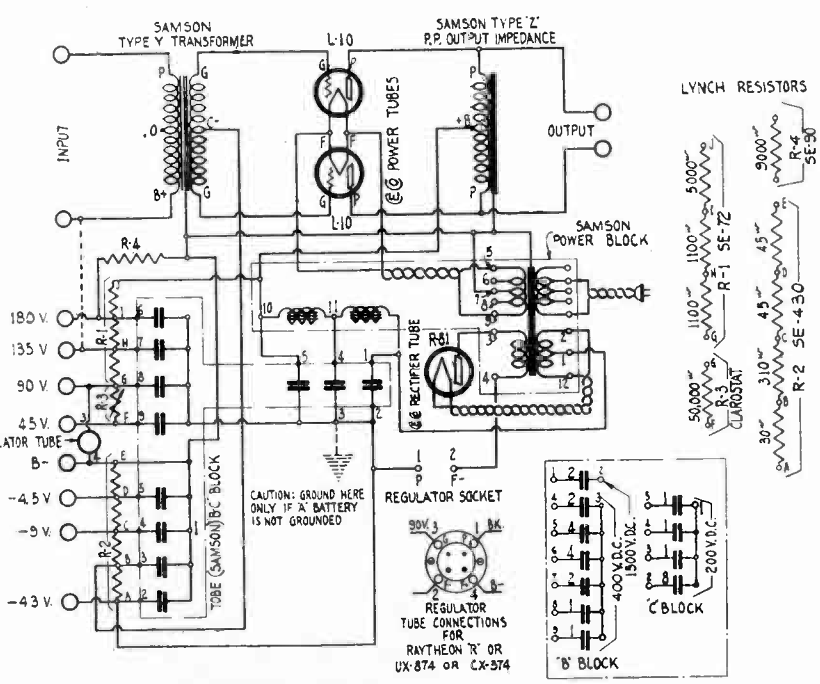
For detecting distortion or overloading in an amplifier the use of a milliammeter is recommended. This should be connected in series with the plate return of the last two power tubes, that is, the connection which comes from the middle of the output choke. A Jewell 0-100 milliammeter should be used.

Excellent control of voltage is achieved by the use of a Clarostat. Many devices of this sort use fixed outlets for plate supply but it has been the experience of the writer that for maximum results a variable voltage device is desirable, especially when a unit may be used with several different types of receivers.

Tubes are an important factor in any radio receiver and even more so in power amplification work. Ceco tubes have been used throughout in the experimental models and good results obtained. The new design of power and rectifying tubes have a large margin of safety.

In addition to the variable voltage supply there is a fixed supply which is taken care of by a specially designed voltage regulator tube. This will give a constant voltage of 90 regardless of the amount of drain from its particular tap.

This amplifier is extremely simple to build due to the compact design of the Samson power units which have most of the connections made inside of the cases, greatly reducing the amount of external wiring. Acme Celatsite wire is used as it is flexible and has a thoroughly proven and tried insulation. This is an important point, for in dealing with high voltages the insulating



Complete schematic diagram and explanatory details of the Samson De Luxe Power Amplifier. This unit will supply the "B" and "C" voltages for the receiver and the first A.F. stage.

material must be of the very highest grade.

A Celoron panel is used for mounting this amplifier and in order to strengthen it as well as give it a much better appearance, reinforcing strips are fastened around by the edges. The base panel is 14 by 24 by ½ inches. Two other pieces of Celeron ½ by ½ by 14 and two pieces ½ by ½ by 24 inches should be obtained.

The necessary holes may now be drilled along the edge of the panel for screwing on these last mentioned reinforcing strips. These also act as legs, raising the panel a half inch from the table so that sub panel wiring may be easily carried out if it is desired.

Having assembled all the parts they should be mounted in their respective positions as shown in the illustration. Holes should then be drilled for mounting these parts. All holes should be drilled so that they can be tapped with a 6/32 tap for smaller objects and an 8/32 tap for the transformer and condenser blocks.

To make a really professional looking job it is advisable to mount the General Radio sockets as follows:

Cut out the sub panel to permit the top of the socket to extend through, and then fasten the socket on the underside of the panel.

LIST OF PARTS REQUIRED

1—Samson No. 210 Power Block.
1—Samson Symphonic Push Pull Combination (Type Y transformer and type Z impedance).
1—Tobe Deutschmann special Samson "B" Block for 210 power supply.
1—Lynch SE-430 Tapped Resistor.
1—Lynch SE-72 Tapped Resistor.
1—Lynch SE-9000 Tapped Resistor.
4—General Radio UX-349 Sockets.
1—American Mechanical Lab. Power Clarostat. 200 to 100,000 ohms.
12—Eby Binding Posts.
50—Feet Acme Celatsite Flexible Hook-up Wire.
2—Ceco L-10 Power Tubes.
1—Ceco R-81 Rectifier Tube.
1—CX-874 Voltage Regulator Tube.
1—Celoron Panel, 14"x24"x½".
2—Celoron Strips, ½"x½"x14".
2—Celoron Strips, ½"x½"x24".
Miscellaneous Hardware.

The "All-Wave Electric 9"

By R. E. Lacault

THE main features incorporated in the R.E.L. 9 receiver, described in the February issue of *Radio News*, are, first; complete electrification without any hum, and without the use of complicated balancing arrangements in the circuit. Second; great sensitiveness, due to the use of the "modulation" system originated by the author and used in his previous designs. Third; selectivity sufficient to separate stations only 10 kilocycles apart, without distortion. The set is capable, for instance, when operated in New York City, of receiving station WSM on 880 kilocycles at the same time that WLS on 870 kilocycles is operating, with WGBS, a local station, on 860 kilocycles going at the same time. Fourth; the sensitiveness is even all along the broadcast-frequency band. Fifth; plug-in coils are used in order to permit the reception of short-wave broadcast or amateur stations on the set proper, without any external adapting devices. The change of wave-length is accomplished by merely changing the coils. Sixth; a high-quality audio amplifier is incorporated into the receiver, producing marvelous quality.

The quality and volume are enhanced by the use of of a push-pull amplifier in the second audio stage, which will be described in the April issue of RADIO ENGINEERING. This permits the reception of a band or orchestra with full volume and with excellent quality. All those who have witnessed demonstrations of the R.E.L. 9, when using a good loud-speaker, were amazed at the truthful reproduction possible with this amplifier arrangement. The power supply and push-pull amplifier are built as a separate unit and may be used with any other receiver; a feature which should be of interest to those owning more than one set. It is possible, by merely plugging the output of the receiver into the input of the power unit, to operate the loud-speaker from any set and get the full volume and all the advantages of push-pull amplification, in addition to the necessary "B" and "C" voltages.

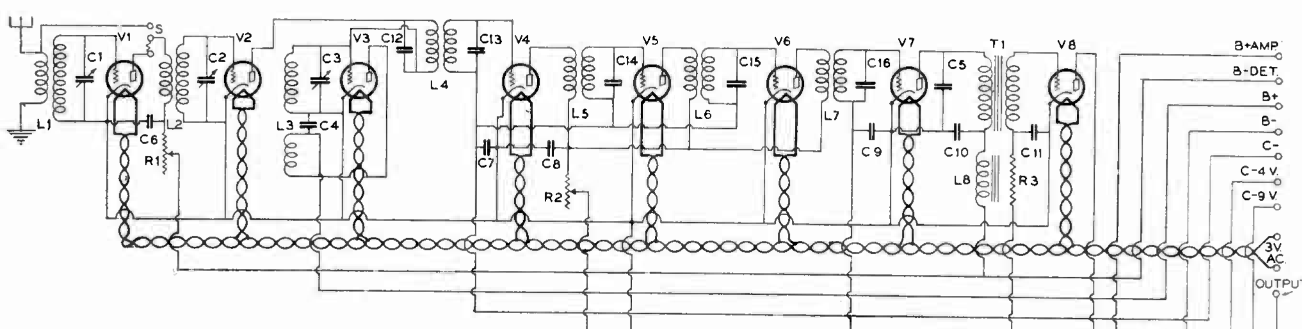
The radio-frequency part of the set is shielded, and drum dials are used for the control of the tuning condensers. The tuning is extremely simple, as only two small knobs are used, in addition to the main tuning dials. One of these is a volume control, and the other a sensitivity control regulating the action of the amplifier. Last, but not least, the set is extremely easy to build and the wiring very simple.

The Modulation System

In the ordinary type of superheterodyne, the first tube employed as a frequency changer is connected like a detector; with either a grid condenser and grid leak, or a "C" battery. This detector rectifies the incoming signal after it has been heterodyned, and the variation caused in the plate circuit is amplified through a long-wave radio-frequency amplifier.

In the system to be described a new principle is made use of; this, which has been called the "modulation" system, causes the incoming signal to modulate the oscillations produced locally, in the same way that the speech modulates the output of the oscillator tubes in a broadcast transmitter. This system, which is a departure from the conventional detector arrangement, is not only simpler, but produces a greater signal strength, which is more noticeable on weak signals.

The first tube, which is called the modulator, is connected across the oscillating circuit of the oscillator. Its plate-filament space is acting as a resistor, the value of which is varied by the incoming signal impressed upon the grid. In this arrangement no "B" battery is necessary; for the plate of



Circuit diagram of the receiver portion of the "All-Wave Electric 9". The power unit and output amplifier stage will be described in the April issue of Radio Engineering.

the modulator tube is supplied by high-frequency current from the oscillating circuit. To receive continuous waves, this arrangemnt is very efficient: and it has been applied very successfully to the receiver described in this article.

Advantages of Modulation

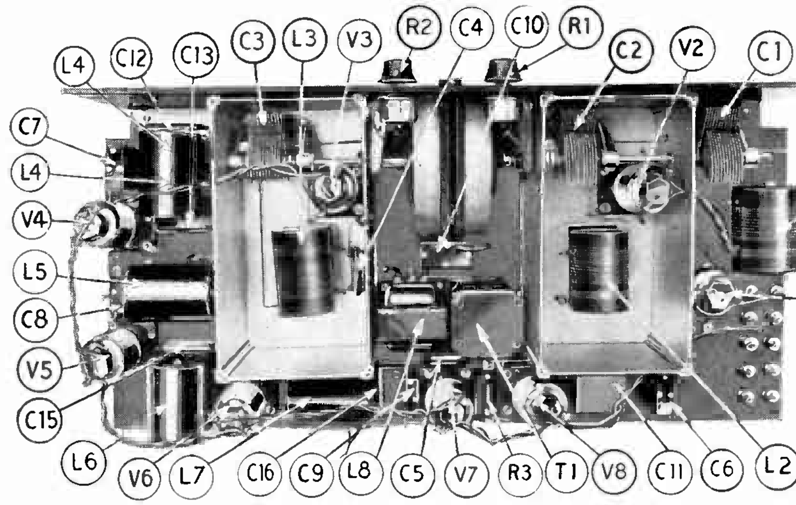
In the modulation system the response is even, for strong or weak signals, and this is what makes it better. Normally, when the set is in operation but no signals are received, the resistance of the modulator tube maintains its average value; but as soon as a signal is impressed upon the grid, the voltage on this grid varies and this, in turn, varies the internal resistance of the tube within wide limits, causing plate-current variations of a much greater order of magnitude than is the case with a regular first detector. At the same time, no matter how small the impressed signal, a response in direct ratio to the impressed voltage is obtained.

Another advantage of this circuit is that the tube, operating with high frequency on the plate, produces better rectification; because the modulated plate current increases from zero to a given value during each of the positive half cycles instead of merely varying from an average value in accordance with the square of the applied voltage as explained above.

In practice it is found that a very weak signal, which is not heard at all or only faintly when a detector is used, is received with good volume with the modulation arrangement.

The R.E.L. 9 incorporates also ahead of the modulator, a stage of radio frequency, which, in addition to increasing the signal strength, sharpens the tuning and prevents stations from being heard at more than one setting on the dial when the dials are revolved simultaneously — as they should when tuning.

In addition the radio-frequency tube, which is controlled by the left upper knob on the panel, may be made to regenerate the signal — which results in tremendous sensitivity on weak signals. When receiving loud signals from local stations the R.F. tube may be controlled to act as a volume control, thereby permitting even and gradual amplification on all stations.



Interior view of the completed "All-Wave Electric 9" receiver, using A.C. tubes. The symbols correspond to those given in the list of parts.

LIST OF PARTS REQUIRED

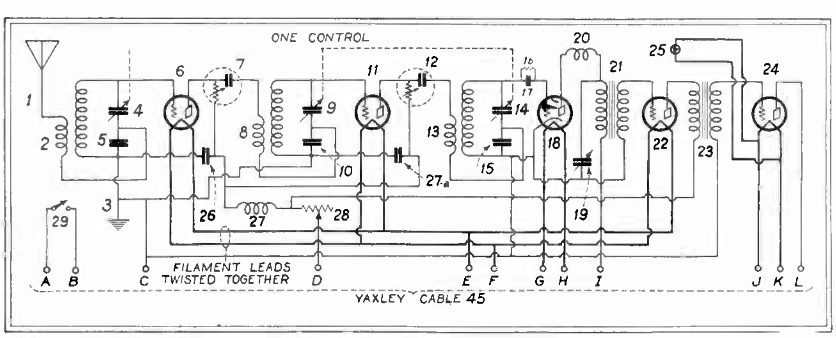
C1, C2, C3 Hammarlund .0005 Mfd. Variable Condensers.
L1, L2 Radio Electric Labs. Type B1 Plug-in Coils.
L3 Radio Electric Labs. Type B2 Plug-in Coils.
L4–7 Radio Electric Labs. Type F Plug-in Coils.
L8 Thordarson Plate Circuit A.F. Choke.
T1 Sangamo 3 to 1 ratio A.F. Transformer.
R1, R2 American Mechanical Labs. Clarostats.
C4 Sangamo .001 Mfd. Fixed Condenser.
C5 Sangamo .002 Mfd. Fixed Condenser.
C6–9 Acme Parvolt 0.5 Mfd. (400 volt) By-Pass Condensers.
C10, C11 Acme Parvolt 1.0 Mfd. (400 volt) By-Pass Condensers.
C12–16 Radio Electric Labs. .00025 Mfd. Matched Fixed Condensers.
R3 Arthur Lynch 100,000 Ohm Fixed Resistor.
1 Arthur Lynch Resistor Mounting (For R3).
1–8 Sovereign Heated Cathode A.C. Tubes.
1 Formica Front Panel, 24"x8" x¼".
1 Formica Sub-base Panel, 25½" x12"x¼".
10 Eby Binding Posts.
2 Aluminum Co. Stage Shields.
8 Radio Electric Labs. Coil Sockets.
2 Yaxley Tip Jacks.
2 Yaxley Tip Plugs.
8 Benjamin UX Tube Sockets.
1 Tyrman Double Drum Dial.
2 Rolls Belden Hookup Wire.
2 Hammarlund Extension Shafts (For C1, C2 and C3).
12 ft. Belden Bus Bar Wire.

The New "A. C. Optimum Five"

By T. B. Rhodes

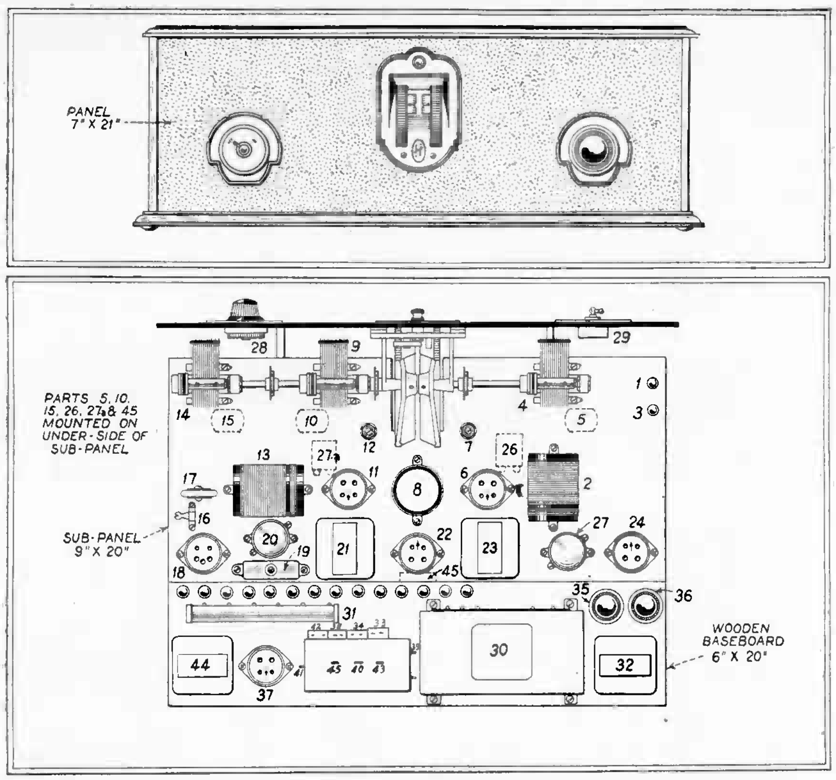
IN designing the new "A. C. Optimum Five," the purpose has been two-fold:—First, to give the set constructor complete details regarding the assembly of a perfected and modern batteryless set; second, to enable anyone who has previously constructed the battery operated "Optimum Five," described in the January issue of RADIO ENGINEERING, to convert this easily to A. C. operation.

An important feature of the "Optimum Five" circuit is the obtaining of constant coupling and hence constant energy transfer at all wave lengths over the broadcast band. This means that the receiver can be operated both at high and low wave lengths and at all intermediate ones at maximum efficiency without special adjustment. The method of obtaining this desirable characteristic consists of a system of electromagnetic and electrostatic coupling between the radio frequency stages. A. C. operation in no way impairs this feature.



Schematic diagram of the "A.C. Optimum Five." A.C. tubes are used throughout.

The circuit details, with the exception of the filament circuit, are practically identical with the original "Optimum Five." Eby sockets are used throughout, the detector socket being of the UY type, designed especially for the 227 five prong detector tube. In the place of the ordinary filament switch a Carter "Imp" power switch is used, as shown at (29) on the diagrams. In wiring the filament circuit, each pair of filament leads should be twisted to prevent A. C. hum. For this reason, those who are converting the original "Optimum Five" to A. C. op-



Layout details of the "A.C. Optimum Five." Note that the power unit extends along the rear of the receiver baseboard and fits into the same cabinet.

eration, will have to remove the old filament wiring, discard the amperites and rewire this portion of the circuit twisting the wires as directed.

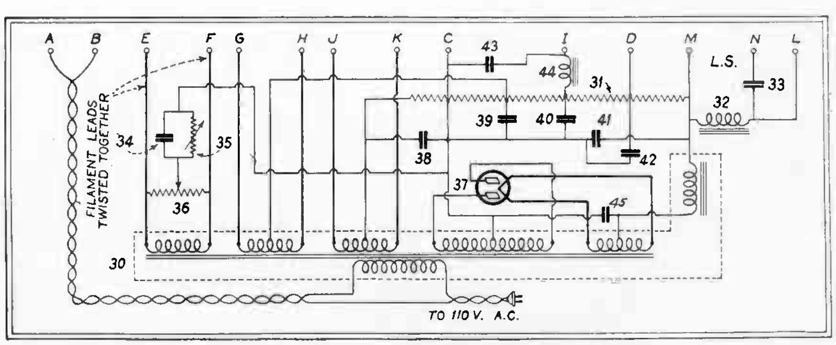
A 13 wire Yaxley cable connector with cable is recommended for the connections between the receiver and the power supply unit. (Note: Only 12 wires will be utilized.) In the place of the 6-ohm rheostat, a 100,000 ohm Royalty resistance is used for volume control, as shown at (28). As an alternative method of volume control. it may be found preferable to shunt this resistance across the primary of coil (2).

The power supply is assembled on a wooden baseboard. This unit may be placed directly in back of the receiver as shown, or it may be located at any convenient point, limited only by the length of the Yaxley cable. The ends of the cable are connected to 12 Eby binding posts. The loud speaker terminals may also be connected to binding posts or two Yaxley "Pup" jacks may be used for this purpose.

In order to obtain best results with the new A. C. tubes the power transformer must be designed with exactness so as to meet the specifications of the tube manufacturer. The new Jefferson Electric combination filament and plate supply transformer is one of the most efficient power transformers obtainable. It has an output voltage of 1.5 volts for the 226 tubes with a capacity of from one to six tubes and a maximum output current of 7 amperes. For the detector tube, it has a 2.5 volt winding having a maximum output of 2 amperes. As the 227 tube is not critical as to filament voltage no variable resistance is required for voltage control. Since a separate heater element is used on the detector tube, the grid return is not at all critical. Hence it is possible to use a center tap on the transformer winding for this purpose. The center tap is connected to "B" plus 45 thus giving a negative bias to the cathode. Referring back to the 1.5 volt winding, this has no center tap, inasmuch as the 226 tube is quite critical with respect to filament voltage and grid return. In the place of the center tap, a 10-ohm Yaxley rheostat is used as a potentiometer (36) by soldering a connecting lug at the open end of the resistance winding. In this way it is possible for the grid return to be brought to the point of exact potential balance of the filament voltage. The negative grid bias is secured by means of the 2000 ohm Royalty resistance connected between the mid-tap of the potentiometer and "B" minus. This resistance is shown on the diagram at (35). A variable resistance is used so that it may be adjusted for variations in plate voltage. It requires no further adjustment, however, once it has been correctly set. The Jefferson Power transformer also contains a 5 volt center tapped winding for supplying two power tubes with a maximum current output of one ampere.

LIST OF PARTS REQUIRED

2—Sangamo Audio Transformers, type "A" (21. 23).
3—Precision R. F. Transformers, type 4 D (2. 8. 13).
3—.0005 Mfd. Hammarlund "Mid-Line" Variable Condensers (4, 9, 14).
3—Hammarlund Insulated Flexible Couplings.
1—Hammarlund Drum Dial with panel light (25).
2—Hammarlund R. F. Chokes, type RFC-85 (20, 27).
1—X-L Variodenser, type G-1 (19).
4—Eby Sockets, new style (6, 11. 22, 24).
1—Eby Socket, UY type (18).
2—.004 Mfd. Sangamo fixed Condensers tested to within 5% (5. 10).
1—.004 Mfd. Sangamo fixed Condenser (15).
1—.00025 Mfd. Sangamo By-Pass Condenser (17).
1—2 Meg. Durham Metallized Resistor Grid Leak with Vertical M't'g (16).
2—Electrad Phasatrols (7. 12).
2—½ Mfd. Acme "Parvolt" series "A" cubical condensers (26. 27-a).
1—Electrad Royalty Variable Resistance type "B" (28).
1—Carter "Imp" Power Switch (29).
2—Eby Engraved Binding Posts (1, 3).
1—Yaxley 13-Wire Cable, complete with Connector Plug and M't'g Plate (45).
2—Rolls Acme Celatsite Wire.
1—Can Kester Radio Solder (rosin core). By the Chicago Solder Co.
1—Panel, 7"x21"x3/16".
1—Sub-Panel, 9"x20"x3/16".
2—Brackets, low type.
3—"Speed" super emission tubes, type SX-226 (6, 11, 25).
1—"Speed" super emission tube, type SY 227 (16).
1—"Speed" super emission tube, type X 171 (24).
1—Jefferson Electric Combination Filament and Plate Supply Transformer (30).
1—Ward Leonard Vitrohm Resistor No. 508 -1 (13).
1—"Speed" full wave rectifier tube, SX 280 (37).
1—Eby socket, new style (37).
1—Sangamo type "E" Output Impedance (32).
1—Sangamo type "F" Plate Impedance (44).
12—Eby Engraved Binding Posts.
1—Acme "Parvolt" 2 Mfd. Condenser (33).
1—Acme "Parvolt" Microfarad Reservoir, type R-210 (41-4 Mfds.) (40, 43, 45 -2 Mfds. each) (39-1 Mfd.)
3—Acme "Parvolt" 1 Mfd. series "A" cubical condensers (34, 38, 42).
1—Yaxley 10-ohm rheostat, to be used as a potentiometer (36).
2—Yaxley "Pup" Jacks (M, N).
1—Electrad Royalty Variable Resistance type "F" (35).
1—Roll Acme Heavy Celatsite Wire.
1—Wooden baseboard, 6"x20"x¾".



Schematic diagram of the power unit designed for the "A.C. Optimum Five." This unit supplies all the necessary "A", "B" and "C" voltages.

The Electrified Everyman Four

THOSE who build the Electrified Everyman Four will find in this receiver the same simplicity of control, economy of parts, and good quality reproduction that has made the battery operated set so popular. The electrified set is essentially the same as that using D.C. tubes: the only additional parts used are those necessary for the successful operation of a receiver with A.C. tubes. The simplicity and efficiency of this four-tube receiver is the result of using one stage of balanced tuned radio frequency amplification with tuned impedance coupling to the detector, so that both the plate circuit of the radio frequency tube and the grid circuit of the detector tube are tuned with the same variable condenser. Increased sensitivity is obtained by regeneration which is easily controlled with the .00005 Mfd. condenser shown in the center of the panel. Then follows two stages of high quality transformer-coupled audio amplification with a 171 power tube and an output transformer in the last stage.

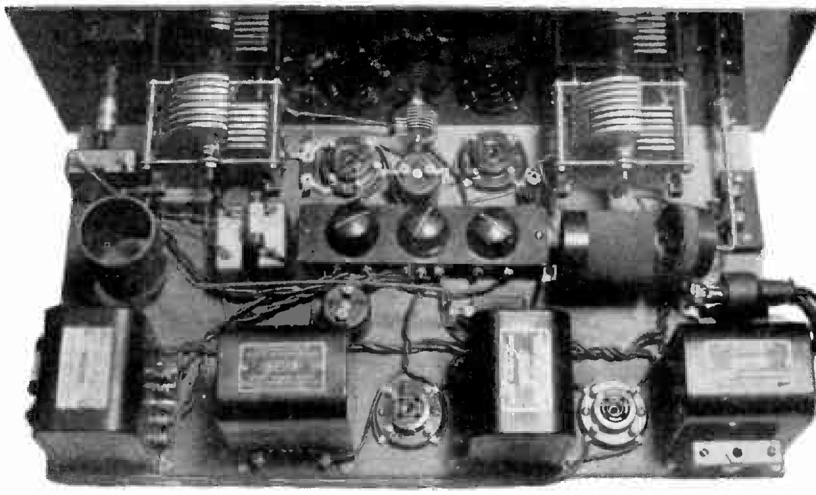
The radio frequency and audio frequency amplifying tubes are those using alternating current directly on the filaments and are the 226 type tubes requiring 1.5 volts for operation. The detector tube is the 227 heater type with five prongs requiring from 2.0 to 2.5 volts for operation. The last tube requires about 30 seconds to warm up after the switch has been turned on.

The ½ ohm and 1½ ohm rheostats and 30 ohm potentiometer are mounted on the A.C. control panel shown in the center of baseboard layout. The 1½ ohm rheostat is used to control the voltage across the terminals of the 227 tube while the ½ ohm rheostat controls the filaments of the 226 tubes. The 30 ohm potentiometer is used to balance out the hum in the 1.5-volt tubes. When the rheostats have once been set for most satisfactory operation and the potentiometer adjusted to minimum hum, it will not be necessary to give these controls any further attention. For this reason they are not mounted on the front panel.

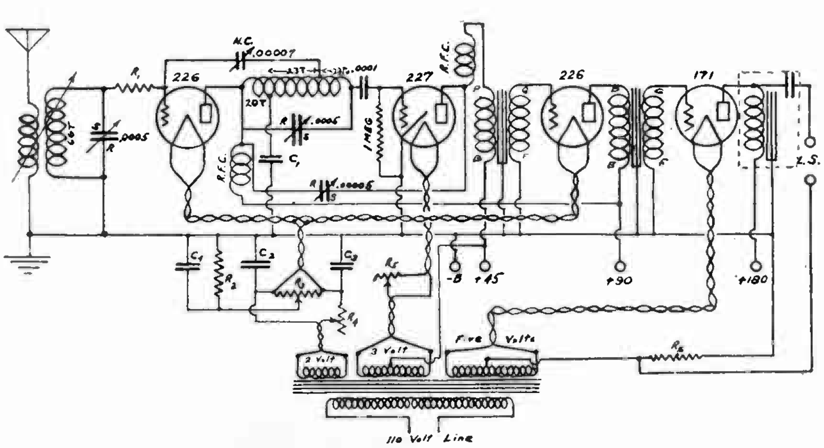
The A.C. receiver takes up no more space than the battery operated set while the space required for accessories is considerably less since a B power unit is the only additional part required for the operation of the A.C. receiver. The 2000 and 750 ohm resistors provide the C-bias so that no C batteries are required. The filament supply transformer is mounted on the base with the set, eliminating the necessity of additional space for the A supply.

With the exception of the filament circuits and a few other wires, the wiring is almost the same for both A.C. and D.C. receivers.

Interstage coupling is reduced to a minimum by using care in the wiring and placing of the parts. The coils are well spaced to prevent any coupling through their fields, and each coil is placed close to its own tuning condenser so that the leads from coil to condenser may be kept as short as possible. It is always well to keep wires carrying radio frequencies short and apart from all other wires, since this very materially assists in making a set both selective and sensitive. The low resistance resulting from short wires and the absence of capacity between wires, thereby making the receiver easier to balance, are important factors in this set. The connections of the radio frequency amplifier are made principally above the base, separating them from the other wiring under the base. Particular care must be used in the wiring to prevent any other wires from running parallel and close to the twisted filament supply wires. Any wires running parallel to the twisted A.C. wires should be spaced at least ½ inch from them.



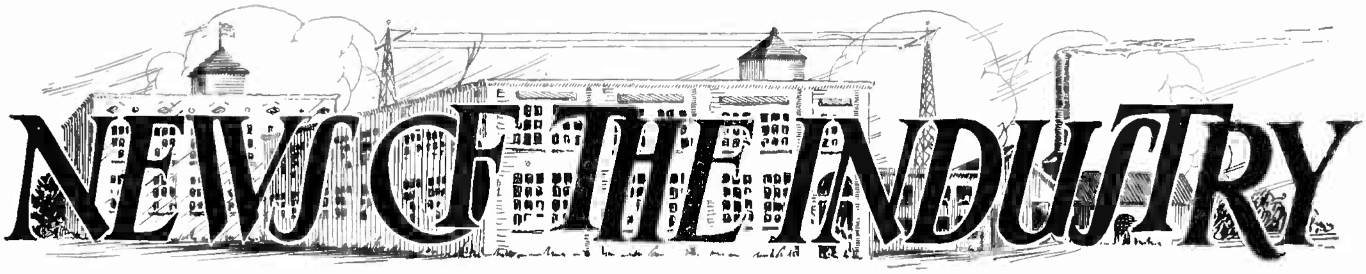
Top view of the completed Electrified Everyman Four. Note that the two inductances are mounted at right angles to each other. All A.C. filament leads are twisted pairs.



Schematic diagram of the Electrified Everyman Four, using A.C. tubes.

LIST OF PARTS REQUIRED

1 Muter No. 3300 Supreme A.F. Transformer, first stage
1 Muter No. 3320 Supreme A.F. Transformer, second stage
1 Muter No. 2700 Clarifier-Output Transformer
1 Muter No. 3710 One Megohm Heavy Duty Grid Leak
1 Muter No. 800 Grid Leak Mounting
1 Muter No. 301 .0001 Mfd. Moulded Bakelite Condenser
3 Muter No. 507 .5 Mfd. By-Pass Condensers
1 Muter No. 508 1. Mfd. By-Pass Condenser
2 Muter No. 2750 Radio Frequency Chokes
1 Muter No. 1900 Variable Balancing Condenser
1 Muter No. 2305 ½ Ohm Power Rheostat
1 Muter No. 2315 1½ Ohm Power Rheostat
1 Muter No. 2331 30 Ohm Potentiometer
1 Muter No. 2902 2000 Ohm Power Resistance Unit
1 Muter No. 2975 750 Ohm Power Resistance Unit
1 Muter No. 2950 500 Ohm Power Resistance Unit
1 Muter No. 3600 A.C. Filament Transformer
1 Muter Binding Post Strip, 1" x 6" x ⅛"
1 Muter A.C. Bakelite Control Panel, 2" x 6" x ⅛"
1 Muter No. 1650 Power Switch
2 Muter .0005 Mfd. "Camfield" Condensers
1 Muter 50 M-Mfd. "Camfield" Midget Condenser
1 Twin Coupler Co. 17" x 21" Micarta Panel, Drilled and Engraved
1 Twin Coupler Co. set of "Everyman 4" Coils
3 Benjamin No. 9040 Cle-Ra-Tone Sockets
1 Benjamin No. 9036 5-Prong Socket
7 X-L Binding Posts
1 Fritts Baseboard (20½" x 10" x ¾")



Van Doorn Opens Eastern Sales Office

The Van Doorn Company, of 160 No. LaSalle Street, Chicago, Ill., have announced the appointment of Mr. John C. Hindle as eastern sales representative of the Van Doorn Company.

Mr. Hindle is supervising sales work on radio and special metal products from the new sales office at 100 Fifth Avenue, New York City.

Peerless Announce Staff Additions

To keep pace with the rapidly increasing number of its customers, The United Radio Corporation, makers of

Captain F. W. Piper, Western Sales Manager, United Radio Corp.

Peerless Reproducers, have announced the appointment of the following able and experienced men to their organization.

Captain F. W. Piper will be Sales Manager in charge of the Western District with headquarters in Chicago. Captain Piper was formerly associated with the Amplion Corporation of America as Sales Engineer, having been associated with them since their inception.

H. C. Goodrich, formerly field representative for the King Manufacturing Corp., will be district representative in the Middle West covering the states of Michigan, Ohio, Indiana and Iowa.

Milton C. Bickford also of the Peerless Sales Staff will be the district representative for the South Atlantic States.

These men will work with wholesalers and retailers assisting them in increasing their sales and merchandising radio.

Majestic Increases Manufacturing Facilities

The Grigsby-Gruno-Hinds Company, of Chicago, Ill., makers of the Majestic line of radio products have just leased the property of the Yellow Truck and Coach Manufacturing Company in Chicago.

The Grigsby-German-Hinds Company has just completed an addition to their original plant at 4540 Armitage Avenue which doubles the facilities of this plant. The two Armitage plants will be known as plants No. 1 and No. 2 and the Yellow Coach property will be known as Majestic plants Nos. 3, 4, 5 and 6. The floor space of the Majestic Organization available for manufacturing purposes now totals nearly a half-million square feet.

Hartzell Sales Company Moves

The Hartzell Sales Company, with headquarters formerly at 50 Church Street, New York City, have moved their principal office to 508 South Dearborn Street, Chicago, Ill.

Bosch Appoint New Director of Sales

The American Bosch Magneto Corporation of Springfield, Mass., announce the appointment of Mr. Frank B. Goodman as Manager of Sales in the Radio Division. Mr. Goodman was formerly with the Souora Phonograph Company in a similar capacity. His headquarters will be at Springfield.

Empire Company Moves

The Empire Electrical Products Company, formerly located at 132 Greene Street, New York City have moved to 141 Wooster Street, New York City where they have incrased plant facilities for the manufacture of their cone speakers.

The Empire Electrical Products Company, along with several other well-known companies, has been licensed to manufacture loud speakers under the Himmer patents.

Thordarson Appoints H. P. Manly as Sales Manager

Mr. C. H. Thordarson, President, has just announced the appointment of Mr. H. P. Manly as sales manager for the Thordarson Electric Manufacturing Company. Mr. Manly entered the Thordarson organization in the early part of 1924. His services in directing sales of Thordarson transformers to manufacturers and the trade will begin immediately.

The sales policy of the company will remain unchanged.

Air-King Co. Enlarges Plant

The Air-King Products Company, 222 Grand Street, Brooklyn, New York, have increased their facilities to

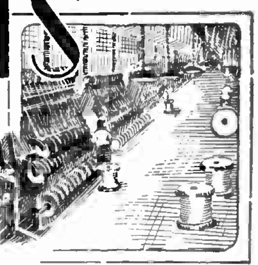
H. C. Goodrich, Midwest Sales Representative, United Radio Corp.

handle the manufacture of special type inductance coils for manufacturers. They also have a department specializing in short wave and transmitting coil types.

New Westinghouse Catalogue

Publication of the 1928-1930 catalogue of Electrical Supplies of the Westinghouse Electric and Manufacturing Company has just been announced. This catalogue presents the electrical and mechanical features and application information for all supply apparatus and appliances manufactured by the Westinghouse Company, and in addition describes and illustrates a representative list of large motor and generating apparatus.

NEW DEVELOPMENTS OF THE MONTH



The New UX-250 Super-Power Amplifier Tube

A still larger and more powerful amplifier Radiotron is announced by the Radio Corporation of America. It is designated as the UX-250 Power Amplifier Radiotron, and is capable of delivering over three times as much undistorted energy as the UX-210.

R.C.A. UX-250 Super-Power Tube.

The UX-250 is considerably larger in size than the UX-210, although its base is identical. The filament of the UX-250 is of the improved coated ribbon type, which insures great mechanical strength and long operating life. The plate, which is blackened, is tall and narrow, as in the UX-281 rectifier tube. The standard UX or push type base is used.

This new tube will provide a far greater loud-speaker volume, without distortion, than has heretofore been possible, especially in conjunction with auditorium loud-speakers and in the operation of a plurality of loud-speakers from a common amplifier, as in hospital and exposition work. It is interesting to note that while the plate voltage has not been materially increased over that of the UX-210, the required plate current is three times as great as for the UX-210. Obviously, while the new tube is capable of enormous volume—far more than can be utilized in the largest of living rooms—it is unnecessary to operate it at full output. Instead, it may be employed at but a fraction of its full capacity, thus securing undistorted output at all times with ample reserve power. It is this reserve of power which gives that character to reproduction often referred to as "depth" or "timbre."

The characteristics of Radiotron UX-250 are as follows:

	Recommended				Maximum	
Plate voltage......	250	300	350	400	450	Volts
Negative grid bias.	45	54	63	70	84	Volts
Plate current......	28	35	45	55	55	Milliamp.
Plate resistance (a-c)	2100	2000	1900	1800	1800	Ohms
Mutual conductance	1800	1900	2000	2100	2100	Micromhos
Voltage amplification factor......	3.8	3.8	3.8	3.8	3.8	....
Maximum undistorted output....	900	1500	2350	3250	4650	Milliwatts

Filament........ 7.5 volts 1.25 amperes
Maximum overall. Height 6¼" Diameter $2\frac{11}{16}$"
Base............ Large RCA Standard UX

When used as a transmitting Radiotron the UX-250 is rated at 25 watts as against the 7½-watt rating of the UX-210. As a power amplifier tube the maximum undistorted output of the UX-250 is 4650 milliwatts (4.65 watts) as against 1540 milliwatts (1.54 watts) for the UX-210, 700 milliwatts for the UX-171, 195 milliwatts for the UX-112-A, and 110 milliwatts for the UX-120 dry-battery power tube.

Samson Phonograph Amplifier

The Samson Electric Company, of Canton, Mass., are now manufacturing a completely assembled Phonograph Amplifier of distinctive design.

The amplifier is complete in itself in that it supplies all of the "A", "B" and "C" voltages required for its operation.

The Samson Phonograph Amplifier employes a one stage transformer coupled audio frequency amplifier, utilizing a 227 type A.C. tube which feeds into a push-pull amplifier with a transformer input and an impedance output. This stage employs two 210 power tubes.

Each amplifier is supplied with three feet of heavy rubber-covered cable and a line voltage variation input plug.

The units composing the amplifier are sealed in metal containers which in turn are secured to a metal chassis. There are no exposed connections from which a person using the amplifier could receive a shock.

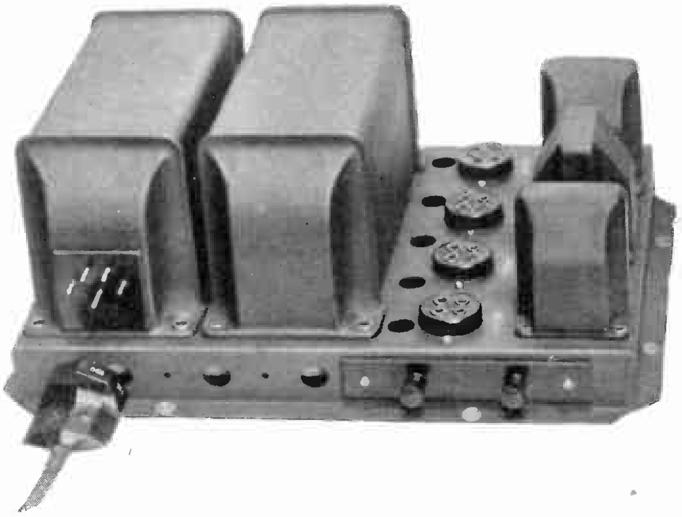
The overall size of the amplifier is 15⅛"x11¼"x6⅜", not including height of tubes, and the approximate weight is 35 lbs. The total overall height of the amplifier with the tubes in the sockets is approximately 7¼".

It is practical to adapt this amplifier to radio receivers as well.

Marathon A.C. Kit

The Northern Manufacturing Company, of Ogden Street, Newark, N. J., are now manufacturing four A.C. kits using a new type Marathon A.C. tube. These new A.C. kits include a special filament lighting transformer in a pressed metal case, with a toggle switch and extension cord; a milti-

The Samson PAM type push-pull phonograph amplifier which employs one 227 A.C. tube and two 210 power tubes. A 281 half-wave rectifier is used in the power unit.



wire adapter cable, a volume control and the special Marathon A.C. tubes.

It is claimed by the manufacturer that the Marathon A.C. tube is a new development and is self-biasing.

The Marathon A.C. kits are made for 5, 6, 7 and 8 tube radio sets. Each kit is completely wired up and ready to install. It is an easy matter to convert any battery operated receiver over to complete A.C. operation.

Rola Model 20 Speaker

The Rola Company have announced their new Table Cabinet Model 20 Loud Speaker which is now in production.

The Rola Model 20 Table Speaker.

The new Rola reproducer unit employs the same type of laminated armature used in other models of the Rola speaker.

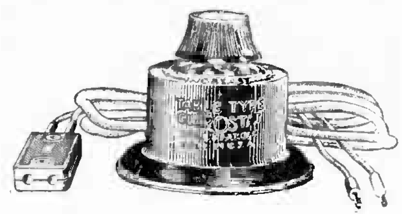
It is claimed that this new speaker has a response range on the average set from 70 to 5,000 cycles. It is also stated that the Model 20 Speaker is free from periodic resonances due to an accurately adjusted friction dampening of the air-waves behind the cone; and this dampening combined with the constructional features of the cabinet cause the instrument to radiate sound waves as though from a baffle three or four feet in diameter.

The speaker is equipped with a filter to suppress tube distortion and parasitic noises. The Model 20 Speaker is finished in hand-rubbed walnut, stands 11¼″ high, has a width of 11¾″ and is 6¾″ deep.

Table Type Clarostat

Providing precise variable resistance in the form of an accessory rather than as a radio part, together with sufficient current-handling capacity for reliable and long-life operation, the Table Type Clarostat, manufactured by the American Mechanical Laboratories, 285 N. 6th St., Brooklyn, N. Y., has a wide range of applications in radio and laboratory work.

Briefly, the Table Type Clarostat comprises a micrometric variable resistor of from zero to 500,000 ohm range, mounted in a neat metal stand.



The New Table Type Clarostat.

together with two flexible conducting cords provided with standard cord tips as well as a connection block to take the usual loud-speaker cord tips. The metal case is handsomely finished in nickel and bronze, with a neat bakelite knob to complete the attractive appearance of this accessory. The bottom is provided with a soft felt pad to protect the finest furniture.

There are various ways in which the Table Type Clarostat may be employed. First of all, it may be employed as a through connection, with one cord to the receiver and the other, by means of the connection block, to the loud-speaker. Again, it may be employed to cut in resistance in any given circuit, by using just one cord, since the resistance is shunted across the cords.

The Table Type Clarostat provides an ideal volume control for the usual loud-speaker, either alongside or as a remote control. It may be employed as a volume control for electric phonographs. It may be used in connection with A-C tube harness.

Yaxley Full Automatic Power Control

The Yaxley Manufacturing Company, 9 South Clinton Street, Chicago, Ill., have introduced a very clever Full Automatic Power Control which is designed to perform a double purpose.

Yaxley Full Automatic Power Control.

First, it controls the switching of the "B" eliminator and charger, or either, when the filament switch of the set is turned on or off. When the set is turned on, the "B" eliminator is cut in and the charger cut out. The reverse is true when the set is turned off. Second, when the battery is fully charged, the full automatic power control cuts out the charger.

The Full Automatic Power Control consists of two relays—one with a low resistance to control the switching of the "B" eliminator and charger and the other with a high resistance to cut out the charger when the battery is fully charged.

It is stated that the relays are made to have a good strong pull and as a result they are not affected by vibrations encountered in service.

By means of a special resistance, voltage drop is held to less than two-tenths of a volt on sets having a current draw of 2¾ amperes or less.

This unit is primarily designed for use with a high rate charger, though it works equally well with chargers of the trickle type.

General Radio 2,500 Ohm Rheostat

The General Radio Company, of Cambridge, Mass., have brought out a 2,500 ohm rheostat to meet the need for a high variable resistance for obtaining bias voltage from a "B" eliminator, thus doing away with the usual "C" batteries.

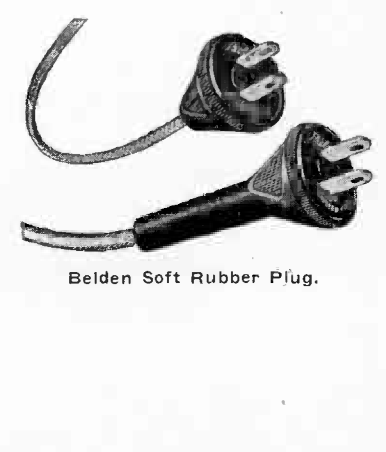
General Radio 2,500 Ohm Rheostat.

This 2,500 ohm rheostat, known as the 214-A, is identical with other General Radio type 214 resistors. The power rating capacity is 12 watts and the current carrying capacity 70 milliamperes.

The New Belden Soft Rubber Plug

The Belden Manufacturing Company, 2300 S. Western Ave., Chicago, Ill., have added to their cord department a new and remarkable Soft Rubber Plug. This plug is a distinct advancement in electric plug design and can be used to great advantage for household appliances, office and store equipment, portable shop tools and all other devices using a plug.

The Soft Rubber Plug is ruggedly constructed of solid soft rubber. It



Belden Soft Rubber Plug.

can be dropped. knocked about or jumped upon without injury. It is shaped to form a convenient grip for the fingers when plugging-in or pulling out, and is attractive in appearance. The insulating qualities make it ideal for use in damp places and the soft rubber construction makes it highly desirable for washing machines, mangles, toasters, percolators, and all other devices which require a nonbreakable plug for uninterrupted service. The plug is made in different shapes for various uses.

The Belden Soft Rubber Plug is sold only as a part of Belden Cord service and is furnished attached to their many varieties of cords. Cords with plug attached are furnished in 10, 20 and 50 foot lengths.

A Hookup Wire Kit for A. C. Receivers

The Belden Manufacturing Company, 2300 South Western Avenue, Chicago, announces the addition of an A.C. Wire Kit to their extensive line of radio wire accessories.

Belden A.C. Hookup Wire Kit.

The Colorubber A.C. Wire Kit, as it is called, smooths the path of the custom set builder in constructing an alternating current receiver. The Kit consists of a black twisted pair of Colorubber Insulated Hookup wires for the 1½ volt filament circuit, a yellow twisted pair for the 2½ volt filament circuit, a red twisted pair for circuits of five volts or more, and a coil of green Colorubber Hookup Wire.

Conductors are flexible tinned copper. A cotton serve inside the Colorubber insulation makes stripping for soldering easy.

Durham Grid Suppressors

A Grid Suppressor must, to accomplish its purpose, be as nearly free from inherent inductance and capacity as possible. If a measurable amount of inductance is present it is almost certain to affect the circuit as well as to nullify the advantages of the use of a grid suppressing resistance.

In this connection, the International Resistance Company, manufacturers of Durham resistors, have developed low range resistance units of the

Durham Grid Suppressor.

values of from 250 ohms to 3000 ohms which are not of the wire wound type but of the Metallized Filament type, consequently, entirely free from any inductive or capacitative affects.

New Burl Walnut Celoron Radio Panels

A beautifully designed Burl Walnut Grain, for Radio Panels, has been announced by the Celoron Company, of Bridgeport, Pa. This announcement is made in conjunction with their announcement of a new grade of Celoron known as Grade 10-R which has exceptional electrical and mechanical qualities. This combination gives a beautiful panel, practically free from surface leakage and with great mechanical strength, making it possible to use a thinner piece of material than has been possible heretofore.

Tobe Radio Interference Filters

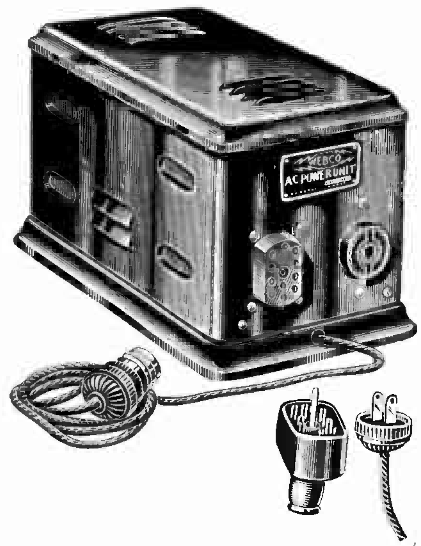
The Tobe Deutschmann Company, 11 Windsor Street, Cambridge, Mass., have introduced two new Radio Interference Filters. These filters are designed for the purpose of eliminating electrical interference from electric motors and electrical machinery employing small electric motors or make-and-break contacts.

Tobe Interference Filter.

The Tobe Radio Interference Filter No. 1 is designed to take care of motors up to ¼ H.P. Radio Interference Filter No. 2 is designed to take care of motors up to 5 H.P.

Webster A.C. Power Pack

The Webster Company, 850 Blackhawk Street, Chicago, Ill., have gone into production on their new A.C. power pack. This unit provides all the necessary A. B and C voltage for any type of receiver using standard A.C.



Webster A.C. Power Pack.

tubes. Sufficient grid bias can be obtained from this unit for a 171 power tube.

Webster Bone-Dri "A" Eliminator

The Webster Company, 850 Blackhawk Street, Chicago, Ill., also manufacture an "A" eliminator, known as

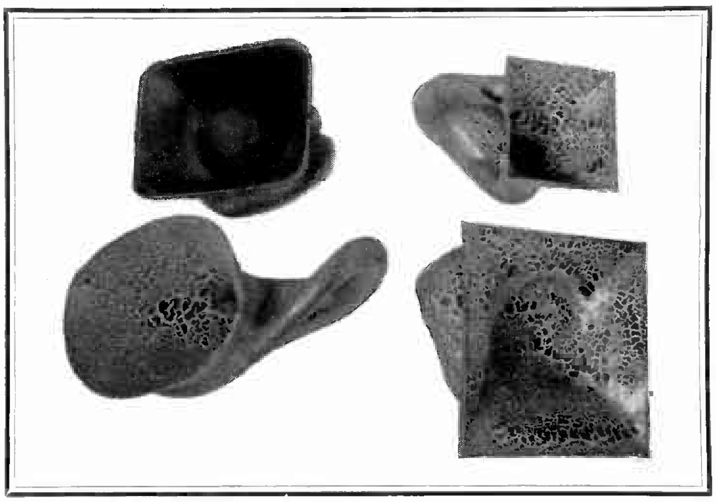
Webster Bone-Dri "A" Eliminator.

the Webster Bone-Dri A-10 which will supply current to the extent of 2½ amperes at six volts, for lighting the filaments of the standard type battery tubes.

The rectifier used in this "A" eliminator is of the dry disc type.

ANNOUNCING

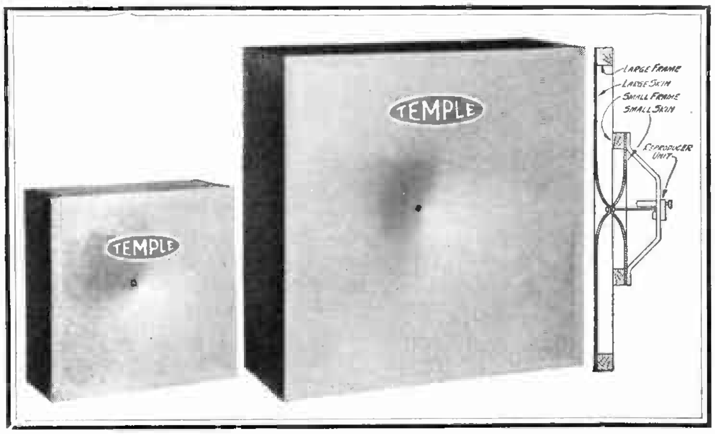
New Manufacturers' Models



OF CONSIDERABLE importance to manufacturers and engineers is the announcement that new light weight Temple Air Column Speakers are now available in many shapes and sizes — in models that will fit every standard cabinet dimension. Each of these models has been designed by Prof. P. G. Andres, and are correct exponential designs for maximum response. They cover a wider frequency band than heretofore.

The Temple patented process of manufacturing exponential air columns, which is responsible for the brilliancy of reproduction, has been employed in these new light weight models.

Temple Speakers

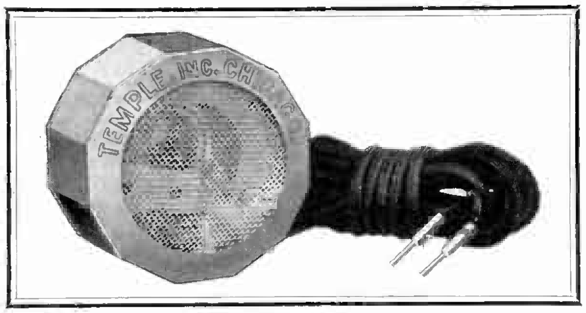


Temple Air Chrome Speakers

Announcement is also made that Temple, Inc., have secured a license under the Whitmore air chrome invention, and are ready to supply manufacturers with Temple Air Chrome speakers of the balanced tension open radiator type similar to illustration. Any size is available to meet manufacturers requirements.

These speakers are particularly applicable to high quality audio systems, made possible by the use of power tubes.

Double Action Units



A number of special manufacturers' types of Temple Double Action Units are available depending on the output tubes used and the frequency requirements to best operate between the audio system and the air column.

Laboratory equipment is available to make complete tests to determine the proper unit with your receiver together with its application to the correct air column.

Write for engineering data and prices.

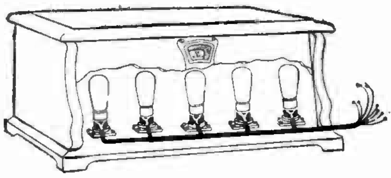
TEMPLE, INC., 1925 S. Western Ave., Chicago, Ill.

LEADERS IN SPEAKER DESIGN

The output of the "A" eliminator is controlled by a small knob on the front of the case. Two tip jacks are provided so that a voltmeter can be plugged in if desired. A standard receptacle is mounted on the front of the case and is intended to accomodate the "B" eliminator plug. A push switch on the end of long cord turns on and off both the "A" and "B" units.

Corwico A.C. Adapter Harness

The Cornish Wire Company, 30 Church Street, New York City, are now marketing a new A.C. Adapter Harness which enables one to convert practically any battery set into an electric receiver without any re-wiring.



Corwico A.C. Adapter Harness Installed in Set.

The Corwico A.C. Harness is made in two types, one type for use with R.C.A. and Cunningham type '26 and '27 A.C. tubes and another type for use with the Arcturus A.C. tubes which have 15 volt filaments. "Briadite" wire is used in these Harnesses.

By connecting the Harness to any standard step-down "A.C. filament" transformer and inserting the A.C. tubes, the battery operated set is changed into an A.C. receiver, the plate and grid connections of the original circuit remaining unchanged. A volume control is supplied with each Harness.

Acme ABC Converter

The Acme Electric and Manufacturing Company, of 1444 Hamilton Avenue, Cleveland, O., are now in production on their new ABC Converter designed for use in connection with

Acme ABC Converter.

sets using A.C. tubes. The ABC Converter is built in two models; one to operate with the R.C.A. or Cunningham A.C. tubes and the other model to be used with the Arcturus tubes. The transformer of the "A" unit has a 1½ volt winding which will accomodate five 226 type A.C. tubes; a 2½ volt winding which will carry one 227 type A.C. tube and a 5-volt winding designed to supply filament current for one 171-A or one 112-A tube in the last stage of the receiver.

The "B" power unit delivers 40 milliamperes at 180 volts and uses a 280 type full wave rectifier tube. A "C" voltage tap of negative 45 volts is also furnished to provide the necessary "C" bias for a 171-A tube.

United Electric Pick-Up

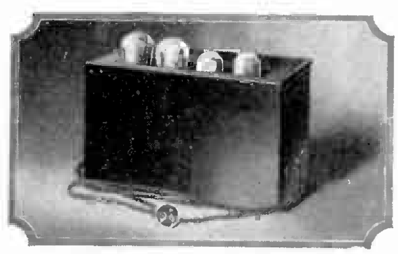
The United Air Cleaner Company, of 9705 Cottage Grove Avenue, Chicago, Ill., are marketing an electro-magnetic phonograph pick-up which can

United Electric Phonograph Pick-up.

be used in connection with any type of phonograph. A special tone arm is supplied with the pick-up and can be obtained in gold, silver, or bronze finish.

United Tone Amplifier

The United Air Cleaner Company are also manufacturing a special audio amplifier to be used in connection with



United Tone Amplifier.

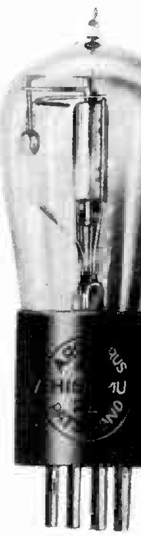
their electro-magnetic phonograph pickup. This amplifier is of the 3-stage resistance coupled type and employs two A. C. Hi-mu tubes and a 210 type power tube in the output. The rectifier is of the 216-B type.

The amplifier is entirely self-contained and is designed for 110-volt 60-cycle alternating current.

Arcturus Hi-Mu A. C. Tube

The Arcturus Radio Company of Newark, New Jersey, have added a hi-mu tube to their line of detector, amplifier and power amplifier alternating current tubes.

The addition of a hi-mu tube in the alternating current field greatly enhances the possibilities of A.C operation, admitting to a basis of efficient operation resistance coupled amplifiers and similar receivers requiring hi-mu tubes for best results.



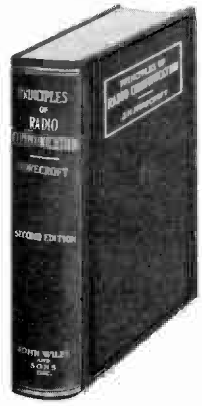
Arcturus Hi-Mu A.C. Tube.

The Arcturus hi-mu tube, type A.C 32, follows the general mechanical and electrical practice of this line of alternating current tubes. The tube is mounted on a standard four prong base plugging into the usual UX socket. The cathode is common with one side of the heater circuit (leading to the plus post on the UX socket) eliminating the necessity of additional side or overhead connections. The tube is of a heater cathode type operating from a 15 volts source, the heater consuming .35 ampere.

The amplification constant of the A.C type 32 tube is 30, the plate impedance 40,000 ohms and the mutual conductance 700 ohms. They are recommended for use with an applied amplifier voltage of 180 and higher, and a grid bias potential of minus 1.5 volts.

Dubilier Tone Clarifier and Filter Unit

The Dubilier Tone Clarifier, made by the Dubilier Condenser Corp., of 4377 Bronx Boulevard, N. Y. C., is in the form of a neat metal case with four binding posts. It contains a special choke coil and a 4 mfd. condenser of 400-volt rating. When employed as an output filter or loud-speaker filter coupler, the output from the receiver or amplifier is connected to two binding posts, and the loud-speaker to the other two binding posts. When employed as an external filter section, such as for additional filtering for the detector plate circuit in reducing hum to an absolute minimum as well as overcoming a most common cause of motor-boating, only three binding posts are used. In this manner there is introduced a high-grade choke coil in series with the plate supply, with a 4 mfd. condenser between the plus B and the minus B, for extreme filtering.

RADIO  BOOKS

Let Radio Engineering Assist When You Are Adding to Your Technical Library

See offer at foot of this advertisement

FOR SERVICE MEN AND PROFESSIONAL BUILDERS

Another addition to the RADIO ENGINEERING Book Family is "Modern Radio Reception" by Charles R. Leutz. Although this book has been made as non-technical as possible with mathematical equations confined to simple examples, it furnishes a wealth of servicing and construction data of a practical nature. The book contains 383 pages, is well illustrated and sells for $3.00.

ENGINEERING WORKS

RADIO FREQUENCY MEASUREMENTS (out of print until September)	by *E. B. Moullin, M.A., A.M.I.E.E.*	$10.00
THERMIONIC VACUUM TUBE	by *H. J. Van der Bijl, M.A., Ph.D.*	5.00
*MANUAL OF RADIO TELEGRAPHY AND TELEPHONY (out of print until Sept.)	by *Admiral S. S. Robison*	5.50
EXPERIMENTAL ELECTRICAL ENGINEERING (and Manual for Electrical Testing)	by *Vladimir Karapetoff, Prof. EE., Cornell Univ.*	5.00
VECTOR ANALYSIS	by *Joseph G. Coffin, B.S., Ph.D.*	2.50
THEORY OF VIBRATING SYSTEMS AND SOUNDS	by *Irving B. Crandall*, Bell Telephone Labs.	5.00
PRINCIPLES OF RADIO COMMUNICATION	by *Prof. J. H. Morecroft*	7.50

GENERAL PUBLICATIONS

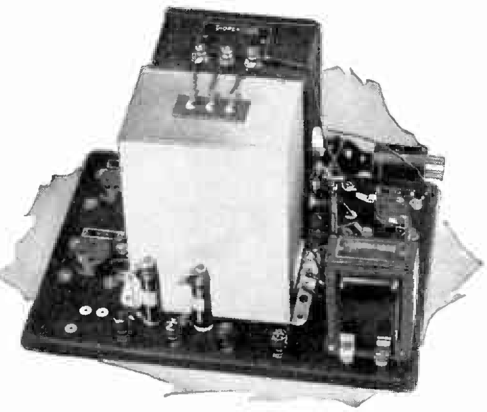
MODERN RADIO RECEPTION	by *Charles R. Leutz*	3.00
PRINCIPLES OF MODERN RADIO RECEIVING	by *L. Grant Hector, Ph.D.*	5.00
PRACTICAL RADIO CONSTRUCTION AND REPAIRING	by *Moyer & Wostrel*	2.00
ELEMENTS OF RADIO TELEPHONY	by *W. C. Ballard, Jr., M.E.*	1.50
WIRELESS PICTURES AND TELEVISION	by *T. Thorne Baker*	2.50

Note.—Radio Engineering will be glad to give information concerning the above works and other radio and engineering books, in which subscribers may be interested

Note: Your subscription, or the renewal or extension of your subscription saves $1.00 toward the purchase price of any of the above publications.

Just add $1.00 to the price listed opposite the book desired. Send check or Money Order to RADIO ENGINEERING, 52 Vanderbilt Ave., New York City, and you will receive a full year's subscription to RADIO ENGINEERING and the book (postpaid) by return mail.

for improved usical performance



THORDARSON

210 Power Amplifier and Plate Supply

Easy to build — Simple to install — Economical to operate — Quiet in performance

Full, rich tonal reproduction with a generous supply of power for the heavier tones. You can bring your receiver up to these present standards of reception by building this Thordarson 210 Power Amplifier and B Supply.

Easy to build. Every effort has been made to make assembly as simple as possible. The metal baseboard is equipped with all sockets and binding posts mounted. All necessary screws, nuts and hook-up wire are furnished complete; simple pictorial diagrams are supplied. You can assemble this unit in an hour.

Simple to install. No changes in receiver wiring are necessary. This amplifier can be attached to set in a moment.

Economical to operate. Highly efficient and cool in operation. Consumes less current than an ordinary 50 watt lamp.

Quiet in performance. The reliability of Thordarson engineering assures you of unquestionable performance and quietness in operation.

Thordarson supply transformers are available for power units using all existing types of power tubes.

For sale at all good parts dealers

Write Today For This Free Booklet

THORDARSON ELECTRIC MFG. CO.
500 W. Huron St., Chicago.

Gentlemen: Please send me free of charge your booklets describing the home construction of power amplifiers.

Name ....

Street and No..

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

3575-K

A Simple Guide for Selecting Resistors

No matter how many claims are made for a resistor, you can always check up on its true worth by finding out who uses that particular make, and how it stands up under the rigid pressure of daily service.

We strongly recommend that you ask any one of the following companies about Harfield Resistors. They are but a few of a great number of concerns now purchasing Harfield Resistors in large quantities.

Stromberg-Carlson Tel. Mfg. Co.	Western Union Telegraph Co.
Crosley Radio Corporation	Sonora Phonograph Co.
American Transformer Co.	Conner-Crouse Corp.
Fansteel Products Co.	Magnavox Corporation
Martin Copeland Co.	Electrical Research Lab's.
Splitdorf Electric Co.	Samson Electric Co.

Tell us about the resistor you want, and let us make up a sample for you with prices. Write to

HARDWICK, FIELD, INC.

Factory **215 Emmett Street, Newark, N. J.**

HAR-FIELD *WIRE-WOUND* **RESISTORS**

Sales Dept. **100 Fifth Avenue, New York City.**

VITREOUS ENAMEL
(FIXED)
RESISTORS
"L M C"

Constant in value. Consistent.

Free from flaws.

Very low temperature co-efficient.

Capable of withstanding considerable mechanical and electrical abuse, including short overload of 100 per cent.

Accurately calibrated.

Non-Hygroscopic. The electric element is thoroughly sealed with special Vitreous Enamel made in our laboratories and fused on under 1400 degrees fahrenheit.

Vitreous Enamel not easily chipped.

Not affected by temperature changes, owing to fact that the co-efficient of expansion of metals and minerals are on a par.

Samples gladly submitted from your specifications.

LAUTZ MANUFACTURING CO., INC.

Electrical Alloy Products—Controlling Devices

245-247 N. J. R. R. Ave., Newark, New Jersey

For the Convenience of our many friends in Engineering and Production Departments, Radio Schools, Radio Clubs, etc., who are sending us Group Subscriptions.

RADIO ENGINEERING,
52 Vanderbilt Ave., N. Y.

Kindly enter the following subscriptions to RADIO ENGINEERING for one year at $1.00.
(This subscription rate applies on 4 or more subscriptions)

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

Name . . . .
Address . . . .
Town . . . . State . . . .

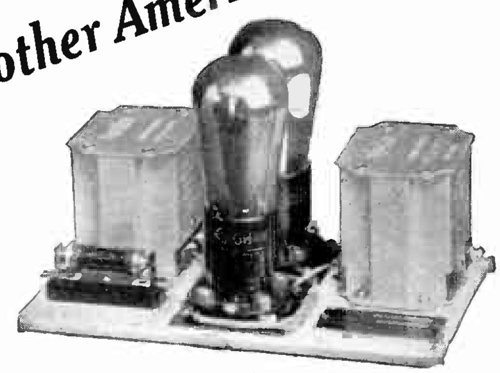
To the attention of Chief Engineers—Laboratory Heads—Service Managers—Plant Executives:

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

WHY NOT START THIS CIRCULATING AS A ROUND ROBIN?

GROUP RATE—$1.00 A YEAR

Another AmerTran Achievement!



A Complete Push-pull Power Stage

Increases Clarity, Reality and Volume

HERE is an AmerTran wired unit which meets the demand for a power stage that may be easily assembled in the average receiver.

It contains an AmerTran type 151 input transformer* wired to two power tube sockets, a 50,000 ohm mounted resistance connected in series with the C— or grid bias lead, and an output transformer of the type required by the combination of power tubes and speaker desired. As in every case, AmerTran has considered all factors before offering a product to the public, and that is the reason for the fine results obtainable with this new power stage. It is designed for specific tubes and speakers, and when used as instructed, will produce a very high standard of performance.

For best tone quality, this power stage should be preceded in the first stage by an AmerTran DeLuxe audio transformer, and the output connected to a high-grade speaker. The parts are firmly secured to a strong metal base, provided with mounting holes and the whole unit is compact and neatly finished. Complete information together with data on other products will be gladly sent free on request. Write to this company or see an authorized AmerTran dealer in your neighborhood.

*AmerTran Input and Output transformers have finest high permeability alloy core laminations and excellent frequency characteristics.

The AmerTran Push-Pull Power Stage list price $43 complete with two UX-171 tubes, $54 with two UX-210 tubes. The unit is licensed under R C A patents and must be sold complete with tubes as indicated.

AMERICAN TRANSFORMER COMPANY
179 Emmet St., Newark, N. J.
"Transformer Builders for Over 28 Years"

PROFESSIONAL DIRECTORY

QUESTIONS

The circulation of *Radio Engineering* has grown tremendously during the past year. Every day, scores of questions reach us, such as:

"How would you set up a one man service department?"
"Give the measurements of each foot for a 44 ft. Exponential Horn."
"Provide layout and circuit diagram of complete Broadcast Station."
"Supply calculations for power dissipation in an A.B.C. eliminator."

If they are answered a few days late we are properly "sat upon" in a following communication

We have had to increase our technical staff to handle this correspondence. Many of the questions require research work and laboratory analysis, which devolves upon the the editorial staff.

Effective at once, the following scale of charges will be made:

Average Questions	$0.25 ea.
Standard Circuit Diagrams	.50 ea.
Special Circuit Diagrams	1.00 ea.

Prices on diagrams and questions requiring research work or application of special reference work will be quoted at time of receipt of inquiry.

NOTE

We will, of course, be glad to continue to answer requests for information on sources of supply, technical publications, manufacturers lines, etc., without charge.

RADIO ENGINEERING
READERS' SERVICE BUREAU
JOHN F. RIDER, *Mgr.*

Buyers Directory of Equipment 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 advertisements—see index on page 62.

ADAPTERS:
Carter Radio Co.

AMMETERS
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

ANTENNAE, LAMP SOCKET
Electrad, Inc.

ARRESTERS, LIGHTNING:
Electrad, Inc.,
Jewell Elec. Inst. Co.

BASES, VACUUM TUBE:
Formica Insulation Co.

BINDING POSTS:
Eby, H. H., Co.
X-L Radio Labs.

BOXES, PACKING:
Tifft Bros.

BRACKETS, ANGLE:
Scovill Mfg. Co.

BRASS:
Copper and Brass Research Assn.
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America.
Copper and Brass Research Assn.
Crowe Nameplate Mfg. Co.

CELLS, PHOTOELECTRIC:
Burt, Robert C.

CHASSIS:
Aluminum Co. of America.
Copper and Brass Research Assn.
United Scientific Laboratories, Inc.

CHOKES, AUDIO FREQUENCY:
American Transformer Co.
General Radio Co.
Thordarson Elec. Mfg. Co.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.

CHOKES, B ELIMINATOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.

CLAMPS, GROUND:
Electrad, Inc.
Scovill Mfg. Co.

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

COILS, CHOKE:
Dudlo Mfg. Co.

COILS, IMPEDANCE:
Dudlo Mfg. Co.

COILS, INDUCTANCE:
Dresner Radio Corp.
Hammarlund Mfg. Co.

COILS, MAGNET:
Dudlo Mfg. Co.

COILS, RETARD:
Hammarlund Mfg. Co.

COILS, SHORT WAVE:
Hammarlund Mfg. Co.

COILS, TRANSFORMER:
Dudlo Mfg. Co.

CONDENSERS, BY-PASS:
Aerovox Wireless Corpn.
Automatic Electric, Inc.
Burt, A. G., Jr.
Electrad, Inc.,
Fast, John E. & Co.

CONDENSERS, FILTER:
Aerovox Wireless Corpn.
Automatic Electric, Inc.
Electro-Chemical Co.
Fast, John E. & Co.

CONDENSERS, FIXED:
Aerovox Wireless Corpn.
Automatic Electric, Inc.
Burt, A. G., Jr.
Electrad, Inc.
Fast, John E., & Co.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.

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

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
Karas Electric Co.

CONDENSERS, VARIABLE:
Benjamin Elec. Mfg. Co., Inc.
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Karas Electric Co.
Scovill Mfg. Co.
United Scientific Laboratories

CONNECTORS:
Saturn Mfg. & Sales Co.

CONTROLS, ILLUMINATED:
Hammarlund Mfg. Co.
Karas Electric Co.

COPPER:
Copper & Brass Research Assn.
Scovill Mfg. Co.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

DIALS:
Crowe Nameplate and Mfg. Co.
Karas Electric Co.
United Scientific Laboratories

DIALS, DRUM
Hammarlund Mfg. Co.
Karas Electric Co.
United Scientific Laboratories

ELIMINATORS, A BATTERY:
Acme Elec. and Mfg. Co.
Electro-Chemical Co.
Grisby, Grunow, Hinds Co.
Karas Electric Co.
Radio Receptor Co.

ELIMINATORS, B BATTERY:
Acme Elec. and Mfg. Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Grigsby, Grunow, Hinds Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.

ELIMINATORS, UNITS FOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
Electro-Chemical Co.
General Radio Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.

ESCUTCHEONS:
Crowe Nameplate and Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FILAMENT, OXIDE COATED:
Independent Laboratories, Inc.

FILAMENT CONTROLS, AUTOMATIC:
Radiall Co.

FOIL:
U. S. Foil Co.

GALVANOMETERS:
Jewell Elec. Inst. Co.

GETTER MATERIAL
Independent Laboratories, Inc.

GRAPHITE:
Acheson Products Sales Co., Inc.

GRID LEAKS:
Aerovox Wireless Corpn.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.

HARNESSES, A-C.:
Carter Radio Co.
Cornish Wire Co.
Eby, H. H., Co.
Northern Mfg. Co.

HORNS:
Racon Electric Co.
Temple, Inc.

HORNS, MOLDED:
Racon Elec. Co., Inc.
Temple, Inc.

INDUCTANCES, TRANSMITTING:
General Radio Co.

INSTRUMENTS, ELECTRICAL:
Jewell Elec. Inst. Co.

INSULATION, MOULDED:
Bakelite Corp.
Formica Insulation Co.
General Plastics, Inc.
Westinghouse Elec. Mfg. Co.

JACKS:
Carter Radio Co.
Electrad, Inc.

JACKS, TIP:
Carter Radio Co.

KITS, SHORT WAVE:
Aero Products, Inc.

KITS, TESTING:
General Radio Co.
Jewell Elec. Inst. Co.

KITS, TRANSMITTING:
Aero Products, Inc.

LACQUER:
Zapon Co., The

LABORATORIES:
Electrical Testing Labs.

LEAD-INS:
Electrad, Inc.,

LOCK WASHERS:
Shakeproof Lock Washer Co.

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

MAGNETS:
Thomas and Skinner Steel Products Co.

METERS:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

MOUNTINGS, RESISTANCE:
Electrad, Inc.,

NUTS:
Shakeproof Lock Washer Co.

PACKING:
Tifft Bros.

PANELS, COMPOSITION:
Cortlandt Panel Eng. Co.
Formica Insulation Co.
Westinghouse Elec. & Mfg. Co.

PANELS, METAL:
Crowe Nameplate and Mfg. Co.
Scovill Mfg. Co.

PAPER, CONDENSER:
Dexter, C. H. & Sons, Inc.
Strype, Fred C., Co.

PAPER, CONE SPEAKER:
Seymour Co.

PLUGS:
Carter Radio Co.
Saturn Mfg. Co.

POTENTIOMETERS:
Carter Radio Co.
Central Radio Laboratories
Electrad, Inc.
United Scientific Laboratories

RECTIFIERS, CARTRIDGE:
Acme Elec. & Mfg. Co.
Electro-Chemical Co.

RECTIFIERS, OXIDE:
Electro-Chemical Co.

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Ward Leonard Electric Co.

RESISTANCES, VARIABLE:
American Mechanical Labs.
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Ward Leonard Electric Co.

RHEOSTATS:
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.,
United Scientific Laboratories.

SCHOOLS, RADIO:
National Radio Institute.

SHIELDING, METAL:
Aluminum Co. of America.
Copper and Brass Research Assn.
Crowe Nameplate Co.

SHORT WAVE APPARATUS:
Cardwell, Allen D., Co.
General Radio Co.

SOCKETS, TUBE:
Benjamin Electric Mfg. Co.
General Radio Co.

SOLDER:
Chicago Solder Co. (Kester).
Westinghouse Elec. & Mfg. Co.

SOUND CHAMBERS:
Racon Elec. Co., Inc.
Temple, Inc.

SPEAKERS:
Racon Electric Co.
Temple, Inc.
United Radio Corp.

STAMPINGS, METAL:
Scovill Mfg. Co.

STRIPS, BINDING POST:
X-L Radio Laboratories.

SUBPANELS:
Cortlandt Panel Eng. Co.
Formica Ins. Co.
Westinghouse Elec. & Mfg. Co.

SWITCHES
Carter Radio Co.
Electrad, Inc.,
Saturn Mfg. Co.

TAPPERS
Eastern Tube and Tool Co.

TESTERS, B-ELIMINATOR:
General Radio Co.
Jewell Electrical Inst. Co.

TESTERS, TUBE:
General Radio Co.
Jewell Elec. Inst. Co.

TESTING INSTRUMENTS:
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

TESTING KITS:
Jewell Elec. Inst. Co.

TESTING LABORATORIES:
Electrical Testing Labs.

TOOLS
Eastern Tube and Tool Co.

TRANSFORMERS, AUDIO:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Karas Electric Co.
Thordarson Electric Mfg. Co.
United Radio Corp.

TRANSFORMERS, B-ELIMINATOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.

TRANSFORMERS, OUTPUT:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.

TRANSFORMERS, POWER:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Karas Electric Co.
Thordarson Electric Mfg. Co.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.

TUBES, A. C.:
Arcturus Co.
C. E. Mfg. Co.
Northern Mfg. Co.

TUBES, RECTIFIER:
Arcturus Co.
C. E. Mfg. Co.
Northern Mfg. Co.

TUBES, VACUUM:
Arcturus Co.
C. E. Mfg. Co.
Northern Mfg. Co.

UNITS, SPEAKER:
Racon Electric Co.
Temple, Inc.

VOLTMETERS, A. C.:
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

VOLTMETERS, D. C.:
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

WASHERS:
Shakeproof Lock Washer Co.

WIRE, ANTENNA:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

WIRE, BARE COPPER:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

WIRE, COTTON COVERED:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, ENAMELED COPPER:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, LITZENDRAHT:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, PIGTAIL:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, SILK COVERED:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, TINNED COPPER:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

INDEX OF ADVERTISERS

A New And Improved Volume Control For "A C" Circuits

Centralab Radiohms RX-100 and RX-025 have been built with exact taper of resistance to give effectual control of volume smoothly, without jumps and sudden blasts.

When the RX-100 is placed across the secondary of one of the R.F. stages it surely and positively controls the volume from a whisper to maximum on all signals—powerful locals notwithstanding. This Radiohm will also control oscillation very effectively.

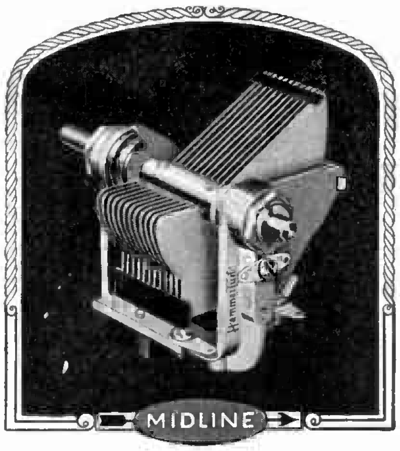
The RX-025 has the exact taper of resistance for a volume control when placed in the antenna circuit, or across the primary of an R.F. transformer.

One of these two Radiohms and the Centralab Power Rheostat are essential resistances for all "AC" circuits. They help to maintain the delicate balance of voltages throughout the circuit and in no way affect the balance between plate and filament current, so necessary to maximum efficiency.

Central Radio Laboratories
25 Keefe Avenue, Milwaukee, Wis.

Write for new folder showing applications.

Centralab



Licensed under Fitz Lowenheim patent No. 1258423.

The fame of the Hammarlund "Midline" Condenser consists not merely in one extraordinary feature—but in *all* that denotes a real engineering achievement.

It is a precision instrument that commands respect because it embodies every refinement of design and adaptability that modern radio receivers require in condenser equipment.

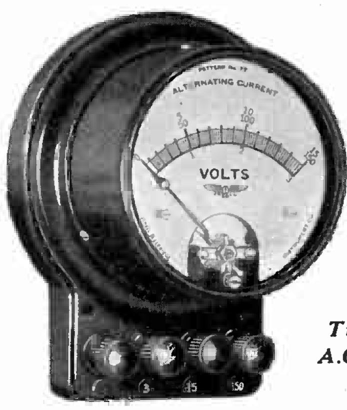
Write for Folder

HAMMARLUND MANUFACTURING CO.
424–438 W. 33rd St., New York, N. Y.

For Better Radio
Hammarlund
PRECISION
PRODUCTS

JEWELL

Find A. C. Set Trouble Quickly



Pattern No. 77 Triple Range A.C. Voltmeter

For locating trouble in the new A. C. operated radio sets the Jewell Pattern No. 77 triple range voltmeter is the best addition that can be made to any service man's kit of service equipment.

One of the chief troubles in the new A. C. sets, using D. C. tubes in series is paralysis of the tubes due to improper filament voltage. Another source of trouble is traced to line voltage which varies considerably in some localities. Most sets have some means of compensating for variations in line voltage, but some method of knowing definitely what values are being obtained is quite essential. In sets using the new A. C. four and five prong tubes it is often more important that the filament is right than in sets employing D. C. tubes, as it is found that a particular setting of the filament is sometimes necessary to eliminate hum.

Primary and secondaries in charging transformers also need occasional checking to determine cause of trouble.

Any of the above conditions may be quickly located with the Jewell Pattern No. 77 A. C. voltmeter. The O-3, O-15 and O-150 volt ranges are ample for all ordinary A. C. testing. The Pattern 77 is a quality instrument throughout and holds forth the usual Jewell assurance of years of satisfactory use. The size is such that it can be easily handled and arrangement is made for either bench or wall mounting.

Write for descriptive circular No. 1145.

"28 Years Making Good Instruments"

Jewell Electrical Instrument Co.
1650 Walnut St., Chicago

CHICAGO

JUNE 11th To 15th Inclusive

STEVENS HOTEL

2nd ANNUAL RADIO TRADE SHOW

RADIO MANUFACTURERS ASSOCIATION
RMA

4th ANNUAL RMA CONVENTION

A BIGGER SHOW

More manufacturers have signed up for exhibition space than for last year's show. There will be more to see, more to select from and more new products to sell and profit on.

A BETTER SHOW

Both the Exhibition Hall and the Ball Room of the Stevens Hotel will be used for exhibits. All that's new for the 1928-29 season will be so arranged that you will not miss a thing.

A MORE INTERESTING SHOW

The variety and number of exhibits and entertainment features will surpass last year's show—and that was a hummer! Many manufacturers are arranging to entertain you—to make your visit both profitable and pleasurable. The R. M. A. banquet will have for its speakers the leading men in the industry.

YOU MUST GO

Distributors, dealers and jobbers will be admitted by invitation only. Full particulars regarding your credentials will be sent to you in April. For any other information address

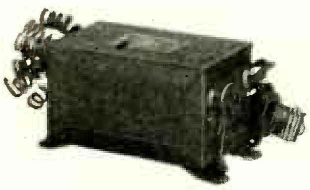
Radio Manufacturers' Association Trade Show

UNDER DIRECTION OF U.J.HERRMANN AND G.CLAYTON IRWIN, JR.

Room 1800 Times Bldg, New York City

QUALITY DONGAN PRODUCTS

A Message to Custom Set Builders



No. 6512

A C Transformer

One of the best types. Equipped with cord and plug outlet for B-Eliminator. Also control switch tap. Operates with 4 UX 226, 1 UY 227 and 1 UX 171 tubes.

$5.75 list

No. 5553

A B C Power Supply Unit

Supplies B-power as well as A C power. For one to eight UX 226, 2 UY 227, 2 UX 171 tubes and one UX 280 Rectifier tube.

$22 list

FANS—Prompt deliveries assured on this and other items upon receipt of check or money order.

Building, as you do, a receiving set for the buyer who insists upon the best in radio, you naturally seek the very latest in design and finest construction in parts — at a price that permits a profit. Just as Dongan has always devoted its entire facilities to the manufacturers of sets, now Dongan recognizes the Custom Set Builder as a distinct factor in the radio industry.

Establish a Direct Source on Fine Parts

You can avail yourself of special discounts on audio transformers, B-Eliminator transformers, chokes and units, A C transformers and units, power amplifier transformers, etc.—all approved parts designed in one of the world's finest radio parts laboratories and manufactured in one of the most modern and well-equipped plants.

For converting D C sets to A C — or for building new sets — write for our Custom Builders' proposition. Your source is direct and satisfaction guaranteed.

Find out about this at once. You can improve the quality of your work and receive added profit.

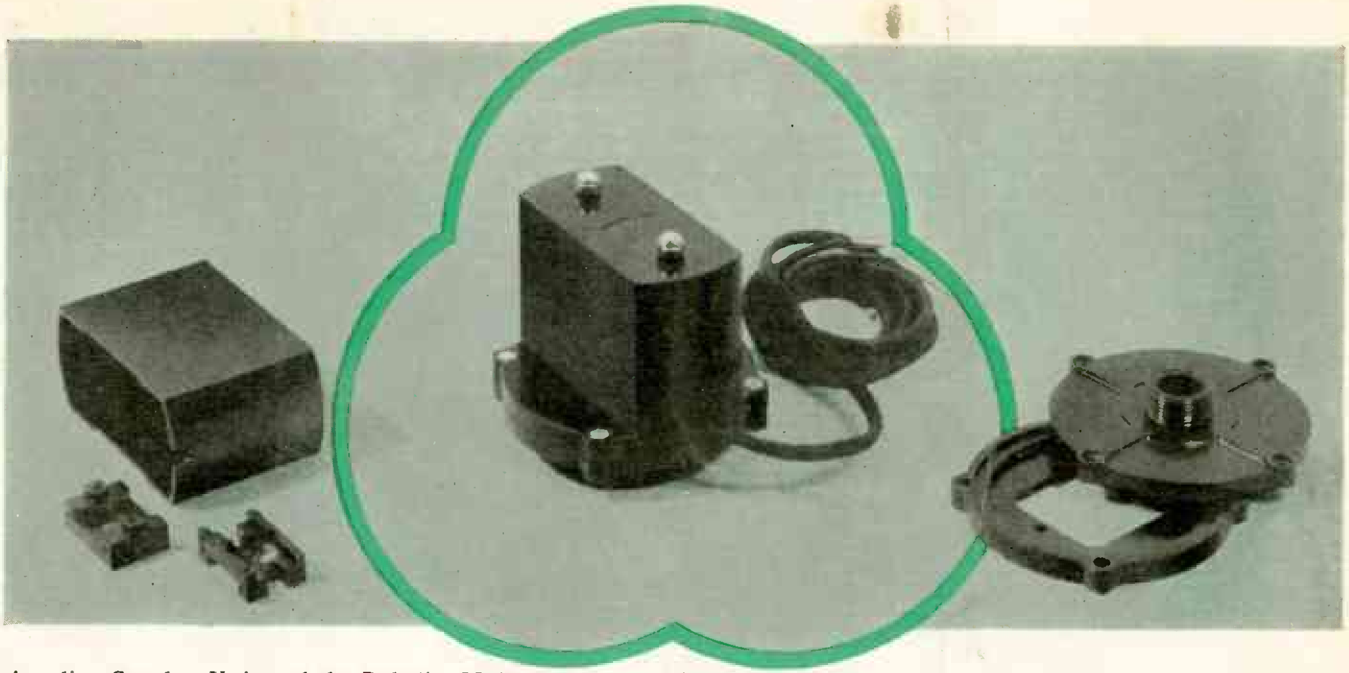
Transformer Headquarters for

SET MANUFACTURERS

In designing your new set, take advantage of the research work on power transformers developed in the Dongan laboratories. Every feature of approved design available.

DONGAN ELECTRIC MANUFACTURING COMPANY
2995-3001 Franklin St.
DETROIT, MICHIGAN

TRANSFORMERS of MERIT for FIFTEEN YEARS



Amplion Speaker Unit and the Bakelite Molded parts of which it is formed. Made by Amplion Corp., New York, N. Y.

A Radio Speaker unit completely housed in Bakelite Molded

THE magnet coils and diaphragm of a speaker are sensitive parts which require complete and lasting protection from injury, if quality performance is to be retained. Shorting of the coils and any damage to the diaphragm must be carefully guarded against.

In the Amplion speaker unit the diaphragm is housed within the Bakelite Molded two-part circular base, shown at the right. Each of these two parts is formed in a single operation with finished threads and holes, and to such close dimensions that a snug-fit and perfect interchangeability are assured. The two small Bakelite Molded blocks have replaced metal for the coil mounting, removing any chance of shorting the coils. To complete the assembly a deep Bakelite Molded cover encloses the electrical parts.

Bakelite Engineering Service

Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resins for industrial and radio uses provides a valuable background for the cooperation offered by our engineers and research laboratories.

BAKELITE CORPORATION

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

BAKELITE CORPORATION OF CANADA, LTD., 163 Dufferin St., Toronto, Ont.

BAKELITE

REGISTERED U. S. PAT. OFF.

THE MATERIAL OF A THOUSAND USES

"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."