EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. VIII JULY 1928 Number 7

R. M. A. SHOW REPORT NUMBER

Sold Only by Subscription $2.00 per Year

The TECHNICAL MAGAZINE of the RADIO INDUSTRY

From 222 to 250

From the delicate resistance requirements of the 222 shielded grid tube for super radio-frequency amplification, to the brute resistance requirements of the 250 power tube for super power amplification, you have the marvelous span of present-day radio reception. And in the CLAROSTAT line you have a resistance ready to meet these two extremes as well as everything in between. There is the Grid Leak Clarostat, with a resistance range of 1/10 to 10 megohms for the detector circuit. The Volume Control Clarostat serves for the radio-frequency circuit. There is the Power Clarostat for the plate and grid requirements of the largest power tube—a sturdy resistance instantly adjustable to meet specific conditions of any circuit—not a haphazard, fixed resistance guess in the face of many variables. And in between, there are the Standard Clarostat for the control of plate voltages of various circuits, the Duplex Clarostat for semi-fixed plate voltage and grid bias adjustments as well as for split and balanced resistance requirements, and the Table Type Clarostat for resistance in accessory form.

There is a CLAROSTAT for every pupose — no matter what the resistance range, the power rating or the mounting. Ever since the days of the first B-eliminators, the Clarostat Engineering Staff has co-operated with radio engineers in the solution of radio resistance problems.

And for TELEVISION—

the latest child of the radio art, CLAROSTAT again steps in, this time with the Power Clarostat as the ideal means of speed control for the motor-driven scanning disk. Nothing short of this micrometric speed control will provide clear images. Other types of Clarostat serve for the delicate short-wave receiver, the distortionless amplifier and other components of the television equipment, at the transmitting as well as the receiving end.

WRITE for our technical data bulletin, issued every so often, which deals with resistance problems and their solution. Your name will gladly be placed on our mailing list. Also, do not hesitate to place your special problems before us. Helping solve your resistance problems is our main aim in life.

AMERICAN MECHANICAL LABORATORIES, INC.

Specialists in Variable Resistors

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

CLAROSTAT

Reg. U. S. Pat. Off.

RADIO ENGINEERING

for JULY 1928

Edited by M. L. MUHLEMAN

52 Vanderbilt Avenue
New York, N. Y.

Managing Editor
G. C. B. ROWE
Associate Editors
JOHN F. RIDER
AUSTIN C. LESCARBOURA

VOLUME VIII NUMBER 7

Editorial

TELEVISION is steadily gaining ground in the public mind. Reams of publicity and human-interest material are released each month to be digested eagerly by the man on the street who has become enamoured with scientific progress.

Television is a pretty name, easily rolled off the tongue. As a subject it is readily gossiped about by those who do not have to worry their grey matter over its development.

Television represents something more than a mere machine to the man on the street. Being akin to his most cherished dream of transporting himself through space to any distant point in less time than it takes to tell it, the subject naturally stimulates his imagination and partially satisfies his realization of a mental Utopia. Obviously then, he accepts it with open heart and open mind.

Through a condition which will always prevail, the man on the street has again set a new responsibility on the engineering minds. Should we blame the publicity man, the promoter and the over-enthusiastic for letting the cat out of the bag at a very indiscreet moment? Certainly not. Television *is* an accomplished fact. Many of us have witnessed very convincing demonstrations "in the laboratory," so to speak.

"In the laboratory" we have seen the remarkable. Out of the laboratory the vision fades to a mere shadow and we observe the act of advertising eggs to the public with no fresh eggs to sell. The best that can be supplied are the eggs of yesterday and they simply will not hatch.

Television must come out of the laboratory. This cannot be so easily accomplished by throwing the responsibility on the shoulders of the eminent research engineers. Time has displayed the interesting fact that the majority of the original inventions spring from the minds of individual investigators and not from grouped mentalities in research laboratories. The latter very seldom demonstrate originality. The research laboratory is a highly and specifically trained force and is operated for the purpose of improving on the existing. The individual laboratory works under no such handicaps.

At any rate, Television is an open field, a new Klondike where anyone may prospect and hope for returns. The prize is well worth the effort and the prize may fall in the lap of the boy in the attic workshop or the engineer working in his own laboratory.

We are confident that something will evolve from the raw material at hand and that Television will be a practical accomplishment in much less time than predicted.

RADIO ENGINEERING is anxious to stimulate research work along these lines. However, the editorial staff is not of the opinion that the dressing up of old editorial material will serve in a constructive way. RADIO ENGINEERING attempts to reflect the engineering and industrial thought which cannot be acclimated to visionary smoke clouds and therefore must offer material of substance.

Progress is being made in the development of Television systems. As yet there is little to offer, but we are confident that RADIO ENGINEERING will be in a position to present constructive material in the very near future.

M. L. MUHLEMAN, *Editor.*

Contents

Departments

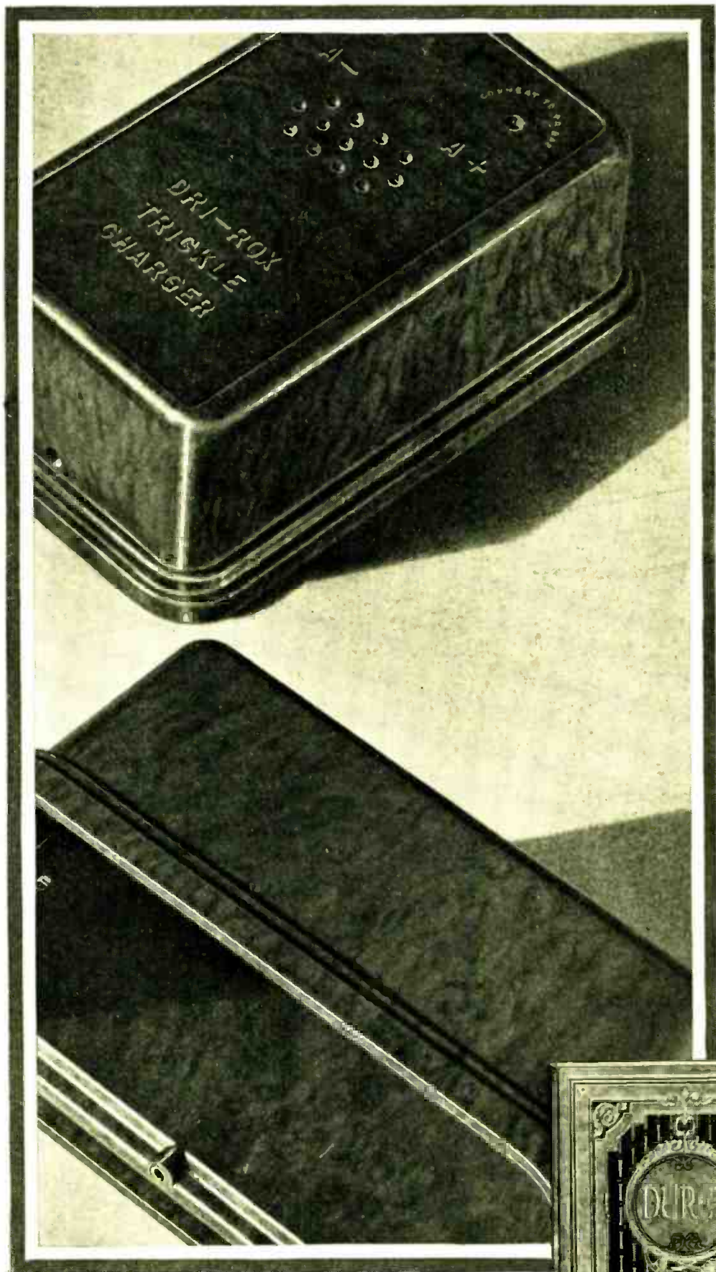
Published Monthly by
RADIO ENGINEERING MAGAZINE, INC.

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; $3.00 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.

Where the race of competition is keen, Durez *helps to get there first*



In the close competition of the radio field Durez offers truly remarkable production economies which no manufacturer can afford to overlook.

The Mack Molding Company, Little Falls, New Jersey, can bear witness to that truth. They make charger covers and other radio parts with Durez.

Durez parts come from the mold in finished form. One single operation—that's all. No tooling. No buffing or polishing. No costly finishing work. Durez molds quickly and faithfully into the most intricate design. It comes out hard as flint and with the lustre of burnished ebony. And—a tool has not touched it!

The quick fusing and hardening properties of Durez assure rapid and economic production. It has high mechanical and dielectric strength. It is ideally suited to the manufacture of durable, colorful radio panels, bases, dials, covers, binding posts and other parts. Indeed, many manufacturers, in many lines, tell us that Durez is the most satisfactory molding compound they have ever used.

Let us aid you in determining the most desirable application of Durez in your manufacturing processes. Our laboratory and the services of our engineers are at your disposal at all times.

General Plastics, Incorporated, 64 Walck Road, North Tonawanda, N. Y. Also New York City, Chicago, San Francisco.

DUREZ

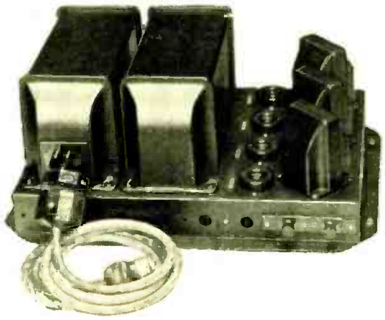
Send for free copy of this interesting booklet, "Do it with Durez"

It tells the complete story of this wonderful plastic. Shows how it may be economically adapted to meet the most exacting needs; and the beautiful color effects (plain, mottled or striated) which may be attained. Profusely illustrated in full colors.

Worth while profits for you in this year 'round seller—

When you sell a Samson "Pam" Amplifier you can usually sell tubes, phonograph pick-up and turn-table, microphone, radio set, loud speakers or head sets and wiring for installation.

Type "PAM" 16 is for all ordinary types of loud speakers.



Type "PAM" 17 is for and supplies field current to dynamic type speakers.

A self contained, rugged, all electric two stage audio amplifier, with the famous Symphonic and Symphonic Push Pull Transformers, uses the new AC tubes and operates from 110 volt 50-60 cycle AC current. Compensation is made for line voltage variation. Designed to meet Underwriters' and AIEE Standards, and made for either dynamic or ordinary type loud speakers as specified. List Price $125 without tubes.

Wide variety of uses make the Samson "Pam" Amplifier a universal all year ready seller for:

Electrification of Phonographs.

Quality Power Amplifier for Home Entertainment.

Announcement Amplifier, Public and Private Institutions, Incidental Music in Theatres, Lodges, etc.

Distribution of Radio Programs to Apartments, Hotel and Hospital Rooms, etc.

Beauty Parlors, Shops, etc.

Sound Detecting Systems.

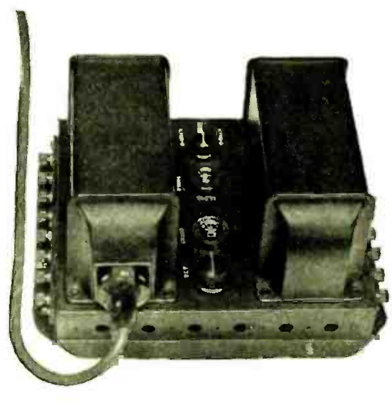
Dance Music in Tea Rooms, Dancing Schools, Dance Halls, Restaurants, Cabarets, etc.

Roadside Stands, Filling Stations, etc.

Athletic Contests, Races, Fairs, etc.

Samson ABC Eliminator, Type ABC-71

supplies raw AC filament current from 105, 110, 115, 120 volt 50-60-cycle power source to five 226, two 227 and two 171 type tubes. Also supplies B voltages as follows: 30 to 75 volts variable and 90, 135, 180 fixed. C voltages supplied are —4½, —9, and —40. This is practically a constant voltage eliminator, and it has a total capacity of 70 mils. Tubes required—one UX280 and one UX874.

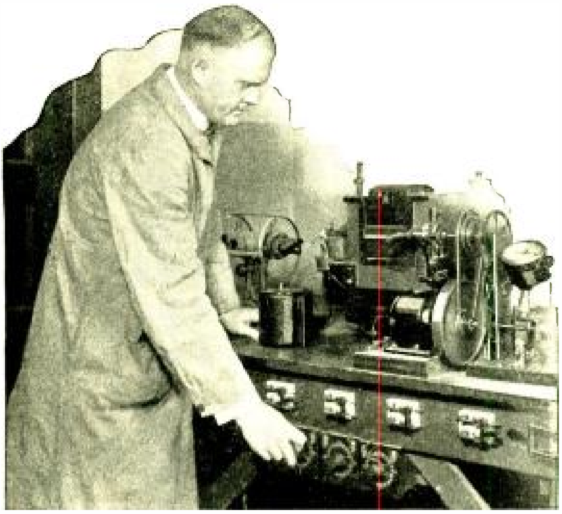


Samson Electric Co.

Manufacturers since 1882

General Offices
Canton, Mass.

Factories
Canton and Watertown, Mass.



EVERY FACILITY FOR EXPERT RESEARCH

THE Research and Development Laboratory of Automatic Electric Inc., manufacturers of Strowger Automatic condensers, is one of the most completely equipped of its kind in the world. The use of its many sensitive and complex instruments enables the development engineers to *know exactly* rather than to guess what occurs in any electrical circuit at any time.

The design and manufacture of satisfactory condensers for radio purposes is dependent upon such exact scientific knowledge. The reliability and efficiency which have become synonymous with the name Strowger in automatic telephony, are incorporated to a like extent in the line of filter, by pass and high voltage condensers now available to the radio trade. The company's research facilities are always at the disposal of any interested parties requiring condensers of special design for special purposes.

[See that your radio set is equipped with Strowger Automatic condensers]

A. G. BURT, JR.

1033 WEST VAN BUREN STREET
CHICAGO, U. S. A.

REPRESENTING

STROWGER AUTOMATIC
CONDENSERS

MADE BY
Automatic Electric Inc.
CHICAGO, U.S.A.

Silvery Aluminum, just one product in the Elkon Dry Condensers.

One of the many special machines needed in the accurate manufacture of Elkon Dry Condensers.

ELKON DRY HIGH CAPACITY CONDENSERS

Elkon were the originators and still make the only dry High Capacity Condenser. Unlike any of the so-called dry condensers which depend on moisture for their action, Elkon condensers are baked in ovens at 200 degrees to be sure that all of the moisture is out before sealing in their cans.

Standard size of can is 2″ x 2″ x 6¾″, capacities to 4000 mfd. Voltage 12. Special sizes and capacities may be made where quantities are sufficient.

Elkon Dry Condensers are used by the leading manufacturers of "A" Eliminators, and are also being specified this year by some dynamic speaker manufacturers and set manufacturers who want a high capacity condenser in small space. Submit specifications for samples.

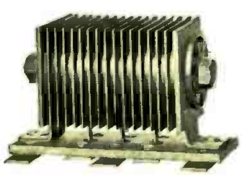
ABSOLUTELY DRY

There is an ELKON Dry Rectifier for *your* problem

No matter what the problem of rectification, Elkon has or can build a rectifier for your individual problem.

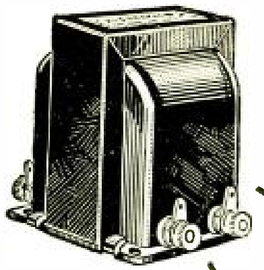
There are sixteen standard rectifiers covering a wide range of voltages and current carrying capacities.

An engineer will appreciate the inherent quality of Elkon rectifiers as soon as he looks at one—and they are as efficient as they look. The self-healing feature, exclusive with Elkon, is but one guarantee of their long life. Send your specifications for a sample which will answer your problem.



ELKON, INC.
PORT CHESTER, N. Y.
Division of
P. R. MALLORY & CO., INC.

Radio Department ELKON, Inc.
Fox Island Road, Port Chester, N. Y.
Please put us on your mailing list to receive your engineering bulletins as they are published.
Name ....
Address ....



In Most of The Better Radio Receivers

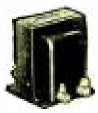
Watch dogs of tone quality safeguarding the musical reproduction of broadcast programs, Thordarson Audio Transformers do their part in making real musical instruments of hundreds of thousands of receiving sets annually.

Among leading set manufacturers, Thordarson transformers have long been recognized for their fidelity of reproduction. Today their use is so universal that it is difficult to find a dealer who does not sell at least one make of receiver so equipped.

Try this simple experiment. Ask your dealer for a demonstration of his receivers. Pick out the instrument with the most natural reproduction, and then look inside the cabinet. You will find, in the majority of cases, Thordarson amplifying and power supply transformers.

You will realize that it is wise to specify Thordarson amplification when buying your receiver, for the manufacturer who is far-seeing enough to equip his sets with Thordarson transformers, may be depended upon to have the balance of his instrument in keeping with this high standard.

new!



THORDARSON
R-300
AUDIO TRANSFORMER

A superior audio transformer that will satisfy the most critical musical ear. The high impedance windings of the R-300 are wound on a core of D-X Metal, a recent development of the Thordarson laboratory. This new core material has an exceedingly high A.C. permeability, and an inductance that is 50% greater than that of the highest grade silicon steel. In performance, this transformer responds exceptionally well to the lower frequencies and provides the same degree amplification to the diapason of the grand organ as to the note of the flute. Ratio 3:1. Dimensions, 2½" x 2½" x 3" high. Weight, 2 lbs. Price, $8.00.

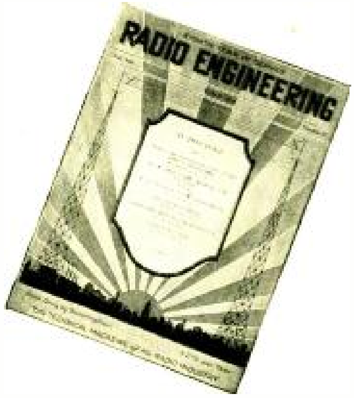
THORDARSON

RADIO TRANSFORMERS

Supreme in musical performance

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets — Chicago, Ill. U.S.A.

3581



ANNUAL

FACTORY *and* PRODUCTION

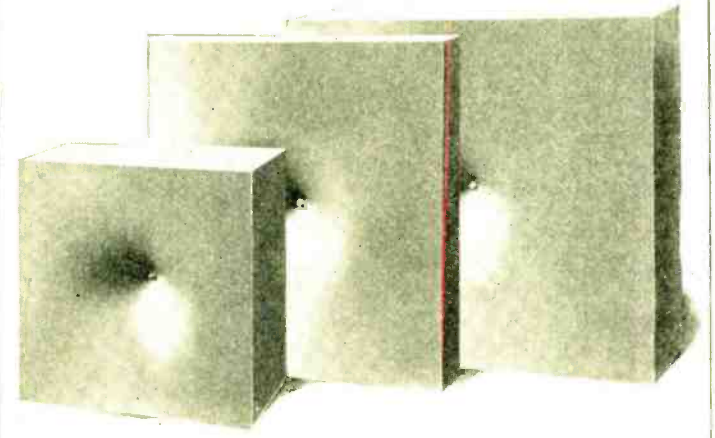
NUMBER

THE August issue of Radio Engineering is the annual Factory and Production number.

It will deal primarily with materials, processes, instruments, machinery, plant equipment and methods.

Insofar as possible the August issue will be made a lasting reference manual covering active sources of supply for the radio industry.

The Original Air-Chrome Speaker Now Available to Set and Cabinet Manufacturers



WE all know that tone is all important this year. You are vitally interested in the tone performance of your set. The speaker you use in your consoles can make a tremendous difference in your set's tone efficiency.

Matched to Your Output

It would be ridiculous for us to claim that the standard Air-Chrome will operate with the same efficiency on every set.

The standard Air-Chrome speaker favors no band of frequencies. Low, intermediate and high are all reproduced with the same relative intensity—so that the Standard Air-Chrome will reproduce naturally everything the audio amplifier gives it.

Some sets, however favor the lower frequencies, some the higher. We are able to match the output of your set exactly, by building up the high or low frequencies, as the occasion demands.

The Custom-Built Air-Chrome

The Air-Chrome Speakers for set manufacturers are made in 3 standard sizes as shown above, 24" x 24", 18" x 23", 14" x 14", these will fit most of the cabinets.

On account of the construction we can build any special size where the quantities warrant.

Test the Air-Chrome in Your Own Laboratory

The only way to tell whether you want to use the Air-Chrome on your set is to try it. Try to make it chatter—demonstrate it against any speaker—if you find that some frequencies are over-emphasized, remember that we can give you exactly what you want. The tone of the Air-Chrome is uneffected by atmospheric changes.

Send the coupon or write us today for complete information.

AIR-CHROME STUDIOS, INC.
161 Coit Street, Irvington, N. J.

Air-Chrome Studios, Inc., 161 Coit Street, Irvington, N.J.
Please send us complete information on the Air-Chrome Speakers.
Name ....
Address ....

Application of the Four-Electrode Receiving Tube

A Discussion of the Uses of the UX-222 as a Screen-Grid Tube

By Alan C. Rockwood and B. J. Thompson*

PART I

THE latest receiving tube of unique character to appear on the market in this country is the Radiotron UX-222 (Cuningham CX-322). It is the purpose of this article to discuss the theory, characteristics, and uses of this tube. The UX-222 is a two-grid tube designed primarily as a screen-grid amplifier, but it is suitable for use in most of the other applications of two-grid four-electrode tubes.

Fig. 1 shows the UX-222 in its various stages of construction. In outward appearance it differs little from ordinary three-electrode tubes, having a standard UX-base and the same bulb as the UX-201-A, except for the addition of a metal cap at the top of the bulb. Fig. 2 is a sectional diagram showing the arrangement of the elements. There is a straight filament, surrounded by a coarse mesh grid (the control grid) which is supported from the glass bead only and is connected to the cap at the top of the bulb. Around this grid is another grid of fine mesh supported both from the bead and stem. At the upper end of this grid is a metal disk connected to it and extending out over the top of the plate. The plate, which is considerably larger than the second grid, surrounds it and is supported from the stem only. Around the plate is a cage-like extension of the disk reaching below the bottom of the plate. The second grid connects to the regular grid pin of the UX base, the plate being connected in the usual way. The filament is of thoriated tungsten with a rating of 0.132 amperes at 3.3 volts—the same as the UX-120.

The principal uses of the UX-222 are as a screen-grid tube and as a space-charge-grid tube. These two uses will be discussed separately.

As a Screen-Grid Tube

Screen-grid tubes were first investigated by Schottky in Germany and later developed into a more generally useful form by Dr. A. W. Hull of the General Electric Company Research Laboratory. The UX-222 is a development of Dr. Hull's tubes into a commercially practicable form.

In any radio-frequency amplifier using tuned plate and grid circuits the problem of oscillation due to feed-back of energy from the plate circuit to the grid circuit is one of fundamental importance. When all external sources of feed-back have been eliminated there still remains the plate-grid capacity of the amplifier tube. In the past there have been two general methods of preventing oscillation due to this capacity—the "losser" method, and the "neutralization" method. In the former, sufficient losses are introduced into the circuit to keep the amplification down to a safe value, while in the latter, the feed-back due

* Research Laboratory, General Electric Co.

From a paper delivered before the Radio Club of America, February 8, 1928.

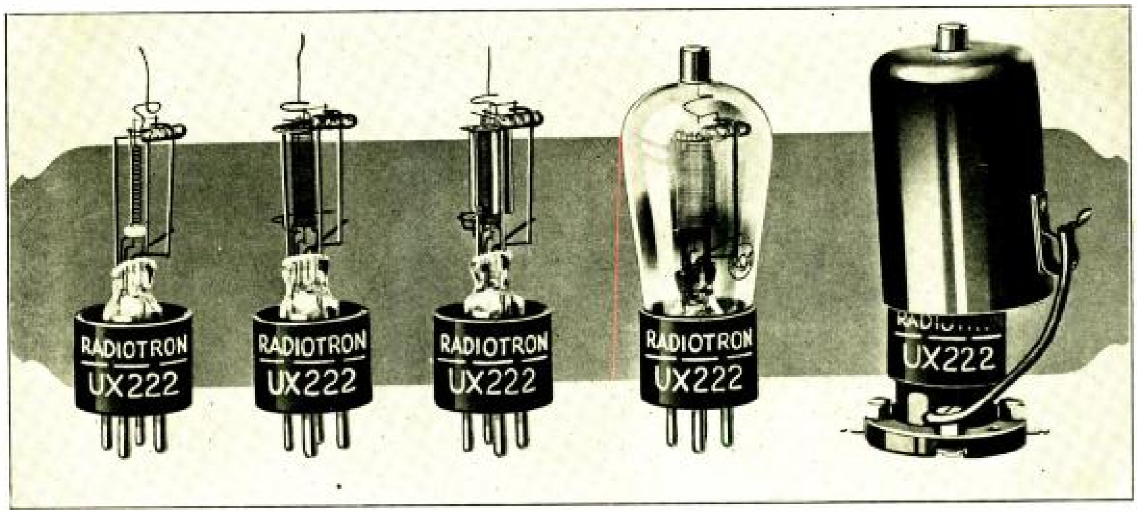


Fig. 1. A number of views of the U.X. 222 four element tube illustrating the step by step construction. The special shield is shown in the last view.

to the internal capacity of the tube is balanced by a feedback of equal magnitude, but opposite in phase, introduced outside the tube. Stability with the UX-222 as a screen-grid tube is obtained by eliminating the feed-back capacity.

This elimination of plate-grid capacity may be understood better by reference to the following example. Between any two parallel plates (see "A," Fig. 3) there exists a capacity which may be measured by the alternating current which flows (in Fig. 3) through the ammeter "A" for some alternating voltage "V" at any definite frequency. If another plate is placed between the two and connected as in "B," Fig. 3, the effect is now of two condensers in series, but the capacity between *o* and *n* is shorted out of the circuit and the current indicated by the ammeter drops to zero, and we may say that the effective capacity

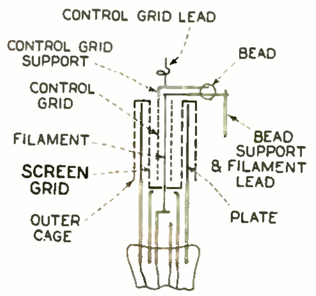


FIG.2

Illustrating the arrangement of the four elements in the UX-222 tube.

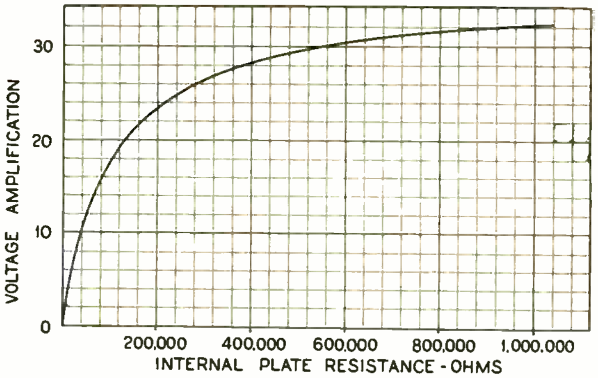


FIG.5

Illustrating how voltage amplification varies with internal plate resistance, the mutual conductance remaining constant for the UX-222, assuming a load resistance of 100,000 ohms.

between *m* and *n* has been reduced to zero by the addition of the plate *o* connected as shown. It may be said that *n* is shielded, or screened, from *m* by *o*.

In the UX-222 this method of reducing the capacity between plate and grid is employed. Since it is obviously impossible to place a solid sheet of metal between the grid and plate without preventing the flow of plate current, a grid-like screen, consisting of many turns of fine wire, is used. This is practically as effective in reducing capacity as a solid sheet. The plate-grid capacity is not affected by the introduction of a bias voltage since the screen is still grounded as regards an impressed a.c. signal. In addition to the screen directly between plate and grid, the outer surface and the ends of the plate are screened from the control grid and its lead. To make this possible, the control grid lead is brought out of the top of the bulb. So effective is this screening that the direct plate-grid capacity in the UX-222 is only 0.02 mmfd. compared to 8 mmfd. in the UX-201-A.

Fig. 4 is of interest in showing some stages of the development of the UX-222. The tube of Hull's at the left has a disk over the top of the plate which extends to the walls of the bulb, permitting a continuous shield, except for the thickness of the glass, both inside and outside the bulb. The next three developmental tubes show vary-

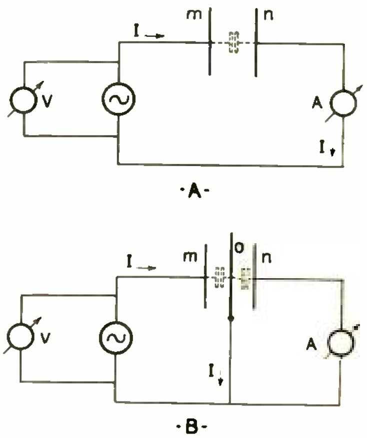


FIG.3

Diagrams which illustrate the elimination of plate-grid capacity.

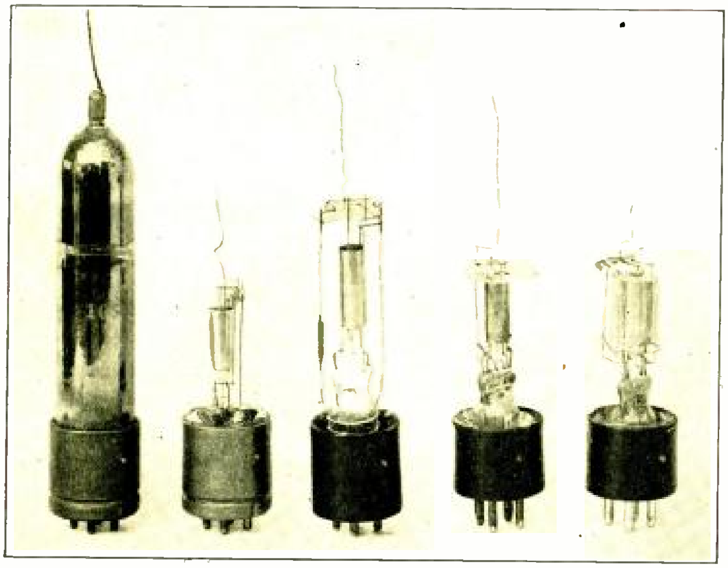


Fig. 4. Some of the tubes which were constructed in the evolution of the UX-222 shown at the right.

ing amounts of screening outside the plate, the second tube having no outside screening, the third only a small strip shielding the leads in the bead, and the fourth having a complete disk very similar to the Hull tube, except that it was intended to be used in a pear-shaped bulb. The last tube to the right is the final form, the UX-222, showing the top disk made smaller in diameter and extended down as a cage around the plate.

The introduction of the screen causes interesting and important differences between the characteristics of the UX-222 and those of a three-electrode tube. For the most generally useful condition when the plate is at

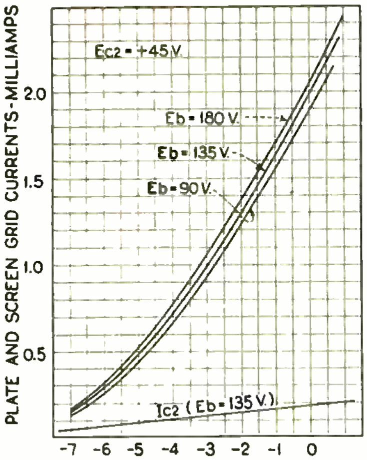


FIG. 6

The mutual characteristics of the UX-222 tube taken at 45 volts on the screen grid.

a higher potential than the screen these differences may easily be explained. The voltage of the plate has very little effect on the screen because of the shielding effect of the screen. Thus, with a positive voltage on the screen, the screen attracts the electrons from the filament exactly as does the plate in a three-electrode tube. These electrons travel to the screen with relatively high velocities and most of them pass through the spaces between the wires of the screen. If the plate is at a higher voltage than the screen these electrons pass on to the plate and constitute the plate current. It may be said that the screen attracts the electrons and the plate merely acts as an accumulator of them after they have passed through the screen. Changes in plate voltage have little effect on the plate current, and consequently the plate resistance ($\Delta e_p / \Delta i_p$) is very high. With voltages on the plate less than that of the screen various secondary emission effects may exist. Such characteristics do not affect the practical operation of this tube.

The desirability of high plate resistance in a screen-grid tube is to be seen from the expression for the voltage amplification of a vacuum tube and load circuit:

$$A_v = \frac{\mu R_p}{r_p + R_p}$$

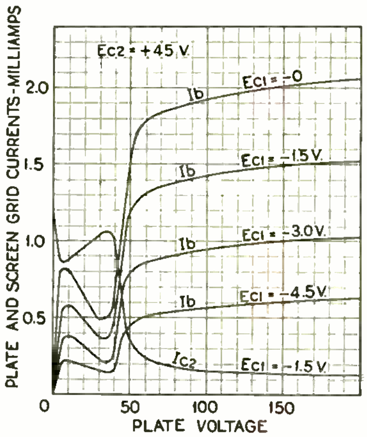


FIG. 7

The plate characteristics of the four-electrode tube at 45 volts on the screen grid.

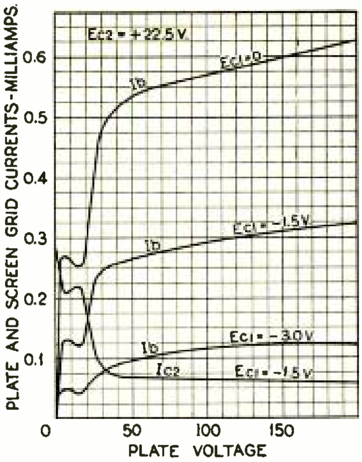


FIG. 8

The plate voltage characteristics of the UX-222 with a screen grid voltage of 22.5.

where A_v is the voltage amplification, μ the amplification factor of the tube, r_p the internal plate resistance of the tube, and R_p the resistance of the load circuit. This expression may be rewritten:

$$A_v = \frac{g_m r_p R_p}{r_p + R_p}$$

where g_m is the mutual conductance of the tube. In a three-electrode tube it is impossible to increase r_p without lowering g_m, so that it is undesirable to have a value of r_p above a certain

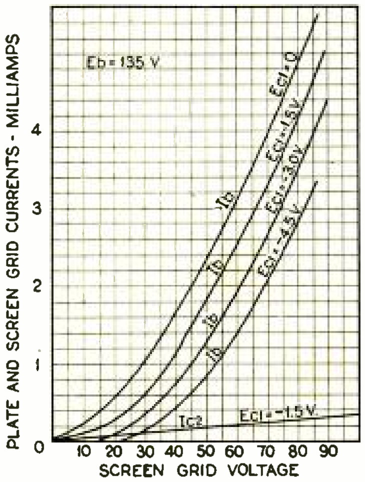


FIG. 9

The plate current-screen grid voltage characteristics of the UX-222 tube.

The nine characteristic curves on the right illustrate the variation with several voltages of the plate resistance, the mutual conductance and the amplification factor of the UX-222.

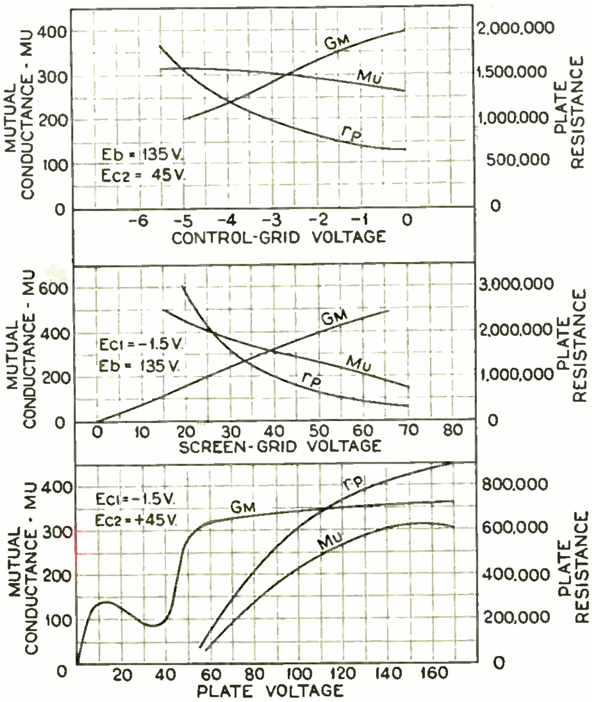
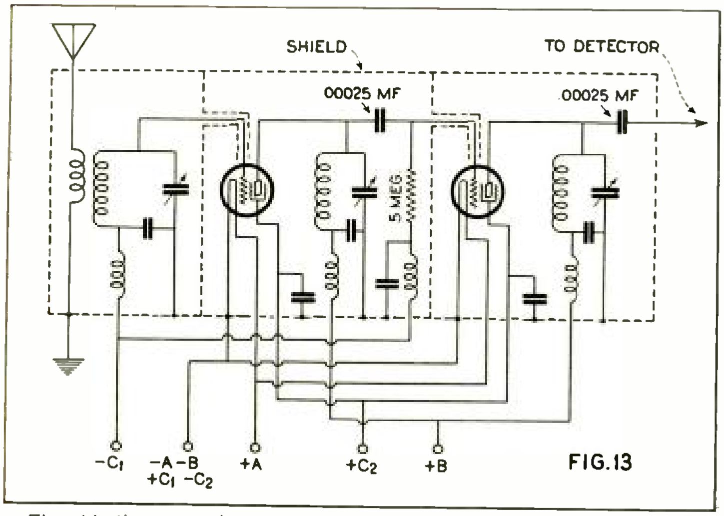


FIG. 10



The objection to an impedance-coupled amplifier of this type is that the circuit may oscillate at some frequency below radio frequencies and amplify other frequencies than those intended, through common coupling.

point depending on the value of Rp. In the screen-grid tube, however, an increase in plate resistance does not result in a decrease in mutual conductance, so that the result is an increase in voltage amplification. Fig. 5 shows how voltage amplification varies with internal plate resistance, the mutual conductance remaining constant for the UX-222, assuming a load resistance of 100,000 ohms. It will be seen that at 850,000 ohms r_p, the voltage amplification, is 31.3, while at 100,000 ohms r_p it is only 17.5.

Fig. 6 shows the mutual characteristics of the UX-222 taken at 45 volts on the screen. Fig. 7 gives the plate characteristics at the same screen voltage and Fig. 8 gives the same characteristics at 22.5 volts on the screen. Fig. 9 gives the plate-current screen-voltage characteristics. Fig. 10 shows how plate resistance, mutual conductance, and amplification factor vary with the several voltages.

It will be seen from these curves that the only unique characteristic of the tube is the plate characteristic. The mutual characteristic is normal, except that the several curves are spaced very closely together, showing the small effect of changes in plate voltage. The screen characteristic is very similar to the plate characteristic in a three-electrode tube.

Table No. 1 gives the standard operating voltages and the constants of the UX-222 as a screen-grid tube.

The most general use of the UX-222 is as a radio-frequency amplifier, since here its two outstanding characteristics—low feed-back capacity and high amplification factor—may be utilized to best advantage. At radio frequencies, or in any case where amplification is desired over only a small frequency band, it is possible to build up relatively high impedances by resonant circuits. Fig 11 shows the relation between load impedance and voltage amplification for such resonant circuits at recommended operating voltages for the UX-222, the UX-240, and the UX-201-A. The effect of the high amplification factor of the UX-222 is manifest. This comparison is not entirely just, however. It is customary to use a step-up transformer with the UX-201-A so that the gain may be greater than that shown. Due to the high internal resistance of the UX-222 there is no appreciable gain from using a step-up transformer.

Showing the relation between load impedance amplification for resonant circuits at recommended operating voltages for the UX-222, UX-240 and the UX-201A. Note the high amplification factor of the UX-222.

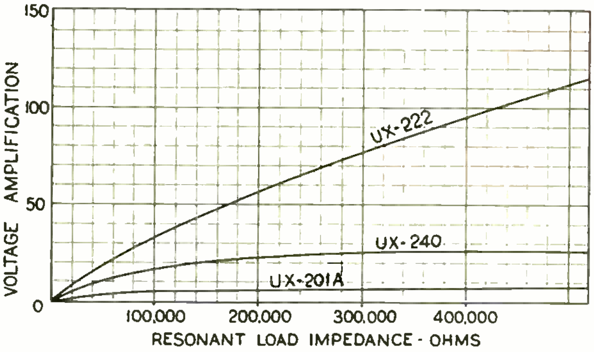


FIG. 11

It must not be assumed that the only limitation on amplification is that imposed by the impedance which it is possible to build up, however. Even the very small feed-back capacity of the UX-222 causes a certain amount of regeneration and when the load impedance reaches a sufficiently high value, the circuit will oscillate. If, as is usually the case in circuits designed for the UX-222, the input and output circuits are both similar tuned impedances and it may be assumed that the only feed-back is that through the plate-grid capacity, it can be shown that the maximum load impedance, which may be used without oscillation, is given by the expression

$$R_p = \frac{1.41\ r_p}{r_p \sqrt{2 \pi f C_{pg} G_m} - 1.41}$$

where C_{pg} is the feed-back capacity in farads and f is the frequency in cycles per second. Fig 12 shows the relation between maximum load impedance and frequency for the UX-222 as determined by this expression. The circuit is also shown in simplified form.

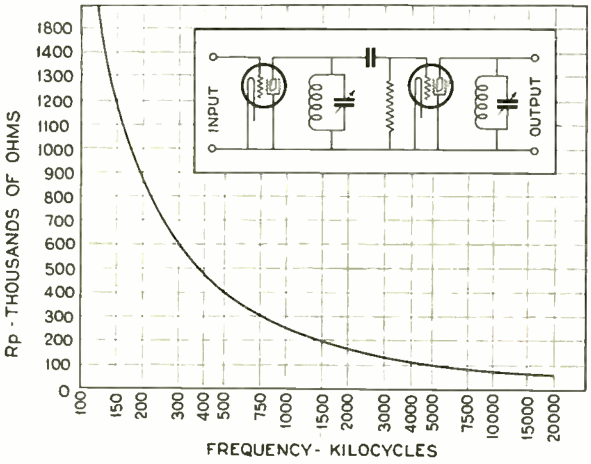


FIG. 12

The relation between maximum load impedance, Rp, and frequency is here plotted as calculated by the formula at the right. The simplified circuit diagram of the amplifier is included.

From this curve it will be seen that at 120 K. C. a load impedance of 1.5 megohms may be used without oscillation, while at 1000 K. C. an impedance of 240,000 ohms may be used with stability. At 20,000 K. C. a load of 45,000 ohms is possible before oscillation occurs. These values are about the maximum which it is possible to build up in the customary manner. Thus it may be said that at any frequency below 20,000 K. C. and with any ordinary circuits, the UX-222 will operate as a stable amplifier without neutralization provided all external sources of feed-back are eliminated.

TABLE No. 1

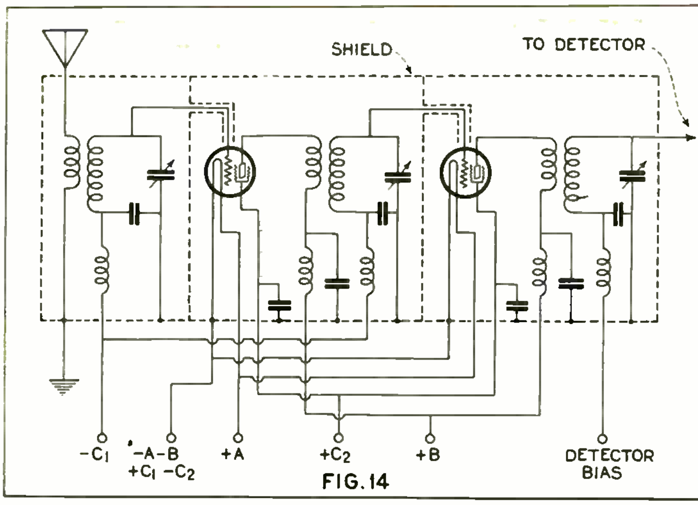
SCREEN-GRID UX-222

Filament Voltage	(E_f)	3.3	
Plate Voltage	(E_p)	135.	
Control-Grid Voltage	(E_{g1})	—1.5	
Screen-Grid Voltage	(E_{g2})	+45	
Plate Current	(I_p)	1.5	mA
Plate Resistance	(r_p)	850,000	Ohms
Mutual Conductance	(g_m)	350	Micromhos
Amplification Factor	(u)	300	
Effective G-P Capacitance	(C_{gp})	0.025 mmfd. max.	

There are three general sources of feed-back other than the plate-grid capacity which must be kept at a minimum. These are: (1) Capacitive coupling between the plate and grid leads, (2) inductive or capacitive coupling between the plate and grid tuned circuits, and (3) coupling due to the impedance of the B supply. The first two causes may be eliminated by proper shielding. Because of the high amplification of the UX-222, the importance of thorough shielding between all parts of the grid circuit and the plate circuit cannot be overstressed. It is recommended that the tuned grid circuit be completely enclosed in one metal compartment, while the tube and the plate circuit are enclosed in another, with a shielded grid lead extending through to the grid terminal. Insulated wire with a metallic braid or tinfoil covering may be used for this purpose. The remaining difficulty, coupling through the B supply, is a problem only in a case where two or more stages of r. f. amplification are used. This coupling may be eliminated by simple filters in the plate-supply leads where they pass through the shields.

It is of great importance also that the impedance of the screen-grid circuit be kept very low at the frequency to be amplified, as any such impedance tends to destroy the screening effect, reducing the amplification and increasing the effective plate to grid capacity.

A simple amplifier circuit for broadcast frequencies is shown in Fig. 13. This method of coupling may be called impedance coupling. The possible objections to this type of coupling are that the circuit may oscillate at some frequency below radio frequencies due to the coupling between plate and grid through the B supply, as in the case of "motor-boating" in a resistance-coupled amplifier (and for the same reason) and that the circuit may amplify some frequencies other than those intended if choke and condenser filters are used in the plate leads, since these filters will resonate at some relatively low frequency. These difficulties may be largely obviated by the use of transformer coupling, as shown in Fig. 14.



The difficulties experienced with the impedance-coupled amplifier (Fig. 13) can be eliminated by the use of R.F. transformers. The primary windings are designed to have a comparatively high impedance value.

(To be continued)

The Status of Frequency Standardization

Piezo Crystal Oscillators May Lead to Simultaneous Operation on a Single Frequency Band

IN a paper which appeared in the May, 1928, *Proceedings of the Institute of Radio Engineers*, page 579, J. H. Dellinger, chief of the radio section of the Bureau of Standards, shows that frequency standardization of hitherto laboratory character only has become of first-rank importance in reducing radio interference. The recent International Radio Conference recognized frequency as the cornerstone in the radio structure by devoting its major attention to a frequency allocation to provide for the orderly development of all radio services.

Because of increasing use of all available radio channels, particularly those for broadcasting and the very high frequencies, the requirements of frequency measurements are a hundred times more rigorous than they were five years ago. The perfection of standards and measurements to the necessary accuracy requires the most intensive work by the Government and by various large organizations to produce standards and instruments that can be used to keep radio stations each operating on its own channel. This development has been facilitated by a special cooperative plan organized by the Bureau of Standards a year ago and involving the Commerce, Navy, and War Departments, the General Electric Co., the Westinghouse Co., American Telephone & Telegraph Co., Radio Corporation of America, and the General Radio Co.

Piezo oscillators are now available to hold radio station frequencies extremely constant. For instruments of this type equipped with temperature control, national and international comparisons have shown that they are reliable to a few parts in 100,000.

This brings in sight the possibility of the use of special Piezo oscillators in broadcasting stations, which will hold the frequency so close that several such stations can operate simultaneously without heterodyne interference on the same frequency. This is the only practical scheme so far developed for solving the problem of too many broadcasting stations.

The use of frequency standards of this high accuracy is also vital to all users of very high frequencies. Many more high-frequency channels will become available when all stations use the best available frequency standards and keep the stations on their frequencies with great accuracy.

General Considerations in the Design of Broadcast Amplifiers

Pertaining to Interference Level, Gain, Volume Control and the Theory and Design of Attenuation Networks

By E. L. Bowles*

Interference Level

An illustration of the effect of interference is served by a microphone-amplifier-line combination. The output energy of a microphone is small, for the sound energy actuating it is small. If this energy were fed with a line, and thence to an amplifier, trouble due to external disturbances would be likely to appear, especially if the microphone lead is over about 300 feet in length. Disturbances appearing in these lead wires, induced from other sources, may be of the same order of magnitude as the legitimate ones produced by the microphone itself, so that it would be impossible to obtain a predominance of the desired energy from the microphone. However, where the energy of the microphone can be amplified, and then sent into the line by an appropriate matching transformer, the level of the microphone energy in the line will be far above the level of the energy of the disturbances appearing in the line. Under such conditions the signals from the microphone will come through with but a relatively small trace of the disturbances. In fact, by amplifying the desired energy to a sufficient degree before transmitting the energy over a line in which disturbing energy appears, the relative level between the desired energy and the undesired energy may be made so great that the disturbing energy will not be perceptible.

To prevent such interference, it is necessary to supply a small amplifier with a condenser microphone. The amplifier is placed in the neighborhood of the microphone. The voice energy is so small that were it transmitted over a long line to an amplifier the disturbing voltages appearing in the line would be of the same order of magnitude as the desired energy from the microphone itself.

* Samson Electric Company

Gain

In order that the "gain" of an amplifier system may be properly interpreted, it must be remembered that usually it is inferred that this gain takes place where an amplifier is working out of one impedance and into another impedance, both of which are identical in value; that is, if gain in either "miles of standard cable" or in "transmission units" (abbreviated TU) is estimated from the effective voltage amplification of an amplifier, it is assumed that this amplifier is working out of one impedance and into another which is identical. The voltages or currents used in computing the gain are measured in these impedances. If a cascade amplifier is the subject of the estimate, and if the ratio of any two grid voltages is taken, from this ratio it is possible to accurately estimate the over-all gain if the input impedances are different, and if they are known, it is also possible to compute the gain, but the relationship used in this computation is more complicated.

The use of the term "gain" in this connection, with devices where the impedance may be one thing where one voltage is measured, and another thing where another voltage is measured, may lead to rather ridiculous results, especially in connection with tube circuits. The following relative magnitudes of gain and voltage amplification are sometimes handy in estimating the gain of a given amplifier. Increasing the voltage amplification by one quarter, that is, increasing it to 125% of its original value, increases the gain by about 2 transmission units, or by slightly over "two miles" of standard cable. Conversely, decreasing the voltage amplification to 79% of its original value causes a decrease in the gain, that is, causes a "loss" of two more transmission units, or 2.1 miles of standard cable. In turn, if the amplification is reduced to 79% of this last value, a loss of 2 more transmission units results. Again, if the voltage amplification is increased to 158% of its original value, the gain will be 4 transmission units, or about 4.2 miles of standard cable. By way of explanation, it may be said that the transmission unit of standard cable is equivalent to 0.947 transmission unit.

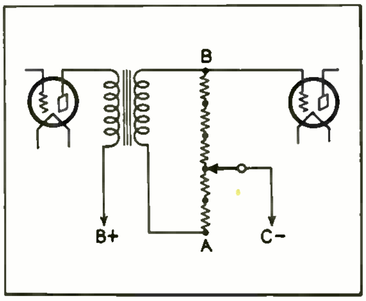


Fig. 3 Preferred method of connection of a volume control in a transformer-coupled amplifier. The resistance A-B functions as a voltage divider.

Doubling the voltage amplification increases the gain by a little over 6 transmission units, or about 6.4 miles of standard cable. Halving the voltage amplification will cause a loss of about 6 transmission units and about 6.4 miles of standard cable. Increasing the amplification to 4 times its original value will cause a gain of about 12.7 miles of standard cable, or 12 transmission units. Conversely, reducing the amplification to one fourth causes a loss of 12.2 transmission units, or 12.7 miles of standard cable.

Volume Control

In order to construct a volume control such that for each given number of divisions on the control dial the gain would be reduced by 2 transmis-

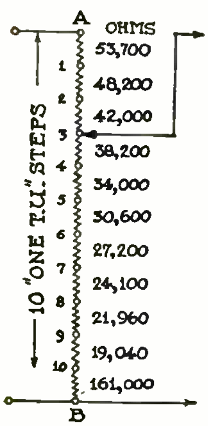
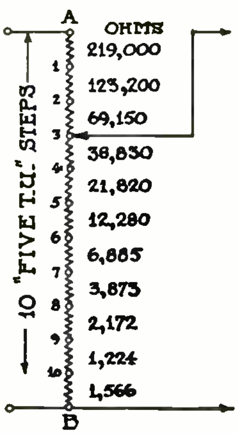


Fig. 1 on the left gives the values of a graduated resistor for a volume control having an antenuating range of 10TUs in steps of 1TU. Fig. 2 on the right has a range of 50TUs, steps of 5TUs being available.



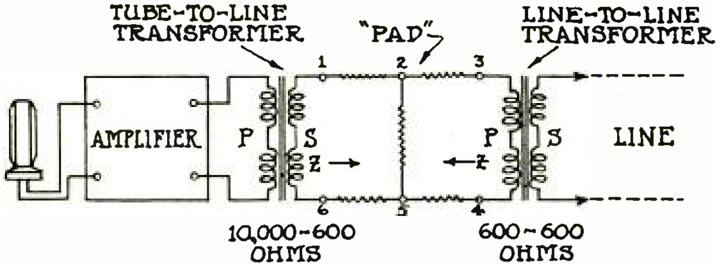


Fig. 5. The position of a "pad" between the tube-to-line transformer of an amplifier and a line.

sion units, or a little over 2 miles of standard cable, each step representing a reduction of 2 transmission units would have to represent a reduction of 79% in voltage amplification over that of the preceding value. In other words, if 10 units on a dial were to represent a change of 2 miles in the gain, and supposing that the total resistance of the potentiometer is 100,000 ohms, then to reduce the gain by 2 transmission units, the contact arm would have to be at 79,000 ohms by the time it is moved 10 degrees; by the time it has moved 20 degrees, it would have to be at the point 79% of 79,000 ohms, or about 62,500 ohms. In order to reduce the gain 2 more transmission units, in moving 10 degrees farther, the resistance would have to be reduced to a value of 79% of 62,500 ohms, and so on down the scale, each time taking 79% of the preceding value. In this way the resistor should have a maximum resistance of 100,000 ohms, and should be graded in a definite way.

Some volume controls are arranged in this way and are available in the market. Their use makes the control of an amplifier much more uniform and convenient, since the use of this type of variation in gain makes the most convenient perceptible unit of change in the sensation of hearing.

It is sometimes desirable to control the gain of an amplifier in terms of transmission units. For example, it may be desirable to change the gain in steps of 1 TU. Again, it may be desirable to change it in steps of as much as 10 or 20 TUs. Figs. 1 and 2 give two graduated resistors arranged for this purpose. Fig. 1 gives the various resistor values necessary to make up a volume control having an attenuating range of 10 TUs in steps of 1 TU. Thus, if this composite resistor is connected across the output terminals of the interstage transformer as in Fig. 3, or across the output of an impedance as in Fig. 4, the amplifier volume may be varied in steps of 1 TU over a maximum of 10 TUs. The use of the resistor of Fig. 2 under similar conditions will yield 10 steps of 5 TUs each. It is possible and practical to use one of these calibrated resistors across the grid and filament of one tube of an amplifier and the other across the succeeding tube of the amplifier. With such a combination, the total gain or loss in TUs is equal to the sum of the TUs gained or lost, as read from the two. For example, in Fig. 1, as the connecting arm is moved from point A to point 3 as shown, the volume has been decreased 3 TUs. Were the pointer to be moved to 4, the gain would be 4 TUs. Supposing that the pointer is left at 4, and

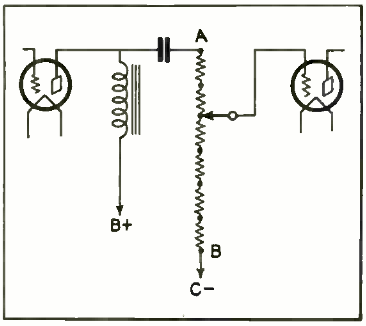


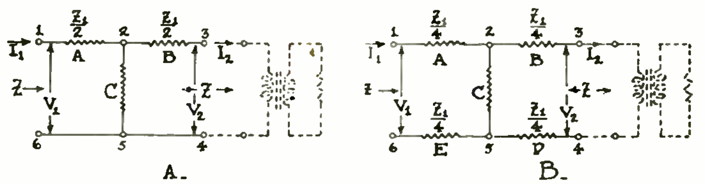
Fig. 4. The resistor in position for varying the volume of an impedance-coupled amplifier.

suppose that the resistor of Fig. 2 is connected to the grid of a preceding tube in the amplifier, if this pointer is moved from A to the point marked 1, the amplification has been reduced 10 TUs by this one volume control. If, however, the pointer of Fig. 1 is at 4, then the total reduction in TUs over what it would be were both pointers at A would be 14 TUs. Thus, by means of the two graduated resistors, it is possible to obtain changes in gain of as much as 50 TUs in steps of 1 TU.

Figs. 3 and 4 show possible connections of the graduated resistors of Figs 1 and 2. In places where a transformer is used, it is convenient to connect the pointer to the C battery side as shown. This precludes the introducing of a "hand-capacity" effect. Fig. 4 shows a case where this cannot be done. In such a situation it is wise to have an insulated shaft on the pointer so that "hand-capacity" does not enter.

Attenuation Networks or Pads

In communication work it is often desirable to insert into a piece of apparatus a network which will reduce the amount of energy transferred from one part of the circuit to another. Such a device, in telephone work, often is called a "pad." Fig. 5 illustrates the interposition of a pad between the output tube-to-line transformer of an amplifier and a line. Such a pad may be inserted here to cut down the energy transferred to the line to a convenient value to suppress cross-talk or simply to reduce the level of the energy coming down from this particular microphone so that it will compare favorably with the level coming through the amplifier at the other end of the line from another microphone. A pad may be described as requiring of itself two characteristics. First, it must have the proper impedance to fit into the circuit where it is to be used. Secondly, it must have the power to re-



$$Z = \sqrt{Z_1 Z_2 \left[1 + \frac{1}{4}\frac{Z_1}{Z_2}\right]} \quad \text{OHMS} \quad 1$$

$$\text{LOSS IN T.U.} = 10 \text{ LOG } \frac{W_1}{W_2} = 20 \text{ LOG } \frac{I_1}{I_2} \quad \text{NUMERIC} \quad 2$$

$$= 20 \text{ LOG } \frac{V_1}{V_2} = 20 \text{ LOG } P$$

$$\frac{V_1}{V_2} = \frac{I_1}{I_2} = P = \frac{Z_1}{2 Z_2} + 1 + \frac{Z_1}{Z_2} \quad \text{NUMERIC} \quad 3$$

$$Z_1 = 2Z\frac{P-1}{P+1} \quad \text{OHMS} \quad 4$$

$$Z_2 = 2Z\frac{P}{[P^2-1]} = Z_1\frac{P}{[P-1]^2} \quad \text{OHMS} \quad 5$$

EXAMPLE: FOR $Z = 600$ OHMS, T.U. $= 10$, FROM TABLE $P = 3.16$,

SO THAT $Z_1 = 2Z\frac{P-1}{P+1} = 2 \times 600\frac{3.16-1}{3.16+1} = \frac{1200 \times 2.16}{4.16} = 623$ OHMS

AND $Z_2 = Z_1\frac{P}{[P-1]^2} = 623 \times \frac{3.16}{[2.16]^2} = 422$ OHMS.

Fig. 6-A is a "T" network and Fig. 6-B is an "H" network. The constants of the pads are calculated from the formulae included.

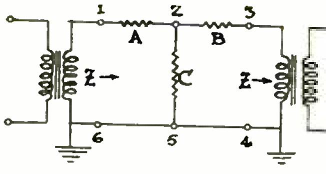
duce the energy to the required level.

In looking to the left into the secondary terminals, that is, terminals 1 and 6 of the amplifier of Fig. 5, the apparent impedance, assuming an ideal tube-to-line, will be 600 ohms. That is, electrically it will be as if there is a 600-ohm pure resistance connected between the terminals 1 and 6. Under such conditions, the impedance Z, looking towards the right into the pad, between the terminals 1 and 6, should likewise be 600 ohms. In the same way, looking into the primary of the second transformer to the right of terminals 3 and 4, an impedance of 600 ohms will be seen in this direction.

Therefore, the impedance looking toward the left of terminals 3 and 4 should be 600 ohms. Thus, under local conditions, the impedances are equal in each direction. In other words, looking to the right from terminals 3 and 4, one should measure an impedance of 600 ohms. Likewise, looking to the right of terminals 1 and 6, one should measure an impedance of 600 ohms; or, again looking toward the left from terminals 1 and 6, one should measure an impedance of 600 ohms. Looking toward the left from terminals 3 and 4, one should measure an impedance of 600 ohms. It follows that the pad must be made up of a particular combination of resistors in order that it shall have the necessary characteristics to fit into this electrical network.

Pad Design

Assuming that a given transformer is connected to its load, then let us see what the procedure is to design a pad to go with this transformer in order to obtain a given attenuation or reduction in the energy level of the electrical disturbance which is being transmitted. In Fig. 5, in looking to the right into the primary of the transformer coupling the line to the pad, a certain impedance Z is observed. That is, if the pad is disconnected from the terminals 3 and 4, and if an electrical measurement is made of the impedance looking into the primary of this transformer coupled to the line, a 600-ohm impedance will be measured. In particular, if the transformer is very nearly perfect for the frequency considered, the impedance will appear to be a pure resistance of 600 ohms. In order that a pad with any desired attenuation whatever shall be appropriate to be used in connection with this transformer, it will be necessary that the combination of the resistors used in its construction shall bear the interrelation X = 10Z = 2X$_1$, X$_1$ = 5Z. With no further requirement, it can be seen that various combinations of L$_1$ and L$_2$ and Z are represented in their appropriate positions in Fig. 6-A and -B. The electrical characteristics of these two figures as used from the input and output terminals are identical. Fig. 6-A corresponds in appearance with the pad in Fig. 1. Fig. 6-B is identical electrically, but the parts of the resistance in the elements E and D have been added to those of A and B. Any currents passing through the arm B to the load must return through the arm D. Electrically it is a question whether all the resistance is in the arm B or whether a part of it is in B and a half in D. The same argument applies to elements A and E. Fig. 6-A may be called a "T" network, and Fig. 6-B may be called an "H" network.



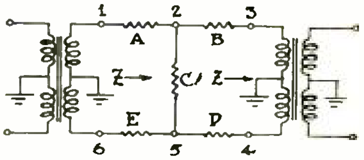


Fig. 7 (left) shows a practical use of the "T" network, where one side of the transformer is grounded. When the mid-points of the windings are grounded, as in Fig. 8, an "H" network is preferable.

			Z = 200		Z = 600	
TU	LOG P	P	Z_1	Z_2	Z_1	Z_2
1	.05	1.12	22.6	1760	67.95	5280
2	.10	1.26	46.0	858	138	2575
3	.15	1.41	68.0	571	204	1714
4	.20	1.58	89.9	422	269.7	1266
5	.25	1.78	112.0	328	336.5	986
10	.50	3.16	207.5	140.6	624	422
20	1.0	10.0	327	40.4	982	121.4
30	1.5	30.0	380	13.5	1140	40.5
40	2.0	200.0	396	2.0	1180	6.0
50	2.5	316	400	1.274	1200	3.822
75	3.75	5620	400	0.712	1200	2.137
100	5.0	100,000	400	0.004	1200	0.012

Fig. 9. Table for use in the calculation of the constants of a pad.

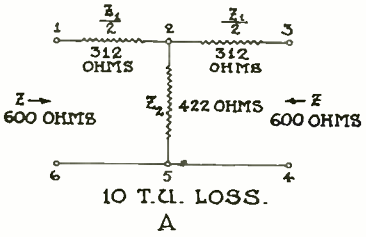
In some cases it is practical to use a T network as in Fig. 7, where the transformers are grounded on one side of the winding; and in other cases it is best to use the arrangement in Fig. 8, where the center point in the transformer windings is grounded. It will be noticed that in each case the network suits the symmetry of the figure. In any case the values of Z$_1$ and Z$_2$ of Expression 1 in Fig. 6 are distributed as shown in Fig. 6-A or -B, depending on which embodiment of these networks is to be used.

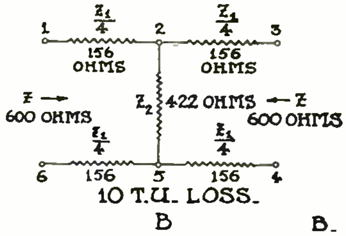
In order to lay out the proper attenuation network or pad, it is necessary to know how much attenuation or reduction in signal level is desired. The attenuation in transmission units is given by Expression 2. Knowing the number of TU's attenuation desired, it is a simple matter to determine what the value of the logarithm of P must be. Knowing the value of the logarithm of P, it is possible to obtain the corresponding anti-logarithm from a table of common logarithms. The first column of the table in Fig. 9 gives the TU's; the second column gives the consequent values of the logarithms of P, and the third column gives the corresponding values of P. Expression 3 gives the relation between P, and the impedances Z$_1$, Z$_2$, and Z. Thus knowing the impedance of Z, sometimes called the "characteristic impedance," and the desired attenuation in TU's, it is possible, by the use of the table, to determine the value of Z$_1$ and Z$_2$ to make up the desired pad.

The values of Z$_1$ and Z$_2$ as functions of P and Z are given as Expressions 4 and 5 of Fig. 6. Following these expressions are computed illustrative data of a pad to work between impedances of 600 ohms and which is to have an attenuation at 10 transmission units or TU's. The value for Z$_1$ comes out to be 623 ohms, or practically 624 ohms, and the value for Z$_2$, 422 ohms. These values of resistance are shown in their appropriate positions in Figs. 10-A and 10-B. These two pads have identical characteristics, and may be used in the arrangement shown in Figs. 7 and 8.

It must be borne in mind in using these pads that it is assumed that they are to work into impedances of the same value as given by Z. If the impedance into which they are working are not of this value, the argument does not hold.

The table of Fig. 9 is worked out on a basis of Expressions 1 to 5 of Fig. 6, and gives the proper values of Z$_1$ and Z$_2$ for various pads to work between impedances of 200 ohms or 600 ohms.





B.

In Figs. 10-A and -B the values of the various resistances are given for the example quoted in the accompanying text and to give an attenuation in TU's of from 1 to 100. In the construction of the actual network Z is divided into two parts or four parts, depending on whether it is to consummate a network such as Fig. 7 or 8.

From Expressions 4 and 5 it may be seen that the values of Z_1 and Z_2 are directly proportional to the impedance Z between which the pads are to work. The quantity P determines the attenuation. The attenuation is independent of Z. That is, in a given network, if it effects a given attenuation, the values of Z_1 and Z_2 will each be twice as large if the impedance Z, between which pads are to work, is twice as large. The relationship between Z, where the characteristic impedance Z is 200, and where it is 600, is seen to be 3 in the table.

To obtain various attenuations it is only necessary to add the individual attenuations in TU's of the individual pads, that is, several pads may be placed in series. In such a case the TU's of the individual pads are added. In the aggregate they will express the total attenuation of the network. Individual pads may be made up so that in combination they may give any desired attenuation. For example, if pads having 1, 2, 3, and 4 TUs respectively are built up, they may be arranged in various (series) combinations where any degree of attenuation up to 10 TU's in grades or steps of 1 TU may be obtained. By adding a pad having 10 TU's the range is extended to 20 in the same steps, then, by adding another pad having 20 TU's, the range is increased to 40, and by adding another pad having 40 TU's, the range is increased to 80, all in steps of 1 TU.

The assumption that these TU's can be added is valid just as long as the assumptions upon which the pad theory is worked out are tenable. It is assumed that the transformer is ideal, that is, that it has a negligible resistance in its windings, and an infinite input impedance with the output windings open-circuited, and vice versa. It is also assumed that the line or other circuit element into which the transformer is working has pure resistance of the impedance value given as the impedance which the transformer is designed to match. It is also assumed that the transformer has no leakage reactance, that is, that all magnetic flux which links one winding links the other. In order that all these different things may hold, it is necessary that the consideration be based on a certain range over which the transformer practically meets all these conditions, and where those not depending on the transformer hold. Of course, as the frequency is reduced more and more, or as it is increased more and more, below and above this range respectively, these assumptions must fall down. Therefore, it must not be thought that a "pad is a pad" over all ranges of frequencies. However, over the range that the circuit element is designed to work, these ideas hold very closely, and the simple addition of the attenuation of individual pads to obtain the total attenuation gives the desired working result, and that is the justification for its wide use in communications circles.

Report of the Annual R.M.A. Trade Show

A General Outline of the Technical Features and Design of the Sets and Accessories Exhibited at the Chicago Show

UPON being asked his impressions of the Trade Show, a certain well known free lancer said, "It is decidedly dry and uninteresting and I therefore predict a record business year."

As unfair as his remark may be in some respects there is still an element of truth in what he said. Of course, he was referring mainly to the absence of "radical engineering achievements" so prevalent in past years and he is of the mind that a rapid succession of new developments of an engineering nature only serve to place the buying public in a state of confusion and indecision.

It is certainly true that the equipment exhibited at this year's show follows a definite trend and adheres close enough to the standardized design and practice to maintain in appearance and in fact, engineering stability, already achieved in the automobile industry.

The equipment exhibited has provided some inkling as to future trends —but let us take each item in its course.

A Bigger and Better Show

The second Annual R.M.A. Trade Show, and Convention, again had its reign in the Hotel Stevens, the largest hotel in the world, which faces the broad expanse of Lake Michigan. So great has been the general expansion of the Radio Industry that the space alloted to exhibitors last year was quickly over-subscribed. In order to accommodate all of the exhibitors it was necessary to lease out the immense space occupied by the Main Ballroom in the hotel as well as the exhibition hall in the basement used last year.

The majority of the exhibitors had rooms in the upper floors of the hotel for the purpose of demonstrating their products aside from their exhibition booths in the Show area. A few companies, unable to secure rooms in the Stevens Hotel, were forced to rent space in the Blackstone Hotel, across the way.

Obviously the attendance was far greater than last year and even exceeded predictions. Jobbers, distributors, dealers, servicemen, custom-set builders, and free-lancers, representing every State in the Union, attended the Show in large bodies.

Generally speaking, the Show and Convention was decidedly more business-like than last year; the individual representatives of the manufacturers appeared to characterize the improved condition of the industry and reflect the stability which has at last reached us. Undoubtedly more actual business was transacted and the individual contacts and good-will created will not pass from the memory so readily.

The individual committees of the R.M.A. held special sessions during the week of the Show and have mapped out a clear course for the industry through their constructive efforts.

The R.M.A. Banquet which took place at the Palmer House on Thursday evening, June 14th, was well attended. At this time the newly elected officers of the R.M.A. for the coming year were officially announced.

The New Receiving Sets

Receiving set design has improved considerably, but it is in this respect where the trace of standardized design is most clearly defined. There are, as usual, sets to meet every purse, ranging from small five tube receivers in attractive cabinets, employing a semi-power amplifier, to six and seven tube sets with power amplifiers, in large cabinets, or consoles, as one may desire.

The bulk of the popular priced sets have five or six tubes, not including the rectifier, and are entirely self contained. They are, in many respects, prototypes of last year's models but considerably improved from the engineering standpoint. The "average" receiver of this class is contained in a stamped metal cabinet, employs three or four 226-type tubes, one 227-type tube, a 171-type tube, as a power amplifier, and a 280-type full-wave rectifier. Likewise, the "average" receiver has a single tuning control, calibrated in most cases, a volume control and an on-and-off switch. They are marvels of simplicity and are far more rugged mechanically and more stable electrically.

The higher priced receivers have, on an average, seven tubes, not including the rectifier and contain superior audio-frequency channels. Transformer-coupled audio-frequency amplifiers still hold the field by a wide margin. There is a great deal of varience in the power stages, however. As we have said, the average low priced receiver employs a 171-type tube in the output. The higher priced receivers on the other hand incline principally toward push-pull amplification, employing two 171-type tubes in conjunction with a 280-type full-wave rectifier and a push-pull output transformer rather than an impedance. A number of receiver models employ a single 210-type power tube in the output, in conjunction with one 281-type half-wave rectifier or two 210s in push-pull or a single 250 tube, in conjunction with two 281 half-wave rectifiers.

The higher priced receivers are likewise of the single tuning control type, with a volume control and main-line switch. Metal cabinets are not so much in evidence in these models, the inclination being more towards desirable wooden cabinets, with inlays or attractive carving, and consoles containing the loud speaker and in some instances an electric phonograph.

In the medium and high priced field there are a number of variations from the standard run of receivers. Notably among these is an automatic set which is tuned by a row of levers. One model has six levers, another ten, making available the respective number of favorite stations any one of which can be instantly tuned in by pushing down a lever. A single drum dial is also included so that stations other than the favorites can be tuned in. The system is ingenious and appears to be fool proof. It is mechanical in operation.

Another model receiver, departing from the general run, employs a combination of screen-grid and A.C. tubes. Two of the screen-grid tubes are used as R.F. amplifiers and one, connected so as to function as a space-charge-grid tube, as the first A.F. amplifier. Used in this manner, it has a very high voltage amplification factor and it works directly into a 250 power tube. A 226-type tube couples the antenna to the first screen-grid R. F. stage and a 227-type tube is used as detector. One of the most interesting features of this receiver is that the screen-grid tubes are connected in a series filament circuit and supplied filament current directly from two 281-type half-wave rectifiers, which also supply the "B" and "C" voltages. Obviously, the A.C. tubes derive their filament current from a small filament heating transformer.

Another unique receiver exhibited has risen to new heights by falling back on old fundamental principles of design, utilized in new ways. The input or antenna circuit is the only one manually tuned. A form of frequency filter is employed which passes only a narrow band of frequencies on to a multi-stage "untuned type" amplifier employing 227-type tubes. We mention "untuned" merely to provide a broad classification, as the manufacturer claims the element of automatic tuning in these R.F. circuits, the automatic tuning being a function of the inherent capacity of each R.F. tube.

NEW OFFICERS AND DIRECTORS OF R.M.A. FOR 1928-29

President—H. H. Frost

1st Vice-President—V. W. Collamore

2nd Vice-President—Morris Metcalf

3rd Vice-President—Lester Noble

Treasurer—John C. Tully

Secretary—M. F. Flanagan

DIRECTORS

Capt. Wm. Sparks

M. Frank Burns

George Kiley

B. G. Erskine

M. P. Bloom

Lloyd A. Hammarlund

A special detector circuit is also employed and it is stated that the detector tube can handle a 40 volt swing without introducing distortion. Oddly, the detector works directly into the output power tube, which is of special design. This elimination of the intermediate A.F. stage is possible because of the tremendous amplification obtained in the R.F. amplifier coupled with the herculean capabilities of the detector.

Difference in mechanical design was evidenced in a number of cases. Probably the most outstanding example of modernism in this respect is a receiver whose case or cabinet is a single aluminum casting. Aside from affording the desirable shielding gained from the use of stamped metal cabinets it has an unusual degree of strength and a charming modernistic symmetry.

Radio-Frequency Amplifiers

With the few exceptions in the design of receivers already cited, this year's models in the main employ the well known and time-tried systems of radio-frequency amplification such as the Neutrodyne, the R.F.L. circuit, etc. All of the popular priced receivers and the majority of the medium and high priced receivers use the 226-type tube in the R.F. stages and only a few of the sets employ the more expensive 227-type tube.

The R.F. transformers are, on the whole, of small diameter, to conserve space, but of good electrical design. In the smaller sets they are unshielded and placed at advantageous angles to each other to prevent intercoupling. The R.F. transformers in the higher-priced sets are, in most cases, individually shielded and in some models the gang condensers are also inclosed in metal.

Power Supply

There appears to be no set rule for the placement of the power supply units, some of them being located on the left or right hand side of the chassis and many at the rear, depending primarily on the dictates of the mechanical design and secondarily on production requirements.

The power supply units are very compact as compared to many of last year's units and are totally shielded from the rest of the receiver. The filter systems are very good and the problem of voltage regulation has not been forgotten.

A few of the receivers have automatic regulators but the majority have power transformers with tapped primary windings, to be adjusted after the set has been installed.

These power units supply the "A", "B" and "C" voltages, the first through the medium of a filament heating transformer and the last two through the medium of half-or full-wave rectifiers in conjunction with small filter networks and voltage dividers.

Direct-Current Receivers

Under direct-current receivers we include battery operated sets and sets designed to operate from a direct-current light socket.

The majority of manufacturers exhibited battery sets and a few companies had D.C. light socket sets. In general, these receivers follow the design of the A.C. sets and differ only in respect to their source of power and the output amplifier. The battery sets employ the 112-A or 171-A-type power tubes and the D.C. socket operated sets employ 171-type tubes in parallel connection.

Audio-Frequency Amplifiers and Power Units

Great strides have been made in the development of power amplifiers and supply units, with a large number of manufacturers marketing them. It is quite impossible to cover the various combinations exhibited but we can give them a general classification. There are new, compact power supply units, without amplifiers, for supplying radio receivers or special phonograph amplifiers with "A", "B" and "C" power, direct from the light socket.

One manufacturer exhibited a very interesting combination 210 push-pull amplifier and external supply unit, which can be used in connection with nearly any type of set, old or new. The same company had on exhibit a three-stage amplifier and supply unit with a push-pull output stage designed for two 250-type tubes, as well as a portable public address amplifier and separate power supply.

Special phonograph amplifiers were exhibited for the first time, some of which had straight outputs and others push-pull operated.

The new amplifiers, like the new receivers have gone entirely A.C. The intermediate A.F. stages of all the amplifiers are designed for either the 226- or 227-type tubes and operate with practically no trace of an A.C. hum.

It is now possible to obtain an amplifier or a combination amplifier and power unit in any conceivable type desired, so great is the selection.

Naturally, many of these units are not designed for home use but rather for commercial application. However, the enterprising set-builder will find a new field of business in this direction, either through the installation of power amplifiers in churches, auditoriums, etc., or on a rental basis. Fortunately, it is now possible to purchase suitable power speakers and microphones to be used with the power equipment.

Loud Speakers

The Trade Show has indicated a new trend in speakers. There are still a great number of electro-magnetic speakers of both the cone and horn type, and decided improvements over those of last year, but the outstanding feature is the new electro-dynamic speaker. There were more of them than we could count and more have appeared since the show. They follow the average dynamic speaker design from all outward indications and probably bear a similar electrical relationship.

We studiously listened to a host of dynamic speakers and eventually came to the conclusion that the majority of them were good, although we would welcome the opportunity of comparing the impedance matching transformer of each make, along with its own moving coil.

The addition of a good sized baffle makes a great difference in the frequency characteristics of a dynamic speaker and the manner in which the proper baffle effect is obtained in each make varies considerably.

Aside from the dynamic cone speakers there were a number of dynamic units, designed for use with the various type horns marketed, exponential and otherwise. These units are made in a number of sizes; small ones capable of handling 5 watts and suitable for home use, up to 50 watt units for public address work, in auditoriums or out-of-doors.

Early dynamic cone speakers were made in two forms, one which obtained its field current from a storage battery and one which had a specially wound field coil which obtained its current from the power unit in the receiver. The popular dynamic speaker models exhibited have self contained step-down transformers and dry rectifiers so that the field current can be derived directly from the A.C. light socket. This change in general design has automatically eliminated a lot of serious complications.

Naturally, there are special models for 25 and 50 cycle lines as well as D.C. lines, and manufacturers' models to meet specific requirements.

From all indications the electro-magnetic speaker is still holding its own. As a matter of fact, a few new types

HERBERT H. FROST
President R.M.A. for 1928-29.

were introduced at the show, notably the drum type air column speaker and the stretched diaphragm speaker, both of which are excellent.

Phonographs and Pickups

With the advent of the electric phonograph there was a merging of units with the result that the public has been offered numerous combination phonograph and radio outfits. This arrangement avoids the duplication of power equipment and is, therefore, a logical merger. The automatic phonograph feature added to the combination makes the proposition even more attractive, so it was not surprising to find numerous radio manufacturers exhibiting machines of this nature. Generally, their standard radio chassis is mounted in the special cabinets, along with the phonograph equipment, and the standard power unit and amplifier used for both the phonograph and radio. The automatic phonograph systems are masterpieces of mechanical engineering and operate without so much as a hitch.

Following up the demand for electric phonograph equipment, manufacturers exhibited improved electric phonograph pick-ups and electric phonograph motors with turntables.

The pickups indicate improved design, having balanced arms to eliminate wear on the records and "blasting," and electric scratch filters usually included in the volume control case. The pickups are provided with long cords and a plug so that they may be plugged into the audio amplifier of any radio receiver if desired.

The electric phonograph motors exhibited were of two types, i. e., universal, for use on either A.C. or D.C. and the induction type, for use on A.C. only. The motors have automatic governors and speed regulators and in most cases are equipped with a turntable. One type of universal motor exhibited has an automatic lubricating system and requires no attention whatsoever. Aside from this feature, it has a unique spring suspension which eliminates vibration.

Cabinet Design

Greater attention is being given to the design of cabinets and consoles for radio receivers and combination radio-phonographs.

It only recently dawned on us why such abominable cabinet designs edged their way into radio. The industry has struggled along for three or more years hindered by cabinets and consoles that were enough to turn the stomach. This atrocious art has practically vanished under the influence exerted by the large and reputable cabinet manufacturers, who have found the radio field to be an excellent market. We believe these manufacturers and a small group of professional designers, who have also looked to the radio industry, have done their bit in promoting the sale of radio receivers. At any rate, present radio cabinet design is up to normal standards of taste, something we couldn't have truthfully said before.

The cabinets and consoles exhibited at the Show were indeed pleasing to the eye. More manufacturers were represented this year and the lines are more flexible to individual taste. Included in the exhibits were numerous models of modernistic design, indicating French influence. This progressive work, symbolizing the mechanical to a great extent, is rather severe but is greatly favored by the public nevertheless.

So—this year we will have radio sets with a new symmetry, combining beauty of sound and appearance and a convenience never before achieved.

General Exhibits

A further indication of progress in the field of development is seen in the parts and accessories introduced to the radio market. Here again we note a definite trend towards mechanical and electrical simplicity. Such general parts as transformers, variable and fixed condensers, resistors, etc., down to cables and plugs and even hookup wire, show improvement. Healthy competition has lifted parts into a

(Continued on page 36)

Measurement of the Ripple in the Output of Power Devices

Description of the Equipment and Its Operation for the Testing of "A" and "B" Power Devices

By Kendall Clough*

IN a perusal of many pages of matter, some time ago, the writer found no account of a system of measurement of the ripple in the output of "A" and "B" power devices that was immediately adaptable to the pressing needs of the laboratory. Listening to a receiver supplied by the device is a criterion of the operation of the device with that receiver only, while with some other receiver having a greater audio gain the performance of the device may appear inadequate. It is also desirable when experimenting with filters and the like to be able to divorce the supply from any considerations of operation with the receiver as a whole to permit a more accurate and detailed study of the supply device.

One system for this measurement, which has been used extensively, compares the eliminator under study with a standard by the use of an audio amplifier and headphones. A rapid changeover switch permits the determination of whether the eliminator under test is better or inferior to the standard, but the test possesses all the inaccuracies common to tests utilizing the ear as the ultimate measuring device. In addition, the data is not such that it can be recorded with accuracy and certainty of repetition at a future date for comparison with future developments.

Oscillographic methods are quite reliable but are time consuming and beyond the capabilities of the average laboratory. It is felt that a test set to be described in what follows has certain advantages as inferred above and will be discussed together with some of the results that have been obtained by its use. These results can be repeated from time to time with close agreement, the test is rapid and the results are such that they can be recorded for comparison with data taken on other devices at a future date.

The circuit diagram of the complete test is in Fig. 1. The equipment within the dotted line is constructed in one cabinet, the other equipment being detachable and so available for other purposes. The whole set-up will be recognized as a conventional two-stage transformer-coupled amplifier, with a variable resistor shunting the input and a thermocouple meter connected in the output circuit through a suitable output transformer and protective switches and resistor. The operation of the test will be described briefly at first so that the design and calibration of the device will be more evident.

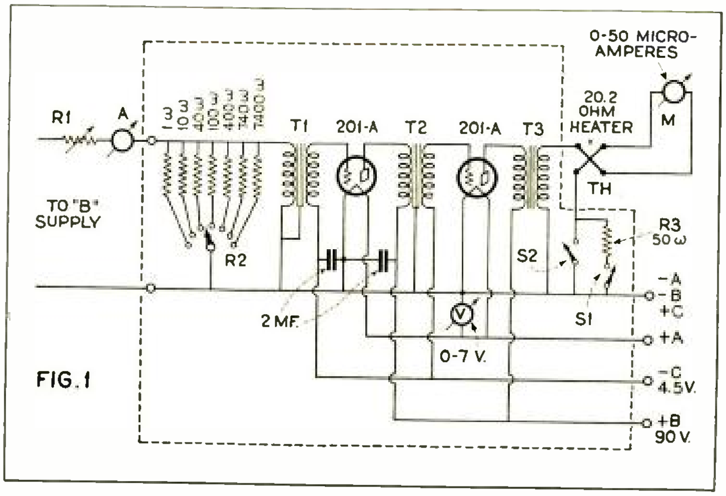
Description of Operation

The "B" supply is turned on and the current delivered by it adjusted by means of the resistor, R1, and the meter, A, which is ordinarily a 0-100 milliammeter. The resistor R2 is then set at some low value and the "safe" switch, S1, is closed. If no deflection is in evidence in the thermo-meter M, the next higher value of the resistor, R2, is chosen and the operation is repeated. After obtaining a small deflection with the switch S1, the switch, S2, may be closed and the resulting deflection tabulated. The eliminator is then adjusted to a higher output and measurement repeated. In this way the data, which can be plotted, is secured and is ultimately reduced to the "percentage ripple current" or in other words the percentage of the output current from the device which is alternating in character. With the equipment as constructed it is possible to measure with good accuracy ripples from .02% at 10 ma. output to 27.0% at 100 ma. output.

The Transformers Used

The transformers for the set, T1 and T2, should be of high grade so as to have sufficient amplification at 120 cycles, the fundamental of the various frequencies comprising the ripple. Even in the best of such devices the amplification of the 120 cycle tone is inferior to the amplification of the harmonics (240,360,480, etc., assuming 60 cycle supply). This has been disregarded in the calibration and operation of the test set, because these harmonics, if present, will be more in evidence to the ear in actual reception due to the rising characteristic of both the audio amplifier and the ear. These harmonics are over amplified in the test set and hence produce a greater deflection per unit strength in the output meter than the fundamental. In this manner devices having strong harmonics are discredited by the test set in much the same manner that they would be in actual test.

The transformers are of three to one ratio and operate in conjunction with 201-A tubes (90 volts B and −4.5 volts C). The last tube of the amplifier is connected to the thermocouple through a transformer T3 of high reactance, having a step-down ratio of 23.3/1 in order to adapt the high impedance of the tube to the resistance of the thermocouple, as well as to insulate the latter from the plate current of the tube. With the particular thermocouple and meter used a current of 11.0 ma. is required for a full-scale deflection. The 50-ohm resistance R3 reduces the full-scale deflection to 1/5 scale and is useful in protecting the thermocouple against damage when



The circuit diagram of the testing equipment showing the variable resistor bank shunted across the input of the transformer-coupled amplifier.

* *Pres., Research Laboratories of Chicago, Inc., Consulting Engineer, General Transformer Corp.*

testing eliminators having large ripple currents.

It may be mentioned here that the switches, S1 and S2, are conveniently push buttons. In this way the thermocouple circuit is opened when an actual reading of the meter is not in process. It is imperative that the thermocouple circuit be opened when altering the current through the input circuit, as surges are apt to be set up in the inductances of the system that will prove destructive to the couple.

It will be apparent that by operating the test set with the same tubes and battery voltages each time, the ripple of devices may be recorded in terms of the resistor, R2, and the deflection of the thermo-meter, at various output currents. On the other hand, many will prefer to reduce the results of their test to terms of greater physical significance as has been done in the results of tests shown below.

Calibration of the Amplifier

Calibration is accomplished by introducing various voltages at 120 cycles from an audio oscillator across the resistor, R2, and noting the corresponding deflections in the output meter. This data is plotted in a curve and need not be remeasured in the future, provided the same equipment and voltages are used throughout. Now, if a current of I amperes (D.C.) flows through the resistor, R2, and there is superimposed on this current an alternating current of x per-cent of I, then there will appear across the resistor, R_2, an alternating voltage of

$$e = x\,.01\,I\,R_2 \text{ (effective)}$$

Transposing, we have for the "per-cent ripple," x,

$$x = \frac{e}{I\,R_2} \times 100\%$$

As the calibration of the amplifier will be conveniently in milli-volts and the current from the eliminator in milliamperes, these units may be used with no change in the constants of the equation. The voltage e is found, of course on the calibration curve. This whole procedure may sound rather formidable, but it has been found that after one has become familiar with the equipment a complete curve may be plotted on an eliminator in about fifteen minutes. In order to illustrate the application of the method a representative study will be presented.

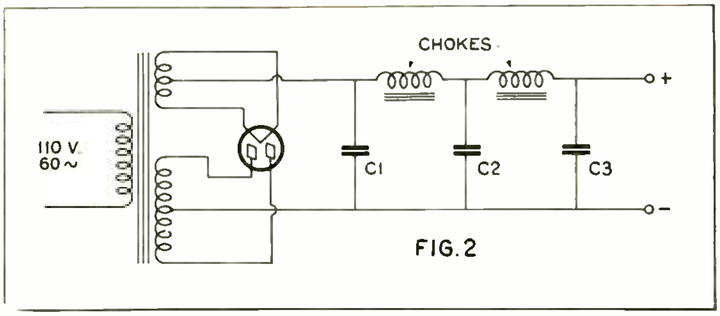


FIG. 2

The circuit diagram of the power supply device used as an example in this article.

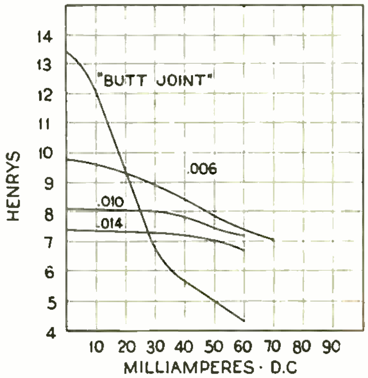


FIG. 3

These characteristic curves were plotted from tests made on the chokes in the circuit of Fig. 2.

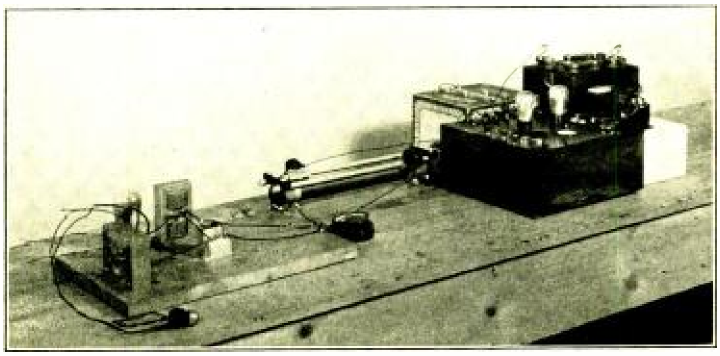
Consider, for the moment, a supply device whose circuit is Fig. 2. The transformer operates from 60-cycle supply and the rectifier is the 280 type. Two chokes are to be used whose characteristics are as shown in Fig. 3. As we are interested in the operation of the device up to 60 ma. only, we will use the .006-inch air gap as indicated in the figure. It will be apparent from the figure that for currents in excess of 60 ma. the .010-inch gap would be preferable even though the inductance at the lower currents is less with this larger gap.

Testing the Filtration

Having this portion of the filter established we now wish to dispose of the condensers of the system in such a way that they will be most effective. We may start by making C1=0, C2=1 mfd., and C3=1 mfd. A curve is run in the manner indicated earlier and is plotted as Curve "A" in Fig. 4. It will be noted that the ripple varies from about .6% to 1.5%. Such a filter is adequate for a receiver having an audio amplifier with poor gain at the low frequencies, for the ripple as indicated will not be reproduced with sufficient intensity to be objectionable.

In order to improve the filtration to make the device capable of operation with a better audio supply we will add capacity to the system. The question now arises as to where to add another microfarad to get the maximum utility. We will first add it at C1, making each of the filter sections 1 mfd. capacity and producing the ripple curve of "B", Fig. 4. The performance is better with regard to ripple and the output of the device has been improved from a direct current standpoint but the strain on the tube has been increased. (See Wise, "Filter Circuits for Filament Rectifiers," RADIO ENGINEERING, Dec. '27.) Now, removing the condenser from C1 and adding it to the next section we make C1=0, C2=2 mfd., and C3=1 mfd. rendering the ripple curve shown at "C", Fig. 4. The output is materially better at currents above 30 ma. than when the extra 1 mfd. was used at the position C1. As the receiver drain is usually in excess of 30 ma. we may consider this performance better, on the whole.

There still remains the possibility that the added 1 mfd. could be used to better advantage when placed at C3. This may be examined by making C1=0, C2=1 mfd., and C3=2 mfd., producing the ripple curve shown in "D", Fig. 4. It will be seen that the added 1 mfd. is not as effective in filtration when used at C3 as when used at C2, which is in accordance with the theory of filters of the type with which we are dealing. In cases where the characteristics of the speaker and



The author's testing equipment on the right connected to a power device filter.

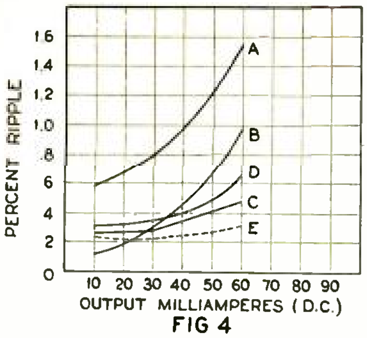


FIG 4

These "ripple" curves were made by varying the amount of capacity in the filter system of Fig. 2.

audio amplifier are such that the hum, as shown in Curve "D", is tolerable, it is good practice to utilize the added 1 mfd. as indicated in order that the instantaneous demands of the audio amplifier may be better supplied. In this case the condenser at C3 is being used as a "tank" capacity rather than for its direct benefits in filtration.

Influence of the Choke's Positions

Curve "E", Fig. 4, illustrates an interesting application. In preparing this curve the same chokes and condenser values were used as in the preparation of the Curve "C", but, in addition, the chokes were placed with their cores in contact and adjacent in such manner that the flux in one opposed the flux in the other. It will be seen that the filtration has been materially improved by this juxtaposition.

In order to indicate the tendencies of modern practice the curves of Fig. 5 have been prepared. Curve "F" indicates the performance of "B" supply employing the 280-type tube as embodied in a complete receiver design of popular manufacture. It will be seen that the hum is allowed to rise to rather extreme values where the device is to supply an audio amplifier and speaker of known characteristics. Contrasted to this is the device, employing a gas type tube, whose performance is shown in Curve "G". It will be seen that the filtration is of the best, which it must be to assure a satisfactory product that is to be sold separately from any receiver and to be operated under any and all conditions. We record parenthetically that the low value of ripple shown in Curve "G" should not be interpreted in favor of the superiority of the gas tube over the 280-type as the filter in this device contains more than four times the total capacity of any of the 280 systems discussed in this article.

It will be obvious that the measurement discussed can be applied to the measurement of ripple in any of the "A" supply systems as now manufactured, by the shunting of known resistors of heavy-current capacity across the input of the amplifier, Fig. 1, and proceeding as in the measurement of the ripple from "B" supplies. In order to record some standard for measurement of devices of this type the curve of Fig. 6 is supplied, indicating the performance of a Tungar-type 2 ampere charger operating in conjunction with an "A" filter of standard manufacture. This combination, producing the ripple as shown, has been found very satisfactory in operating a wide variety of receivers under different line conditions.

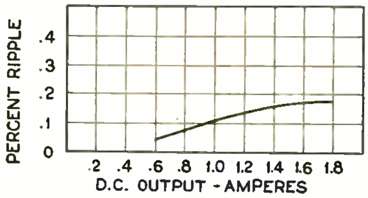


FIG.6

The "ripple" curve of an "A" power device.

It is also apparent that the measurement outlined is of value in the measurement of various conditions obtaining in receivers supplied in any portion from an alternating-current source. Thus the resistor R2 may be placed in the output of the completed receiver in series with the proper resistance to simulate the speaker impedance in order to note improvements in manner of balancing the hum from A.C. filament type tubes and to preserve a permanent record of the experiment in addition to listening tests with the speaker actually in circuit, so that future experiments may be compared to the record rather than setting up old conditions for comparison's sake.

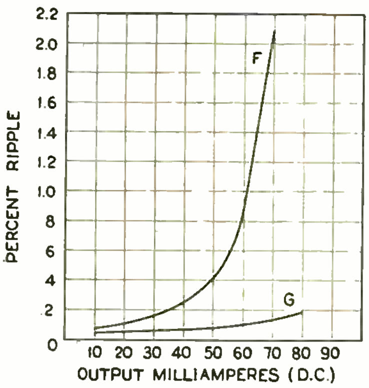


FIG.5

Curve F is the "ripple" curve of a 280-type rectifier and G. that of a gaseous rectifier.

Re — "Paper vs. Mica Condensers in R.F. Circuits"

Editor, RADIO ENGINEERING

In your issue of June, 1928, an article appeared on page 53 entitled, "Paper vs. Mica Condensers in R.F. Circuits" written by Mr. J. G. Uzmann of the Dubilier Condenser Corp.

We note that the author by incorrect assumptions and errors in his computation came to results and conclusions which are contradictory to the facts.

Accepting first the values for power factors given by Mr. Uzmann, namely, .01% (.0001) for mica and .25% (.0025) for paper, we find in the case of a reactance Rc = 370 ohms (as assumed in the example of the article) the equivalent resistances

$R_m = 370 x .0001 = .037$ ohms for mica condensers and

$R_p = 370 x .0025 = .925$ ohms for paper condensers, instead of the corresponding values $R_m = .925$ ohms and $R_p = 3.7$ ohms given.

Assuming a tuning inductance of 8 ohms (as does Mr. Uzmann in the first example) we find the total circuit resistance for mica condensers

$R_{tm} = 8.037$ ohms

and for paper condensers

$R_{tp} = 8.925$ ohms

(instead of the $R_{tm} = 8.925$ and $R_{tp} = 11.7$ of the article)

The difference in resonance current would be

$$\frac{8.93 - 8.04}{8.04} = 11\%$$

instead of 31% given by the author.

For a tuning inductance of 5 ohms the corresponding values are

$R_{tm} = 5.037$ ohms (instead of 5.925 ohms) and

$R_{tp} = 5.925$ ohms (instead of 8.7 ohms) and the difference in resonance current is

$$\frac{5.93 - 5.04}{5.93} = 15\%$$

instead of the 47% given.

From the above it appears that even for values of power factors as given by Mr. Uzmann, there is too great a difference between his results and those obtained by correct computation to give importance to his conclusions.

But the power factor for mica assumed by Mr. Uzmann is much too low and represents a value which may be exceptionally found for test-samples, but not for commercial condensers. Recent tests made in the Electrical Laboratory of the Massachusetts Institute of Technology show that the power factor of commercial mica condensers of the best makes runs up as high as .003 to .004.

It is, therefore, safe to state that no practical advantage is derived from using mica condensers in R.F. circuits instead of high grade paper condensers, this being well known by set manufacturers.

L. P. GRANER, M. A. I. E. E.
Consulting Engineer for Sprague Specialties Co.

The Engineering Rise in Radio

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

PART II

IT is to be remembered that Hertz did not discover or invent radio telegraphy. The thing he did was to establish by demonstration that electric waves produced by electromagnetic means are propagated through space, and that the presence of such waves at points remote from the source may be shown as electric energy in intercepting wire systems properly designed. This is exactly what the mathematician, Maxwell, had told the experimentalists they should find to be so if they searched diligently and carefully.

Hertz lived but seven years after making his great discovery—dying less than a year before the first experiments were made in the use of electromagnetic waves for signaling without connecting wires. By this is meant the first experiments in which the phenomena involved were understood.

The Ether

Employment of the word *Space* as the name of the medium through which electromagnetic waves are propagated is in the interest of simplicity, and while in scientific circles there is doubt about the exact nature of the medium, we have arrived at a step in the intellectual rise in radio where it is necessary to record the progress of thought and speculation relative to the existence of the ether.

The term *Space* is convenient as a name for the element through which the earth and astral bodies move, or in which they are immersed. It is convenient as a name for the medium, other than the earth's atmosphere, which serves as a vehicle for the transfer of energy.

Huygens, a Dutch philosopher, in the year 1670, was perhaps the originator of the undulatory theory, which assumes that light is propagated by means of vibratory motion of an imponderable medium called ether. Isaac Newton, in 1686, published his great work on natural philosophy, describing his theories of force, action and reaction; his conception of mass, and an explanation of gravity. Newton's standing as a philosopher was such that in his time it was like questioning the gospel for others to present hypotheses at variance with those of the great Master. Newton's notion, that light consists of material particles projected from luminous bodies, referred to as the corpuscular theory of light, continued as the accepted theory for a period of one hundred years, until, in the year 1773, Dr. Thomas Young re-established the undulatory theory of Huygens. The last hope for the corpuscular theory seems to have been removed when Foucault, in 1851, demonstrated that the velocity of light was less in water than in air, as it should be if the undulatory, or wave theory were true. Thus as a space-filling medium the ether was recognized as having the property of transmitting light waves, known to have a velocity of 186,284 miles per second.

It was early given the distinguishing name of *Luminiferous Ether* marking it as different from other ethers, such as electric ether for electric phenomena; magnetic ether for magnetic phenomena, and various other *ethers* imagined to account for other phenomena.

Glass tube containing metal filings, used by Branly to detect the presence of electric waves.

It remained for Faraday to head off further indiscriminate invention of ethers. He suggested that the so-called luminiferous ether might be the one involved in all of the phenomena observed. And, Maxwell's work, which started with Faraday's conceptions of magnetic phenomena, concluded that the waves, which constitute light and the waves produced by changing magnetism, are identical in their natures; travel with the same velocity, and *travel in the same medium.*

With Hertz's researches published and in circulation many scientists engaged in mathematical study and experimental inquiry with the thought of extending knowledge: of squaring the now proven Maxwellian theories with established electrical practices, and of finding uses for electromagnetic waves which might be propagated at will and detected at points remote from the point of origin of the waves.

In the years immediately following Hertz's announcement additional light was thrown on the general subject by Horace Lamb, J. J. Thomson, Herr Zehnder, Vernon Boys, Prof. Fitzgerald, Rubens and Ritter, Prof. Gotch, Paalzow and Arons, D. E. Jones, Kolacek, Prof. Minchin, Prof. Boltzman, Prof. Hicks and others.

The First Detector of Electric Waves

The first designed detector of electromagnetic waves in space was the Hertz micrometer spark-gap, or resonator, consisting of an insulated handle on which was mounted an open metal loop, the abutting ends carrying small metal spheres, whose distance apart could be adjusted by means of a micrometer screw. For laboratory purposes this detector answered the needs of experiment and quantitative measurement.

During the four years, 1888 until 1891, nothing of note was contributed in the way of improved means of detecting Hertzian waves, but in the latter year Edouard Branly, of Paris, discovered that a polished coat of porphyrized copper spread over an insulating surface, such as glass, was very greatly reduced in electrical resistance when subjected to electromagnetic radiation. He found also that a small glass tube filled with metallic filings exhibited this same characteristic, and that in the case of both of these detectors, restoration to the high-resistance state was accomplished by jarring them mechanically.

It will be recognized that the Branly detector worked on the microphonic principle. (See the references to the Edison microphone for telephony and to Hughes' observation of 1879 in regard to microphonic contacts.)

During the days when detectors of the *coherer* type were employed in radio telegraphy a number of hypotheses were advanced to explain their operation. Branly suggested that the dielectric, or insulating films separating the metallic elements of the detector, might be modified in character by the action of arriving electric waves. Dr. Lodge suggested that the electrostatic attraction between the very close surfaces "squeezes out" the dielectric, thereby establishing metallic contact (welding) by pressure; possibly aided by a heat effect.

CHAPTER 2

Marconi

Janus, the Latin deity who, in the days of mythology, was reputed to preside over the beginning of all things, may have returned to earthly duty for a spell when the art of wireless telegraphy had its beginning. About four years elapsed between the time of Hertz's discovery in Denmark and the advent of the Branly coherer in France. Dr. Lodge, in England, who as early as 1888 demonstrated the transmission of electric waves along wires, in his later experiments with waves in space was interested in the use of galvanometers for indicating the reception of transmitted impulses.

The idea of employing electric waves in space in conjunction with wave detectors for the purposes of space telegraphy appears to have occurred to Captain Jackson, of the British Navy, upon hearing Dr. Lodge's lecture of June 1, 1904, on the subject of Hertz's work. Dr. Alexander Muirhead, on the same occasion, foresaw the telegraphic importance of electromagnetic waves in space. Captain Jackson inaugurated experiments which resulted in signaling between ships in 1896. Dr. Muirhead devised a receiving arrangement consisting of a coherer and a siphon recorder with which signals could be registered on a strip of paper tape.

Through some slip of circumstances, detailed information in regard to Branly's coherer was slow in reaching the German scientists. Even later than 1894 they were still using the original Hertz loop detector—excellent for measurement purposes, but little suggestive of distance or of signaling value.

It was Marconi, in Italy, who took the first bold and practical step in the direction of utilizing Hertz's discovery for the purpose of space telegraphy.

Mr. Marconi left school when he was about eighteen years of age. Later he studied under a tutor, and in 1895 attended scientific lectures under Professors Righi, Rosa and Dessau. These lectures were on general electrical subjects. Marconi gained knowledge of Hertz's demonstrations in much the same way as amateur experimenters the world over gained that same knowledge in later years. He relates that in 1894 or 1895 he read an illustrated article in German in *Wiedmann's Annalen* dealing with Hertz's announcements. He read also parts of the book by T. C. Martin entitled "Inventions, Researches and Writings of Nikola Tesla," published in the United States in 1894.

Although he attacked the subject in an amateurish way, Marconi had the inventor's knack, or gift, of being able to make important improvements, improvements which enabled him to increase considerably the distance over which signaling could be carried on.

Within six months after Marconi began his Hertzian wave experiments he realized that waves sent out from an induction coil—Leyden jar transmitter were reaching distances not suspected by other investigators. He improved the Branly coherer by moving the terminal electrodes closer together, leaving only a small pocket between them into which a small amount of metallic filings were placed. This increased the sensitiveness of the detector and simplified the de-cohering process.

The First Elevated Antenna System

Marconi's most important discovery was that the distance of transmission was greatly increased by employing an elevated conductor at the transmitter and at the receiver. In 1896 he employed an antenna forty feet in length. He had the foresight in 1897 to realize that grounding one terminal of the transmitting oscillator, while the other side of the oscillator was attached to the antenna wire, would add still greater distance to the range of operation. The receiver in each instance had a circuit from antenna conductor, through the coherer

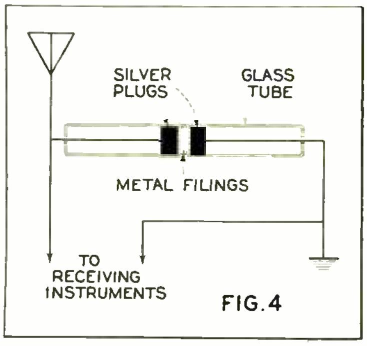


Illustration of the assembly of the Marconi coherer.

and to earth; the coherer being connected in parallel with a sensitive relay and local battery. Incoming waves caused the electrical resistance of the coherer to be considerably reduced, sufficiently to permit the current from the local battery to energize the magnet and attract the armature of the relay. A *tapper* connected in the local circuit of the relay automatically jarred the coherer causing the filings to decohere, ready to respond to the following signal.

Marconi then had the elements of a practical wireless telegraph system. For several months he carried on experiments, making improvements in the apparatus and gradually extending the range of signaling. At the beginning of the year 1896 he had a demonstration outfit which he believed was worth exhibiting in quarters where the practical possibilities of the system might have an appeal. It was time for "wireless" to venture forth from the laboratories in search of useful employment. Mr. Marconi's scientific ability and business acumen, coordinating properly, prompted him to take his wares to market.

Arriving in England in February, 1896, Mr. Marconi got in touch with W. H. Preece, the engineering head of the British Post Office Telegraph System, who arranged for tests and demonstrations. In a way it was an odd situation. An Italian youth—then but twenty-one years of age—and who had been thinking about and experimenting with electromagnetic waves but a little over a year, journeyed to the capital of Great Britain, the headquarters of the world's submarine cable business, to exhibit a system of wireless communication by means of which he had telegraphed a distance of a few miles.

In England at that time William Thomson (Kelvin) was seventy-two years of age; Oliver Lodge, forty-five; William H. Preece, sixty-two; J. A. Fleming, forty-seven; William Crookes, sixty-four, and Lord Rayleigh, fifty-four. Each of these men was a profound scientist and, no doubt, had kept pace with progress both before and after Hertz.

It is true that following Marconi's first appearance several of these gentlemen brought to the new art the direct and immediate benefits of profound knowledge and experimental skill, which in large measure accounted for the astonishing increases in distance range accomplished within a few years.

The boldness, or simplicity, of Mr. Marconi's short-cut from the laboratory to the field of practicability precipitated no end of comment and speculation in scientific and communication circles. The distances over which Marconi was able to operate within a year or two after his first experiments prompted the thought that perhaps he had discovered a new system of electric waves, differing from those of Hertz, the latter having been employed in the laboratories for demonstrations over a range only up to two hundred feet.

Richard Kerr, in the first book on Wireless Telegraphy, London, 1898, says on page 85:

"So far as the Hertzian wave researches are concerned the two great authorities are Mr. Marconi and Dr. Oliver Lodge. But if results later on should prove that Mr. Marconi is utilizing a new set of waves, say a set more penetrating than those of Hertz, we should have a case on all fours with that of the X-ray discovery where Lenard hit upon the cathode rays and Röntgen on those called after his name. And this seems not at all unlikely. Without any extraordinary battery power Marconi seems to be working with waves that will penetrate anything."

It would seem after all that had been contributed by Faraday, Maxwell, Thomson, Hertz, Heaviside and Lodge that the orthodoxy of electro magnetic waves should have been established. That in 1897 and 1898 there was still open-mindedness in the matter must remain as a tribute to the surprise engendered by Marconi's brillant demonstration.

(To be continued)

The Problem of Radio Set Power Supply

The Design and Theory of a Voltage Regulator for Receivers Employing A.C. Tubes or Series Filament Connection

*By George B. Crouse**

PART VII

IT IS THE purpose of this article to discuss the requirements of voltage regulators for A.C. tube receivers and for A.C. receivers employing series-wired filaments, and to describe a specific type of regulator developed to meet the needs of this service.

In the design of voltage regulators, consideration must be given to two factors: first, through what range of voltage must the device operate: second, within what limits must the output voltage be held.

The first point is determined by the actual extreme values of voltage obtaining at the outlets of nominal 110-volt service, and can be ascertained only by field surveys. In making such surveys it must be borne in mind that the voltage at the outlet is affected by the house wiring, and the effect of loading by household appliances on the same line with the outlet, as well as by the variations permitted by the power company at the distribution transformer must be taken into account. Attention is also called to the fact that it is the extreme and not the average condition which must be met.

Voltage Variation and Tube Life

The unpublished results of several independent surveys throughout the country east of the Mississippi shows that the extreme values are 90 to 130 volts, with an insignificant number of cases where the potential goes down during a small part of the day to 85 volts. There are, however, a sufficient number of cases at the upper and lower limits to make it certain that the range of line voltage through which a voltage regulator must work is 90 to 135.

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

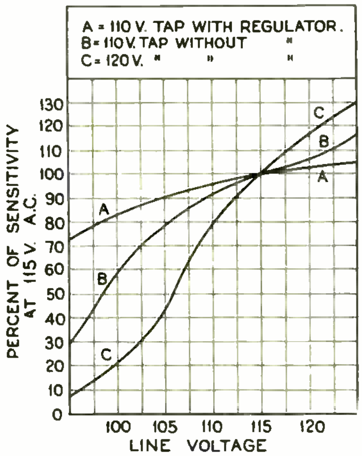


FIG. 1

Voltage-sensitivity curves taken on a Radiola 17 under set conditions.

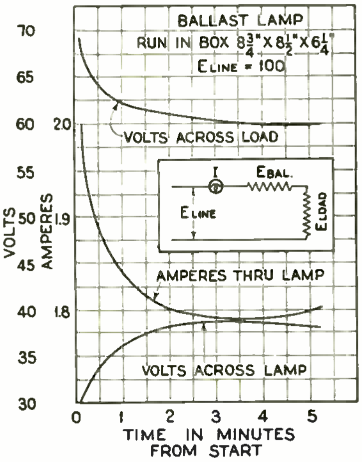


FIG. 2

Time curves of a ballast lamp voltage regulator.

In seeking an answer to the second question—within what limits of voltage must the output of the regulator be held?—we may reasonably ask at the outset, why is it necessary to have a regulator at all?

Probably the most obvious reason for regulation is found in the fact that audions are designed for a certain filament excitation and when the value of the excitation departs very greatly from the specified value, either up or down, the life of the tube is shortened. The effect of an increase of filament temperature is much more disastrous than that of a decrease, but the effect of the latter must not be neglected. It is not obvious how this effect comes about, until it is considered that at some low value of filament current, no emission at all occurs, and therefore, for this current, the tube has zero life. At any higher current less than the rated value, some part of the active material of the filament will fail to come into effect, and the life will be less than normal.

The best figures obtainable for tube life under different excitations indicate that 5% above to 10% below rated value is the limit in which satisfactory life will be obtained.

Another reason for regulation is found in the apparatus for supplying the plate excitation. This apparatus always utilizes condensers, usually of the paper dielectric type. These units are, from the standpoint of possible failure in service, the weakest part of the entire apparatus and also the most expensive. Both the available safety factor and the cost depend upon the voltage which they must withstand. Suppose that one of the condensers in the filter mesh is subjected to a D.C. voltage of 250 volts at the lowest operating line voltage, say 90 volts. When this apparatus is connected to a line having a terminal voltage of 130, and taking into account the magnifying characteristic of the rectifier, this condenser will be called upon to withstand a D.C. voltage of 420. Voltage regulation within 15% throughout the specified range of line voltage will reduce this upper value to about 300 volts, which is permissible.

Still another factor, which has not received proper attention, is the effect of wide voltage fluctuations on the ratio of "C" bias to plate voltage, particularly in the last, or so-called power tube.

Lastly, the sensitivity of the set varies with change of line voltage. In Fig. 1, Curve A, is shown the change of over-all sensitivity of a Radiola 17, at a wave length of 300 meters and a

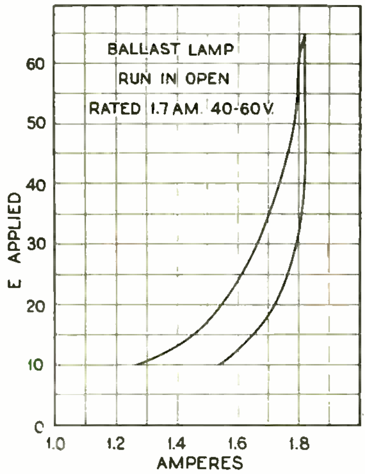


FIG. 3

Curves of ballast lamp operated in the open.

modulating frequency of 400 cycles, using 30% modulation. In curve B in the same figure is shown the change in sensitivity throughout the same range of line voltage, using a voltage regulator which held the voltage applied to the set within plus 7½%.

A balancing of all of the above factors against the cost and simplifity of the regulator design indicates that, for the range of line voltage of 90 to 130 volts, the regulated voltage should be held between plus and minus 7½%, but any further nicety seems commercially unnecessary.

Systems of Regulation

Two methods have been proposed in the past for effecting regulation. The first is not automatic, and comprises a tapped transformer primary with a switch, which may be manipulated either by the service man or the user. Experience with this arrangement has proven very unsatisfactory. It does not, of course, regulate the hourly fluctuations, and the tendency on the part of the user to increase the voltage applied to the set to gain increased sensitivity results in an exaggeration of the very effect which the switch is designed to prevent.

The second device was automatic in operation, and comprised the so-called ballast tube. This device is a resistance having a high temperature coefficient, generally of iron, located in an atmosphere of hydrogen.

The disadvantages of this arrangement are many, the most prominent being the following: First, the device is very slow in action, due to the necessity for heat transfer successively from the iron filament to the hydrogen, to the glass, to the surrounding air. In Fig. 2 is shown a curve taken with a well-designed and constructed unit, in which time is plotted against voltages and current in the circuit. It is possible that this disadvantage may be at least partially overcome by the use of alloys having a temperature coefficient comparable with that of iron, but which will be non-corrosive and non-oxidizing in air at the operating temperatures. None of the alloys so far appearing have shown suitable mechanical properties, however.

Second, the ballast tube is inefficient. This in itself, in most cases, may not be a serious commercial difficulty, but an incidental effect of its inefficiency is very troublesome. A high voltage must be absorbed across the tube, and when the power is thrown on to the apparatus, only a small part of the final drop across the ballast is absorbed, with the result that an excessive voltage is applied until final temperatures are reached. This often means blown condensers, and destruction of tubes.

Thirdly, the ballast tube is exceedingly sensitive to load changes, and to changes in ambient temperatures. Both of these effects are shown in Figs. 3 and 4, taken on the same device as used to obtain Fig. 2. All of these difficulties are overcome with the device about to be described.

Schematic diagram of a simplified voltage regulator comprising a specially designed power transformer and a temperature varient resistor.

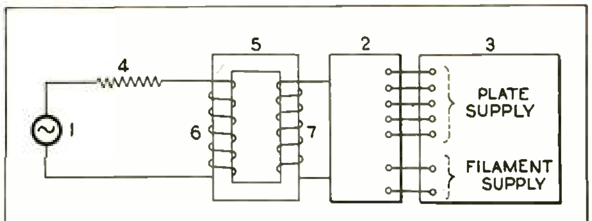


FIG. 5

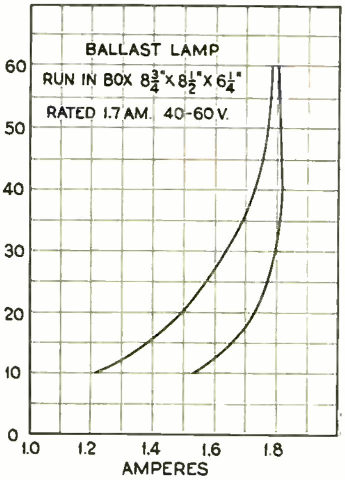


FIG. 4

Curves of ballast lamp operated in an inclosure.

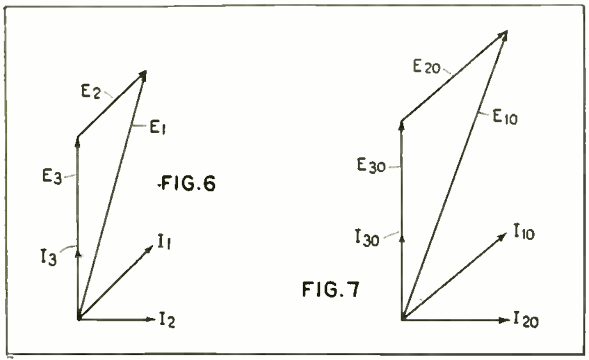
Simplified Voltage Regulator

In Fig. 5 is shown a schematic diagram of the regulator in form of an external or accessory unit.

In this figure, the numeral 1 indicates a source of alternating current supplying energy to the socket power device 2, which in turn supplies energy of the proper kind to the radio set 3. The voltage regulator comprises the resistance 4 having a positive temperature coefficient, and a transformer with an iron core 5, a primary 6 and a secondary 7. The core of the transformer is so designed that the temperature of the resistance, and therefore its effectiveness as a regulator, is controlled substantially entirely by changes of magnetizing current under changes of load, instead of by changes of load current.

The theory of operation of the device as a voltage regulator will be made clear from a consideration of Figs. 6 and 7.

Fig. 6 represents the conditions at the lowest operating voltage of the source 1 and the vector E_1 represents the voltage of this source. The vector E_2 represents the voltage across the primary 6. The current flowing in this primary will have two components, one caused by the load and the losses in the core 5, which will be in phase with E_3 and indictated at I_3. The other current component required to magnetize the core is designated at I_2 lagging E_3 by 90 degrees. The total current flowing through the resistive element 4 will be I_1, the vector sum of I_2 and I_3; this current flowing through the resistance 4 will cause the voltage drop E_2. Now consider that the voltage of the source rises to the value E_{10} of Fig. 7. Under these conditions a relatively small rise will occur in E_3 bringing this value up to E_{30}. This increased voltage across the primary 6 will cause a proportionate increase of the load current to I_{30} and a magnified increase, due to the saturation effect of the quadrature current, bringing it up to the value I_{20}. I_{20} and I_{30} add up vectorially to I_{10} which causes the drop across resistance element 4 to rise to E_{20} from two causes. First, a larger value of current flowing there through causes a larger potential drop directly, and second, this larger current, because of the positive temperature coefficient of



Vector diagrams which serve to illustrate the theory of operation of the voltage regulator shown in Fig. 5.

the material, raises the actual resistance of the element 4.

Some distortion of the wave form occurs, due to the saturation current flowing through the resistance, and this and disturbances of wave form arising from other causes, together with high frequency disturbances on the line, are eliminated by the fact that the geometrical arrangement of the coils and core introduce an effective T section filter. The manner in which this filter is formed will be clear from a consideration of the equivalent diagram of Fig. 8.

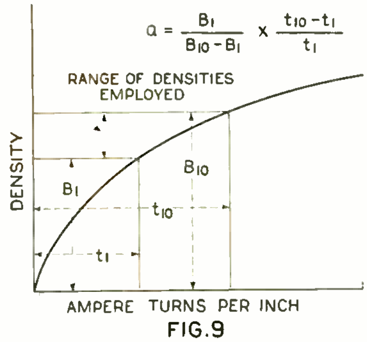


FIG. 9

Representative A.C. magnetization curve.

In this figure 1 is a source, and 4 is the temperature variant resistance, and 20 is the resistant load. The coils 21 and 22 represent respectively the primary and secondary leakage reactance, both of these being given very substantial values by the relative location of the primary and secondary windings. These windings, as shown in Fig. 5, are located on the opposite legs of the transformer core. The shunt winding 23 represents the magnetizing inductance of the transformer and plays very little part in the filtering action, this function being performed by the resistive element 24, which is equivalent to the power losses in those parts of the core located geometrically between the primary and secondary windings.

By constructing this effective T section filter or corrective network out of the leakage and core loss elements of the transformer we have an equivalent of air core inductance in our series elements, having neither resistance nor distributed capacity. In other words, they are ideal inductances. Due to this fact the filter is effective at all frequencies up to the highest radio-frequency disturbances on the line.

Generalized diagram illustrating the formation of an effective T section filter from the power transformer 5-6-7 in Fig. 5.

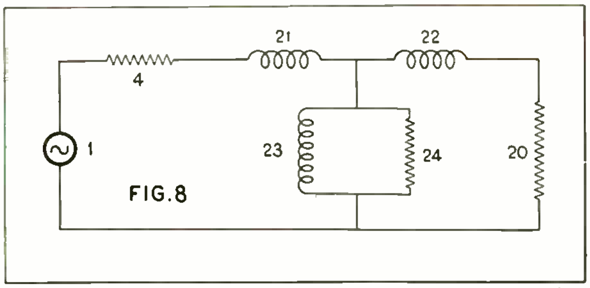


FIG. 8

Mathematical Analysis

Mathematically, the arrangement may be analyzed as follows: At some arbitrarily selected initial condition, let

E_1 = the voltage of the source

E_2 = the voltage across the variable resistance

E_3 = the voltage across the primary

I_3 = primary load and core loss current

I_2 = magnetizing current

I_1 = total current = vector sum of I_3 and I_2

R_4 = equivalent load resistance referred to primary.

With E_1, E_3, I_3 and I_2 known, the initial value of the variable resistance will be given by the equation

$$R_2 = \frac{-E_3 I_3 \pm \sqrt{E_3^2 I_3^2 - (I_3^2 + I_2^2)(E_3^2 - E_1^2)}}{(I_3^2 + I_2^2)} \qquad (1)$$

Then to find the source voltage corresponding to any new value of the primary voltage, we have

$$E_{10} = \sqrt{\left[E_{30} + R_{20}\frac{E_{30}}{R_4}\right]^2 + \left[R_{20}\ I_{20}\right]^2} \qquad (2)$$

The new values of the quantities being indicated by multiplying the subscripts by 10.

In equation 2, we have new values for I_2 and R_2, which are not linear functions of the primary voltage E_3, and these new values are found as follows:

$$I_{20} = \frac{E_{30} - E_3}{E_3} \cdot a\, I_2 + I_2 \qquad (3)$$

This equation for the new value of the magnetizing current contains a term (a) which must be determined empirically from an A.C. magnetization curve, made on the particular quality of steel it is proposed to use, and under approximately the circuit conditions which will be employed in the final design of the apparatus. The method of determining (a) is shown in Fig. 9.

The new value of the variable resistance is determined from

$$R_{20} = \frac{I_{10} - I_1}{I_1} \cdot b\, R_2 + R_2 \qquad (4)$$

In which the factor (b) is also determined empirically from a current-resistance curve of the material which it is proposed to use for the variable resistor. The method of determining this factor is shown on Fig. 10.

Practical Considerations

In practice it is found that ordinary silicon transformer steel may be used for the transformer core, worked at densities within the usual range, i. e., from 75,000 lines per square inch upward. Pure nickel wire is used for the resistance, this material having a fairly high temperature coefficient, and being non-oxidizing in air at all temperatures up to and even above red heat.

In the practical design of the apparatus, many advantages may be secured. It may be made very fast in action: the regulation is partly effected by an increase in the resistance of the series temperature variant element and partly by an increase in the drop across this element due to the increased magnetizing current. This latter effect is, of course, instantaneous, and is momentarily magnified until the system reaches a new condition of stability. For this same reason, the sudden exaggerated voltages, which occur on a sudden rise of source voltage with a ballast tube, are practically eliminated, with a resultant reduction of wear and tear on filter condensers, tubes and other parts of the receiver sensitive to overload.

While the device has been described as an external, or accessory unit, it may be built into the radio set, as an integral part thereof, the only element added to the receiver being the temperature variant resistor. The transformer is built with the requisite secondary windings and substituted for the usual power transformer.

This regulator may be built economically in sizes up to 150 watts output. For higher powers, or where closer regulation is required, we have designed a magnetic type, in which perfect and instantaneous regulation may be secured, and capable of being built practically in much larger sizes. It is proposed to make this magnetic regulator the subject of a future article.

(This article terminates the present series. We hope to hear from Mr. Crouse again, in the near future.—Editor.)

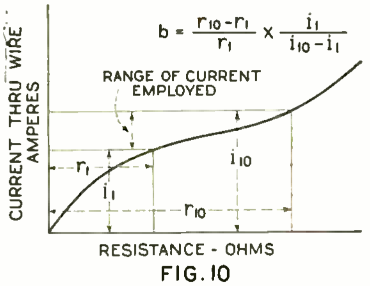


FIG. 10

Representative current-resistance curve of material used for resistance 4

The Mathematics of Radio

Covering the Mathematical Design and Practical Construction of Iron-Core Chokes and Transformers

By John F. Rider, Associate Editor

PART VIII

ANOTHER arrangement showing the core and winding of a choke suitable for use in B-eliminator filter circuits is shown in Fig. 42. A, B, C and D are the strips used for the core. The space between A and C and A and D is the air-gap. The winding is shown in dotted lines and located upon the core specified as B. The arrangement in Fig. 43 is maintained constant after the proper length has been determined. This is a side view of the winding and core shown in Fig. 42 and indicates how the clamps are placed upon the core.

Since this series is written to show how radio units are designed, we will discuss the general design of a choke suitable for use in the filter system of a B-eliminator. The first essential is to decide upon the inductance value of the choke, because a certain amount of inductance is necessary in order to obtain the required retarding effect upon the A.C. component of the rectifier system output. The next important item is the direct current-carrying capacity of the choke. The effect of the direct current flow was discussed in Part VII and repetition is therefore unnecessary. After the inductance and current capacity have been decided upon, a reasonable value of air-gap and flux density are chosen. This is followed by the number of turns and the size of the core. Since it is impossible to give complete tables whereby the calculation of all chokes would be simplified, we will give two examples of filter choke design; values which will be suitable for actual radio practice.

Design of Filter Chokes

Let us suppose for example, that we desire a choke to be used in the filter system of a B-eliminator, and which is to have an inductance of 20 henrys and be capable of carrying 150 milliamperes of direct current, with a relatively low value of D.C. resistance, let us say 400 ohms. By using a low resistance winding, the D.C. voltage drop is kept at a minimum value. We are going to build a choke similar in physical characteristics to the one shown in Fig. 42. It should be remembered, however, that the design of a filter choke differs from the simple design of an air-core inductance, because of the variable ratio between the copper of the turns and the iron of the core. Furthermore, the equivalent air gap is an uncertain value. Since we know the desired inductance and the required current carrying capacity, let us first design a choke on paper so we can study its physical dimensions and general layout.

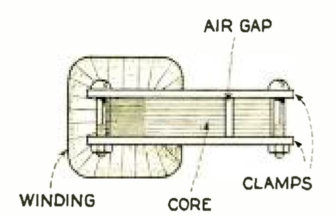


FIG. 43

General design of an iron core choke.

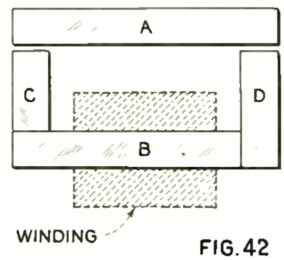


FIG. 42

Illustrating formation of core laminations and location of airgaps.

The equivalent airgap is determined by means of the formula given in Part VII and again repeated in this text, viz.:

$$G = 3.2 \frac{I \times N}{B}$$

where G is the equivalent airgap, N is the number of turns, I is the current in amperes and B is the flux density in lines per square inch.

Arbitrarily we can select a flux density of 35,000 lines per square inch and 5500 turns for the winding. Substituting into the formula and solving, we arrive at an equivalent airgap of .03 inches. The induction of the choke is governed by a formula which was also mentioned in Part VII but will again be repeated so as to facilitate comprehension of the design and is as follows:

$$L = 3.2 \times \frac{N^2 A}{G \times 100{,}000{,}000}$$

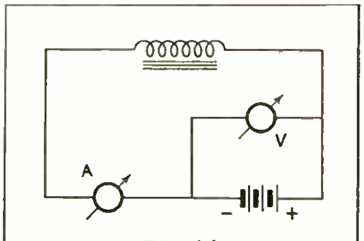


FIG. 44

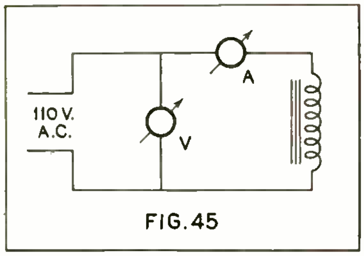
Circuit for taking voltage and current measurements on iron core choke to obtain the D.C. resistance.

where L is the inductance in henrys, N is the number of turns in the winding, A is the net area of the cross section of the core in square inches and G is the equivalent airgap in inches.

In order to be able to apply this formula, we must choose a value for A, the net area of the cross section of the core in square inches. Suppose we again select an arbitrary figure and say that the core is going to be square with a net area of 1.625 inches, equivalent to approximately 1.3 inches for the side of the core. Substituting these values into the formula and solving (G in this formula is the value .073 obtained in the preceding formula), we obtain the inductance value (approximate) of 20.7 henrys.

It is customary with the average silicon steel core material to figure on approximately .005 inch airgap per inch of core length. Since the equivalent airgap is .073 inch, the approximate length of the complete core is slightly less than 15 inches. Referring to Fig. 42, this would mean a length of approximately 6 inches and a height of approximately 3.5 inches. After these dimensions have been laid out by the constructor, he can decide if the physical layout is satisfactory from a standpoint of compact design. Since the inductance of the choke is proportional to the cross section area of the core and to the square of the number of turns and inversely to the length of the airgap, unsatisfactory design in the first instance may be modified by varying the above three constants.

A modification in design can also be effected by increasing the airgap or reducing the flux density value. With respect to the length of the gap used in the calculation, the minimum value for the equivalent airgap is around .025 inches although the usual mini-



Circuit for determining the impedance of an iron core choke.

mum is approximately .03 inches. If we reduce the length of the airgap, which is a dangerous procedure because of the possibility of saturation, we can reduce the cross section area and still obtain the desired amount of inductance, reducing in this manner the size of the choke. However, let us assume for the sake of simplicity that the dimensions quoted are satisfactory and let us proceed with the design.

Having decided upon a maximum D.C. resistance of 400 ohms, we must select wire which will provide the resistance limit specified. The accompanying wire table is suitable for the selection of wire which will carry the specified amount of current and also for the determination of the D.C. resistance of the choke. We can consider as the basis a thousand circular mils per ampere and we find that No. 28 wire will carry 160 milliamperes and that its resistance is 64 ohms per thousand feet. According to the table 74 turns of B & S. No. 28 enameled wire can be wound in a linear inch. If we plan a length of winding equivalent to 2 inches, we will require an approximate depth of 38 layers, which is equivalent to approximately a little more than one-half inch.

If the core is 1.3 inches thick and we allow 1/16 of an inch for insulation between the core and the winding, the mean radius of the winding will be equal to one-half the core thickness plus the 1/16 of an inch for the insulation, plus half the depth of the winding. Insulation between layers for choke coil windings is unnecessary. Under the circumstances, the mean radius is equal to .962 inches. Consequently, the length of a mean turn is equal to .962 x 6.2832 since the circumference of a circle is equal to the radius x 2 pi. Solving we find that the length of the mean turn is 6.02 inches. The total length of the winding is, therefore, equal to 6.02 x 5500 or 33,110 inches, equal to approximately 2750 feet. According to the table, the resistance of No. 28 wire is 64.9 ohms per thousand feet and the total resistance of the winding is therefore equal to 64.9 x 2.75 a result approximately half of our calculation. The voltage drop will therefore be very low. One and a half pounds of wire are necessary for this winding.

Determining the D.C. Resistance and Inductance

The D.C. resistance of the choke can be determined experimentally by means of the arrangement shown in Fig. 44, a battery of 6 volts shunted by a voltmeter to indicate the voltage is arranged in series with an 0 to .5 ammeter and choke. The resistance of the choke (D.C.) is equal to the voltage divided by the current or

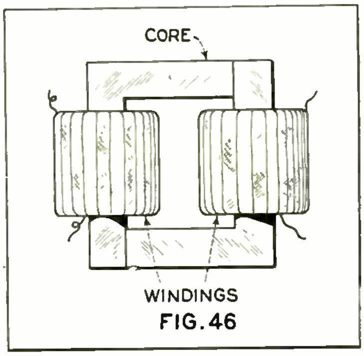
$$R = \frac{E}{I}$$

After the assembly of the choke has been completed, the gap is filled with paper and the unit clamped as shown in Fig. 43 or by any other arrangement, so that the gap distance remains constant. By utilizing the arrangement shown in Fig. 45, the impedance of the choke can be determined. It is connected in series with a milliammeter (A.C., 0 to 50) and shunted across the 110 volt A.C. line. An A.C. voltmeter is connected across the line to indicate voltage. The impedance again is equal to the voltage divided by the current. If one cares to solve for the impedance, it is

$$Z = \sqrt{R^2 \text{ plus } (6.28 \times F \times L)^2}$$

The inductance on the other hand is equal to

$$L = \sqrt{\frac{Z^2 - R^2}{(6.28 \times F)^2}}$$



General construction of a closed core transformer.

The design details for a filter choke of 30 henrys capable of carrying .85 mils, similar to that shown in Fig. 42, is as follows: equivalent airgap .05. Flux density considered 35,000, number of turns required is 65,000, mean total length of core. 10 inches, net area of core, 1.1 square inches, side of core, 1.1 inches, size of wire and total length required determined as before, size depending upon resistance (D.C.) desired.

Transformers

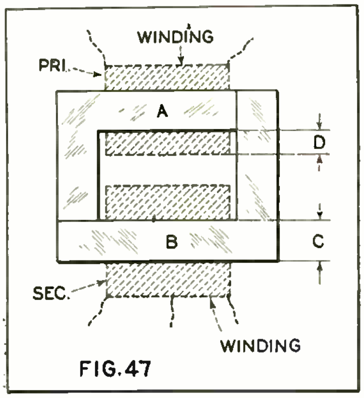
While on the subject of iron core chokes, we might as well consider transformers, since they are classified in the category under which is listed the iron-core choke. The design of transformers differs from the design of the choke, because the transformer core does not carry direct current and consequently it is unnecessary to provide an airgap. The transformer core is continuous as shown in Fig. 46 and it is customary to place the primary winding on one of the legs and the secondary winding on another. In some cases where several secondary windings are employed, such as a plate-voltage winding and one or two filament-voltage windings, the plate-voltage winding is on one of the legs and the filament-voltage windings are located on top of the primary winding or on the remaining legs of the transformer core.

Transformers are classified in two ways, step-down and step-up. The first classification covers transformers wherein the output voltage is less than the voltage applied to the primary, and the second classification covers transformers where the output or secondary voltage is higher than the voltage applied to the primary. In the event that several output windings are employed, some of which supply a voltage higher than the input voltage and some of which supply an output voltage lower than the input, the transformer is usually classified by quoting the function of the various output windings.

As in the case of the choke, various ratios between copper and iron can be used. That is, various ratios between

Copper Wire Table

Size B & S	Current Capacity (Amperes) 1000 C. M Per Amp.	Res. per 1000 Ft. (Ohms)	Turns per Linear inch (Enam.)
23	.51	20.4	42
24	.40	25.7	47
25	.32	32.4	53
26	.25	40.8	59
27	.20	51.5	66
28	.16	64.9	74
29	.13	81.8	82
30	.10	103	92
31	.08	130	103
32	.063	164	116
33	.05	207	130
34	.04	261	145
35	.032	329	164
36	.025	415	182
37	.02	523	206



Indicating design considerations of a closed core transformer.

the number of turns and the size of core can be employed. A frequently suggested constant for this ratio is 35 and the first step in the design of a transformer is the determination of the number of turns per volt in the output winding or windings, as the case may be. The formula employed to obtain the turns per volt for the output winding or windings is

$$\text{Turns per volt} = \frac{35}{\sqrt{\text{Watts Output}}}$$

General Transformer Design

Let us consider the transformer shown in Fig. 47, where P designates the primary winding and S designates the secondary winding, which can be for argument's sake the plate-voltage winding of a transformer. The three leads indicate that the winding is tapped at the middle, and let us assume that it is designed for use in a full-wave rectifying system, where each half of the winding is supposed to supply 300 volts. In the calculation for the turns-per-volt value, we add the output voltage of each half of the winding and consider the total required as 600 volts.

When considering the watts output of winding, it is necessary that we have a current as well as a voltage rating. This current rating is necessary in the design of a transformer for a certain rectifying tube. Let us say that this transformer is to be used with a tube which has a direct current rating of 125 milliamperes. To be safe, we will rate the winding at 300 volts and 150 milliamperes. The output wattage rating is therefore equal to 300 x .150 or 45 watts. Substituting this wattage value into the turns-per volt formula mentioned previously, we obtain a turns-per-volt value of approximately 5.2. Since the voltage output is to be 600 volts (300 volts in each half) the total number of turns required is equal to 600 x 5.2 or 3120 turns. According to the wire table No. 28 wire will carry the amount of current considered in the design.

The next step is the determination of the amount of turns necessary for the primary winding. We have determined the turns-per-volt constant. Considering a line voltage of 110 volts, the number of turns necessary in the primary winding are 110 x 5.2 or 572 turns. Before we can determine the size of wire necessary for the primary, we must know the current flow. Assuming an operating efficiency of 80%, the input into the transformer is equal to the watts output of the secondary divided by the operating efficiency or 45.8 or 57.2 watts. The current flow is equal to watts divided by voltage, which in this case is .51 amperes. Considering wire rated at 1500 circular mils per ampere, B. & S. No. 21 is the wire required for the primary winding. The current carrying capacity of various wires at various circular mil ratings not mentioned in the preceding table can be obtained from any copper wire table or chart. We now know the number of turns and size of wire required for the primary and secondary windings. The current carrying capacity of various wires at various circular mil ratings not mentioned in the preceding table can be obtained from any copper wire table or chart. We now know the number of turns and size of wire required for the primary and secondary windings. The next step is the determination of the core area. Since it is impossible at this time to show a chart giving core area specifications, we will mention various values of primary turns and the core area, when the transformer is to be operated at 110 volts and 60 cycles and 110 volts and 25 cycles.

With respect to the "side of square" mentioned in the above table, the designation C in Fig. 47 indicates this dimension. It is really nothing more than the width of the lamination. With the size of the core determined, the next step is the layout of a theoretical transformer, taking into consideration the number of turns required in the primary and secondary windings and the physical layout of these coils. After the cross section of the core has been determined, it is customary to decide upon the depth of the windings so as to determine the "window" required for the core. Referring to Fig. 47, the inside square is the window, A and B designating two laminations of the built-up core. The depth of the winding D is determined by first deciding upon the length of the winding and determining from the table in this paper or from any other copper wire table, the number of turns per linear inch and then deciding upon the number of layers necessary to afford the required total of turns. The method of determining the depth of the winding was discussed in detail in the chapter describing the design of filter chokes. The finished transformer should have a physical appearance similar to that shown in Fig. 46. Excessive length or width of the core denotes bad design.

110 Volt, 60 Cycles Supply

Primary Turns	Net Area of Core Sq. in.	Side of Sq.
500......	1.38	1.21
550......	1.26	1.19
600......	1.18	1.13

110 Volt, 25 Cycles Supply

Primary Turns	Net Area of Core Sq. in.	Side of Sq.
500......	3.4	1.9
550......	3.05	1.82
600......	2.8	1.76

(To be continued)

R.M.A. SHOW REPORT

(Continued from page 25)

new realm of excellence. Engineers have been on the job and have isolated the illusive mechanical and electrical microbes which undermine before the eye, which is unable to see, but meet their end under the scrutiny of the unerring testing and measuring devices. Thus, we have filter condensers as tough as nails, fixed condensers with better power factors, resistors that will last almost indefinitely under constant load—and so on down the line.

Testing equipment has also been greatly improved. Some of the larger outfits are engineering masterpieces and will perform most any test associated with tubes and radio receivers. The smaller outfits, mounted in compact carrying cases, are ideal for the radio serviceman and custom-set builder. They will check any part of a radio receiver, test power units, tubes, etc.

Very little change is seen in the vacuum tube field. The same type tubes hold sway and will probably continue to do so for some time to come. A few special duty tubes have been introduced, however. A number of independent tube manufacturers displayed A.C. screen-grid tubes, similar in filament characteristics and heater design to the 227-type tube. There are also a number of 201-B type tubes which have 125 m.a. filaments, making them particularly adaptable to the battery-operated set and series filament operated receivers. It is reported that they stand up very well under operating conditions.

One manufacturer has introduced a photo-electric cell and a neon tube. They are designed particularly for use in conjunction with television equipment, what there is of it, but will find any number of other uses.

Apropos television, a few built-up receivers were exhibited at the Show, these adhering closely to general design, with the usual synchronous motor, the scanning disc, etc. It is very fine material for experimental work.

We also saw flocks of voltage regulators, both of the automatic and manually operated types which are suitable for use with any form of receiver or auto-power amplifier. The automatic jobs really provide very good regulation over wide limits of line voltage variation.

Radio Kits

Kits were not in great evidence, but this is not indicative of a change in the business. Most of the popular kits are not introduced until early fall. Nevertheless, as few as they were in number we must add that the manufacturers are getting down to brass tacks insofar as attractive design and price are concerned.

The short-wave kit-sets are equally as attractive and are well engineered. Many of the multi-tube jobs employ screen-grid tubes in the R.F. stage and it is claimed that European stations are picked up with no great difficulty.

Televox—The Electrical Attendant

Explaining the Functioning of the Latest Development in Remote Control Apparatus

By R. J. Wensley*

IN response to a need for a simple and relatively inexpensive form of remote control, a mechanism called the "Televox" or "Mechanical Man" has been developed. This was done to supplement but not supplant supervisory control systems, which have come into such general use in the last few years.

The use of small distributing substations is becoming more and more the accepted method of supplying the electrical needs of large cities. To carry this plan to its logical conclusion these stations must be unattended. Wholly reliable means are available for the periodic reclosing of the local distribution feeders. It is not so simple to control the incoming high tension feeders, which may form part of a ring or other complicated network. It is most desirable that the system operator be given some means by which he can issue instructions to the apparatus in the unattended stations and receive replies that his instructions have been obeyed.

For important or large substations where the expense is warranted, there is no better method than by the use of one of the available types of supervisory control. These systems require individual control circuits of from two to four wires. These wires may be specially installed for the purpose or may be leased from the telephone company. In either case there is considerable expense involved. For the more important stations this expense is fully warranted, but for the lesser stations the tendency among many power companies is to take a chance and depend on quick transportation to get a man to the station after an outage. If a man were actually in the station, the solution would be quite simple. The dispatcher would pick up his telephone, call the substation and order certain breaker movement. But, as we have already stated, these stations are too small to justify human attendance, hence, the telephone is useless.

The public telephone systems have been brought to a high state of perfection. Recent improvements in operating technique have greatly speeded the connection time of the Bell system. In spite of the time worn jokes regarding the slowness of the exchange operators it is now a matter of common comment that connections are secured with an accuracy and speed that leave but little to be desired.

Introducing Televox

WE are pleased to introduce you to Televox. He is still a youngster but has a mind of his own. A short time ago he graduated from the silent class. He now has a voice, prompted by his own mechanical mind.

Televox has ideals—and vision. Being young he still imagines he wants to be an engineer on a steam engine or the director of a sub-station. However, as he grows older and drops a few of his childish illusions regarding play, and comes to the realization that one must work, and work hard, to make a living, he is going to assume a very important position in industry.

Fortunately, Televox has a strong constitution and an unerring mind with which to cope with the strenuous competition of the times. He can work 24 hours a day without experiencing fatigue—a truly extraordinary accomplishment. Even now, he can do simple jobs exceedingly well.

Televox's father is proud of him and is anxious to have you know how well he can do things. Now that he can talk he is a very interesting child and though we do not usually submit to the whims of proud fathers we make this one exception, in the belief that you will be interested in Televox's biology.

We hope you will follow his growth.

THE EDITOR.

With this great and reliable means of public communication available in every corner of our cities and towns it seemed a pity that it could not be used for the purpose of controlling these small, unattended stations. If there were only a machine with sufficient intelligence to answer the telephone and carry out a few simple instructions and give some replies, the problem would be solved.

Intelligence by Proxy

In response to this need came the Televox. This is literally a machine endowed with enough apparent intelligence to carry on a conversation over a standard telephone through exchanges and their connecting cables in exactly the same manner as would a human operator, were such available. This device must not transgress the rules laid down by the telephone companies regarding attachments to their lines or instruments. Every effort is put forth by these companies to maintain their service at a high degree of efficiency. This could not be done were unauthorized persons permitted to make changes in the electrical circuits or the telephone instruments themselves. The telephone companies' very rigid but justifiable restrictions, therefore, made it necessary that the Televox actually "listen" to the receiver and "speak" into the transmitter.

The standard telephone systems provide channels which will carry all frequencies between 300 and 2800 cycles with a reasonably small attenuation. The operating tones or "voice" of the Televox must stay within these limits. For the first sample, tones corresponding to 600, 900 and 1400 cycles were chosen. It will be noted that the upper frequency falls between the second harmonics of the two lower frequencies. This is necessary to prevent possible false operation due to the harmonic operation of the ampli-

* Switchboard Engineer, Westinghouse Electric & Mfg. Co.

fier for the higher frequency, should this be a multiple of one of the lower frequencies.

The first model was an experimental device and necessarily crude: although in no way does it exhaust the possibilities in this new form of control.

The Televox Equipment

The dispatcher's equipment consists of three tuning-fork oscillators, a two-stage audio amplifier, a loud speaker unit and three push buttons. The standard desk telephone is placed on the desk in front of the loud speaker unit.

At the substation there is a larger cabinet which contains a two-stage amplifier, three ladder-type filters and three individual frequency amplifiers. Relays in the plate circuits of the output tubes in these final amplifiers operate the selective portion of the equipment. A set of telephone relays and selector switches comprises the selective equipment. On the side of the box is a shelf on which the standard desk telephone is placed. The receiver is left off the hook and is placed on a microphone, which forms the electrical "ear" of the unit. A weighted arm projects from the side of the box to depress the hook switch on the phone. This is arranged to be lifted by a magnet inside the cabinet. The telephone may be lifted from the shelf and used in the ordinary manner without the necessity for detaching or disconnecting any device. When finished with its use as an ordinary telephone, the instrument is replaced on the shelf and is immediately in readiness for automatic operation.

All language is but a succession of sound strung together in various combinations. As there are but few operations to perform, the language need not be complicated. The three frequencies before mentioned are used as three monotone syllables and all the various commands are translated into a language composed of these. This might be called "Televoxanto" with apologies to Esperanto.

How Televox Functions

Let us vision a scene in the dispatchers office of a central station equipped with the Televox.

The telephone rings. "Dispatcher speaking."

"This is the service department. We have three calls from 26th and Y Sts."

"All right. We'll investigate and call you back."

The Dispatcher hangs up and turns to his system map. "Lets see. That will be feeder 16-S-5 out of Sub 16."

The dispatcher consults his telephone index and picks up his telephone receiver. "A line please" this to the private branch operator.

"Number please."

"Valley 6000."

"Thank you - - - - - - - - - - 6000"

And then the dispatcher hears in the telephone receiver "Buzz - - - - - - buzz - - buzz - - buzz - - buzz - - buzz - - buzz" which translated from Televoxanto into English says "This is the Televox at Substation 16 speaking. What can we do for you?"

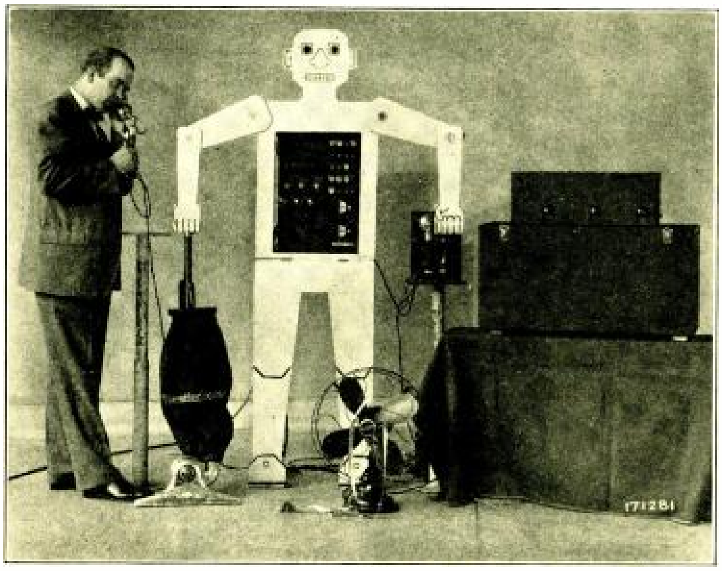
The dispatcher places his phone in front of the speaker unit on the front of his Televox cabinet and pushes the button marked 1400 five times. The loud speaker says "Tweet - - tweet - - tweet tweet - - tweet" which says to the substation "Connect me with breaker number five and tell me if it is open or closed."

And then the buzzer at the substation buzzes out the information that breaker number five is open. The dispatcher pushes the button marked 900 and the loudspeaker says "Toot" which is short for "Close it." The buzzer then says that the breaker closed but opened again almost immediately. "Close it again" This time the buzzer says that the breaker stays in.

The 600 cycle button causes the speaker to say "Whoop" which is the way Televox has of saying "That is all. Goodbye." The substation hangs up; the dispatcher hangs up but immediately calls the service department and asks them to call the persons making the complaint to see if service has been satisfactorily restored, also to send out a man to patrol the line and locate the trouble if possible.

An ordinary ringing signal relay of the type used for operating special loud gongs or signal devices is installed by the telephone company and furnishes the initiating means for the rest of the substation equipment. The relay makes contact when the bell rings, thus energizing the magnet which lifts the weight from the hook switch and completes the circuit to the amplifying tube filaments. After an interval of about thirty seconds, during which the substation buzzer sends out the station code at intervals, the actuating circuits will be opened by a timing device unless the dispatcher sends one or more 1400 cycle tones. This is to take car of wrong number calls which are inevitable as long as human beings use the telephone.

For portable use the device can be operated by three carefully tuned pitch pipes of the proper tones. This enables the line repair man to operate the substation breakers from any telephone in private houses or pay stations near the case of trouble. Testing of defective circuits is thus greatly expedited.



Mr. Wensley and Master Televox doing a few turns for respectful admirers. Mr. Wensley is calling Televox on the phone preparatory to asking him to operate the vacuum cleaner and the electric fan. Master Televox is about to answer his private phone. Note the batch of relays and band filters composing Televox's constitution.

Now Televox Speaks

All the earlier Televox models have used an answering signal consisting of a buzzer mounted in front of the telephone transmitter, this buzzer sounding various codes to denote the response of the devices. Owing to the possibility of errors in calling, there are times when outside persons might call the telephone equipped with the Televox. Should such be the case, there would be nothing but a meaningless buzz to tell them of their mistake. In order to make the equipment more suitable for use over the public telephone system, the Televox has now been given a voice with which it responds in the English language or any other language that may be desired.

The previous models were not able to originate a call should something unusual happen in the substation. With the new model, however, should a circuit breaker trip automatically or a machine overheat or any of the various protective devices function, the machine is automatically started and the voice of the mechanism speaks to the telephone operator giving her the number of the dispatcher's telephone—thus putting through a call in the usual manner.

Televox's Larynx

To give the mechanism means for emitting articulate speech of good quality, use is made of developments in the "talking movie" industry. A piece of moving-picture film about 15 or 20 feet long is spliced to make an endless loop. In the present model two sentences are spoken. These are photographed near the two edges of the standard film, the rest of it being left blank, the sound appearing in the form of closely spaced lines of various shades and widths and frequency. Individual lamps with special straight filament are arranged with lenses to concentrate the light on a very narrow portion of the film at any one time.

A small motor drives the film whenever the voice is required. A selecting mechanism in the Televox lights either one of the two lamps, depending upon the sentence desired. The image of the filament is projected through a narrow slot, onto the speech record through which it passes to a photoelectric cell. As the lines on the film pass in front of the light, the corresponding change of currents which take place in the photo electric cell are amplified through a special shielded three-stage amplifier to a volume sufficient to operate a small loud speaker. This speaker is placed in front of the telephone transmitter and is heard by the person at the other end of the telephone line exactly as though a human being were speaking the words into the transmitter.

"Televox Speaking"

When a call is put through to a substation equipped with a Televox having this voice attachment, the person at the remote end will hear a voice saying, "Televox speaking at Randolph 6400." This will repeat a second time and if the proper signal is not given by means of whistles or other musical devices, the Televox will then hang up the receiver upon the assumption that the call is a wrong number call. In the meantime the person at the distant end has heard the number of the telephone to which he has been connected and should it be a wrong number, will be able to hang up and signal the operator again to get the correct number. However, should the dispatcher have made this call with the expectation of operating something in the substation, he listens for the voice and as soon as he has verified the correctness of the number of the substation, as indicated by the telephone number, he blows a blast on the proper whistle and the voice ceases and the machine is then in condition for further operation by means of the whistle notes.

Should a circuit breaker open automatically, the Televox is put into action and lifts the receiver of the telephone and immediately begins saying at intervals, "This is the Televox calling for Main 5000." This will be continued at intervals until the central operator is able to complete the connection to the dispatcher's telephone. As soon as he hears this voice, he will stop it by a blast of the proper whistle and then proceed to question the machine by further whistles as to what has happened. The answers to these questions will be in the buzzer code which the dispatcher understands.

As soon as the whistle stops the voice, the motor is also stopped and the lamps extinguished so that the film is in use only a very short time.

Mr. Wensley examining Televox's vocal cords, in other words, talking film. Note the driving motor and the black case which contains the photo-electric cell. The "speech amplifier" is mounted on top of the case.

Further Possibilities

The addition of this automatic voice considerably broadens the possible field of application for the Televox. It is not limited to the speaking of the two sentences but may be made to answer quite a number of questions correctly when necessity for such answers has been determined in advance. For instance, where it is not desired to use code signals indicating the amount of water in a reservoir, this mechanism can be made to state the height of water in feet, or it can be made to say that a machine is cool or hot, or a machine is dangerously hot. It can be made to repeat any sort of routine report that can be selected by electrical circuits.

Applications of Heavy Current High-Voltage Supply Units

Various Uses of the 350-Milliampere Rectifier Tube in Common Type Filter Circuits

*By James Millen**

With the advent of electro-dynamic speakers, experimental television, low voltage, high wattage power tubes, and many other devices requiring any where from ⅛ to ½ ampere of direct current at voltages between one and two hundred, or so, the necessity for a power supply operating directly from the 110 volt A.C. supply becomes quite evident. About a year ago such a power system was developed for use with series filament operation of the 201-A tubes in batteryless radio sets. This power unit was built around the 350 M.A. B.A. gaseous full-wave rectifier tube, which had been developed for just such uses.

* *Raytheon Manufacturing Co.*

wherever exceptional heavy current drain was a prerequisite.

As the main use for this rectifier tube and its associated circuit in the past has been almost entirely restricted to supplying "A-B-C" voltage to 201-A radio tubes, it is only natural to overlook the possibilities for its application in other fields—both in and out of radio.

New Applications

But let us first consider some of the newer radio applications. Take, for instance, the electro-dynamic cones, which are attracting so much attention at present amongst those radio fans who are primarily interested in obtaining the best of tone quality. While some of these devices are intended for field excitation on a six-volt storage battery, this practice can hardly be considered in keeping with the present-day socket-power operation. On the other hand, many of the electro-dynamic speaker fields require for best results, from 1/4 to 1/2 ampere of direct current, which is beyond the capacity of most high-voltage rectifiers. In some electro-dynamic speakers the practice is to employ the electromagnet winding as a filter choke, thus serving two functions at the same time. However, this practice may result in a considerable A.C. hum.

The BA rectifier is ideally suited in connection with energizing the electromagnet of an electro-dynamic speaker. Most commercial speakers of this type operate best with an input to the field of twenty watts, which is very difficult to obtain from ordinary sources. This high wattage, of course, requires special field windings, but does permit exceptionally good results to be obtained. The creation of an intense magnetic field across the gap in which the moving coil is suspended dampens the action, and slight rattles often noticed in electro-dynamic speakers are eliminated. To supply this heavy current, the BA tube, while rated at a little better than one-third ampere, will actually deliver one-half ampere, if the input voltage is kept below three hundred volts per anode. It is often desirable to take a BA transformer, in series with the primary of which a resistance is inserted, and feed in through a very simple filter circuit to the electromagnet of the speaker. Most constructors prefer to have a separate power unit to supply the field and often obtain their radio power supply through another unit.

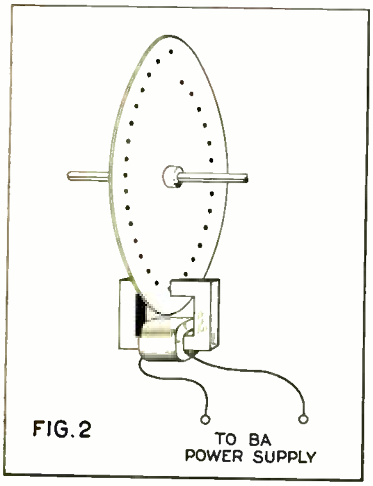


FIG. 2

Dynamic brake for altering speed of a motor-driven scanning disc.

Push-Pull Amplification

Another application in radio for the BA tube is in conjunction with push-pull amplification and particularly multi-tube push-pull amplification, now coming into extensive favor. Instead of resorting to the high voltages required for the —10 and —50 type power tubes operating at maximum capacity, it is often considered better practice to employ a plurality of —71 type power tubes in push-pull, or again in double push-pull or four tubes for the final stage. It is also possible to operate a —10 type tube push-pull amplifier at a plate voltage of 250 or 300. Invariably, it will be found that the push-pull amplifier provides better tone quality than a single tube operating at higher voltage.

For auditorium use where a large undistorted power output is required, it has been customary in many installations in the past to use the "50 watt" transmitting tubes operating on a plate voltage of approximately 1,000 in the last audio stage. Now that the new 250 tube is available, however, better results are possible from an output stage, comprising a plurality of four of the 250's in combination parallel push-pull arrangement with but 300 volts on the plates and a total plate current of approximately 200 milliamperes.

Both the plate voltage and current requirements for such an installation are readily met by a power supply unit employing but a single BA full-wave rectifier.

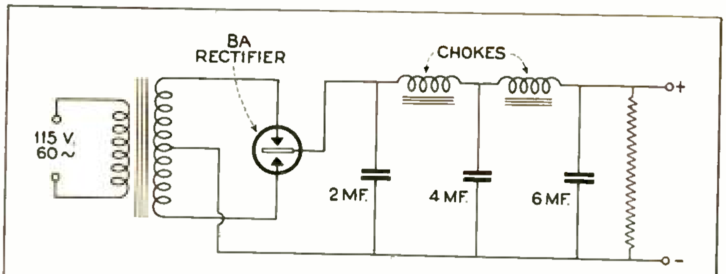


FIG. 3

Circuit of an A-B-C power supply unit employing a high voltage, high current gaseous conduction rectifier tube.

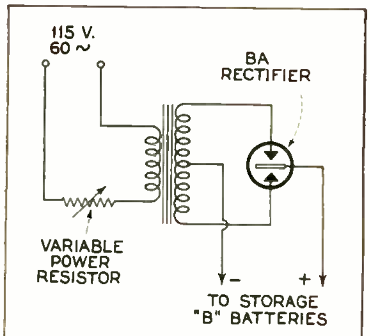


FIG. 1

Circuit, utilizing a gaseous rectifier, for charging storage "B" batteries in series connection.

Series Filament Operated Receivers

But perhaps the most recent power supply requirement that is well met by the BA rectifier and associated equipment, is for lamp socket operation of sets employing the new 222-type screen-grid tubes in series filament operation. In some instances, the 222-type tubes are used as R.F. amplifiers, as detectors, and as first A.F. amplifiers, with either a 171 or a 250, with A.C. in the filament, in the output stages. The 135 mils. of filament current, as well as the plate current, are easily handled by the BA rectifier.

Charging Storage "B" Cells

For short wave work and also experimental laboratory work, it is often advisable to use "B" batteries rather than eliminators as a source of plate voltage. For such use most laboratories, as well as many experimenters, employ storage "B" batteries. Using the conventional methods of charging, it is necessary to disconnect groups of the small storage cells and connect them in a series-parallel circuit before putting on charge. By using just a BA tube and transformer for charging purposes, banks of batteries having volt-

Regulation Data

E line	Watts pri	I p	E anode	I by-pass	I load	E load
115	117.	1.25	231.0	.140	.300	150.
115	108.	1.15	231.5	.140	.250	152.
115	97.	1.05	232.0	.140	.200	156.
115	86.	1.00	232.5	.110	.150	157.
115	76.	.85	233.0	.138	.100	154.
115	63.	.75	234.0	.135	.050	153.
115	52.	.70	234.9	.129	0	150.

ages of as much as 250 or so may be charged at one time without the inconvenience of changing to a series-parallel circuit arrangement. See Fig. 1. A variable series resistor should be used in the primary circuit of the transformer for regulating the charging rate.

Magnetic Brake

There are also many other uses which will become evident in the laboratory from time to time, where a simple, reliable, silent and inexpensive source of high direct current at high voltage will prove valuable. Take television experiments, for instance. In the system that is being most generally experimented with in this country at present, a scanning disc is employed. The general practice is to mount such a disc directly on the shaft of a motor, the speed of which can readily be varied, so as to bring the speed of the disc employed at the receiver into synchronism with that at the transmitter. One method is to employ a small D.C. motor with a field rheostat for speed control. A D.C. power supply delivering between 1/4 and 1/2 ampere at 110 volts is just the thing for such operations. Another system employed in at least one laboratory at present, is to use an induction motor operating from the local A.C. line. A magnetic brake is then used to "slow up" the disc until it is in synchronism with the transmitter disc. See Fig. 2. Such a brake requires anywhere from 1/8 to 1/2 ampere of direct current at about 110 volts for its operation. For this service the BA rectifier serves admirably. Its inherent load regulating characteristics enables the construction of a power unit that will give practically constant output voltage over a wide range of load drains.

Of late this gaseous rectifier has found increasing use in railway signaling systems, in place of troublesome high-voltage storage batteries and primary cells. It permits of harnessing the usual alternating current to the requirements of signaling and telegraph circuits, at a very low first cost and operating cost.

Interesting possibilities are offered in connection with applying the BA tube to electro-plating, on an experimental or small scale, of course. The high output voltage may be reduced by means of a series resistance, and it is possible to obtain 1/2 to 1 ampere at 100 volts, without injuring the rectifier.

Because of the negative current resistance characteristic of the BA tube a power unit using this tube can be made to deliver almost constant voltage with a wide variety of load current. To do this, input voltages of around 200 to 250 are used and a load of 100 milliamperes will have little effect on the output voltage and the circuit can be so designed that the decrease in drop through the tube with increasing current will compensate for the drop through the filter circuit.

In Fig. 3 is shown the conventional circuit for a power unit using the BA rectifier as most generally used in connection with "A-B-C" power supply for radio receivers.

For dynamic speaker operation, power amplifier use, and almost all laboratory work, the simplified arrangement shown in Fig. 4 will be found better suited. This circuit was developed in the laboratory several months ago to meet some rather severe requirements—low cost, almost perfect regulation from 0 to 300 milliamperes load, and low A.C. ripple in the output.

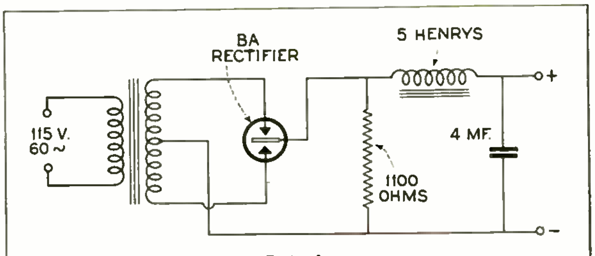


FIG. 4

Rectifier and filter circuit for supplying field energy to an electro-dynamic speaker.

The excellent regulation results from so selecting the values of the shunt filter resistor and the D.C. resistance of the filter choke, as to take full advantage of the normally "rising" characteristic curve of the BA rectifier and result in practically a constant voltage output regardless of load.

A very good idea of the performance of such a power unit may be had from the table in Fig. 5.

Condensers Have Many Uses in Industry

By Engineering Staff
Dubilier Condenser Corporation

ONE of the most important applications of condensers today is in the protection of motors, generators and instruments near radio and other high-frequency and high-tension systems. Surges and resonance effects in power plants and lines are dangerous unless the proper provision is made to prevent the potentials from rising above certain definite limits. The proper provision often takes the form of special condensers which take care of surges and resonance effects set up in the plant or the line by direct strokes of lightning, induced potentials from lightning, proximity of radio or other high-frequency systems, operation of circuit breakers, switches, fuses, etc., harmonic alternator EMF's in resonance, and low proportioned capacity of alternators.

The industrial and power condensers follow the same general technique as those intended for radio applications. In fact, it is the experience gained in making industrial and power condensers, which are intended for the most rigid kind of service, that has taught condenser specialists how to make really good radio condensers, particularly filter condensers. The making of a coupling condenser for carrier telephony, or wired wireless telephony, to operate on a 110,000-volt transmission line—a condenser capable of withstanding this astounding voltage without even a remote possibility of breakdown—is the sort of engineering experience which has led to the production of filter condensers capable of giving dozens of years of life in the usual radio power units.

NEW OFFICERS OF NEMA RADIO DIVISION

The results of balloting for officers for the radio division, National Electrical Manufacturers Association after their annual meeting in June gave to Louis B. F. Raycroft of the Electric Storage Battery Company the vice presidency and leadership of the radio group for another year. This is Mr. Raycroft's third term in office.

In the division dealing with trade and merchandising problems, George A. Scoville was reelected chairman of the Merchandising Council, and H. Curtiss Abbott was chosen vice chairman. Mr. Scoville is with the Stromberg-Carlson Company, and Mr. Abbott is general sales manager of the Crosley Radio Corporation.

In the important technical committee sections, L. W. Chubb of the Westinghouse Company was chosen chairman of the radio receiver section, George Lewis, Arcturus Radio Company, head of the vacuum tube section, H. L. Olesen, Fansteel Products Company, head of the power supply section, and Julius Weinberger, Radio Corporation of America, head of the radio transmitter section.

AMERICAN MECHANICAL LABORATORIES CHANGES NAME

The American Mechanical Laboratories of 285 North Sixth Street, Brooklyn, N. Y., it has been announced by John J. Mucher, president, will be hereafter known as the Clarostat Manufacturing Co., Inc. operating at the same address. The personnel of the organization, its policy and products will remain the same.

REORGANIZED DE FOREST RADIO COMPANY ANNOUNCES PLANS

With the complete recapitalization and reorganization of the DeForest Radio Company, one of the best known names in the radio industry may be said to be back in the ring. The new organization represents the mobilization of finances running well into seven figures, quite aside from the cancellation of all indebtedness. The best ability and experience which the radio industry has to offer, have likewise been mobilized. The plant in Jersey City is being remodelled and re-equipped for utmost efficiency.

The President and General Manager of the new organization is James W. Garside, an executive long experienced in production and merchandising activities. The Board of Directors is as follows: A. J. Drexel Biddle, Jr., Trustee, Duke Foundation, and Chairman of this Board; Wiley R. Reynolds, Chairman of the Board, Reynolds Spring Co.; James I. Bush, Vice-President, Equitable Trust Co.; Arthur B. Westervelt, Vice-President, American Trust Co.; Harris Hammond, President, International Petroleum Co.; Paul L. Deutsch, President, Sonora Phonograph Co.; Victor C. Bell, A. D. Mendes & Co. and Orlando P. Metcalf, Metcalf McInnes, Allen & Hubbard.

An Advisory Board, comprising men long prominent in the radio industry and allied industries, reporting directly to and consulting with the President, will shortly be announced.

With the possession of numerous DeForest basic patents and improvement patent rights, the new organization plans the early production of a complete line of perfected vacuum tubes representing the latest achievements in this highly specialized field. There will also be produced a complete line of radio receivers and accessories, representing the utmost in research and engineering, it is stated.

Realizing the close and growing partnership between phonograph and radio arts, the DeForest Radio Company will be associated with the Sonora Phonograph Company—a pioneer in phonographic and acoustic development—in the production of radio receivers and phonographs.

SPARTON LINED UP FOR SEASON

Captain William Sparks, President, W. J. Corbett, Vice-President, and H. C. Sparks, Sales Manager, have just returned from Cleveland, Ohio, where they attended a meeting of the Board of Directors of The Sparks-Withington Company, radio and motor signal manufacturers of Jackson, Michigan. The general plans and policies of the company were discussed for the 1928-29 season and the company's activities in general are to be greatly increased.

RADIO DEALERS OF CHICAGO DISTRICT ORGANIZE TO IMPROVE MERCHANDISING PRACTICES

The Midwest Radio Trades Association is an organization made up of wholesale and retail dealers who are merchandising radio equipment in the Chicago territory. Any retailer who handles radio sets or accessories is eligible for membership in this group. However, this organization has adopted certain fundamental principles that are necessary to sound merchandising and each dealer member will have to indicate his willingness to practice these before his membership can be accepted.

The meetings of this Association are held regularly once a month at the Electric Club, 30 North Dearborn St., Chicago.

The Association also invites any out-of-town dealers passing through Chicago to stop at their offices, or, should they be in town when the meetings occur, to come and listen to the fine programs that have been arranged.

NYMAN OF DUBILIER STAFF TO STUDY EUROPEAN RADIO CONDITIONS

Alexander Nyman, for the past five years a consulting engineer of the Dubilier Condenser Corporation of New York, has sailed for Europe in order to combine a well-earned vacation and a study of European radio conditions and technical developments. He will spend some time with the British and the German Dubilier organizations abroad for an exchange of production and technical ideas.

The contributions of Mr. Nyman to the radio art are well known even if not generally identified with his name. He is responsible for notable developments in the study of mica dielectric, and for the rapid measurement and testing of this material. He has done extensive research on high-voltage phenomena as applied to the condenser art. He has made a long study of transmitting condensers, particularly at high frequencies for short-wave work. His contributions to condenser life test technique have meant much in the development of satisfactory filter condensers for present-day socket power radio. More recently, he has contributed liberally to the development of the condenser shunt ammeter for the measurement of antenna current regardless of wave length.

ROLLER-SMITH SALES ORGANIZATION CHANGES

The Roller-Smith Company, 233 Broadway, New York, N. Y., announces the following changes in its sales organization:

The State of Texas is now being handled by Mr. John A. Coleman, 1006 Washington Ave., Houston, Texas.

The states of Colorado, Utah, Wyoming and northern New Mexico are now being handled by Mr. H. T. Weeks, U. S. National Bank Bldg., Denver, Col.

Both Mr. Coleman and Mr. Weeks are men of wide experience in the electrical business and with the territories that they are covering. Both will handle the entire line of Roller-Smith products, including electrical measuring instruments, relays, and circuit breakers.

NEMA TO PUBLISH TRADE-IN HANDBOOK

Within several months the radio retailer in every part of the United States will have available the "NEMA Handbook of Radio Trade-In Values." Going back as far as 1924 this Handbook will contain suggested trade-in values for used radio sets and will offer the radio dealer a useful guide in selling a new radio set to a customer who wishes to trade in his present used set for a new one. This Handbook, announced Louis B. F. Raycroft, Vice-president of NEMA, will be prepared under direction of George Scoville, Stromberg-Carlson Telephone Mfg. Co. and head of NEMA Merchandising Council, and H. Curtiss Abbott, Vice Chairman of Merchandising Council, and sales manager of Crosley Radio Company. This handbook has the approval and support of leading members of the radio industry who are members of NEMA and is another step in the group of many taken by the NEMA Radio Division at their annual meeting in Chicago.

NEMA AIDS TO SERVICE MEN

The Radio Division, National Electrical Manufacturers Association, are going to help train radio service men. No radio service man, called upon to give service to set owners possessing radio receivers of widely differing design and arrangement can possibly have readily available all the information he needs to give proper service to all kinds of radio sets which differ greatly.

"The National Electrical Manufacturers Association is going to help educate the service man," said Louis B. F. Raycroft, Vice President of NEMA. "We are now gathering the information on radio sets which have been on the market since 1924 and in one of the two books in the NEMA Radio service course will provide wiring diagrams of radio receivers and power units and will supplement this by regular additions to keep the diagram handbook up to date. Our handbook of practical technical information for the service man will complete the course."

WHO NEEDS CHICAGO REPRESENTATIVE?

R. S. Drummond, Manufacturers' Agent of 440 So. Dearborn St., Chicago, Ill., is interested in securing new radio lines to represent in Chicago and the Midwest Territory. Mr. Drummond has over six years experience as manufacturers' agent in radio and is well known in the jobber and dealer field.

NEW SALES POLYMET REPRESENTATIVES

The Polymet Manufacturing Corporation of 599 Broadway, New York City, has announced the appointment of two more Sales Representatives for the entire Polymet line.

Mr. J. L. Simon of 1746 Commonwealth Avenue, Boston, Mass., will call on the radio manufacturers and jobbers in the New England territory. Mr. I. Schubot of 707-8 Hoffman Building Detroit, Mich., will cover the manufacturers and jobbers in the Michigan territory and Northern Ohio.

E & E CO., NEW CHICAGO SALES AGENCY

The E. & E. Company, 549 W. Randolph St., Chicago, Ill., has recently been organized as a sales agency for Chicago territory and vicinity representing the following manufacturers: Tyrman Electric Corp., Benjamin Electric Co., Automatic Electric, Inc., Quam Radio Corp., all of Chicago; General Instrument Co., New York, and Shamrock Mfg. Co., of Newark, N. J. The principals of this company are R. E. Eglaston and H. P. Evetts both well known radio men and connected with the industry ever since its inception.

GREBE TO CONVERT BATTERY SETS FOR A.C. OPERATION

In conjuction with the announcement of the new seven tube electric set, A. H. Grebe and Company, Incorporated, announces that the factory in Richmond Hill is prepared to effect the conversion of battery operated Synchrophase receivers into the new model Synchrophase Seven A.C., for jobbers, dealers and consumers.

The complete cost, which includes additional rewiring, extra material and the external power unit, will be fifty-five dollars.

NEMA PUBLISHES BOOK ON THE RADIO MARKET

The Radio Division, National Electrical Manufacturers Associaton has just announced the publication of "The Radio Market," which is said to be the most comprehensive study, based on statistics gathered by the Department of Commerce in cooperation with the National Electrical Manufacturers Association, ever made of the radio market. It was announced that this was the first issue of a similar study which would regularly be made.

Statistics heretofore available on radio stocks and radio sales have been largely estimates accompanied by deductions frequently drawn by statisticians not directly concerned with radio merchandising. The data offered in "The Radio Market" is based on actual figures from the retail trade as a whole and since it is intended for the radio industry, deductions of doubtful value have been avoided. It has been prepared for the purpose of supplying each phase of the industry with facts which are readily available to those concerned in marketing a particular product. The 32-page publication, full book size was compiled under the direction of Major R. A. Klock, chairman of the NEMA statistical committee.

GENERAL RADIO DROPS JOBBERS AND DEALERS TO CONCENTRATE ON TECHNICAL APPARATUS

Although one of the first manufacturers in the radio parts field to establish a jobber-dealer outlet for its products, the General Radio Company of Cambridge, Mass., discontinued all of its distribution outlets on July 1. This change has been brought about not through failure of this method of distribution, but rather due to a change in the product manufactured.

When the General Radio Company started nearly a decade and a half ago, its product consisted of instruments and parts used in radio and telephone research laboratories. During the war, much of this equipment was used in training camps and emergency research laboratories. In fact, the original superheterodyne developed by Armstrong in France used many GR parts.

Following the war, one of the principal tasks undertaken by the Company was the equipping of the Navy with submarine detecting devices. This special equipment, which now includes many items such as oil-locating-apparatus, occupies much of the efforts of the Company.

With the advent of broadcasting, it was only natural to find a company already organized in the radio field especially equipped to meet the demand for radio parts for the experimenter. For a while this phase of the business nearly swamped the instrument output, but as complete sets became the rule rather than the exception, conditions returned to normal.

As the major part of its output is now in laboratory apparatus, which, because of its special nature, is by necessity a factory-to-consumer proposition, the Company has decided to place all of its output on the same basis. This does not mean that it will discontinue the development and manufacture of radio parts, because such devices are required in large quantities in development and private laboratories. It only means that in the future all such parts as well as laboratory apparatus will be sold only on a factory-to-consumer basis. To facilitate distribution, a West Coast stock will be maintained at 274 Brannan Street, San Francisco, and the Central Scientific Company, Chicago, will maintain a stock of certain items especially adapted to school use.

The engineering and laboratory personnel has been recently increased, and many new instruments are under development, both for laboratory and experimenter use. One of special interest is a wavemeter designed for use with amateur transmitters in accordance with the new requirements of the International Radiotelegraphic Conference. A whole new series of high quality broadcast transformers has just been announced.

POLYMET MANUFACTURING CORP. PUBLISHES NEW MANUAL OF ENGINEERING DATA

The Polymet Manufacturing Corporation of 599 Broadway, New York City, have announced the publication of a new loose-leaf manual which should prove of special interest to radio engineers and radio manufacturers' purchasing agents.

The manual presents complete descriptions, working drawings, prices and test results of all Polymet products—filter and block condensers, wire wound resistances, large and small moulded bakelite condensers, fixed mica condensers, metallized and wire-wound strips, polytrols (automatic rheostats), potentionmeters, rheostats bakelite grid-leak mountings and phone plugs. The loose-leaf form of the manual will permit additional pages of information to be inserted from time to time to take care of future developments.

This manual is not for general circulation, but the Polymet Company will gladly send it free of charge to radio engineers and manufacturers' purchasing agents who will write to The Polymet Manufacturing Corporation.

H. B. CROUSE, NEW NEMA PRESIDENT

Huntington B. Crouse, President of the Crouse-Hinds Company of Syracuse, New York, was elected President of the National Electrical Manufacturers Association at its second Annual Meeting at Hot Springs, Virginia, on June 13th, succeeding Gerard Swope, President of the General Electric Company, who retains membership on the Board of Governors and on the Executive Committee of the Association. The following Vice-Presidents to head NEMA's various Divisions were also elected:

Apparatus Division, N. A. Wolcott, Packard Electric Company; Appliance Division, M. C. Morrow, Westinghouse Elec. & Mfg. Co.; Policies Division, Clarence L. Collens, Reliance Elec. & Eng. Co.; Radio Division, Louis B. F. Raycroft, Electric Storage Battery Company; Supply Division, W. E. Sprackling, President Tubular Woven Fabric Co., Pawtucket, R. I.

For a term of three years the following were selected to become members of the Board of Governors:

H. B. Crouse, Crouse-Hinds Company, Syracuse, N. Y.; R. Edwards, Edwards & Company, Inc., New York City; A. L. Eustice, Economy Fuse & Mfg. Co., Chicago, Ill.; Otto H. Falk, Allis-Chalmers Mfg. Co., Milwaukee, Wis.; W. L. Jacoby, Kellogg Switchboard & Supply Co., Chicago; J. F. Kerlin, National Carbon Company, Cleveland, Ohio; D. H. Murphy, Wiremold Company, Hartford, Conn.; R. J. Russell, Century Electric Company, St. Louis, Mo.; Frank E. Wolcott, Frank E. Wolcott Mfg. Co., Hartford, Conn.

For a term of one year to fill an unexpired term I. A. Bennett of the National Metal Molding Company of Pittsburgh was elected.

UNITED RADIO CORP. TRIPLES PLANT CAPACITY

United Radio Corporation, builders of "Peerless" loud speakers, licensed under Lektophone Corporation basic patents, has tripled their plant capacity and removed their principal assemblage factory at Rochester, N. Y., into larger quarters.

NEW FREED-EISEMANN JOBBERS

The Freed-Eismann family of jobbers is increased by the announcement that the General Ignition Co. of Milwaukee has been added and that the Crescent Electric Supply Co. of Davenport, Iowa, and Madison, Wisconsin, has been enrolled. The Crescent Electric Supply Co. of Dubuque, Iowa, has been merchandising Freed-Eisemann products for a considerable period.

Announcement is made by the Michigan Chandelier Co. of Detroit that it has been awarded the Freed-Eisemann franchise in its territory.

NEW FREED-EISEMANN DISTRIBUTORS

Among the new distributors of the Freed-Eisemann line are the John V. Wilson Co. and the Bigelow-Dowse Co., of Boston, veteran New England merchandisers.

K. L. Allardyce Arnott, managing director of Freed-Eisemann Radio (Great Britain) Ltd., is in the United States for his bi-annual visit to the Freed-Eisemann factory in Brooklyn.

LEKTOPHONE CORPORATION LICENSES ATWATER KENT MANUFACTURING CO. AND GRIGSBY-GRUNOW CO.

The Atwater Kent Manufacturing Company, Philadelphia, and the Grigsby-Grunow Co. of Chicago have been licensed to manufacture controlled-edge cone speakers under the basic Lektophone and Hopkins patents by the Lektophone Corporation, according to Colonel Robert Davis, president of the licensing company.

With the recent development of power driven speakers and the broader application of controlled-edge cone speakers largely necessitated by this change, Lektophone Corporation has materially modified their original licensing policy to conform to the needs of the radio industry and to afford a greater measure of protection for Lektophone licensees.

LEKTOPHONE CORPORATION LICENSES BRITISH RADIO MANUFACTURERS

The Lektophone Corporation, owners of the basic patents on controlled edge radio cone speakers under which principal radio manufacturers in the United States are licensed, has completed negotiations with Standard Telephones & Cables, Ltd., London, the principal electrical equipment manufacturers and operators in Great Britian, to represent the corporation in Europe, it was announced today.

The Lektophone Corporation, together with Standard Telephones & Cables, Ltd. now own and control basic patent letters in practically every country in the world. Graham Amplion Company, Ltd. and Celestian Company, Ltd., largest British manufacturers of radio sets and equipment after the Standard Company, have been licensed under Standard-Lektophone patents and improvements.

BIWAX CORP., NEW CHEMICAL COMPANY

The Biwax Corporation, with offices at 208 South LaSalle St., Chicago, Ill., has just been organized for the purpose of manufacturing waxes, battery seal compound and conducting chemical research work. Mr. J. L. Donovan is general manager with Mr. H. W. Herbst, the engineering chemist. The factory is located at 909 Concord Place.

E. W. LINCOLN, POTTER MFG., CO. SALES MANAGER

E. W. Lincoln has recently joined with the Potter Mfg. Co., North Chicago, Ill., as manager of Sales and Engineering. Mr. Lincoln was formally with Fansteel Products Co. and also with the Kellogg Switchboard & Supply Co.

M. J. BARRETT, GRIGSBY-GRUNOW N. Y. REPRESENTATIVE

Grigsby-Grunow Co., of Chicago, manufacturers of the new Majestic electric receiver appoints Milton J. Barrett special sales representative under the direction of Herbert E. Young. Mr. Barrett will work out of Mr. Young's New York office.

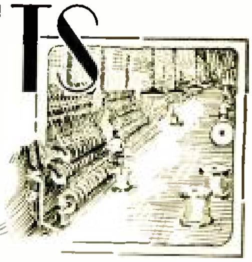
ACHESON CO. FORMS RADIO DIVISION

The Acheson Oildag Company of Port Huron, Michigan, manufacturers of Aquadag, a concentrated colloidal solution of Acheson electric furnace graphite in water, will hereafter distribute their products in the radio field through their radio division at Hillside Station, Elizabeth, N. J.

The division will be under the supervision of Raymond Szymanowitz, formerly of the Acheson Products Sales Company of Newark, N. J.

Aquadag is finding new uses daily in the radio industry. To date it has found successful application as a resistance element in grid-leak and volume control manufacture; as a die lubricant in the drawing of tungsten wire; as a satisfactory shield for special vacuum tubes; as a "getter" material; as a means of establishing positive contacts; as an opaque in photo-electric cell work; as a conductive coating for the electro-deposition of metals and as a dry lubricant for variable condenser bearings.

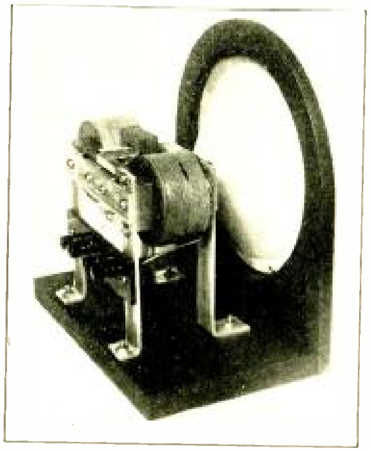
NEW DEVELOPMENTS OF THE MONTH



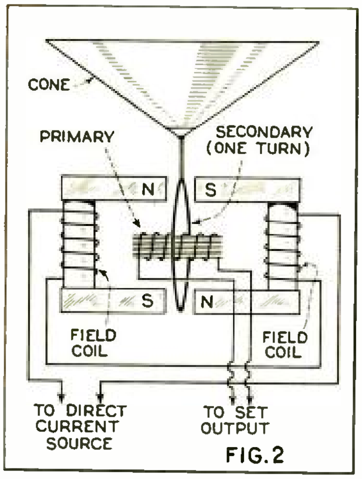
FANSPEAKER INDUCTO-DYNAMIC CONE

A dynamic speaker of unusual and simplified construction has been introduced by the Fanspeaker Radio Co., 74 Dey Street., New York City.

The main difference between this speaker and others of the dynamic type is that the moving coil, or "voice coil," consists of one turn, which turn is also the secondary winding of the output or impedance matching transformer. Thus the entire circuit between transformer and speaker is one turn, consisting of a metal ring supported by flexible springs and attached to the cone apex. The accompanying illustration and sketch clearly indicate the construction and electrical features.



View of the Inducto-Dynamic Cone Speaker.



Electrical design of the Inducto-Dynamic Cone Speaker.

It is claimed that the combining of the secondary and moving coil into one unit gives greater electrical efficiency and mechanical simplicity.

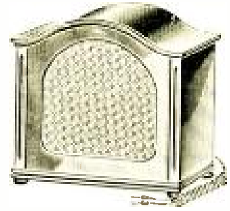
The transformer primary is wound to match the impedance of the output tube of the set, and may be provided with a center tap for push-pull operation. The secondary, consisting of one short circuited turn, is designed to have as great a current carrying capacity as is consistant without adding too much weight to the cone. Cutting the cross-sectional area of the ring down, without decreasing the mechanical strength too much, thus decreasing the weight of the moving parts, tends to increase the efficiency of the speaker. Experimenting along this line has resulted in a dynamic speaker of great efficiency. And with the flat metal ring placed in the flat gaps, great precision can be obtained as regards clearances with little danger of the ring touching the pole tips.

The electric currents flowing in this metal ring are produced by electromagnetic induction, hence the term "inducto-dynamic" speaker.

A free movement of at least one-quarter inch of the cone is allowed in this speaker as well as in other dynamic speakers. It is on this account that the dynamic speaker gives such remarkable bass note reproduction on a small 7" cone. Being freely supported on very flexible springs, the cone can vibrate this distance with little hinderance except the damping effect of the surrounding air. When a bass note is reproduced, such as that coming from a bass viol, the vibrations of the entire cone are clearly visible as it moves bodily back and forth this great distance. It seems to pump the air out into the room, and the tone is enhanced by the use of a baffle surrounding the cone.

NEW WINDSOR WOOD LOUD SPEAKERS

The Windsor Furniture Co., of 1420 Carroll Ave., Chicago, Ill., announce a new all wood loud speaker. This employs a balanced heavy reed unit and special tone filter, which the manufacturer claims gives complete reproduction of the audible range. It is said that the non vibrating qualities of the wood give exceptional results. The Cabinet speaker comes in walnut antique or brown and gold stippled finish.



New Windsor Cabinet Speaker.

ELECTRAD TRUVOLT DIVIDER

To meet a demand on the part of both the professional and amateur builder of B Power Units, Electrad, Inc., of New York City, has designed and placed in production the Electrad Truvolt Divider, a universal voltage separator which greatly simplifies the construction of a B-eliminator.

The Truvolt Divider is an excellent resistor around which to build a power pack. By simply connecting it to the output terminals of the filter circuit of the eliminator, it will deliver proper plate and grid voltages to any receiver of present or anticipated future design. This is accomplished in the Truvolt Divider by using a wire-wound resistor having five adjustable contacts.

With the Divider connected to the output terminals of a "BH" "213" or "280" type eliminator, the following voltages may be obtained: a maximum fixed voltage approximately 180 volts, a variable 135 volt, 90 volt, and 45 volt; also two grid bias each with a voltage variation of about 15 volts. With a conventional receiver the variable "B" voltage taps may be varied at least 15 volts above or below the mean voltage. Thus the 135 volt tap will supply any voltage between 160 and 110 volts, the 90 volt tap will supply any voltage between 110 and 65 volts, the 45 volt tap will supply any voltage between 55 and 20 volts.

Electrad Truvolt Divider.

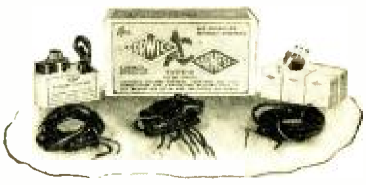
The intermediate grid bias tap will supply a grid bias of from – 1 to –20 volts, the grid maximum bias tap will supply a bias voltage from —20 to 40 volts. The Truvolt Divider is capable therefore of supplying practically any desired voltage required by a radio receiver.

The Truvolt Divider is not only flexible to all receiver current conditions, but it possesses a quality unknown to other types of B Eliminator resistors. It is possible because of the inherent design of the Divider to calibrate the adjustable contacts. It is also possible by the use of either tables or graphs to adjust the Divider to give the proper specified voltages without the use of an expensive high resistance voltmeter. Tables and graphs with complete instructions are furnished with each unit.

The Truvolt Divider may be mounted in any desired position. It may be screwed down to a baseboard, holes being provided at each corner for this purpose. Included with the Divider comes a mounting angle to set the Divider vertically. Its neat appearance due to its bakelite base and knobs, lends itself admirably for mounting as a front panel of the eliminator.

CORWICO A.C. ADAPTER HARNESS

With the popularity of A.C. operated sets, there has been opened a tremendous field for the conversion of battery-operated sets now in use to A.C., both by set owners and dealers. This can easily be accomplished



Corwico A.C. Adapter Harness.

without rewiring even by the non-technical fan by the use of a standard step-down transformer, ordinary A.C. tubes, and a Corwico Adapter Harness, manufactured by Cornish Wire Company, Inc., 30 Church Street, New York.

All important in the design of an Adapter Harness is its universality; that is, the ease and certainty with which it can be applied to all types and makes of receivers.

Corwico Harnesses are so designed that they may be used with practically all receivers, and will fit such sets mechanically and electrically, as if they had been made especially for each set.

Due to the difference in design and characteristics of the R.C.A. type and Arcturus cable type tubes it was necessary to produce a harness for each type. Adapters are supplied with R.C.A. type harness. The Arcturus cable type tubes require no adapters and can be used in any set without raising the height of the tubes. Ample provision is made for the "C" biasing and a volume control is supplied with all harnesses.

T.C.A. FILAMENT TRANSFORMMER

The Transformer Corporation of America of Chicago is announcing a complete line of power transformers, chokes, audio transformers and power amplifier packs for jobber distribution. For the past years the Transformer Corporation of America has been manufacturing special transformers to set and power unit manufacturers' specifications.

T.C.A. Filament Transformer.

One of the items particularly that has created volume sales and interest is a small filament transformer for A.C. conversion known as their No. 688.

This is capable of handling with ease three or four 226 type tubes, one 227 type tube and one 171 tube.

This unit, when used with a harness manufactured by a reliable concern, makes an economical unit for A.C. operation for a five or six tube set.

Size, 3⅝ inches long, 2⅞ inches wide, 3 1-16 inches high. Weight, 5¼ pounds, and finished in black enamel.

THE NEW BRADLEYUNIT-B RESISTOR

The Allen-Bradley Co., 286 Greenfield Ave., Milwaukee, Wis., have added to their line of radio resistance units, the Bradleyunit B, an improved fixed resistor for use as a gird leak or other fixed resistance in radio circuits.

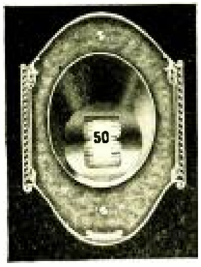
Bradleyunit-B Resistors.

Laboratory tests are said to show the Bradleyunit-B to have a constant resistance regardless of voltage employed. Oscillographs also show that it does not introduce noises or interference in the radio circuit.

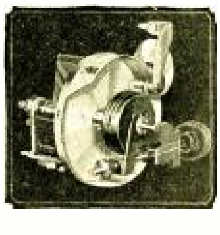
The Bradleyunit-B is composed of a special preparation, baked and solid-molded at high pressure. It is unaffected by moisture or weather conditions. Furnished with or without tinned copper leads in accurately calibrated units of from 500 ohms to 10 megohms.

NEW HAMMARLUND KNOB-CONTROL DRUM DIAL

The Hammarlund Mfg. Co. of New York City offers a new illuminated drum dial of distinctive mechanical features. It is controlled by a knob which can be placed in any position on the panel that is desirable for attractive balance.



Front view of the Hammarlund Knob-control drum dial.



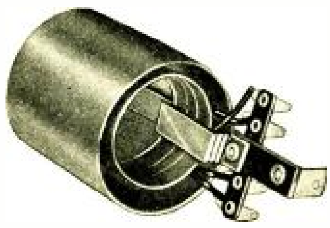
Showing the construction of the new Hammarlund drum dial.

The driving mechanism utilizes a silk and linen cord, gripping a drum, snubber fashion. It is said that due to this manner of fastening the cord there is no back-lash or any lost motion. The manufacturer claims that under working conditions this cord withstood over 35,000 full range movements of a large gang condenser without fraying or breaking.

The dial scale is made of transparent material and is backed by a small Dial light.

HAMMARLUND SHIELDED-GRID R.F. TRANSFORMERS AND ANTENNA COUPLERS

The new shielded-grid tube requires coils of special design if full advantage of this tube's exceptional properties is to be secured. Some of the requirements are that the primary be of high impedance, the secondary of very low resistance, and that capacity coupling between primary and secondary be minimum. The coils should be comparatively small so as to lend themselves readily to shielding. The coil primaries should be tapped so that required selectivity can be balanced against maximum useable amplification.



A view of the new Hammarlund R.F. transformer for screen-grid tubes.

It is claimed that all of the above conditions are completely met in the carefully designed Hammarlund Manufacturing Company's shielded-grid radio-frequency transformers and antenna couplers. The coils are of the low-resistance space-wound self-supporting inductance type; are 2" in diameter, and are provided with mounting legs and with primary tap leads conveniently located on a terminal strip forming part of the mounting bracket.

The primary of the antenna coupler is also tapped so that varying degrees of selectivity and pick-up can be easily secured and best over-all efficiency obtained. This coil is not for use exclusively with shielded-grid tubes, but is equally efficient when used in the antenna stage of any receiver. It may also be used in the Roberts and other balanced radio-frequency circuits requiring a mid-tapped primary and as an interstage transformer in standard tube circuits.

Both of the above coils are made for use with either .0005 mfd. or .00035 mfd. condensers.

DUBILIER CONDENSER BANK FOR HIGH-VOLTAGE RECTIFIERS

In order to meet the high-voltage requirements of the UX-281, CX-381, and similar filament rectifiers, the Dubilier Condenser Corporation of 4377 Bronx Boulevard, New York City, now announces a new condenser bank comprising the Type PL 666 and Type PL 867 units. The former consists of a 2 mfd. 1000 volt condenser section, while the latter consists of 4 mfd. 600-volt, 4 mfd. 600-volt, 1 mfd. 175 volt, and 1 mfd. 175-volt sections.

The condenser bank may be employed in the usual three-section filter network, with the two blocks, or again the Type 867 block may be used alone, eliminating the first condenser, in accordance with more recent practice of a two-section filter network. It will be noted that, following the most advanced practice, this condenser bank is made in two blocks so that the high voltage section is separate.

The PL 666 and PL-867 Dubilier condenser bank may be employed for the American, Samson, Silver-Marshall and other similar power packs and radio power units utilizing the 210 or 250 type power tubes in push-pull.

ACME "ABC" POWER SUPPLY

The Acme Apparatus Co., of Cambridge, Mass., has met the demand for a power supply for a receiver using the alternating current tubes with a unit, which supplies filament, plate and grid-bias voltage. With this unit it is possible to convert a receiver designed for storage-battery tubes into a completely A.C.-operated set, using the A.C. tubes.

The new Acme Apparatus Co. "ABC" Power Supply Unit which is adaptable to most any receiver.

The "ABC" power supply unit is 7 inches high, 3 inches wide and 8 inches long, these being approximately the dimensions of a 45-volt "B" battery. An input cord and one for connection to the 110-volt power line is included.

The grid-bias connections are made within the unit and are automatically adjusted to the correct voltage by the current drawn by the tubes. A terminal board on the end of the instrument carries sixteen binding posts, making it possible to obtain any desired combination of voltages.

The power supply unit is made in three different types for sets using the following A.C. tubes: UX 226, 227 and 171 tubes; Arcturus, Marathon. A UX-280 rectifier tube is used in the first unit and a BH rectifier with the last two.

NEW SOLDERING FLUX SPEEDS RADIO RECEIVER ASSEMBLY

Insistent demand of the radio manufacturer for a fluxing agent displaying a greater activity at oxide solvency has prompted the Research Department of the Chicago Solder Company to develop what they term their "A" Flux Core Wire Solder.

Kester "A" Flux Core Wire Solder is unique in the field of fluxes as it carries a flux containing neither zinc or ammonium chlorides. The corrosion factor is far less than such fluxes as chloride pastes and chloride salt solutions. In fact, its qualities are the nearest approach to the desirable characteristics of rosin, both in respect to corrosion and conductiveness that science has so far been able to produce, it is claimed.

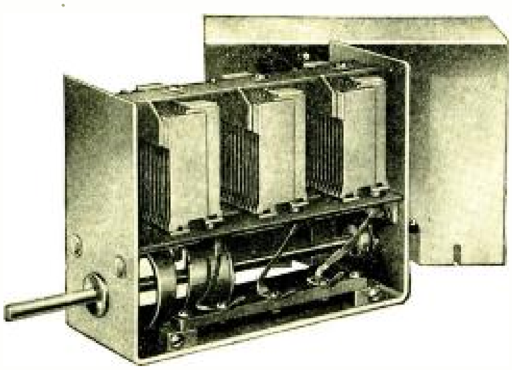
It is true that Rosin is the only absolutely non-corrosive fluxing medium yet available, but there are many places in radio receiver assembly where Kester "A" Flux Core Wire Solder will materially speed up production with satisfactory after results.

From time to time many new and highly acclaimed fluxes have been offered the manufacturer, but analytic investigation invariably discloses the fact that they are the old and well known zinc and ammonium chlorides in some new disguise. The hygroscopic characteristics of these agents, promoting a serious corrosive and conductive action in the flux residual, is a menace to the product of any manufacturer employing such in assembly work.

Experience gained over a period of 29 years in the manufacture of fluxing agents enabled the Research Department of the Chicago Solder Company to develop and offer to the radio set manufacturer a material that is the nearest approach to the ideal qualities of Rosin and yet provide increased speed at oxide solvency.

NEW PEARLCO STRAIGHT LINE GANG CONDENSER

The Pearlco gang straight-line condenser is new in principle, construction and design. As far as can be determined by the most rigid test conducted by noted radio authorities, it meets and overcomes every difficulty and problem heretofore associated with the operation of three or more condensers operated by a single dial. Such things as varying capacities of condensers of the same rated capacities, are taken care of in the new Pearlco Push and Pull Condenser. There are no shafts to wear and no rotating parts.

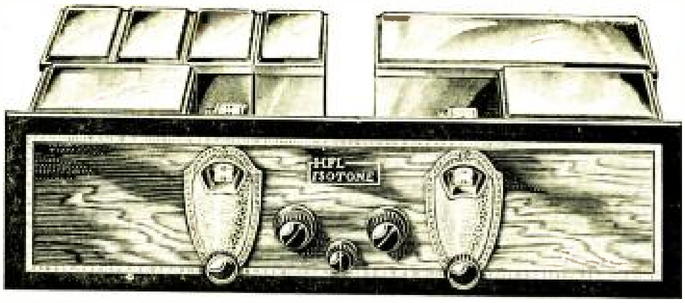


The new Pearlco Straight Line Gang Condenser. This unit is supplied with any number of condensers in tandem. It will be noted that the movable plates slide rather than rotate and are operated by a unique cam arrangement. The unit is entirely shielded. Each condenser employs a special balancing arrangement.

The new condenser is made by the Pearl Radio Corporation, Philadelphia, Pa. The rotor plates are mounted rigidly on a flat metal carriage, which rides on a smooth metal plate that is riveted to each end of the metal frame. These metal ends form part of the shield. The rotor plates are grounded and ground connections supplied.

There is a lug riveted to the bottom of the rotor carriage. This operates in the diagonally-cut slot of the cam under the rotor carriage. This cam is riveted to the shaft, which mounts the dial of the set. Turning the dial pushes or pulls the rotor plates between the stator plates. The operation is smooth as all parts slide freely and easily. The slot in the cam can be cut so as to be adaptable to straight-line-frequency, straight-line-capacity or midline. This will be especially appreciated in connection with high wavelength stations. Also greater and fuller separation of all stations is more easily accomplished, and there is no danger of any one condenser going off position in its relation to the others.

As many condensers as desired can be placed in one gang, all operating on the same carriage. Condenser capacity can be increased or diminished to meet the demands of various set manufacturers. Each condenser is complete with connector for set and rėady to be installed. Bottom metal mounting plate can be drilled according to manufacturer's template.



The new HFL Isotone Screen-grid Radio-Phonograph Combination.

HIGH FREQUENCY LABORATORIES' NEW COMBINATION RECEIVER-PHONOGRAPH

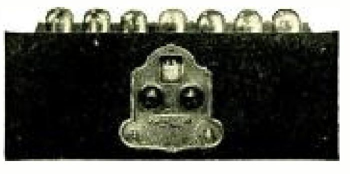
The High Frequency Laboratories, of 28 N. Sheldon Street, Chicago, Illinois, has announced a new kit of parts, which assembles into what is known as the Isotone Screened-Grid Radio Phonograph. The kit itself consists of three completely assembled, wired and tested units, which are bolted down to a foundation plate. The final connections are made underneath the foundation plate by means of small jumper connecting strips. The instrument has an automatic change-over switch, allowing phonograph records to be played through the audio amplifier section, which houses a microphone transformer and power tube for the purpose of playing phonograph records.

All parts are completely shielded and a unique system of assembly permits the wire itself to be completely shielded. The three stage intermediate-frequency amplifier has a gain of 65 per stage it is claimed and the audio-frequency amplifier is a three stage push-pull combination of which two stages are used in radio reproduction.

THE NEW PIERCE-AIRO CHASSIS

The A.C. 171 Chassis manufactured by Pierce-Airo, Inc. of 113 Fourth Ave., New York City, has the following specifications supplied by the manufacturer:

Chassis—Made of heavy gauge, drawn and welded steel, housing all the component parts including power supply.



New Pierce-Airo A.C. 171 Chassis.

Control—Illuminated single drum operated by bakelite knob. Positive friction drive automatically takes up wear. Exclusive feature of compensating control makes possible extreme selectivity and easy tuning.

Amplification—Consists of one stage of audio combined with one stage of power push-pull amplifying transformers, insuring great volume without any sacrifice in quality of reproduction.

Power Supply—This important unit is an integral part of the Chassis. It is of liberal design and construction so as to withstand heavy over-loads without endangering any of the electrical parts. A Hi-Lo Switch in the transformer primary circuit insures delivery of the right amount of power regardless of line voltage variations in different localities. Type 280 filament rectifier tube assures long life and a smooth flow of current for the plate circuit.

Tubes—Type 226 tubes are used for the radio frequency and audio circuits. Type 227 for detector and 2 type 171-A tubes for power amplifier circuit.

Finish—The Chassis is finished in the highest grade bronze Duco lacquer. The panel, of standard size, 7 by 18 inches, is finished in a natural grain burl walnut hard to distinguish from the natural wood. On the panel is mounted a bronze embossed escutcheon of which the pilot lamp and shade are integral parts and illuminating the entire visible portion of the wave band readings making station finding easy and enhancing the appearance of the chassis.

ABOX A.C. CONVERTER

The Abox Company, of 215 N. Michigan Ave., Chicago, Ill., announce a converter for supplying 6 volts D.C. to receivers direct from the 110 volt, 50 or 60-cycles line. This converter thus replaces the storage battery and charger. The manufacturer claims that many of the new special purpose tubes can be operated from the A.C. lines with the Abox. The output is adjustable for sets employing 3 to 8 tubes.

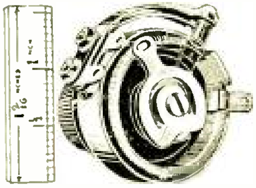
New Abox A.C. Converter.

A receptacle for the "B" unit is provided and a master control switch for controlling the whole installation. The containing box is finished in brown.

YAXLEY JUNIOR RHEOSTATS

The Yaxley Manufacturing Co., of 9 S. Clinton St., Chicago, Ill., has introduced a line of small rheostats and potentiometers, that are especially adaptable for sets in which space saving is of primary importance. The overall dimensions of the rheostat are 1 9/16 inches, which includes a filament switch.

These rheostats are furnished in numerous values from 1 to 1000 ohms and the potentiometers may be obtained in values from 6 to 2000 ohms. These instruments are made with an extra heavy metal base



Yaxley Junior Rheostat.

and an expanded metal retaining cup, which aid in the dissipation of heat. The switch can be attached without tools to either the rheostat or the potentiometers.

CECO 01-B TUBE

For some time engineers have been asking for a ⅛ amp. tube having characteristics similar to the "A" type. By the refinement of an oxide coated filament process made possible through research work done in the laboratories of the C. E. Manufacturing Co., Inc., a tube of this nature has been released and is known as the "CeCo" 01-B.

In respect to mu, impedance and mutual conductance the 01-B and the "A" are identical for all practical purposes. Substitution for the "A" type can be made provided the filament voltage is kept within its rated value. For the interests of long tube life special precautions are necessary in the matter of filament voltage and plate current. Although the tube has a nominal filament rating of 5 volts the characteristics are practically the same

Ceco 01-B Tube. This tube has a 125 mil., 5 volt filament and is therefore a very economical tube for battery operated sets.

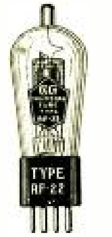
at 4.5 volts and accordingly the filament should be burned as low as is consistent with good reception. It has been found that if the filament is burned at over 5% more than the rated amount rapid deterioration of the oxide coating results with consequent short life. Plate current must not exceed the proper value and it is very essential that grid bias be used with the 01-B whenever the plate voltage exceeds 40.

Many engineers believe that so-called series operation with rectified A.C. on filament is preferable to the use of raw A.C. in connection with special types of tubes. As the 01-B draws only 125 milliamperes filament current at 5 volts it is possible to obtain from rectifying tubes of the R-80 or R-81 types sufficient current for the 01-B filaments provided they are wired in series.

CECO R. F. 22 TUBE

The "CeCo" R.F. 22 tube is of the four element type and has a wide and varied application. In construction it varies considerably from the three element tube, the main difference being the addition of what is called a shield- or screen-grid. This surrounds the plate and performs a very important function in the operation of the tube. The filament employed is similar to that used in the "CeCo" type "E" power amplifier and is thoriated. The inner grid is brought out through the top of the tube.

When the R.F. 22 is employed as a space-charge-grid tube the amplification constant is between 60 and 80. When used as a screen-grid amplifier in R.F. stages a mu of around 300 is available. The grid to plate capacity in this latter case is reduced to a negligible degree, which gives the R.F. 22 a distinct ad-



The Ceco R.F. 22 screen-grid tube which has a 125 mil., 5 volt filament. The tube may be used as a high gain R.F. or A.F. amplifier and as a space-charge grid tube.

vantage where neutralization was formerly necessary with the three element tubes.

As a screen-grid tube the R.F. 22 may also be used in resistance-coupled audio circuits.

CECO A.C. 22 TUBE

While very satisfactory results have been obtained with the direct current screen grid R.F. 22 tube the increasing popularity of A.C. operation has brought a demand for a tube of this type using alternating current on the filament. The C. E. Manufacturing Company has put on the market a tube of this nature known as the A.C. 22. The cathode is of the separate heater type. The heater filament is rated at 2.5 volts, 1.75 amps and in this respect is similar to

The new Ceco A.C. 22 — a screen-grid, A.-C. filament tube of the indirect heater type. It serves the same purposes as the Ceco R.F. 22 tube.

that of the N-27. The inner grid lead comes out through the top of the tube and the base has five prongs. The construction of the heater in the R.F. 22 A.C. differs considerably from that in the N-27.

The characteristics of the A.C. 22 are practically the same as those of the R.F. 22 which is operative on direct current only. This means that the coupling transformers on impedances designed for the D.C. type may be used equally well with the A.C. tube.

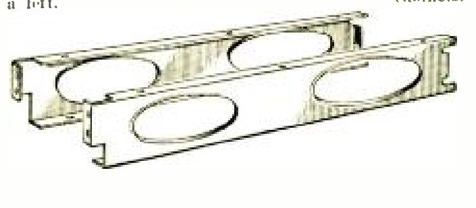
NEW AMPERITES FOR A.C. TUBES

The Radiall Co., of 50 Franklin St., New York City, announce two new types of Amperites, these being for the 226- and 227-type of A.C. tubes. The addition of these devices in the filament circuit of each tube of a set operating from the alternating-current line keeps the filament voltage constant, no matter how the voltage of the mains may vary.

NEW AMERICAN SUB-PANEL BRACKETS

The American Radio Hardware Co., 135 Grand St., New York City, announce a new aluminum bracket that will take any width sub-panel up to 11 inches. There are a number of kits on the market that require a sub-panel of 10 or 11 inches in width and this bracket will take the following widths: 4¾, 6, 7, 8, 9, 10 and 11 inches. The construction of these brackets is strong and they have two holes on the front for panel mounting with three holes on the side.

The dimensions of the No. 11 bracket are as follows: 2 inches high, 11 inches long and are sold in pairs — a right and a left.



The new American Hardware Co. Sub-Panel Brackets, made of aluminum

OHIO CARBON CO. ANNOUNCES RESISTORS AND GRID LEAKS

The Ohio Carbon Company, is now actively engaged in manufacturing a complete line of Carbon Grid Leaks and Resistors with the standard ferrule cap terminal or with the wire terminal, supplied either looped or straight.

The wire terminal has an advantage in that it saves the cost of the clip fixture which is required in the ferrule cap type. It is said that the disadvantage of this type has been that corrosion often occurred at the contact point between clip and cap. The wire terminal type on the other hand is easy to apply and corrosion never occurs.

These resistors and grid leaks can be supplied in ranges from 200 ohms to 10 megohms. This carbon type is not inductive, has low temperature co-efficient and is non-hydroscopic. If desired they can be supplied sealed with special enamels. Normal changes of temperature do not affect them, it is claimed.

CENTRALAB RADIO CONTROL BOX

The Central Radio Laboratories, 16 Keefe Avenue, Milwaukee, Wis., have gone into production on their Radio Control Box which can be used with any form of A.C. receiver, power amplifier or "B" power unit. Through the use of this control box, connected between the light socket and the radio equipment, it is possible to take up for any discrepancy encountered in line voltage. Regardless of how high the line voltage may be, the manual adjustment of the small knob on top of the control box will bring the potential down to 110 volts.

There is a receptable on the box to accommodate the plug of the radio set, and a cord to plug into the light socket.

Centralab Radio Control Box

NEWCOMBE-HAWLEY ANNOUNCES NEW SPEAKERS

Newcombe-Hawley, Inc., St. Charles, Illinois, manufacturers of radio reproducers, announce several important additions to their line for the 1928–1929 radio season.

Through a license agreement with the Magnavox Company of Oakland, California, Newcombe-Hawley will feature a complete line of dynamic cone reproducers in portable, table and console models. These reproducers will incorporate all the advantageous features covered by Magnavox patents which assure a perfected dynamic cone speaker with complete patent protection.

Model 100, Combination Console, is provided with a phonograph turn-table and electric motor, an A.C. dynamic cone reproducer, and space for any A.C. electric set. A simple switch in the console permits the reproducer to be used with either radio set or phonograph. No pickup is included

Dynamic cone chassis units will be merchandised separately to set owners who wish to bring their reproducers up to date.

A magnetic cone has been added to the line and is offered in a series of portable and table models.

The magnetic cone and the air-column are also sold in chassis unit form for set owners who prefer the units without cabinets.

EBY TIP JACK

The manufacture of a new tip jack suitable for general and specific use on metal and insulated baseboards and panels is announced by the H. H. Eby Mfg. Co.

The new tip jack is made with a countersunk head in order to afford special support to the shank of the cord tip and to provide greater rigidity when the tip is plugged into the jack. Double spring contact is provided in order to counteract small discrepancies in the diameter of cord tips, and to provide more perfect contact.

New Eby Tip Jack

Each tip jack is equipped with two special insulating washers permitting use of the tip jack on metal panels and baseboards. The tip jack connecting lug is an integral portion of the contact springs and is soldered into place, thus assuring perfect contact. Each tip jack is equipped with a color code washer (black and red making a pair) to facilitate wiring into the circuit and to expedite determination of polarity when in the circuit.

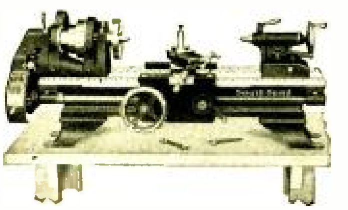
NEW RECEPTRAD POWERIZERS

The powerizer, manufactured in various types by the Radio Receptor Co., Inc., of 106 Seventh Ave., New York City, is essentially a transformer for supplying alternating current of the proper voltage for the filaments and heaters of A.C. tubes. Thus the "A" model is designed to supply current to seven 226-type tubes, two 227-type and two 171 tubes. The "P 171" model supplies "B" and "C" voltages by means of an '81 half-wave rectifier tube, in addition to the "A" current. The "PXY-1" model not only supplies "A", "B" and "C" current to the set, but also to a 210-type power tube in the device itself, making it a combined power plant and power amplifier. A special type of this model is made for use with the Radiola 25 or 28 sets. The "PD-5" is for D.C. sets using 199-type tubes. It supplies "B" voltage and 0.5 ampere "A" current at 3 volts.

In this line also are two power amplifiers without current supply for the set. The Powerizer "PX-2" is a two-stage unit with a 226-type tube in the first stage and a 210-type tube in the second stage, together with an '81 rectifier. The "PX-3" has three stages, using 227-type tubes in the first and second stages and a 250-type power tube in the third stage. Both use special alloy core transformers.

NEW SOUTH BEND 9-INCH LATHE

Useful in the radio part replacement field because of its wide range of work, the new 9-inch Junior South Bend lathe has been welcomed heartily by factories, small radio repair shops, individual mechanics and persons interested in building their own sets. This lathe is a back geared, screw cutting tool and is made by the South Bend Lathe Works, E. Madison St., South Bend, Ind.



New South Bend 9-inch Lathe

Included among the many jobs done by the 9-inch Junior lathe are: Turning special condenser shafts, rheostat shafts, bakelite parts, and widening coils. Other jobs that are commonly done on this lathe are: Reaming, turning of all kinds, milling, boring, drilling, knurling, chucking, refacing, thread cutting and general work.

The 9-inch Junior has six changes of spindle speed. Three are direct belt and the others are obtained through the back gears. The hollow spindle permits long rods, bars and tubing to pass through it while being machined, making it especially useful in radio replacement part work.

Swing measurement over the bed is 9¼ inches and over the carriage it is 6¾ inches. Five models are available, ranging with bed measurements of from 2½ to 4½ feet. A one-quarter horse-power motor drives this lathe from an ordinary lamp socket at a cost of about two cents an hour. Either an overhead countershaft or three types of direct motor drives may be used in operating this tool.

NEW GREBE SHORT-WAVE RECEIVER

A new short wave receiver, completely shielded, equipped with screen-grid tubes, and, having facilities for narrow and wide frequency band reception, the latter so necessary for television work, was officially announced and exhibited at the R.M.A. Trade Show by A. H. Grebe & Company, Incorporated, of New York and Los Angeles.

The new receiver, which is particularly adapted for reception of short wave broadcasting stations, uses five tubes, a screen-grid type 222 tube in the radio-frequency stage; a 201-A detector, two hi-mu tubes and a 112-A power tube in the resistance-coupled audio frequency system.

The screen-grid type 222 R.F. tube is used as a tuned radio-frequency amplifier. The antenna input to the tube is tuned by a straight-line frequency condenser. This input circuit has its own individual low-loss plug-in coils; (four coils being provided to cover the entire band with ample over-lapping of individual ranges).

The coupling between the screen-grid tube and the regenerative detector is impedance tuned by means of a variable condenser and a corresponding set of plug-in coils, which consists of both impedance and tickler coils on one form. This means that each individual impedance coil has its own tickler winding associated with it, which facilitates quick change from one wavelength to another.

Regeneration in the detector stage is accomplished by means of a variable resistance associated with two fixed condensers in such a manner that regeneration does not change the wavelength.

It is possible to tune in the carrier of a broadcasting station and reduce the regeneration without the necessity of retuning the dials—this is a most desirable feature when the highest frequencies are considered.

In order to prevent any reaction between the radio-frequency stage and regenerative detector, filters are incorporated in the power supply of the plate and the screen-grid tube. In employing radio-frequency amplification on the short waves this is very important, and, the CR-19 is so shielded that with the antenna disconnected it is almost impossible to hear a local transmitter, even when the receiver is tuned to the same wavelength as that local station.

By providing a compensating condenser in the radio-frequency stage it has been possible to line-up the dials and connect them together with a chain drive, similar to the arrangement employed in the Grebe Synchrophase Five Receiver. This saves time in as much as one dial will follow the other to approximately the same position. The beat-frequency control, the advantages of which are well-known is incorporated in the new Grebe model.

Quality with ample power is assured in this short wave receiver by using three stages of resistance-coupled audio amplification, the first two of which are hi-mu tubes with characteristics suitable for a wide audio-frequency band, such as will be necessary for television.

The power tube socket is provided with separate grid and plate leads, which will permit the use of any size of power tube required. The initial equipment, however, is a 112-A tube, selected because of its economical power requirements.

A color-coded cable is provided for making connections to all batteries. Two binding posts for antenna and ground and two for the loud speaker cord are provided at rear of set.

The control of volume is variable from head-set level to loud speaker volume. A jack is provided for plugging in a headset while the loudspeaker is in operation—thereby making it possible to tune-in weak signals without disturbing the adjustments of the set, and maintaining reception through both mediums.

NEW TEMPLE AIR COLUMN SPEAKER

Retaining all of the characteristics of the previous models the new Temple Model 15 is now announced. The same mathematically correct exponential air column of previous models has been retained but by improvements in manufacture the tone of this new model is even better than

New Temple Air Column Speaker

that of its predecessors. It has a center-line air column length of 54 inches, yet because of its design it is small—being but 11½ inches in diameter. It responds perfectly to all the audible frequencies, and with volume to spare. Model 15 is encased in genuine walnut with sides of the same color in beautifully grained leather effect.

JOHNSON-GORDON PHONOGRAPH MOTOR

The Saal Co., 1800 Montrose Ave., Chicago, Ill., has announced a motor for driving the turntable of a phonograph, which they claim is noiseless in operation. The motor is of the universal type and will operate on either 25 or 60 cycles A.C., or D.C.

The motor possesses, it is said, a high starting torque, which gives correct turntable speed from the moment the switch is turned on. Also a good governor holds this speed constant, even though the line voltage may vary. The motor comes equipped with turntable, speed regulator and automatic stop.

ZETKA SPECIAL DUTY TUBES

Zetka Laboratories, Inc., 67—73 Winthrop St., Newark, N. J., have produced two new power tubes and a half-wave rectifier. The idea behind the design of these tubes was to have their individual characteristics more nearly coincident with those most desirable in the respective parts of the radio circuits than have been obtainable heretofore.

The ZO is an output tube which can handle the output of receivers employing 5, 6 or more tubes and can deliver the resultant volume without distortion. It has a low amplification factor (2.5) and uses a 5-volt filament, drawing one-half ampere. It operates at 180 volts on the plate with 40 volts negative grid bias. The manufacturer claims that this tube is especially adapted for push-pull amplification, when used with transformers of recent design.

The ZP is a power tube operating at 7½ volts filament and drawing 1¼ amperes. It operates at a plate voltage of 450 with from 36 to 40 volts of negative grid bias. It is similar in operation to the 210 type tube, but it is claimed that it has a capacity for delivering undistorted volume more nearly corresponding to the new 250 type tube.

The half-wave rectifier tube is designated as the ZH and operates at 7½ volts filament. It has been designed especially to deliver voltages such as are obtained from the high-duty power transformers. It is claimed that it will maintain a steady voltage supply under a drain in excess of 125 milliamperes.

Manufacturers—Engineers

should notify RADIO ENGINEERING promptly of changes in executive or engineering personnel so that the information can be recorded in the "News of the Industry" section.

Behind the POLYMET Trade Mark

The natives of an obscure Scottish isle specialize in weaving the finest of woolens. Shipments can be made only when a chance vessel calls. Quality? Yes, but delivery lacks dependability.

A one-time manufacturer of very fine automobiles is no longer in business. Again *Quality*, but owners lack service.

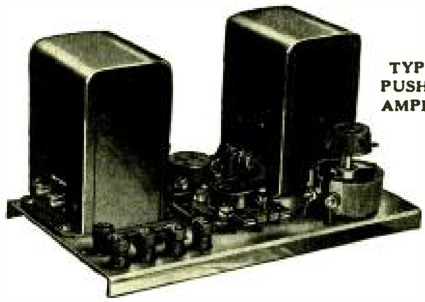
Behind the Polymet seal there is unquestioned *Quality*, and something more—the Polymet organization—insuring the utmost in *Service* and *Dependability*.

Send for the Polymet Catalogue.

POLYMET MANUFACTURING CORP.
601 Broadway, New York City

POLYMET PRODUCTS

POWER AND QUALITY



TYPE 441 PUSH-PULL AMPLIFIER

A Push-Pull amplifier in the last stage provides the speaker with ample power to sustain a high volume level without tube overloading, transmitting the full effects of large swings in intensity common in orchestra music.

For use with UX 226, CX 326, UX 171, CX 371, UX 210 or CX 310 tubes.

Input inductance	30 henries
Input turns ratio	1:2.25
Output impedance ratio (whole primary to secondary)	10:1
Price, completely wired	$20.00

Licensed by the Radio Corporation of America for radio, amateur, experimental and broadcast reception only, and under the terms of the R. C. A. license the unit may be sold only with tubes.

GENERAL RADIO CO.

Bulletin No. 929 on request

30 STATE ST., CAMBRIDGE, MASS.
274 BRANNAN ST., SAN FRANCISCO, CALIF.

PACKING PROBLEMS SOLVED

We can overcome your packing difficulties, whether you ship large sets or small sets—heavy power equipment or fragile speakers—whether the weight is *ten pounds* or *five hundred pounds*. Our years of experience in the radio shipping field are at your command without obligation.

TIFFT BROS.
8 Broadway, New York City
Shipping Cases for Difficult Problems

CLEVELAND ACME DRAD

SUPER-LINE OF RADIO PRODUCTS as announced at the R. M. A. Exposition

The ACME Universal Dry "A" Power Unit, takes raw A. C current and delivers smooth D.C. current at the proper voltage for your set. This unit will give you real satisfaction because it's built right.

The sensation of the year, ACME'S Dry "B" Power Unit. A 12000 ohm voltage divider is employed giving it a wide range voltage of 22½, 45, 67, 90, 135 and 180. A unit built to give real service.

The ACME ABC-4 and ABC-5 convert A.C. operated sets to D.C. operation. They operate quietly and deliver smooth D.C. current. Bring your old set up-to-date.

THE ACME ELECTRIC & MFG. CO.
Established 1917
1439 Hamilton Ave. Cleveland, Ohio
Representatives in all principal cities

TWO NEW AMPLION ITEMS

AMPLION MICROPHONE

from our English Laboratory

A sensitive, accurate single button Microphone, free from carbon noises. Takes from 6 to 36 volts with corresponding sensitivity. For broadcasting, theatre or public address use.

AMPLION GIANT DYNAMIC UNIT

Largest Ever Made

for Public Address or Theatre Use. Built for 30 Watts Undistorted Power. This Giant Amplion Dynamic (weight 20 lbs.) is capable of range and volume heretofore unattainable in any unit.

Information on unit and 10-16 ft. exponential horns sent on request. Demonstration at our Laboratory.

Amplion Microphone

Of Interest to Leading Engineers

Giant Dynamic Unit

AMPLION CORPORATION OF AMERICA
133 W. 21st St., New York City
Telephone Chelsea 5257

Cardwell Condensers

Professional men are invited to communicate with us regarding

SHORT WAVE APPARATUS
TRANSMITTING APPARATUS
CONVERTERS

All types of condensers from midget to broadcast station types

ALLEN D. CARDWELL MFG. CORP. 81 Prospect St., Brooklyn, N. Y.

Ferranti Audio Frequency Transformers and Chokes

Cover every radio requirement. Built to the highest standards. Tested to 1,000 volts throughout.

The 1928 Ferranti Year Book, just off the press, contains 60 pages of useful information on the use of Ferranti Transformers, along with circuits and instructions for building receivers, power amplifiers, etc.

Sent post paid anywhere for 15c in coin. No stamps.

FERRANTI, Inc.
130 West 42nd St. :: New York, N. Y.

Latest Additions to the POWERIZER

Reg. U. S. Patent Office

Powerizer A—for filament supply and "C" bias 226, 227 and 171 tubes.

Powerizer 171—gives "A" and "B" supply, as well as "C" bias for 226, 227 and 171 tubes.

D-C Tube Powerizer for UX-199 and UX-222 Shielded Grid Tubes designed for use where AC Tubes cannot be used.

Radio Receptor Co.
106 Seventh Avenue
New York City

NEW
Bakelite Insulated
Push Posts

The perfect binding post at last. Vibrations will not loosen. Releases instantly when you wish. Engraved in all standard markings. Price each 15c.

X-L Push Post

PEP UP YOUR SET

Used in every high-grade circuit or receiver today. **Model N Vario-Denser** Micrometer adjustment, easily made, assures exact oscillation control. Quick easy tuning, more volume, clearness and stability. Capacity range 1.8 to 20 micro—micro farads. Price each $1.00.

Model G Vario-Denser made in three variable capacity ranges. Price each with grid clips $1.50

FREE New up-to-date book of wiring diagrams of all leading circuits including Goodwin Aperiodic Circuit applicable to any set. Adds a stage without adding tuning controls. Write today.

X-L RADIO LABORATORIES
Dept. K, 1224 Belmont Ave., Chicago

DO YOU WANT ACCURACY—DELIVERY—ON

INDUCTANCE COILS

Space Wound, on Threaded Forms Complete Tuning Units, of All Types for Receiving and Transmitting.

Coil Winding Specialists Since 1920

AIR-KING PRODUCTS CO.
222-226 GRAND ST., BROOKLYN, N. Y.

COPPER, BRASS, PHOSPHOR BRONZE

We specialize in the manufacture of rolled metals .001" thick and thicker, either plain or hot tinned for

RADIO MANUFACTURERS

Good deliveries; prices right; expert mill supervision.

THE BALTIMORE BRASS COMPANY
1206 Wicomico Street Baltimore, Md.

PHOTO-ELECTRIC CELLS
THE BURT CELL

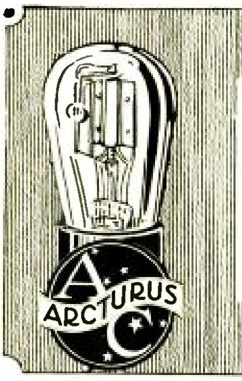
Without Fatigue—Highly Sensitive
Absolutely Reproducible—Instantaneous in Response

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

We also manufacture the STABILIZED OSCILLOSCOPE—the only VISUAL OSCILLOGRAPH having a linear time axis and no inertia—giving an accurate picture of high frequency wave forms.

Write for Bulletin 273

DR. ROBERT C. BURT
Manufacturing and Consulting Physicist
327 S. Michigan Ave., Pasadena, Calif.



ARCTURUS

Without Adaptors!

ARCTURUS A-C TUBES

—amplifier, detector, high mu and power types

With special and universal **A-C CABLES**

ARCTURUS RADIO CO.
255 Sherman Av., Newark, N. J.

A-C TUBES

AMPLI-PACK

Makes Any Set an A.C. Power Receiver

Complete A. C. Power Supply "A" and "B"

Can Be Assembled in One Evening

AmplipaCk makes any D. C. Set into a modern A. C. Receiver. Uses 210 type tubes. Gives complete power amplification. Assures full musical range found only in the most modern and expensive receivers.

Simple to install — Dependable in operation. Makes Any Radio a Real Musical Instrument.

FREE BOOK

We have prepared a booklet giving the latest word on Power Amplification and A. C. Conversion Your copy is ready for you FREE. Write us for it.

Transformer Corporation of America
1428-1432 Orleans St., Chicago, Ill.

Manufacturers of the T. C. A. Line of Power Transformers, Audio Transformers, Chokes, Power Packs, and Power Amplifier Packs

---

See Page 12

PATENTS

TRADEMARKS — COPYRIGHTS

Special Attention to Radio Inventions

EUGENE E. STEVENS
Attorney at Law
Registered Solicitor of Patents

905 F St., N.W., Washington, D. C.

Big Radio Season Ahead

World's Series, Presidential Election, Tunney-Heeney Fight, Football, Concerts and Chain Programs—Meaning More Radio Buyers.

SELL THEM

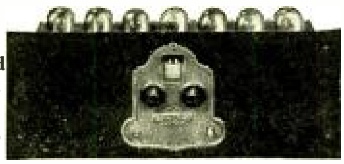
PIERCE AIRO

SELF-CONTAINED

7 TUBE ELECTRIC CHASSES

AND LET THEM SELECT THEIR OWN CABINETS AND CONSOLES

Fits All Standard Cabinets and Consoles



Power Amplification Pure Tone

1929 Model A-C 171

Hundreds of dealers throughout the country have cashed in on PIERCE-AIRO Chasses. You can, too. Get on the PIERCE-AIRO band wagon this season. Write or wire for detailed specifications, price and discounts, or, better still, let us send you a sample PIERCE-AIRO Chassis for a tryout in your own store.

PIERCE-AIRO, Inc. 115 Fourth Avenue New York City

New!

A. C. Line Voltage Control

For Radio Set Manufacturers

A remarkably convenient and efficient device which automatically handles A. C. line fluctuation over a broad range.

Cost surprisingly low.

by the makers of

AMPERITE

REG. U. S. PAT. OFF.

The "SELF-ADJUSTING" *Rheostat*

For information, Write Dept. R.E. 7

RADIALL CO.
50 Franklin St.,
New York, N. Y.

The first of their kind!

2 books written specifically for the

RADIO

ENGINEER
EXPERIMENTER
SERVICE MAN
CUSTOM SET BUILDER

By JOHN F. RIDER

HERE ARE THE TWO BOOKS YOU HAVE BEEN AWAITING....Modern....Up to the minute....Written to meet PRESENT day requirements....No obsolete material....No discussions of magnetism....No wasted, useless words....Facts, facts and more facts....Vital, useful information from the first to the last page.

Read what the N. Y. Sun says. "Now comes John F. Rider, well known for his excellent series of Laboratory Scrap Book items, with two volumes....carried out in a way that is eminently satisfactory....There is an engineering atmosphere about the whole get-up, and....will find the text correspondingly interesting....Since practically every receiver nowadays employs a B eliminator, this book can and is heartily recommended to all who would know the insides of this important adjunct....To the experimenter who prefers to assemble his own units, yes, even design them, the statement is made here that he can scarcely blame himself for failure if he proceeds without reading what Rider has to say on the subject."

Read what the N. Y. Sun says about the Service Treatise. "The second volume ....will appeal primarily to employees of service stations....Then he proceeds to describe the construction of the instruments and to describe their correct usage.... His data covers the design of tube testers, eliminator testers....output indicating systems....Although consisting of only twenty-eight pages, the conciseness of the data makes the book equivalent to one of many times its size...."

Can you service a manufactured B eliminator? ....Can you locate an open tuning condenser circuit in a receiver?....Can you locate an open grid circuit in a receiver?....Are you interested in a simple and inexpensive A C and D C tube tester?....Can you tell if an A C tube is defective and produces excessive "hum"?....Can you test filter chokes?....Are you interested in a B battery eliminator tester with which you can service B battery eliminators?....Are you interested in the construction of equipment with which you can do all of the above?....Are you interested in the construction of ALL the units necessary for rapid and economical servicing?....

THEN READ
John F. Rider's

"A Treatise on 25 Testing Units for Service Men"

28 pages 8½"x11", 30 illustrations....28 pages just full of concise information—information of utmost value to the service man....Highly recommended by service men....EVERY SERVICE MAN SHOULD HAVE ONE....AND the price is only 50 cents.

Is there anything you want to know about B battery eliminators?....Do you want to know how to design a B battery eliminator?....Do you want to learn how to calculate the B eliminator output resistances?....Do you want to know how to adapt a B eliminator to all receivers?....Are you interested in the function of the various parts of a B eliminator?....Are you interested in the improvement of your present B eliminator?.... Do you want to get the most out of your present B eliminator?....Do you want to eliminate motorboating?....Do you want to know how to calculate the plate current drain of your receiver? ....Are you interested in designing any special B battery eliminators?....

THEN READ
John F. Rider's

"A Laboratory Treatise on B Battery Eliminator Design and Construction"

88 pages 8½" x 11", 71 illustrations. 88 pages just full of data and comprehensible illustrations. This treatise will answer any B battery eliminator questions which will arise in your mind. It will solve your B power unit problems....AND the price is only $1.00.

RADIO TREATISE CO., 270 Madison Ave., New York City

USE THIS COUPON

☐ Kindly send me postpaid John Rider's Laboratory Treatise on B-Eliminator Design and Construction" for which I am enclosing $1.00.
☐ Kindly send me postpaid John Rider's "Treatise on Service Units" for which I am enclosing $.50.

Name ....
Street ....
City .... State ....

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.

ALUMINUM:
Aluminum Co. of America

ALUMINUM FOIL:
Lehmaier and Schwartz Co.
U. S. Foil Co.

AMMETERS:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

ANTENNAE, LAMP SOCKET:
Electrad, Inc.

ARRESTERS, LIGHTNING:
Electrad, Inc.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

BASES, VACUUM TUBE:
Formica Insulation Co.

BINDING POSTS:
Arrow Automatic Products Corp.
Eby, H. H., Co.
X-L Radio Labs.

BOOKS:
Radio Treatise Co.
Wiley, John, Co.

BOXES, PACKING:
Tifft Bros.

BRACKETS, ANGLE:
Arrow Automatic Products Co.
Electrad Inc.
Scovill Mfg. Co.

BRASS:
Baltimore Brass Co.
Copper and Brass Research Assn.
Scovill Mfg. Co.

BROADCAST STATION EQUIP'T:
Cardwell, Allen D., Mfg. Co.
Radio Engineering Laboratories.

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America.
Copper and Brass Research Assn.
Crowe Nameplate Mfg. Co.

CELLS, PHOTOELECTRIC:
Burt, Robert C.

CERIUM:
Independent Labs.

CHARGERS:
Acme Elec. & Mfg. Co.
Elkon Co.

CHASES:
Aluminum Co. of America.
Copper and Brass Research Assn.
United Scientific Laboratories, Inc.

CHOKES, AUDIO FREQUENCY:
Acme Elec. & Mfg. Co.
American Transformer Co.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Thordarson Elec. Mfg. Co.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.

CHOKES, B ELIMINATOR:
Acme Electric and Mfg. Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.

CLAMPS, GROUND:
Electrad, Inc.
Fahnstock Elec. Co.
Scovill Mfg. Co.

CLIPS, SPRING:
Arrow Automatic Products Co.
Electrad, Inc.
Fahnstock Elec. Co.
Scovill Mfg. Co.

COILS, CHOKE:
Dudlo Mfg. Co.
Westinghouse Elec. & Mfg. Co.

COILS, IMPEDANCE:
Dudlo Mfg. Co.

COILS, INDUCTANCE:
Air King Products Co.
Cardwell, Allen, D., Mfg. Co.
Dresner Radio Mfg. Co.
Hammarlund Mfg. Co.
Radio Engineering Laboratories.

COILS, MAGNET:
Dudlo Mfg. Co.

COILS, RETARD:
Hammarlund Mfg. Co.

COILS, SHORT WAVE:
Dresner Radio Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Radio Engineering Laboratories.

COILS, TRANSFORMER:
Dudlo Mfg. Co.

CONDENSER PARTS:
Arrow Automatic Products Co.
Scovill Mfg. Co.

CONDENSERS, BY-PASS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Automatic Electric, Inc.
Burt, A. G., Jr.
Carter Radio Co.
Condenser Corp. of America.
Deutschmann, Tobe Co.
Dongan Electric Mfg. Co.
Electrad, Inc.
Fast, John E. & Co.
Flechtheim Co.
Polymet Mfg. Co.
Sterling Mfg. Co.

CONDENSERS, FILTER:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Automatic Electric, Inc.
Carter Radio Co.
Condenser Corp. of America.
Deutschmann, Tobe Co.
Dongan Electric Mfg. Co.
Fast, John E. & Co.
Flechtheim Co.
Polymet Mfg. Co.
Sterling Mfg. Co.

CONDENSERS, FIXED:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Automatic Electric, Inc.
Burt, A. G., Jr.
Carter Radio Co.
Condenser Corp. of America.
Deutschmann, Tobe Co.
Dongan Electric Mfg. Co.
Electrad, Inc.
Fast, John E., & Co.
Flechtheim Co.
Polymet Mfg. Co.

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

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
General Instrument Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.

CONDENSERS, VARIABLE:
Amsco Products Co.
Cardwell, Allen D. Mfg. Co.
General Instrument Co.
DeJur Products Co.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

CONNECTORS:
Arrow Automatic Products Co.
Carter Radio Co.
Fahnstock Elec. Co.
Jones, Howard W. Co.
Scovill Mfg. Co.

CONTROLS, ILLUMINATED:
Hammarlund Mfg. Co.

CONTROLS, VOLUME:
American Mechanical Laboratories
Carter Radio Co.
Central Radio Laboratories

CONVERTERS:
Cardwell, Allen D., Co.

COPPER:
Baltimore Brass Co.
Copper & Brass Research Assn.
Scovill Mfg. Co.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

DIALS:
Crowe Nameplate and Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

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

ELIMINATORS, A BATTERY:
Acme Elec. and Mfg. Co.
Radio Receptor Co.
Sterling Mfg. Co.
Webster Co.

ELIMINATORS, B BATTERY:
Acme Elec. and Mfg. Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Sterling Mfg. Co.
Thordarson Electric Mfg. Co.
Webster Co.

ELIMINATORS, A-B-C:
Acme Elec. and Mfg. Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.
Webster Co.

ELIMINATORS, UNITS FOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.
Webster Co.

ESCUTCHEONS:
Crowe Nameplate and Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FILAMENT, OXIDE COATED:
Independent Laboratories, Inc.

FILAMENT CONTROLS, AUTOMATIC:
Radiall Co.

FOIL:
Lehmaier and Schwartz Co.
U. S. Foil Co.

GALVANOMETERS:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

GETTER MATERIAL:
Acheson Oildag Co., Inc.
Independent Laboratories, Inc.

GRAPHITE:
Acheson Oildag Co., Inc.

GRID LEAKS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
Amsco Products Co.
DeJur Products Co.
Deutschmann, Tobe Co.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Polymet Mfg. Co.

HARNESSES, A-C.:
Carter Radio Co.
Eby, H. H., Co.

HINGES:
Scovill Mfg. Co.

HORNS:
Operadio Co.
Racon Electric Co.
Temple, Inc.

HORNS, MOLDED:
Operadio Co.
Racon Elec. Co., Inc.
Temple, Inc.

INDUCTANCES, TRANSMITTING:
General Radio Co.

INSTRUMENTS, ELECTRICAL:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. 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.
Eby, H. H., Mfg. Co.

KITS, SHORT WAVE:
Radio Engineering Laboratories.

KITS, TESTING:
General Radio Co.
Jewell Elec. Inst. Co.

KITS, TRANSMITTING:
Radio Engineering Laboratories.

LACQUER:
Walker, J. V., Co.
Zapon Co., The

LABORATORIES:
Electrical Testing Labs.

LAMINATIONS:
Arrow Automatic Products Co.
Lamination Stamping Co.
Sterling Mfg. Co.

LEAD-INS:
Electrad, Inc.
Fahnstock Elec. Co.

LOCK WASHERS:
Arrow Automatic Products Co.
Shakeproof Lock Washer Co.

LUGS:
Arrow Automatic Products Co.
Fahnstock Elec. Co.
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

MAGNETS:
Thomas and Skinner Steel Products Co.

METERS:
Jewell Elec. Inst. Co.
Sterling Mfg. Co.
Westinghouse Elec. & Mfg. Co.

MICROPHONES:
Amplion Co. of America

MOLDING MATERIALS
Bakelite Corp.
Formica Insulation Co.
General Plastics Co.
Westinghouse Elec. & Mfg. Co.

MOTORS, ELECTRIC PHONOGRAPH:
Gordon, L. S., Co.

MOUNTINGS, RESISTANCE:
DeJur Products Co.
Electrad, Inc.
Fahnstock Elec. Co.

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

NUTS:
Arrow Automatic Products Co.
Shakeproof Lock Washer Co.

OSCILLOGRAPH:
Burt, Dr. Rob't C.

OSCILLOSCOPE:
Burt, Dr. Rob't C.

PACKING:
Tifft Bros.

PANELS, COMPOSITION:
Formica Insulation Co.
General Plastics 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.

PHONOGRAPH MOTORS:
(See Motors)

PHOSPHOR BRONZE
Baltimore Brass Co.

PHOTOELECTRIC CELLS:
(See Cells)

PICK-UPS:
Gordon, L. S. Co.

PLATES, OUTLET:
Carter Radio Co.

PLUGS:
Carter Radio Co.
Jones, Howard B., Co.

POTENTIOMETERS:
Allen-Bradley Co.
Carter Radio Co.
Central Radio Laboratories
DeJur Products Co.
Electrad, Inc.
United Scientific Laboratories

RECEIVERS, ELECTRIC:
United Scientific Laboratories.

REGULATORS, VOLTAGE:
DeJur Products Co.
Radiall Co.
Sterling Mfg. Co.
Webster Co.

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

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Amsco Products Co.
Carter Radio Co.
Central Radio Laboratories.
De Jur Products
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Polymet Mfg. Co.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
American Mechanical Labs.
Amsco Products Co.
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Polymet Mfg. Co.

RHEOSTATS:
Amsco Products Co.
Carter Radio Co.
Central Radio Laboratories.
De Jur Products.
Electrad, Inc.,
United Scientific Laboratories
Westinghouse Elec. & Mfg. Co.

SCHOOLS, RADIO:
National Radio Institute.
Radio Institute of America

SCREW MACHINE PRODUCTS:
Arrow Automatic Products Co.
Scovill Mfg. Co.

SHIELDING, METAL:
Aluminum Co. of America.
Copper and Brass Research Assn.
Crowe Nameplate Co.

SHIELDS, TUBE:
Carter Radio Co

SHORT WAVE APPARATUS:
Cardwell, Allen D., Co.
General Radio Co.
Radio Engineering Laboratories.

SOCKETS, TUBE:
Benjamin Electric Mfg. Co.
General Radio Co.

SOLDER:
Chicago Solder Co. (Kester).
Westinghouse Elec. & Mfg. Co.

SOUND CHAMBERS:
Air Chrome Corp.
Lektophone Co.
Operadio Mfg. Co.
Racon Elec. Co., Inc.
Temple, Inc.
United Radio Corp.

SPEAKERS:
Lektophone Co.
Operadio Mfg. Co.
Racon Electric Co.
Temple, Inc.
United Radio Corp.
Vitalitone Co.

STAMPINGS, METAL:
Arrow Automatic Prod. Corp.
Fahnstock Elec. Co.
Scovill Mfg. Co.

STRIPS, BINDING POST:
X-L Radio Laboratories.

SUBPANELS:
Formica Ins. Co.
Westinghouse Elec. & Mfg. Co.

SWITCHES:
Carter Radio Co.
Electrad, Inc.,
Westinghouse Elec. & 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.

TINFOIL:
Lehmaier and Schwartz Co.
U. S. Foil Co.

TOOLS:
Eastern Tube and Tool Co.

TRANSFORMERS, AUDIO:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
United Radio Corp.
Webster Co.

TRANSFORMERS, B-ELIMINATOR:
Acme Elec. & Mfg. Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Webster Co.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
General Transformer Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

TRANSFORMERS, OUTPUT:
Acme Elec. & Mfg. Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.
Webster Co.

TRANSFORMERS, POWER:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
General Transformer Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Westinghouse Elec. & Mfg. Co.
Webster Co.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.

TUBES, A. C.:
Arcturus Co.
Cunningham, E. T., Co.

TUBES, RECTIFIER:
Arcturus Co.
Cunningham, E. T., Co.

TUBES, VACUUM:
Arcturus Co.
Cunningham, E. T., Co.

UNITS, SPEAKER:
Air Chrome Corp.
Lektophone Co.
Operadio Mfg. Co.
Racon Electric Co.
Temple, Inc.
United Radio Corp.
Vitalitone Co.

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:
Arrow Automatic Products Co.
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

WIRE, ANTENNA:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons, Co.

WIRE, BARE COPPER:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons, Co.

WIRE, COTTON COVERED:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J A., Sons Co.

WIRE, ENAMELED COPPER:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons Co.

WIRE, LITZENDRAHT:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons Co.

WIRE, PIGTAIL:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons Co.

WIRE, SILK COVERED:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons Co.

WIRE, TINNED COPPER:
Dudlo Mfg. Corp.
Holyoke Co.
Roebling, J. A., Sons, Co.

INDEX OF ADVERTISERS

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

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

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

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

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

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

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

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

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

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

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

Until September First

The response to this group subscription plan has been very gratifying. Nearly every mail contains several new lists.

We want to thank our readers for their efforts in bringing the group plan to the attention of their associates and friends.

The Group Plan will be continued until September first.

Will you not cooperate with us by classifying subscriptions sent in as follows:

(M) Manufacturer
(E) Engineer
(D) Dealer or Distributor
(S) Service Man
(P) Professional Builder
(T) Technician.

Williams Press, Inc., New York—Albany

QUALITY DONGAN PRODUCTS

The Logical Source on Parts

Scientifically designed and Precision-Built Audio and Power Transformers, Chokes and Fixed Condensers—every single one fundamentally correct and guaranteed by one of the oldest manufacturers in the industry. Naturally Dongan has been chosen as the source of supply by so many of the substantial companies who have learned that Dongan usually is the first to introduce the new designs and can be depended upon to foster nothing that smacks of the freakish.

No. 6570

Popular A C Transformer designed for use with 4 U X 226, 1 U Y 227 and 1 U X 171 power amplifier tubes. Equipped with terminals for wiring harnesses, lamp cord and plug outlet for B-eliminator, also tap for control switch.

$6.50

Transformers
Chokes
Condensers
—the very heart of the radio set. For authentic information write the Dongan Laboratories.

Send check or money order for immediate delivery on any of the items illustrated. Ask for Radio Parts Catalogue.

Filter Condensers

Illustrating one of 9 types of Filter Condensers. Built in all capacities for use with filter circuits and power amplifiers. Exceptionally high insulation and permanent stability. For either gaseous or filament type rectifier tube.

$1.50 to $7.00

Also By-Pass Condensers and Condenser Block.

No. 1177

A splendid straight power amplifier output transformer designed for use with U X 250 P.A. Tube. One of several power supply and output transformers.

$12.00

Set Manufacturers—Custom Set Builders

To meet your individual manufacturing requirements is the duty of our Sales-Engineering Department. You will be assured of Approved Parts as per samples submitted and deliveries as specified.

DONGAN ELECTRIC MANUFACTURING COMPANY
2995-3001 Franklin St.,
DETROIT, MICHIGAN

TRANSFORMERS of MERIT for FIFTEEN YEARS