EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. VIII APRIL 1928 Number 4

IN THIS ISSUE

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The TECHNICAL MAGAZINE of the RADIO INDUSTRY

ENDURING WONDERS
Of Scientific Achievement

"ALL THINGS DREAD TIME, BUT TIME ITSELF DREADS THE PYRAMIDS!"

ALL THINGS Dread Time and the elements, except true creations of science. And in radio receivers PARTICULARLY, where electricity, the mightiest of the elements, stands ready to destroy, scientific design and engineered strength are vital, for failure to withstand the unrestrained fury of high voltages inevitably results in the destruction of expensive parts. That is why the engineers of leading radio set and power supply manufacturers use Aerovox fixed condensers and Pyrohm resistors—they know they are scientifically built and

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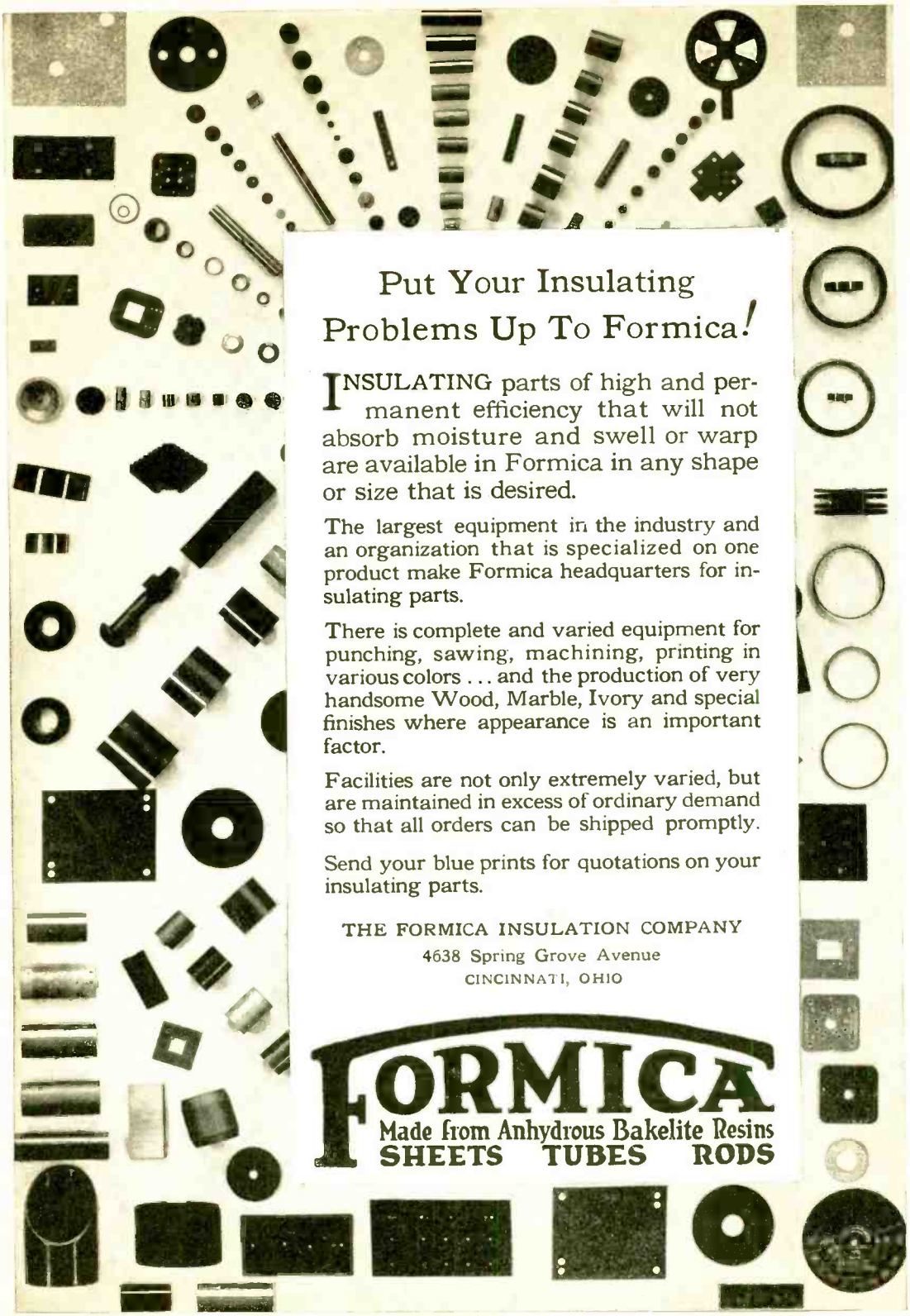

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Made from Anhydrous Bakelite Resins
SHEETS TUBES RODS

RADIO ENGINEERING

for APRIL 1928

Edited by M. L. MUHLEMAN

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VOLUME VIII NUMBER 4

Editorial

AT the moment the radio industry revolves around the popularly termed "A.C. Set." On this class of receiver is pinned the hopes of the majority of radio set manufacturers.

Considering the numerous advantages of the A.C. Set, which are too obvious to mention, it is not difficult to visualize a radio market larger than any the industry has yet been favored with. Surely, with the recent mergers, cooperative plans in the merchandising field and increased stability, a record market will be realized.

The A.C. tube, the backbone of the A.C. Set, has solved once and for all the most confusing merchandising problem that ever beset an industry. We hasten to supplement this with our own belief that the A.C. tube does not completely satisfy the A.C. problem.

Personally, we should like to think of this tube as somewhat of a stepping-stone to a more wide-sweeping development, from both the engineering and sales point of view. Coupled with this attitude, we are decidedly anxious to witness research towards the further improvement of electric receivers.

It is of key importance to build public confidence in radio and efforts should be made to commence developmental work at the earliest possible moment to prevent the recurrence of shortcomings and premature designs.

With the problems of tube life, electrical efficiency, line voltage regulation, perfect filtration and simplicity of design to contend with there is much in favor of the series filament string power unit, employing a single rectifier and a single filter network and "battery type" tubes.

For the past few years we have witnessed a steady growth in the development of high voltage, high current rectifiers of numerous types. We have also witnessed improvements of major importance in the design of simplified filter systems capable of realizing the large current demands of a series string receiver. New developments will be announced shortly.

The series string system is of sufficient importance to receive the consideration of every engineer.

We sincerely trust that developmental work along this line will be carried out in the laboratories of every radio manufacturer. RADIO ENGINEERING will publish a vast amount of information on the general subject in future issues.

M. L. MUHLEMAN, *Editor.*

Contents

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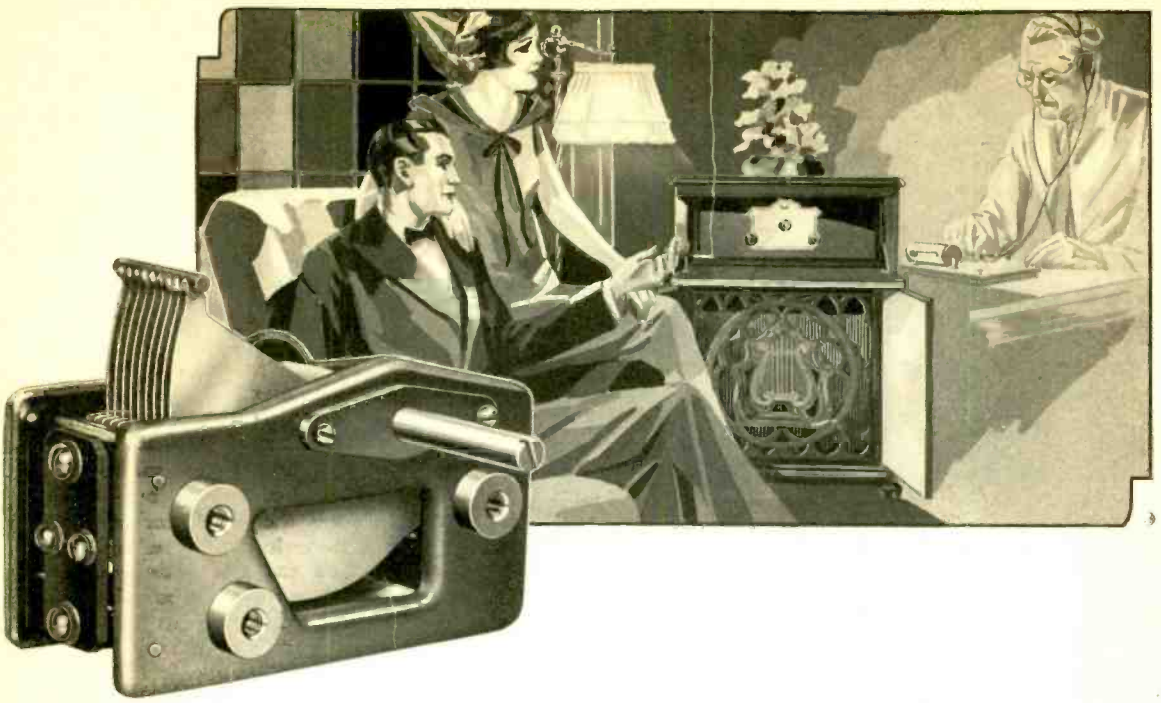
R A D I O - P A R T S



IMPROVEMENTS and changes in radio occur in rapid succession. Manufacturers need a dependable source of supply which can assume production responsibilities for small parts at short notice. Scovill, with its tremendous resources, experience and up-to-date methods, offers consistent quality in large volume. From a sample, blueprint, or even an idea, Scovill will make to order any quantity of radio parts: condensers, condenser parts, metal stampings, screw machine parts, switches, etc. A wide variety of butts and hinges, continuous hinges and machine screws are kept on hand.

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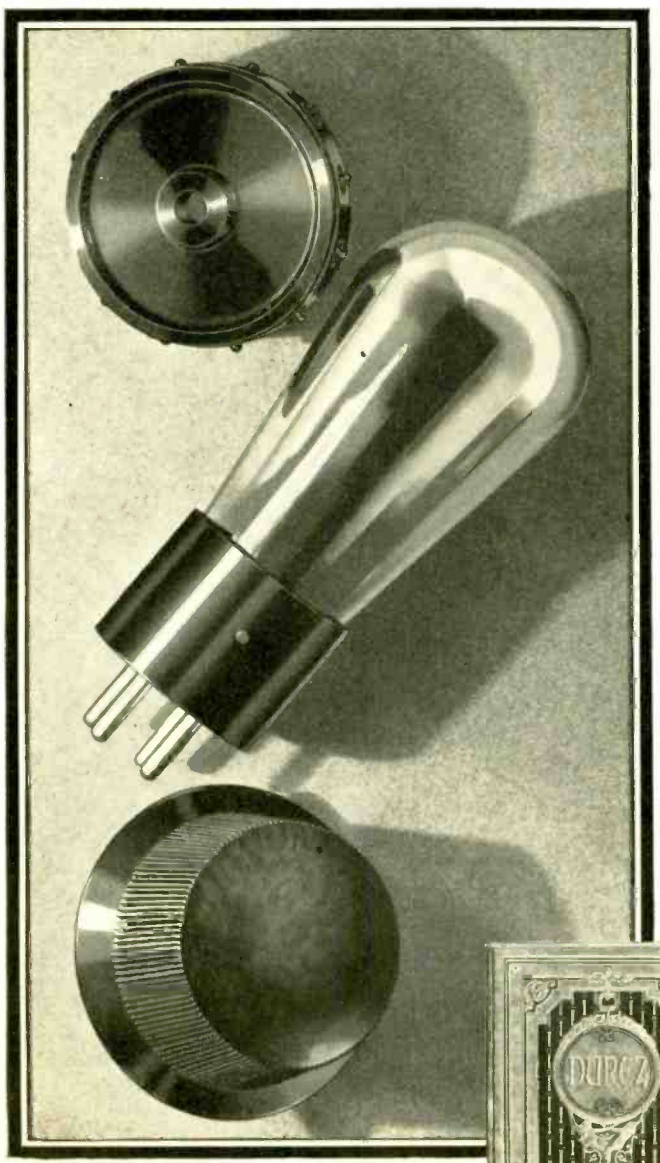
One or a million without variation



THE Sylvania Products Co. of Emporium, Penna., makers of Sylvania radio tubes, now use Durez for their tube bases. They find that this remarkable plastic not only meets their high standards of quality, but—it actually lowers their production costs.

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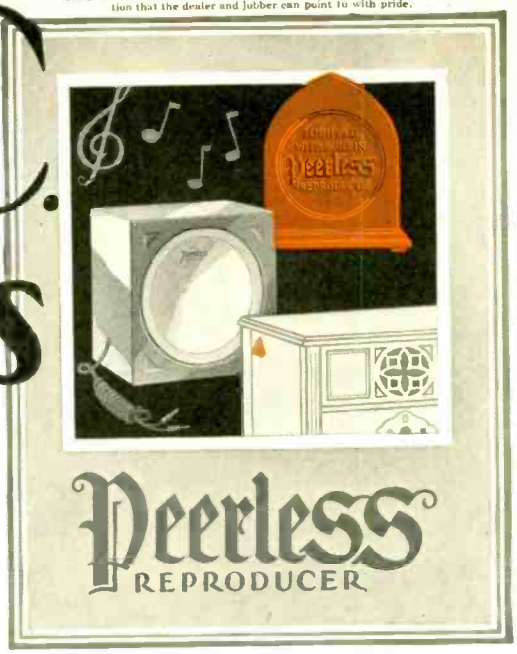
Marvelous Results With A.C. Tubes

BY A. T. HAUGH
Vice-President, United Radio Corporation
Rochester, New York

This little bronze emblem in the familiar shape of the famous Gothic Peerless Reproducer is available to all set-makers using the 7-B Peerless Unit. Attached to the cabinet it is an evidence of Quality Construction that the dealer and jobber can point to with pride.



IN January and February of this year, a funny thing happened!

We had planned to practically close down the factory—and clean up—after a super-hectic six months.

The day after New Year's, orders for twenty-one hundred Peerless Reproducers came in one day's mail.

And they kept coming!

We got busy—put on our full force again—and started trying to beat last fall's peak production record!

Then we looked around to find out WHY. We found dealers buying Peerless Reproducers that never bought before. We sent a couple of men out to probe around and find out why.

It was the new A. C. Tube Sets!

Dealers had tried out their regular lines of speakers. Something happened they didn't like. They tried Peerless Reproducer. It stood the gaff! It took the volume. Its wide frequency range showed up better than ever

Orders came pouring in. One jobber phoned 300 miles to say that he had orders for 14 sets if he could supply Peerless Reproducers with them. "The dealer insists nothing else will do with these A. C. sets!" said the jobber. We sent a rush shipment!

And because the word was passed around that Peerless Reproducers performed so well on A. C. sets our March 1st order file showed unfilled orders in excess of our biggest fall month.

Now, if you're putting out an A. C. Tube set for this season, the moral is simple: Use a Peerless Reproducer Built-In Model 7-B with it.

You have the dealers' word that Peerless Reproducer out-performs any other speaker on the A. C. Tube Sets.

Will gladly send a sample and engineering details at once. Or if you want a Peerless man, say so, and he will gladly see you soon.

This is an "A. C.-Set-Year"—and that means it is a "Peerless-Reproducer-Year!"

Let's hear from you. We can help you to bigger sales and better jobber-dealer-user satisfaction.

UNITED RADIO CORPORATION, ROCHESTER, NEW YORK

UR-129

The Master Hand of the Radio Engineer now brings to the modern Receiving Set the

Poly-Power Transformer Coil

The Coil's the thing!

that makes the "Light Socket" set possible.

Dudlo Poly-Power Transformer Coils can be wound and tapped to furnish A, B, and C currents at any specified voltages required by Radio receivers or power units.

Dudlo engineers are at the service of Radio Manufacturers to assist in designing a Poly-Power coil to meet their special needs.

With the source of power now made as convenient and reliable as electric lights, a great new market is opened up.

Thousands of folks who never before thought they could operate a Radio can now enjoy the wonderful programs without worry about the A, B, or C current supplies.

So again Dudlo meets the needs of the Radio manufacturer by preparing far in advance for volume production of these, the most intricate of all Radio coils. Special machinery has been designed and installed in anticipation of the greatest season the industry has ever known.

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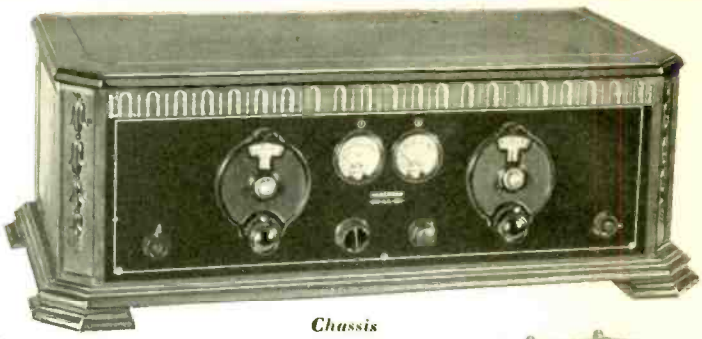


Chassis

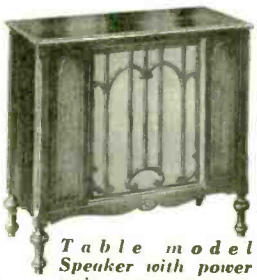
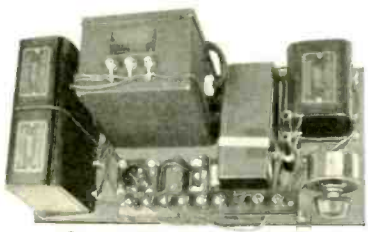


Table model Speaker with power unit compartments.



Super "B" Power Supply

"A" Supply

These Leading Manufacturers Make This

CECO

Ceco Tubes are used in the Hagerman 210-A-Six Ensemble because of their uniform reliability—because they perform well, last longer—because they represent advanced engineering.—C. E. Mfg. Co., Eddy St., Providence, R. I.

JEWELL

Voltmeters

In the Hagerman 210-A. C.-Six Ensemble, Jewell instruments were chosen because of the years of experience of the manufacturer and because of the special fitness of these instruments for adaption to this circuit; Jewell instruments are accurate, sturdy and good looking, and will give untold satisfaction in their use.—Jewell Electrical Instrument Co., 1650 Walnut St., Chicgao.

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"Transformers" and "Thordarson" are almost synonymous. The reliability and efficiency of the radio set or power supply is directly in ratio to the theoretical and mechanical perfection of the voltage supply or amplifying transformers. The R-171 and R-210 Power Compacts are the heart of any power amplifier or "B" supply.—Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago.

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210-AC-SIX
M B L E

Every Desirable *New* Feature in *One* Set

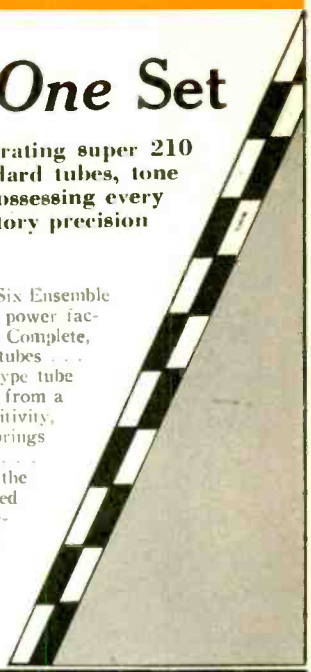
A really new broadcast receiver ensemble for the custom set builder, incorporating super 210 tube power amplification *in the set itself*, complete A.C. operation with standard tubes, tone quality surpassing any but the highest priced manufactured receivers, and possessing every other feature to as great a degree as is possible to obtain with present-day laboratory precision in theoretical, technical and mechanical design.

The Hagerman 210-A.C.-Six Ensemble represents not the efforts or work of any individual, but the combined engineering and technical knowledge of the nationally known manufacturers associated in the promotion of this receiver ***assuring success in its construction.***

In its design every factor has been considered. No one feature has been overdeveloped or sacrificed at the expense of another. It was not built to sell any one part or group of parts, but is offered to the set building public as a feasible and practical means of obtaining in *one* radio set, *all* the new developments of the past year, at a price approximately that of an ordinary, manufactured receiver.

Construction—Particular attention has been paid to the mechanical construction, as well as the theoretical and technical phase. When assembled, a Hagerman 210-A.C.-Six is as workmanlike and beautiful in appearance as the most expensive factory built receiver.

Performance—The Hagerman 210-A.C.-Six Ensemble actually has: 10 kilocycle selectivity . . . A power factor many times that of the ordinary set . . . Complete, perfected A.C. operation, with standard tubes . . . Super power amplification, using a 210 type tube *in the set itself* . . . Perfect tone quality, from a whisper to auditorium volume . . . Sensitivity, combined with great amplification that brings in distant stations with "local" volume . . . Perfect control of oscillation, both of the collective and individual stages of tuned radio frequency . . . An automatic, predetermined tuning system. The station is known before hearing the announcement . . . These features speak for themselves more strongly than any superlative description. Complete parts sold the country over.



Set An Outstanding Radio Achievement

BENJAMIN

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Benjamin Cle-ra-tone sockets are the acknowledged standard. Benjamin Tuned Radio Frequency Transformers will insure the success of any custom-built tuned radio frequency set, with their technical and mechanical perfection, exceptional efficiency and beauty of design.—Benjamin Electric Mfg. Co., 120 S. Sangamon St., Chicago.

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As for years past with Durham Resistors, these modern Powerohms are guaranteed for accuracy and absolute dependability.

Samples and full data with accurate operating curves together with prices, supplied upon request.

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6 *Durham Powerohm—2½ Watts; 500 to 250,000 Ohms; soldered end tapped type.*
7 *Durham Powerohm—2½ Watts; 500 to 250,000 Ohms; screw-end type.*
8 *Durham Powerohm—5 Watts; 250 to 250,000 Ohms; soldered end tapped or screw-end type.*
9 *Durham Powerohm—10 Watts; 250 to 250,000 Ohms; soldered end tapped and screw-end type.*
10 *Durham Powerohm—25 Watts; 250 to 250,000 Ohms; soldered and tapped.*
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12 *Durham Mounting supplied in various lengths to carry any required number of Powerohms where quick change of resistance is necessary.*

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Three Models Are Ready

14″x14″ 18″x23″

24″x24″

Write for Information on Other Sizes

THE Temple Air-Chrome represents one of the most startling speaker developments that the industry has ever seen. It couples Temple engineering and experience in speaker manufacturing with one of the most advanced principles ever developed in sound reproduction and at the same time carries with it more of the essentials demanded by manufacturers than any speaker developed up to this time.

The Temple Air-Chrome is of the open radiator type, but instead of one diaphragm, like the cone, it has two. These two diaphragms make possible the balanced tension principle whereby the slightest impulse is carried from the driving unit to the diaphragms without any loss. Lightness is combined with rigidity in the construction—climatic changes have no influence in that no paper is used, and the mechanical construction and design eliminates the inherent difficulties ordinarily met with.

These factors, plus the performance of a specially developed powerful Temple Double Action Unit, accounts for its handling capacity—for its enormous volume—its brilliancy—its full response to all audible frequencies. That's why the Temple Air-Chrome will not chatter—why it is suited particularly to every kind of power output.

Three sizes of the Temple Air-Chrome speaker are ready in the manufacturers type:

Size	Depth
14″x14″	7″
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24″x24″	9″

Write our engineering department for further data on other sizes—let us help you solve your speaker problem.

For manufacturers desiring air column speakers, Temple designs of almost every shape and size are available. Designed by Prof. P. G. Andres, they are all true exponential models designed for maximum response.

Write for data on special manufacturers types of Temple Double Action Units matched particularly to your output and air column requirements.

Air-Chrome Division

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RACON EXPONENTIAL HORNS

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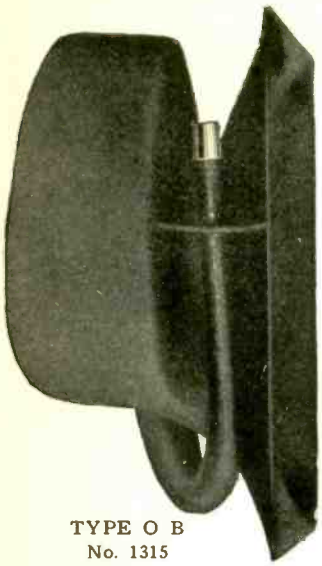
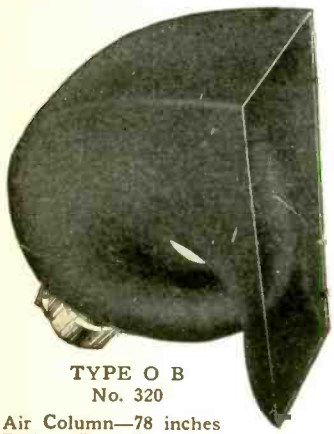
Leading Acoustical Engineers in the United States have pronounced Racon Exponential Air-Column Horns the finest made.

The perfection of their performance—clearness—depth and beauty of tone—faithfulness and accuracy of amplification give the "sales-clinching" proof expected by today's radio customer.

De Luxe Receivers, the Leaders, in the United States, Canada, England and Europe have Racon Installation; a tribute to the engineering exactness with which they are designed and manufactured. The installation of Racon Exponential Air-Column Horns in the Models you are now planning will render them complete units-of-service—assuring customer satisfaction.



TYPE O B
No. 1315
Air Column—104 inches
Bell—18" x 24"
Depth 13"
Price $18.00



TYPE O B
No. 320
Air Column—78 inches
Bell—10" x 20"
Depth 13½"
Price $9.00

Racon Exponential Air-Column Horns are Manufactured Exclusively under Racon Processes and Materials Patented in the United States, Canada and Great Britain. The impregnated, hardened fabric is of absolutely homogeneous, ***non-porous*** and ***vibrationless, one-piece*** construction. The lightest horn made. Nothing to break, chip or crack. No servicing required. Unaffected by climatic conditions or hard abuse. Ship safely.

Racon Exponential Air-Column Horns give longest air-column in the smallest space; acoustically correct and with a mellowness and richness of amplification having demonstration and sales value heretofore unknown.

TYPE A S
No. 100
Air Column—84 inches
Bell—14" round
Depth 9"

Racon Exponential Air-Column Horns are made in all shapes and sizes up to six feet square for Theatres and Auditoriums, demonstrating that Vibrationless Fabric is the only perfect medium for Acoustic Amplification. Stock Models that snugly fit into beautifully designed cabinets; over 100 to select from, 6½" depth upwards. Special Models designed to meet your individual requirements.

Consult Our Acoustical Engineers

Racon's New Sensation—for the Home. To be Announced Soon!

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The Beauty *of* MICARTA

RADIO sets are judged by their appearance as well as by their performance.

Micarta—with its high dielectric strength and low power loss—not only builds efficiency into a radio set, but it also adds permanent beauty. Walnut burl, walnut grain, ebony, and mahogany finishes of Micarta enhance the appearance of any radio set—no matter how artistic the design.

Micarta machines easily. The drill and the saw never chip it.

Micarta radio parts of every design—in any quantity—can be obtained from—

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Sales Offices in All Principal Cities of the United States and Foreign Countries

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the Permanent Panel Material

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X97148

The Stabilized Oscilloscope

*A Stabilized Cathode-Ray Oscillograph With Linear Time-Axis**

By Frederick Bedell† and Herbert J. Reich

THE oscillograph employing a vibrating cathode ray, first used by Braun and later so admirably developed by Ryan and others, has certain distinct advantages over the oscillograph of the Blondel or Duddell type in which a vibrating mirror is used. Foremost among these advantages is the fact that the cathode beam is free from inertia and can readily follow the variations of an electric or magnetic field even at high frequencies. The cathode-ray oscillograph, as hitherto commonly employed, has, however, the disadvantage that it has not been possible with it to show the variations in a number of quantities at the same time, nor to show these variations, as is done with the vibrating mirror oscillograph, as curves with time as abscissa in rectangular coordinates with which everyone is familiar.

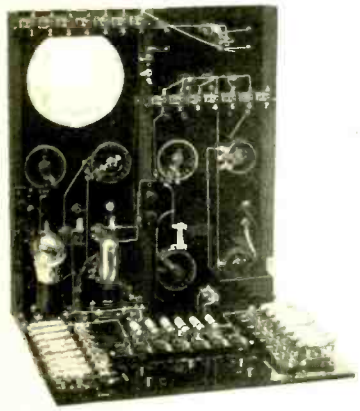

Fig. 1. Internal view of the stabilized oscilloscope.

While the cathode-ray oscillograph has proved a highly valuable tool for a wide range of engineering and scientific investigations, including both cyclic and transient phenomena, and, in certain respects, is superior to the oscillograph of the mirror type, it has suffered by the two limitations, just described. These limitations, however, may be removed and the field of usefulness of the cathode-ray oscillograph so widened that it becomes practically a new instrument. As the instrument developed for this purpose, (shown in Figs. 1 and 1A), is primarily intended for visual observation, we have given it the name "oscilloscope." Permanent record may be obtained, when desired, by a photograph in the usual way. On the other hand, an *oscillograph* of the Blondel or Duddell type, both in name and in fact, is primarily for graphical record.

Not being limited to a single cyclic phenomenon, the oscilloscope is polycyclic; furthermore, it is stabilized so that the wave or waves stand stationary for observation and this becomes particularly important when several waves are observed at one time. Recurrent transients, as well as more usual periodic phenomena, may be observed.

The cathode-ray oscillograph tube is so well known that it needs no description. The cathode beam, focused on a fluorescent screen or photographic plate, is deflected in one direction by one set of plates or coils, and in a perpendicular direction, by another set of plates or coils.

An admirable and full account of various types of cathode-ray oscillographs and their development from the beginning is given by A. B. Wood and others in the *Journal* A. I. E. E. (Nov., 1925), with 63 pages and 125 references. So complete is this account, (with its bibliography), and so admirable is the presentation that further discussion here is unnecessary.

The Polycyclic Distributor

In using the cathode-ray oscillograph, it occurred to the writers that if one pair of deflecting plates or coils could be successively switched by a distributor from circuit to circuit in rapid succession, the cathode beam would follow each in turn, making possible the simultaneous observation of several unknown quantities. We have found this to be the case and that when switched at proper intervals, the curves appear to the eye as simultaneous and continuous, due to persistence of vision, and likewise so appear in a photographic record. The development of a four-way experimental distributor for this purpose is shown in Fig. 2. A resistance is included in each of the four circuits as protection in case of short-circuit. A brush B bears on a continuous slip-ring to which are connected staggered quadrants. Each of the remaining four brushes comes in contact, in turn, with one of these quadrants. The terminals Y_0 Y are connected to one pair of deflecting plates of the oscilloscope, the terminals Y_0 Y_1, Y_0 Y_2, Y_0 Y_3, Y_0 Y_4 being connected to the several circuits under test. It will be noted that Y_0 is a common terminal; if any of the circuits cannot be so connected, an insulating transformer should be interposed between such circuit and the distributor terminals. Avoiding the common terminal, a double distributor can be used in a special case when necessary.

Fig. 1-A. Front view of the stabilized oscilloscope.

Linear Time-Axis

A linear time-axis, desirable for the observation of a single quantity, becomes almost a necessity in order to make a satisfactory interpretation possible when several quantities are simultaneously studied.

The need of a linear time-axis with

* *Courtesy of the Journal of the A. I. E. E.*

† *Professor of Physics, Cornell University.*

the cathode-ray oscillograph has long been recognized and various ingenious methods have been proposed for its accomplishment, often, however, with but limited application. Mechanical devices are limited in range of frequency; electrical devices, although not thus limited, are liable to be unstable, and stability, as has been pointed out, assumes prime importance when several curves are simultaneously observed, as any motion of the curves creates hopeless confusion. Even for

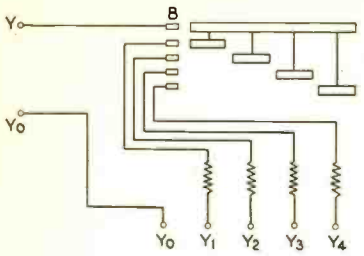

FIG. 2

Connections for the polycyclic distributor.

a single curve, stability is needed if the curve is to be carefully studied and perhaps sketched, traced or photographed. Furthermore, electric devices without proper precautions are liable to produce distortion.

A linear time-axis may be obtained if we have available either a synchronous mechanical switch or a synchronous electric valve. Thus, if a condenser is charged at a uniform rate through a resistance, or otherwise, and is periodically discharged by a synchronous switch, the difference of potential across the condenser terminals will increase linearly with time while the switch is open, and drop suddenly to zero each time the switch is closed.

The Corona Valve

A mechanical synchronous switch is cumbersome and can be operated only at low frequency. A synchronous electric valve that would automatically perform the same function at high or low frequency would evidently be better. Such a valve is found in the gas-discharge lamp, containing commonly neon or argon, the characteristics of which are well known. (See bibliography). When subjected to an increasing voltage, no current will flow through such a lamp until a certain critical "ignition" voltage is reached. Current then flows (analogous to the closing of the switch) and continues to flow until a definite lower "extinction" voltage is reached. Current then stops, analogous to the opening of the switch. The difference between the ignition and extinction voltages depends upon the frequency and type of lamp.

Each gas-discharge lamp possesses a certain capacity, so that, when connected to a source of e.m.f. through a resistance (in excess of a certain "critical resistance"), the lamp will light and re-light at definite frequency. This frequency may be varied through a wide range by varying the resistance and capacitance of the circuit. The gas-discharge lamp acts as a synchronous electric valve, performing the functions of a synchronous mechanical switch. Due to its nature, it may be referred to as the "corona valve."

Many theoretical and experimental studies (see bibliography) have been made of this phenomenon. Suffice it to say that the oscillation frequency is under control by adjustment of resistance and capacitance, the maximum frequency being obtained by reducing capacitance—including the capacitance of all circuit connections—to a minimum. Capacitance may be obtained by means of condensers in parallel with the corona valve or in parallel with a series resistance.

While the oscillating circuit can be adjusted for audio, commercial and lower frequencies, frequencies much higher than audio-frequencies are not readily obtainable with usual apparatus. A frequency of 95,000, however, is reported by Oschwald and Tarrant, using a resonant circuit; but resonance tends to produce a sine-wave oscillation rather than the straight saw-toothed wave required for a true linear time-axis, and is to be avoided in an oscilloscope in which accurate reproduction of wave-form is sought. On the other hand, low frequencies, of, say, one every minute or, indeed, every hour, are obtainable and there is no obvious reason why with sufficient capacitance, (and patience), one could not reduce the lower limit almost indefinitely, if there were any object in so doing.

Oscillating Circuit

Circuit connections for obtaining a linear time-axis, are shown in Fig. 3. In the resistance circuit *A P C*, connected to the battery *A B C*, is inserted the corona value *V*, which, either alone or with supplemental condensers in parallel with it, has a capacitance *c*, and a potential difference $v = q/c$. The corona valve passes no current,

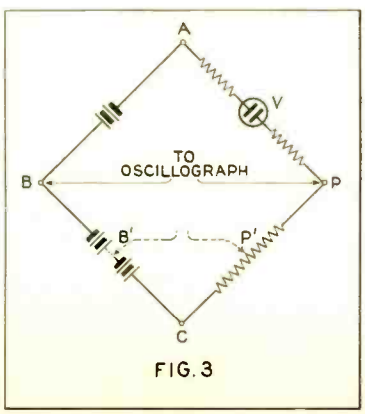

FIG. 3

Circuit connections for obtaining a linear time-axis, using batteries.

acting as an open switch, until the potential difference between its terminals, as charge accumulates, reaches the ignition voltage. Current then flows and the potential difference drops until extinction voltage is reached; the current then stops, the potential difference again builds up and the cycle is repeated.

Fig. 4 shows the variation in the difference of potential between a point *P* in the resistance circuit and a point of reference *B* of fixed potential. The curve of potential-rise is exponential, as shown by the dotted curve. By using only a short element of this curve, the rising part of the saw-toothed curve is sufficiently straight to give the desired linear time-variation, when *P'* and *B'* are connected directly or through an amplifier to the deflecting elements of the oscillograph. Other points, as *P'* and *B'*, give a similar but smaller variation, the amplitude of the time variation being capable of adjustment in this manner. The short, falling part of the saw-tooth curve, corresponding to the brief

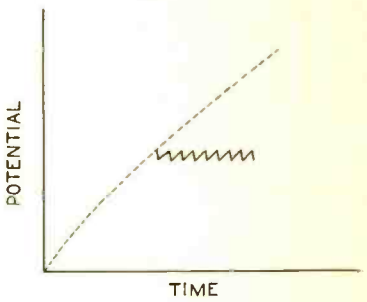

FIG. 4

Illustrating the potential variation between points P and B in Fig. 3.

interval during which current is flowing through the corona valve, is so rapid that the spot of light on the oscilloscope screen shows only a negligible trace as it sweeps back to repeat the cycle.

Fig. 5 shows the connections for operating the oscillating circuit when a thermionic tube *W* replaces part or all of the resistance in series with the corona valve. A constant current through *W*, when operated above saturation, gives a uniform increase in *v* during the rising part of the saw-tooth curve, and so assures a linear time-axis.

Connections are likewise shown in Fig. 5 for operating the oscillating circuit when resistors, supplied with direct current from a generator or battery eliminator, are used in place of batteries. The same resistor system may supply the accelerating potential for the cathode-ray tube as well as any voltages that may be needed for bias or for the vertical or horizontal displacement of the cathode-ray beam. Operation with such a resistor system is very convenient, giving a nicety of

adjustment not possible with batteries, provided precautions are taken to design the circuits, (including the circuits of a battery eliminator, if used), so that the several adjustments are sufficiently independent. The use of

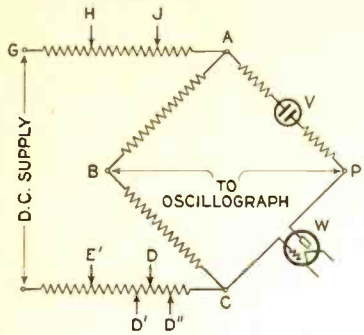

FIG. 5

Connections for obtaining a linear time-axis using a generator or battery eliminator, and a vacuum tube in place of resistance P, in Fig. 3.

more than one eliminator would, of course, obviate the difficulty, but a single eliminator, properly compensated and designed for the purpose, will suffice. After the use of such an eliminator, batteries seem cumbersome and are a source of error when they do not give just the proper voltage. When a generator supply is used, commutator ripples may be filtered out, if necessary.

Stabilizing

In order that the curves shown by the oscilloscope may be stationary, it is necessary first to synchronize and then to stabilize the oscillating circuit: that is, the frequency of the oscillating circuit is first so adjusted that the cathode beam sweeps back once every half cycle, or some multiple of it, of the varying quantity under observation, and is then locked in step and so stabilized. As an automobile engine is first synchronized and then thrown into a particular gear, the oscillating circuit is synchronized and then thrown into the desired gear, electrically, so the curve shown includes one or more cycles, or half cycles, of the quantity observed, as may be desired. Without being thus stabilized, the curves are liable to move and make observation difficult.

Stabilization may be effected in various ways, the simplest method being by introducing into the oscillating circuit a very small e. m. f. of the same frequency as the circuit under observation. This may occur in a way that is *casual* and uncontrolled, (whether by accident or design), through leakage or induction; thus, under certain conditions, we found that curves stood still when the operator merely raised his hand as though warning an animate being. Such stabilizing was promising and fascinating. Casual stabilizing, however, produces distortion; for, unless the stabilizing e. m. f. is controlled, some of it will affect the oscillograph circuit. To avoid distortion, stabilizing must be *definitive*, and the e. m. f., whether introduced conductively or inductively, so localized and controlled as not to affect the oscillograph. Thus, without attempting to discuss all possible methods of stabilizing, it is obvious that the distortion produced by the introduction of an e. m. f. at *J D*, (Fig. 5), while appreciable, would be far less than if the e. m. f. were introduced at *P B*. The authors have found that, for the apparatus employed, it is possible to obtain a definitive stabilization without distortion and with an amount of energy so small that the disturbance to the circuit under test, even when it is very sensitive, is practically negligible.

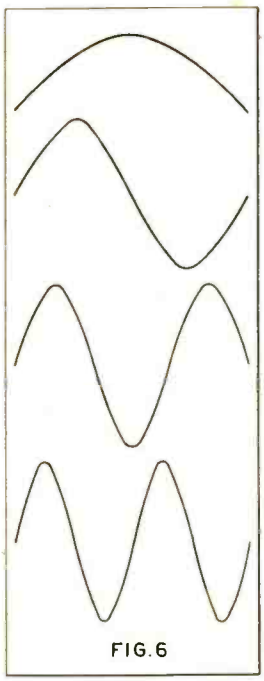

FIG. 6

Curves obtained through the use of different frequency ratios.

The oscillating circuit may be brought to the proper frequency and then stabilized so as to show a single cycle or half cycle; or it may be brought to a lower frequency, (whereby more time is taken for the spot to sweep across the screen along the time-axis) to that several cycles or half cycles are shown. In observing 60-cycle phenomena, the oscillating frequency may, for example, be stabilized at 30, 15, 10 or 5 cycles, with, however, a decrease in stability. In this way, for the same phenomenon, different gear ratios may be used and curves as shown in Fig. 6 be obtained.

Zero Line

Curves are ordinarily superposed, as in Fig. 7, either with or without a zero line. A zero line is obtained by a short-circuiting connection between Y_0 and Y_1, Y_2 Y_3 or Y_4, in Fig. 2.

Displacement

A curve may be displaced (raised or lowered) with respect to the others by interposing a battery, or other source of d-c. voltage, between it and the common terminal Y_0. Several curves may be so displaced, up or down, by varying amounts, depending upon the voltage and polarity of the battery.

A displaced zero line is similarly obtained by using a battery instead of a short-circuiting connection referred to above. Two zero lines may be used, one displaced with respect to the other, as in Fig. 8.

When a resistor system as shown in Fig. 3 is used for supplying accelerating potential to the cathode tube, displacement without batteries may be obtained by connecting the unknown not to Y_0 (and so to some point as D on the resistor) but to D' or D'' displaced therefrom.

Uses

The oscilloscope may be used not only in the varied fields of investigation in which the vibrating mirror or cathode-ray oscillograph is used but, on account of the characteristics here described, in additional fields as well. The stability of the linear time-axis, together with the multiple use of the oscilloscope by means of the polycyclic distributor, at once opens the way to many varied applications. With the oscillating circuit switched off, the instrument becomes available for all the uses of a cathode-ray oscillograph in the usual manner. The stabilizer linear time-axis is an added feature extending its usefulness.

On the other hand, the oscillating circuit may be used independently as a convenient source of current of controllable frequency. An ammeter in circuit may be used to indicate the frequency. A loud speaker connected through an amplifier becomes a source of sound of controllable, known pitch.

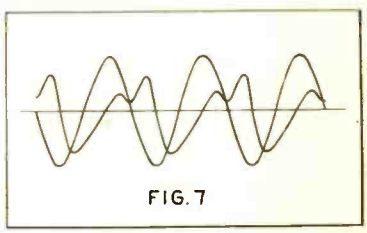

FIG. 7

Superposed, simultaneous curves with or without zero line.

Although not limited to any one type of cathode-ray tube, a well-known low-voltage tube described by Johnson (*Journal* Opt. Soc., 6, 701, 1922) has been found well adapted for the oscilloscope and arrangements have been made for its use.

The principles of operation of the oscilloscope are simple. Practically,

we have found that, in order to avoid error due to leakage or induction, many details though simple in principle are perplexing in execution, particularly when we are not seeking an elaborate laboratory equipment, limited in use on account of its scattered complexity, but an assembled, self-contained instrument, simple in operation and readily portable. Its availability adds materially to its usefulness. The senior author desires to express his appreciation of the assistance rendered by his colleague in the development and construction of the finished instrument.

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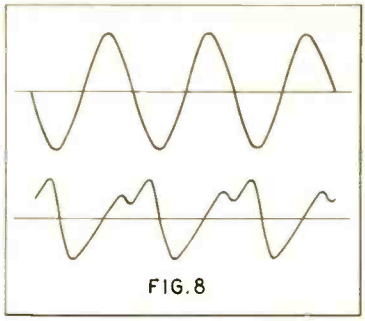

FIG. 8

Simultaneous curves, displaced, with or without zero line.

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Bureau of Standards Transmissions

Radio Signal Transmissions of Standard Frequency, April to October

THE Bureau of Standards announces a new schedule of radio signals of standard frequencies, for use by the public in calibrating frequency standards and transmitting and receiving apparatus. The signals are transmitted from the Bureau's station WWV, Washington, D. C. They can be heard and utilized by stations equipped for continuous-wave reception at distances up to about 500 to 1,000 miles from the transmitting station.

The transmissions are by continuous-wave radio telegraphy. The signals have a slight modulation of high pitch which aids in their identification. A complete frequency transmission includes a "general call" and "standard frequency" signal, and "announcements." The "general call" is given at the beginning of the 8-minute period and continues for about 2 minutes. This includes a statement of the frequency. The "standard frequency signal" is a series of very long dashes with the call letter (WWV) intervening. This signal continues for about 4 minutes. The "announcements" are on the same frequency as the "standard frequency signal" just transmitted and contain a statement of the frequency. An announcement of the next frequency to be transmitted is then given. There is then a 4-minute interval while the transmitting set is adjusted for the next frequency.

Information on how to receive and utilize the signals is given in Bureau of Standards Letter Circular No. 171, which may be obtained by applying to the Bureau of Standards, Washington, D. C. Even though only a few frequency points are received, persons can obtain as complete a frequency meter calibration as desired by the method of generator harmonics, information on which is given in the letter circular. The schedule of standard frequency signals is as follows:

Radio Signal Transmission of Standard Frequency

Schedule of Frequencies in Kilocycles

Eastern Standard Time	April 20	May 21	June 20	July 20	Aug. 20	Sept. 20	Oct. 22
10:00 — 10:08 P. M.	3000	650	1500	3000	125	300	650
10:12 — 10:20	3300	750	1650	3300	150	350	750
10:24 — 10:32	3600	850	1800	3600	175	400	850
10:36 — 10:44	4000	950	2000	4000	200	450	950
10:48 — 10:56	4400	1060	2250	4400	225	500	1050
11:00 — 11:08	4900	1200	2500	4900	250	550	1200
11:12 — 11:20	5400	1350	2750	5400	275	600	1350
11:24 — 11:32	6000	1500	3000	6000	300	650	1500

The Scramble for Short-Wave Channels in the Ether

Both Public and Private Interests Are Involved in the Matter of Short-Wave Assignments

By Donald McNicol

AS was foreseen by commercial communication engineers, the entire complicated problem of disposition of available short-wave channels in the ether has been presented to the members of the Federal Radio Commission. It was not due to good fortune nor to design that the Commission was able to hold back for a year the subject of disposition, or distribution, of the high-frequency swaths through space. If fortune played any part in this postponement it was in having the popular demand for improved broadcasting of entertainment at its height when the Commission was set up. Thus, it was natural that the Commission's efforts should first be directed toward pushing the half-dozen wave-jumping broadcasters back into the channels previously assigned them by the Department of Commerce, and then to begin gathering from radio engineers, and the broadcast managers, facts and figures which when assimilated and consolidated, might contain suggestions for a re-distribution of channels which at least would bring a confirmatory response from the public.

That, in itself, was a task of no small magnitude, and undoubtedly the Commission as at present constituted has so far done about as well with it as any other group of intelligent individuals could have done.

Broadcasting is a one-way service. It is not *Communication* in the sense that telegraphs and telephones supply communication through the medium of wire conductors, and by organized telegraph and telephone service by means of radio.

The subject of the electrical transmission of intelligence, or, simply, the subject of communication, is one of vast ramifications: of far too great importance in its radio application to be classified under the non-informing head of "Short Wave Distribution."

So far, in organizing marine and trans-ocean radio telegraph and radio telephone commercial services, the assignments of wave lengths for the various circuits has been, within certain limitations, largely a matter of adjustment and agreement between the various operating companies and government departments using radio.

This, of course, presented few serious difficulties so long as the number of international circuits in operation was not large. But, when there is up for solution the problem of sensibly distributing the 2,000 ether channels, generally referred to as being in the *short-wave* columns, then the matter is resolved into one of great importance to the Government, to existing communication companies and to individuals in our own country *as well as to corresponding interests in other countries*. And, so that nothing will be overlooked, we should add at the end of the foregoing sentence, "*and vice versa.*"

The Short-Wave Scale of the Radio Spectrum

In the early days of radio telegraph operation wave lengths of from 300 to 600 meters were employed, but in long distance projects the tendency, as time went on, was to employ much longer waves—up to 30,000 meters.

From the time of Marconi's early trials in 1896, until C. S. Franklin's inquiry, beginning in 1919, into the properties of short waves, the whole tendency in service operation was to work toward longer waves, as experience had shown that long waves performed more regularly through varying day and night conditions, and were less affected by fading. Thus, years before the time arrived when there was a shortage of available radio channels, the large commercial operating companies, having a choice, selected the long waves for long distance working. A sort of dictum grew up that for satisfactory working over long distances, a wave length of one five-hundredth part of the distance separating the two stations would be most suitable.

When broadcast radiophone stations began to multiply, beginning in 1921, all of these had, perforce, to accommodate themselves to the wave lengths by convention assigned to public service; those extending between 200 and 600 meters.

Since 1922, exploitation of the short waves—below 200 meters, has resulted in rendering available for practical uses many short wave channels which at one time were regarded as not being suitable for other than laboratory demonstrations.

The technical consideration given the subject at the Washington Conference in the Fall of 1927, had as a result the listing of what are popularly referred to as "short waves."

The present world-wide scramble for a place in the ether of space involves the distribution to various interests and services the wave lengths extending from 150 meters down to fifteen meters (2,000 to 23,000 kilocycles).

With present operating separations there are about 2,000 radio channels in this range of frequencies. The International Radio Regulations which are to become effective on January 1, 1929, divides these frequencies into thirty-six bands.

In the light of actual experience thus far it may be said that the 150 to 100 meter (2,000 to 3,000 k.c.) waves are suitable for daylight operation to a distance of several hundred miles, with a continuous range of about 100 miles. Naturally, applicable to service in an individual country, or between two contiguous countries, of use for aircraft, telephony, or other public or private service.

The wave lengths from 100 to 50 meters (3,000 to 6,000 k.c.) have a useful operating range of several hundred miles in the daytime and about 1,000 miles during dark hours. Obviously, these waves when used for national services, in many applications will spill over into and reach other countries.

The wave lengths of fifty meters (6,000 k.c.) and shorter are usable for long distances both day and night, with a dead or weak area (skip distance) of a few hundred miles out from the transmitting station. Suitable, of course, for long distance telegraph and for relaying broadcast telephony long distances.

The 20 meter band (15,000 k.c.) is

SAFEGUARD THE SHORT-WAVE CHANNELS

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

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

We sincerely trust that you will give Mr. McNicol's excellent article your serious consideration.

practically usable only between stations where daylight obtains, with present equipment, and 15 meters (23,000 k.c.) are about as short as have practical signaling value.

Short-Wave Allocations

Inasmuch as the non-technical reader can comprehensively identify the channels more easily when wave lengths are specified, rather than frequencies in kilocycles, the allocations decided upon by the last Washington Conference are given in that measurement. (See box).

Channels Applied For

All of the telegraph and telephone companies in the United States have not applied for wave length assignments. Of those who have applied to the Federal Radio Commission the following are noted:

Wireless Telegraph and Communication Co., Northbrook, Ill., asks for short wave designations for stations at Chicago and St. Louis.

Intercity Radio Telegraph Co., Cleveland, Ohio, asks for twelve channels for marine service on the Great Lakes and for fixed service between Buffalo, Cleveland, Detroit and Columbus.

Geophysical Research Corp., asks for the 122.9 meter assignment to be used by nine portable stations in mineral exploration work.

The Radio Corporation of America lists six waves which it proposes to use in addition to its present assignments. The new requirements are: 16.75, 21.62, 22.29, 22.341, 43.23 and 44.68 meters.

The Federal Telegraph Company (Mackay) wants 33.6, 34.6, 43.1, 65 to 75, for marine and trans-ocean commercial services. The company states that it will apply for a considerable number of channels for intercity telegraph operation.

The Bull Insular Line Co., New York, would like any channels between 18 and 36 meters, for stations in Baltimore, Md., and in Port Rico.

The American Telephone and Telegraph Company, and the Bell Telephone Laboratories, Inc., New York, ask for additional channels for experimental projects.

The Ford Company, Detroit, wants channels between 84 and 120 meters; the Goodyear Rubber Company, 43 meters for stations at Akron, Ohio, and Los Angeles, Calif.

The New York Times, New York Herald-Tribune, United Press, and International News Service (Hearst), expect to be given due consideration when the other lanes are granted for exclusive use during specified periods of time.

In parceling out the wave channels, the Authority will at some point, perhaps in several instances, have to give consideration to values and rights which have accrued during the time of prior use of designated channels.

Aside from the Radio Corporation's commercial marine and trans-ocean services; the Federal Telegraph Company's and the Independent Wireless Telegraph Company's (now R.C.A.) marine services, which have been in operation ten or more years, various other services have been carried on by corporations not in the communication business. Since 1918 a radio news service between England and the United States has been operated by a group of newspapers. The Ford Motor Co., the General Electric Co., the Goodyear Rubber Company and a dozen other business organizations have for years been handling all or a part of their telegraph correspondence between certain points by privately owned radio installations.

Distribution of Frequency Channels

Wave Length, Meters	*Service*
200 to 175	Mobile
175 to 150	Mobile, Fixed Stations, and Amateurs
150 to 133	Mobile and Fixed Stations
133 to 109	Mobile
109 to 105	Fixed Stations
105 to 85	Mobile and Fixed
85 to 75	Mobile, Fixed, and Amateurs
75 to 54	Mobile and Fixed
54 to 52	Mobile
52.7 to 50	Fixed
50 to 48.8	Broadcasting
48.8 to 45	Mobile
45 to 42.8	Fixed
42.8 to 41	Amateurs
41 to 36.6	Fixed
36.6 to 35.1	Mobile
35.1 to 33.7	Mobile and Fixed
33.7 to 31.6	Fixed
31.6 to 31.2	Broadcasting
31.2 to 27.3	Fixed
27.3 to 26.3	Mobile
26.3 to 25.6	Fixed
25.6 to 25.2	Broadcasting
25.2 to 24.4	Fixed
24.4 to 23.4	Fixed
23.4 to 22.4	Mobile and Fixed
22.4 to 21.4	Fixed
21.4 to 20.8	Amateurs
20.8 to 19.85	Fixed
19.85 to 19.55	Broadcasting
19.55 to 18.3	Fixed
18.3 to 17.5	Mobile
17.5 to 16.9	Mobile and Fixed
16.9 to 16.85	Broadcasting
16.85 to 14	Fixed
14 to 13.9	Broadcasting
13.9 to 13.45	Mobile
13.45 to 13.1	Mobile and Fixed
13.1 to 10.7	Not reserved
10.7 to 10	Amateurs and Experimental
10 to 5.35	Not reserved
5.35 to 5	Amateurs
5 to 0	Not reserved

The Federal Telegraph Company has for years operated a marine service on the Pacific, in addition to a chain of fixed, point-to-point stations in California, Oregon and Washington. The company has forty-two short wave channels; thirty-four of them for trans-ocean working and eight for point-to-point service.

The American Radio Relay League, an association of amateur operators and experimenters, has enjoyed for many years the privilege of operating small power transmitters over the entire scale below 200 meters. The relay stations of this organization send and receive a total of about one hundred thousand radio messages each year.

The Problem of Interference

Remembering that for the expenditure of a few hundred dollars, radio telegraph service may be established between two points several hundred miles apart, it may be realized that unless the national law serves effectively to support Department or Commission control, there will follow widespread interference as a result of a largely increased number of short wave installations.

It would not be surprising if the evolution of economics was setting the stage for a struggle between long established communication interests and other interests who wish to operate their own communication systems.

Between certain of the large wire companies and large radio companies there has been in the past, what might be characterized an unwritten view, conditionally held, that radio telegraph or radio telephone circuits should not be established for commercial purposes where wire lines already are in operation and rendering satisfactory service.

Unlike manufacturing interests, the railroads, agriculture, labor, and other extensive interests, the communication companies are in the unfortunate position of not having the legitimate and indispensable support of a trade press or of a trade association. In the communication field these agencies so valuable and useful in other enterprises, are non-existent.

The present Commission method of handling this important matter is to hold a public conference, sending out invitations which read:

"*All persons who feel that they can contribute information for the benefit of the Commission are invited to be present and to take part in the discussion.*"

This, of course, is a deplorable situation for which there is no evident excuse, but perhaps with our political system a better organization for handling the subject is not possible.

Obviously, the interest or interests which can finance and send to the conference the most convincing orators, and the most imposing delegation of representatives, is most successful in attracting the notice of the members of the commission.

New Issues Involved

It is quite apparent that once the subject opened up to include radio telegraph operation and radio telephone operation over short and long distances, reasons appeared why the members of the Radio Commission might easily be bewildered. The age-old problems of communication; competetive; international, etc., have had the life-time study and attention of a score of long experienced communication executives. The consider-

ation and issues involved are at home In a totally different category from those of radiophone broadcasting. What these issues are can be visualized only by communication executives who have lived their lives with Berne Bureau regulations and requirements, tariff structures, "other line" vicissitudes, etc.

It may be supposed that, like many other problems, the allocation of usable channels in space would have some obvious, sensible basis, but a difficulty is that there are not available more than half as many channels as there are requisitions for.

Proceeding on the basis that no radio wave assignments should be authorized where duplication of existing, satisfactory, wire line service is furnished by a public service company, then mobile services could be provided for very handsomely. The army, the navy, aircraft organizations, ship-shore and ship-ship service, very likely would have all of their demands satisfied.

Once the army, navy and aircraft services are reasonably cared for in the way of peace-time necessities (in case of war all systems, agencies and services will be subject to military or naval use as required) the present situation is that there remain the desires of commercial telegraph and telephone companies for radio channels by means of which they propose to supplement present wire and cable links; replace present wire and cable links; extend commercial service to places not now reached by any commercial service, and parallel radio links now operated by the earlier radio operating companies. Also the desires of private corporations not in the public service communication business, for radio channels over which they may with their own stations handle their own correspondence between plants, agencies and headquarters.

This is the point at which the rising tide of individual demand comes into contact with the rock bound coast of the communication industry which, in the main, is rendering a high grade of service, and which has shown continuous improvement.

The Commission's Basic Considerations

With the desire to learn something about the elements of the short wave problem the Federal Radio Commission considered the applications for short wave assignments in the light of:

1. *The dependence of the proposed service upon short wave radio rather than on wire or other means.*

2. *The humane, social and economic importance of the proposal to employ short wave radio.*

3. *Power required for service proposed, and interference likely to be caused to other services and other countries.*

And, submitting that satisfactory answers to these three questions would be acceptable as grounds upon which licenses for exclusive use of radio channels would be granted, it is plain that a favorable or unfavorable stand on the part of an individual commissioner would be largely based on opinion only.

The large communication companies have substance for much argument favoring granting the organized communication companies all of the channels they desire—at the expense of merchandise manufacturers, newspapers, etc., who desire assignments. The telegraph companies already have in being extensive collecting and distributing systems for telegrams. They maintain offices at all places where there is any excuse for an office. They have day and night message rates, which means a distributed day and night message traffic load. They render twenty-four hour daily service—in many instances where the earnings do not warrant this. They can furnish service uninterruptedly to all places, at specified tariffs and with recognized responsibility. They could show that there are very few non-communication companies which have enough message traffic between any two places to justify the expense of installing, maintaining and operating radio telegraph stations. In the case of those few, if the bulk of their messages pass between two stations (for instance manufacturing plant and headquarters offices) warranting for that traffic the operation of their own stations, what about the economics of the situation when these companies turn over their "night letter," "short haul" scattered traffic to the telegraph companies?

Private Interests

From the viewpoint of prospective owners of private radio telegraph installations there is also much argument with point. Non-communication interests have no more concern for the welfare of the telegraph companies than the owners of automobiles, and auto bus companies had, or have, for vanished street railway systems and suburban railways.

Private interests having a considerable amount of telegraph traffic between two, three or four places feel that when a group of amateur experimenters develop short wave radio signaling to a point where it is serviceable and economical, it would be hardly fair to take this gift and in its major applications hand it on to the existing telegraph companies, who previously ventured little in radio research or development.

Collation of the arguments and views proceeding from these opposed interests, with the notion of abstracting from data presented something of value in making decisions, throws light on the questions 1, 2 and 3, above.

Each question contains but a few words and it is of key importance how the answers are arrived at. Obviously, so far as the fixed station assignments which might be designated for commercial communication, are concerned, questions 1 and 2 could be answered more intelligently and constructively by a Board made up of commercial telegraph, cable and radio executives, including competent public representation, than by a year to year commission composed of appointees who have little or no knowledge of the subject.

Experienced communication executives would be aware of the full significance of the word "dependence" in question 1, and the words "economic importance" in question 2.

Question 3 concerns an engineering condition and would in any event be passed upon by the Radio Section of the Department of Commerce (Bureau of Standards.)

At the late Washington Conference the Broadcast business seems to have been fairly well provided for in the way of ether channels, and this aided by improvements in broadcast technique which are sure to come will tide the art over until new discoveries are made which conceivably might change the entire picture.

The Federal Radio Commission will be fortunate if it can satisfy those who brought it into being (the broadcast listeners) that the owners of receiving sets are being furnished with the grade and quantity of reception they bargained for when they made their purchases.

Embargo on Imported Insulation

SECRETARY of the Treasury Mellon has placed in effect a temporary embargo on imported insulation material which has been selling in the United States as Bakelite panels. Investigation by the Tariff Commission which recommended the embargo showed that most of the imported sheets were used to manufacture cheap radio sets.

American laminators who supply Bakelite panels and other insulation for radio sets made in this country complained that their trade was injured by the importations. Furthermore, as the foreign and American products could not be distinguished except by experts, neither the radio public nor the radio dealers were able to determine whether genuine Bakelite materials were used.

The radio industry depends for its supply of Bakelite laminated materials upon seven manufacturers, namely: the Formica Insulation Company, Cincinnati, Ohio; Continental Fibre Company, Newark, N. J.; National Vulcanized Fibre Company, Wilmington, Del.; Spaulding Fibre Company, Tonawanda, N. Y.; Fibroc Insulation Company, Valparaiso, Ind.; Westinghouse Electric and Manufacturing Company, and General Electric Company.

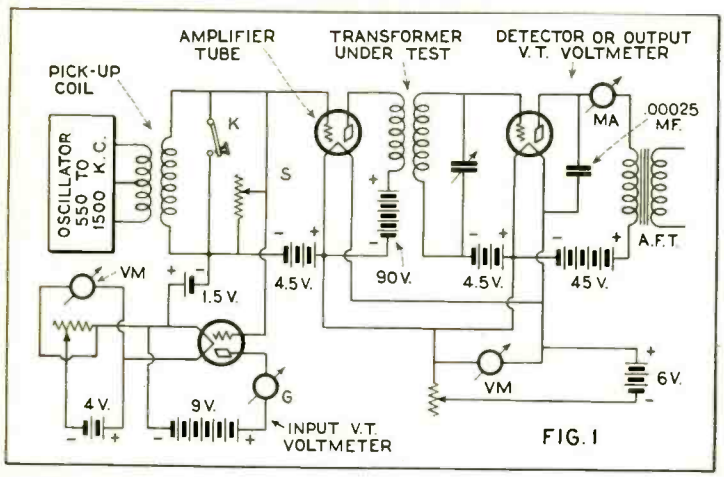
Data on the Voltage Amplification of Radio Frequency Transformers

Dealing With Apparatus for Testing R. F. Transformers and the Operations Involved

*By Burr K. Osborn, B.S.**

PART I

WHILE the technical press has recently carried several articles on the theoretical design of radio-frequency transformers, little has been published of actual experimental data. The investigation described in this article was undertaken with the intention of filling in this gap, and of showing the actual performance of certain types of transformers used in broadcast receivers.



Circuit diagram of the apparatus used in Mr. Osborn's tests, consisting primarily of input and output vacuum tube voltmeters and an R.F. oscillator.

Method of Test

The method used to obtain the voltage amplification of the radio-frequency transformers was the obvious one of measuring the input and output voltages of a one stage radio-frequency amplifier, using for the purpose a vacuum tube voltmeter. This, of course, gives the amplification of one stage; i.e., of one tube and transformer, not just the step-up of the transformer alone, but since the transformer and tube are always used together, the figures obtained are a true indication of the performance of the transformer in an actual amplifier.

Every effort was made in these tests to simulate actual receiver conditions. The input tube (tube preceding the transformer) was of the 201-A type most commonly used in radio receivers, and the output vacuum tube voltmeter was connected to the secondary of the transformer exactly as if it were a detector tube of the grid bias type. Since this is the type of detection now coming into use in the higher class receivers, the test reproduces exactly the stage of amplification preceding the detector in a so-called tuned radio-frequency receiver, and indeed was actually used for the reception of signals by coupling to an antenna. The performance of this stage is not materially different from that of stages working into another amplifier instead of the detector since the detector with negative grid bias has practically the same input impedance as an amplifier used with the correct grid bias.

Apparatus Employed

Fig. 1 gives a connection diagram of the apparatus used in the tests. The radio-frequency oscillator was of the usual Hartley type with the pick-up coil far enough removed to avoid reaction which would affect the frequency. The amplitude of the radio-frequency voltage applied to the amplifier tube was adjusted by varying the resistance of the shunt S. This resistance connected to the input circuit served the further desirable purpose of rendering the grid circuit of the amplifier tube practically non-inductive, thus avoiding any tendency to regeneration due to feedback from the tuned plate circuit to a tuned grid circuit. The input vacuum tube voltmeter was also shunted across the resistance S and hence measures the voltage applied to the grid of the amplifier tube.

The detector or output vacuum tube voltmeter differs from the usual negative bias detector only in the addition of the galvanometer or milliammeter MA in its plate circuit. This instrument required about 0.4 milliamperes for full scale deflection. The secondary of the audio frequency transformer was connected to another tube not shown in the diagram and with which head-phones could be used, if desired.

Calibration of Apparatus

In order to read the very small voltages expected on the input side of the amplifier the grid and plate voltages used with the input vacuum tube voltmeter were much lower than commonly used. The use of a 201-A tube with the filament at 3 volts, grid battery of 1.5 volts and plate battery of 9 volts was found to give very good results. No means of adjustment was provided for either the grid or plate voltages, since fresh dry cells were used, the current drain was zero in the grid circuit and extremely small in the plate circuit, and the tests were concluded before any appreciable change could occur in the condition of the batteries. Both the input and output vacuum tube voltmeters were calibrated from the 60 cycle power circuit using the connections shown in Fig. 2. A laboratory voltmeter, 0-75-150 volts, was connected to the sliding contact of a potential divider. In parallel with the voltmeter was connected a calibrated potential divider having accurately adjusted resistance of 100, 1,000, and 10,000 ohms. The grid-filament terminals of the vacuum tube voltmeter were connected to other terminals of the calibrated potential divider in such a manner that the voltage impressed upon the grid was exactly 1/10 or 1/100 of the voltage read by the laboratory voltmeter. This method of calibration could not be used for an ordinary voltmeter, but may be used

* *Department of Electrical Engineering, Michigan State College of Agriculture and Applied Science.*

for the vacuum tube voltmeter, since the vacuum tube is essentially an open circuit at 60 cycles, and when no current is drawn from the potential divider, its voltage ratio is accurately maintained. The calibration curves of the vacuum tube voltmeters are shown in Fig. 3 and Fig. 4.

The assumption is that these calibrations made at 60 cycles are true at radio-frequencies. There is nothing in the theory of the vacuum tube voltmeter to indicate that this is not true, provided the wave shape of the 60 cycle voltage is the same as that of the radio-frequency voltage. Actually the wave shape is not the same, since the 60 cycle was very nearly a pure sine wave, while the radio-frequency is known to contain fairly strong harmonics. However, this error due to wave shape will effect both vacuum tube voltmeters in the same way, and since it is the *ratio* of output to input voltage and not primarily true voltage in which we are interested, this error is allowable. The radio-frequency oscillator was calibrated from a laboratory wavemeter and settings were recorded for the following frequencies: 550, 700, 850, 1000, 1150, 1250, 1300, 1350, and 1500 kilocycles per second.

Operation

In taking data for voltage amplification curves, the procedure given below was followed:

1. Light the vacuum tube filaments and allow them to burn until the tubes have reached their normal operating temperature. (The calibration of the vacuum tube voltmeters is changed by a slight change in temperature.)

2. Observe the zero of each galvanometer and adjust if necessary (The zero adjustment of a sensitive galvanometer is rarely the same from day to day.)

3. Apply the plate potentials to all tubes and observe the "zero voltage" readings of the two galvanometers. These should check with the zero voltage points of the calibration curves and if they do not it indicates either that the filament voltage is not exactly normal or that the tube has not yet warmed up to its normal operating temperature.

4. Set the radio-frequency oscillator at either 550 or 1500 kilocycles. Adjust the input shunt until the galvanometer of the input voltmeter indicates approximately the input voltage desired. If the transformer under test is of the tuned type, adjust its variable condenser to obtain maximum deflection of the galvanometer of the output voltmeter. Readjust the input shunt to obtain exactly the input voltage desired and read the output galvanometer.

5. Set the radio-frequency oscillator at the next higher or lower frequency desired and repeat No. 4.

6. From the calibration curves of the input and output vacuum tube voltmeters obtain the voltages corresponding to the deflections. The ratio of the output to the input voltage is the voltage amplification for each frequency.

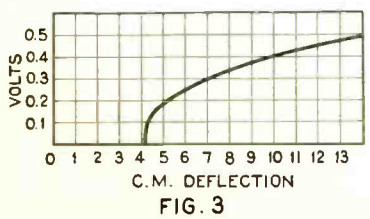


FIG. 3

Calibration curve of the input vacuum tube voltmeter.

The special circuit used in the calibration of the input and output vacuum tube voltmeters employed in the test circuit, Fig. 1.

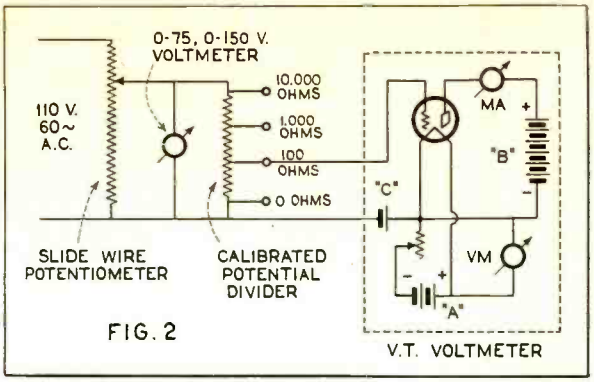


FIG. 2

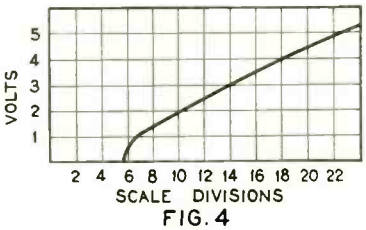


FIG. 4

Calibration curve of the output vacuum tube voltmeter.

Selectivity Test

Since in many cases maximum voltage amplification is obtained with a transformer giving very poor selectivity, it is necessary to have some measure of this quality.

In making selectivity measurements, the apparatus was adjusted to measure the voltage amplification at some particular frequency, say 1300 k.c. The radio-frequency oscillator was then shifted to a frequency 50 k.c. above or below the original frequency, the input shunt adjusted for the same input voltage as before, and the output galvanometer read *without* returning the transformer under test. This procedure gave the voltage amplification at a frequency 50 kilocycles from the frequency to which the transformer was tuned and to have significance it should be divided by the peak amplification thus obtaining the "per cent of maximum amplification at 50 kilocycles from peak."

Common experience indicates that the most bothersome type of radio interference results from strong local signals which may be separated by as much as 100 kilocycles from the desired signal. Hence selectivity expressed as percent amplification 50 kilocycles from the tuned frequency is a reasonable unit. It is a convenient unit to use in the laboratory since a frequency difference of 50 kilocycles may be set with sufficient accuracy on the dial of the radio-frequency oscillator, thus avoiding the use of the wavemeter for every selectivity test. For a frequency farther than 50 kilocycles from the peak it would be difficult to measure accurately the output voltage except with the poorest transformers. Hence 50 kilocycles was found to be a good compromise.

In the case of all types of transformers tested, the selectivity is markedly poorer at the higher frequencies. For this reason the selectivity was measured only at 1300 kilocycles, the amplification being taken at 1250 and 1350 kilocycles with the transformer tuned to 1300. The selectivity is the average of these two results expressed as a percentage of the amplification at 1300 kilocycles.

Part II of this article will cover in detail an analysis of the results obtained in the tests.

Patent Interchange Committee of R.M.A. Perfecting Plan of Cross-Licensing

THE Patent Interchange Committee of the R.M.A. met at Buffalo, recently, in conjunction with the Special Committee appointed to study the necessary changes in the Constitution and By-Laws.

Draft of the Proposed Cross-Licensing Plan was perfected by the committee.

Broadening of radio patent cross-licensing to include future developments, such as television, is provided for in the R.M.A. plan.

The Problem of Radio Set Power Supply

Covering the Design of Socket Power Circuits

*By George B. Crouse**

PART IV

"A" Socket Powers

In the design of "A" Socket Powers for parallel filament operation in which comparatively large currents are required at low voltages, we are met at the outset with two difficulties. In the first place the capacities to be effective must be inordinately large, because of the low voltages available to store energy in them. Secondly, because of the large D.C. components flowing in the inductances, large air gaps must be used and for a given size structure the inductance is very small. These two difficulties are partially offset by the fact that the potential of the alternating ripple from the rectifier is very much smaller than in the case of "B" Socket Powers, but the difficulties of designing low voltage filters are certainly much greater.

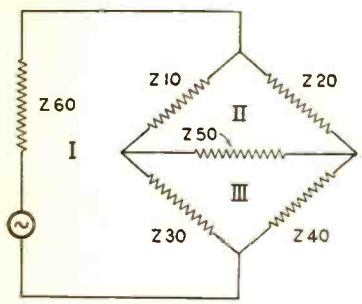


FIG. 7

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

Here again the suppression characteristic is highly desirable and indeed almost necessary. Obviously, we cannot use resonant circuits effectively because of the large size of the parts which would be required. The bridge circuit, however, has been successfully developed for this class of service, and one type is shown in Fig. 9. The balancing arms are formed as follows: Referring to Fig. 7, arm Z_{10} by the resistance 32 and the inductance 33 wound on the iron core 34. Arm Z_{30} by the reverse winding 35. Arm Z_{20} by the inductance 36 on the iron core 37, and arm Z_{40} by the reverse winding 38 on the core 37 together with the resistance 39. In substituting the quantities representing this bridge into equation 8 care must be taken to see that the sign of the mutual inductance existing between coils 31 and 35 and 36 and 38 is properly taken. The load arm Z_{50} is formed by the load connected between the minus and plus A point and a simple T section filter comprising the two coils 40 and 41 and the resistance 42.

The four balancing arms of the bridge are designed to be balanced at the most disturbing frequency and by proper proportioning these arms will exert a considerable suppression at all higher frequencies, which is augmented by the T section filter in the load arm.

"A" Socket Power Unit employing a bridge circuit which provides the desirable suppression characteristics.

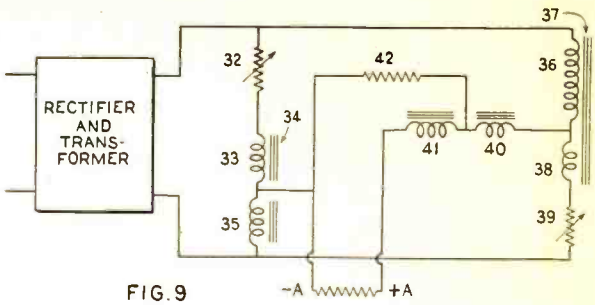


FIG. 9

Considering the direct current characteristics of the mesh the useful current flow will be from the plus terminal of the rectifier through the coil 36, through the coils 40 and 41, through the load and thence through the winding 35 and back to the negative terminal. Obviously, some direct current will be wasted through the other two bridge arms and through the resistance 42, but this loss current may be made surprisingly small. In a good design of filter for this type for suppling 2 amperes at 6 volts only about .75 amperes need be wasted in the resistive elements, and a total actual inductance of less than 1 henry need be used in the entire system.

This low value of inductance required with the type of circuit just described is a highly necessary feature in any high current socket power. The direct current through the load must of necessity flow through some of the windings of the inductance and the copper has, in company with most materials, a postive resistance-temperature coefficient. The result is that unless the resistance of the winding is kept to a very low value, the output voltage will gradually fall as the coils heat up with use. As a result, we cannot design our inductances by the ordinary rules in which the safe temperature on the insulation is the limiting factor. On the other hand, the rise must ordinarily be held down to 10 or 15 deg. C. It will be seen that should the inductance of the coil be required to be very large the coils themselves would become physically so big as to be totally impractical.

Another form of filter suitable for "A" Socket Powers is shown in Fig. 10. This mesh is also of the inductance-resistance type but has the extraordinary property that whereas it is neither a bridge nor employs resonant circuits, it has a point of infinite impedance with a finite but high impedance at all other frequencies.

The inductance system is of the siamese type comprising two adjacent iron cores 43 and 44 on which are wound the three coils 45, 46 and 47, these coils being all wound to aid each other. Two resistances are employed, the first, 48, being connected in parallel with coil 45, and the second, 49, being in shunt across the line between the junction point of the upper resistance and the coil and the negative terminal of the rectifier. A very important element of the system is the closed circuit formed by the copper band 50, linking the two iron cores. Because of the novel and interesting character of the circuit a rather complete analysis is given here.

Another form of filter, of the siamese type, suitable for "A" socket powers. This filter is of the inductance-resistance type.

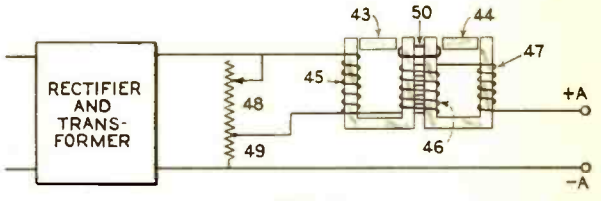


FIG. 10

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

For purposes of analysis, the circuit is redrawn as shown in Fig. 11. Circuit I will include the generator, the resistance R_1 representing resistor 48, and resistance R_2, representing resistor 49. Circuit II comprises R_1 and the inductances L_2 and L_{20}. The

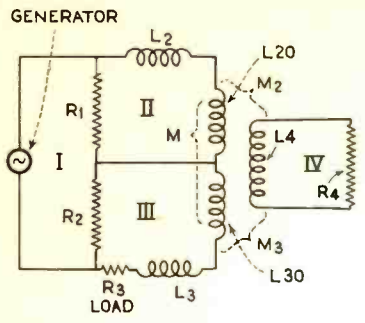


FIG. 11

The filter circuit of Fig. 10 drawn in general form for the purpose of analysis.

quantity L_2 represents the inductance due to the flux of the coil 45 which does not link with the coil 46. L_{20} representing the inductance in coil 45 due to the flux which threads the entire core 43. Circuit III comprises resistance R_2 and the closed resistance R_3 together with the inductances L_3 and L_{30}. L_{30} represents the inductance due to the flux in core 43 acting on coil 46 and L_3 is the inductance due to the entire flux in core 44 acting on coils 46 and 47. The mutual inductance between L_{20} and L_{30} is represented by the quantity M. The copper band 50 in Fig. 10 represents a fourth circuit, designated IV, which has inductance L_4, resistance R_4, and mutual inductance with L_{20}, designated M_2, and with L_{30}, designated M3. It will be noted that this fourth circuit is located entirely outside of the direct line of either A.C. or D.C. propagation. This, however, in no way invalidates the analytical method and we may, as before, write four inter-related equations for the currents in each of the elementary circuits, solve them as simultaneous, and convert the complex quantities appearing in the resulting equation into absolute values. When this is done we come out with Equation (10)

$$I_3 = \frac{E\sqrt{[\omega^2(R_2ML_4 + M_2^2R_3 - M_2M_3R_2 - R_3L_{II}L_4) + R_3R_{II}R_4]_2 + [\omega(-R_2R_4 M + R_{II}R_3L_4 + R_3L_2R_4)]^2}}{\omega^4 L_IL_{II}L_{III}L_4}$$

for the value of the alternating current ripple at any frequency in the load circuit.

In writing the above equation, and in order to save symbols, where the sum of a given quantity in a single elementary circuit is needed, the Roman sub-script has been used to designate this sum. For instance, in circuit I the total resistance in this circuit is designated as R_I and is equal to R_1 plus R_2. Similarly, the quantity L_{II} equals L_2 plus L_{20}, etc. Also in the denominator a large number of numerically insignificant terms have been dropped.

An examination of the numerator of the fraction on the right hand side will yield some interesting facts. It will be noted that here are two brackets under the radical sign, both of which contain quantities connected by both plus and minus signs. It has been found possible to so proportion the various quantities appearing in these brackets that at a given frequency the value of both brackets will simultaneously become zero, in which case the numerator vanishes and we have an infinite suppression characteristic at this frequency. Since the right hand bracket contains no terms which are not directly multiplied by the frequency factor if this bracket vanishes at one frequency it will be zero at all frequencies. Unfortunately, this is not true of the left hand bracket which contains the plus term R_3 R_{II}, R_4 which is not multiplied by the frequency factor. As a result, at any frequency other than the critical frequency this bracket does not vanish, but since its value is determined by R_4 representing the exceedingly small resistance of a heavy copper band 50 (Fig. 10) the whole numerator will remain very small at all frequencies and the device will operate substantially as a "blanket filter."

This circuit also utilizes in its practical form very small values of inductance and is very economical to build and operate. Both of the "A" Socket Power circuits just described may be adjusted to take out any variations in manufacture by a simple change in the resistance values, or in the case of the circuit last described by a change in the physical position of the copper band 50, which change modifies its inductance and its coupling coefficient with both circuits.

Series Set Socket Powers

Under Series Set Socket Powers we include only those arrangements in which A, B and C power is supplied through a single rectifier. This type of socket power is becoming increasingly important. It is economical to build and operate. It will work in conjunction with a radio set employing standard tubes and standard parts and principles of design. It may be built into the cabinet of a set to form a compact and integral unit.

The socket power unit is a slightly enlarged "B" Socket Power and the

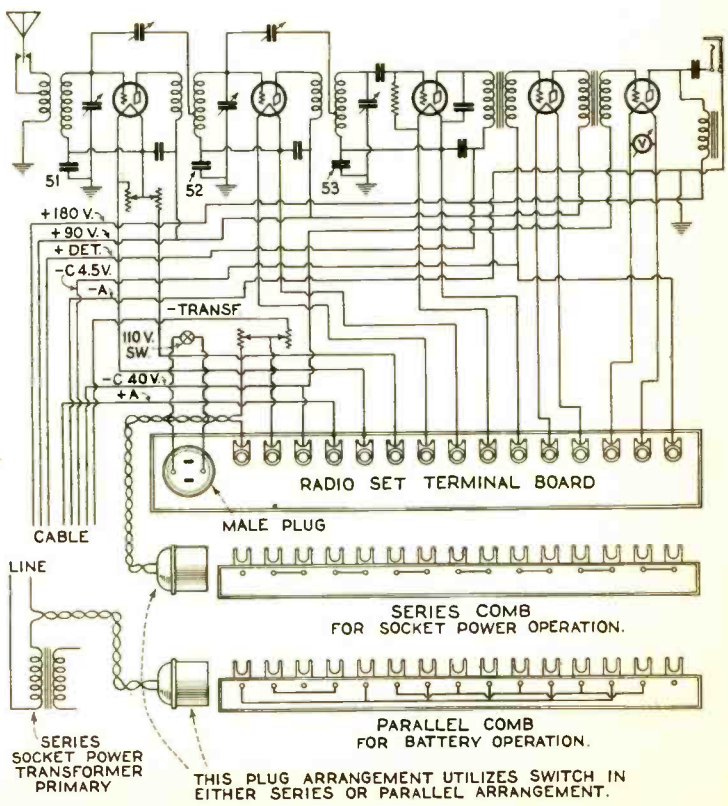


FIG. 12

Universal arrangement of radio set wiring providing series or parallel filament connections by interchanging of connector combs.

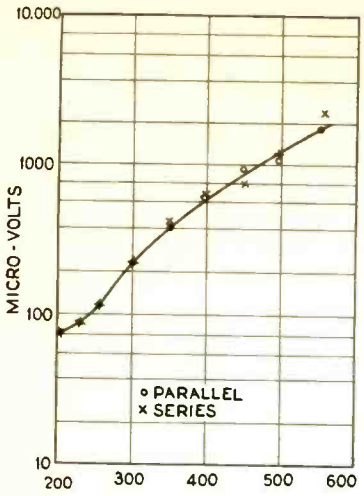


FIG. 13

Sensitivity comparison of parallel and series filament connections.

devices shown in Figs. 5, 6 and 8 of the previous article, may by proper modification of the direct current carrying parts, be converted into very satisfactory Series Set Socket Powers.

Experience in the design of these units shows that they do not require as much capacity when used in this service as when used for "B" Socket Powers, and the values of the inductances can also be considerably reduced. This apparently paradoxical result comes about from the fact that the ripple is partially canceled out in the tubes by the inter-action of the filament and plate circuits. This cancellation takes place for very small values of ripple and, as pointed out above, the suppression of frequency of largest amplitude is not, in the circuit shown, directly dependent upon the absolute value of the electrical constants, but rather on their relationship one to another. It should be pointed out clearly that this cancellation is in no way similar to the vicious practice which has grown up recently of offsetting the effect of a bad filter or A.C. tube by cutting off the lower frequencies in the amplifier response curve. The type of compensation which we have been discussing is in no way dependent upon the amplifier itself, nor does it in any way affect the signal amplification in the tube itself.

The scope of usefulness of these Series Set Socket Powers will undoubtedly be greatly enhanced by an arrangement recently worked out by the author's organization whereby the set may be made universal, i.e., it may be operated with the filaments in series with a Series Set Socket Power, or with the filaments in parallel, on batteries or "A" and "B" Socket Powers. This arrangement as applied to a well known 5 tube set is shown in Fig. 12. The conversion is accomplished in a few seconds by removing one of the two combs from the terminal block and substituting the other.

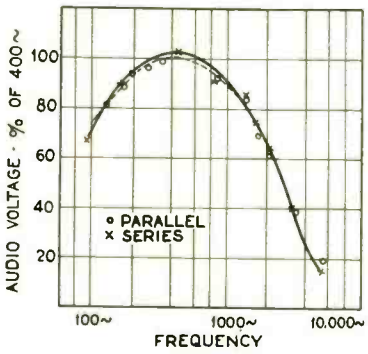


FIG. 15

Comparison of fidelity of parallel and series filament connections.

It is interesting to note that no change of operating characteristics is made by the conversion. In Figs. 13, 14 and 15 are reproduced curves showing comparisons of the sensitivity, selectivity, and fidelity of this receiver for parallel operation with battery supply, and series operation with Socket Power supply. In these curves the points marked by circles are the parallel observations, and the points marked by X's the series operation. It will be noted that the points lie so close together that it is practically impossible to draw separate curves through them. Attention is called to two very significant facts. In the first place, in the selectivity comparison of Fig. 14 the curves there shown are identical with similar curves taken before the condensers shown at 51, 52 and 53 (Fig. 12) were inserted. This proves conclusively that the radio frequency amplifier is in no way affected by the conversion.

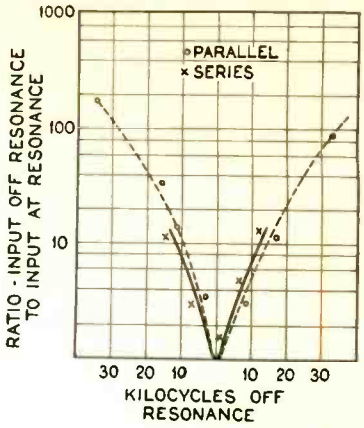


FIG. 14

Selectivity comparison of parallel and series filament connections.

Secondly, Fig. 15 shows that by proper design of the terminating mesh of the Series Set Socket Power no changes are made in the characteristics of the audio frequency amplifier.

Distortion Originating in the R.F. Amplifier

A Physical and Mathematical Interpretation of the Factors Involved

By Nelson P. Case, E.E.

FOR the last two or three years manufacturers of radio sets and kits have been making tremendous strides in those factors of design which have to do with the musical quality of the output of the sets. Of course, all this laboratory activity has been accompanied by a flood of literature and magazine articles, some of which have undoubtedly been valuable contributions to the radio knowledge of the average fan. Unfortunately, however, a great many of these articles seem to have been written by advertising managers instead of engineers, and the result is that a woeful amount of misinformation on the subject of distortion and its causes has crept into the public mind. It is the purpose of this article to clear up the question of how much and what kind of distortion can originate in the radio frequency amplifier.

Inasmuch as we will attempt to give a definite and conclusive proof of any statements made herein, it will be necessary to use some mathematics, but the physical interpretation of the mathematical results will be kept to the front, so that the non-technical reader will be able to follow the reasoning.

The first point which should be kept clearly in mind is that a tuned radio frequency amplifier will pass on

to the detector only a relatively narrow band of frequencies to which it is tuned. Hence, any distortion of the radio frequency currents in the amplifier will not appear in the detector output unless it produces changes in the band of frequencies which is passed by the tuned circuits of the amplifier. This will be made clearer later.

The current in the antenna produced by a broadcasting station sending out music can be represented by the equation.

$$i = (A + B \cos 2\pi f_1 t + C \cos 2\pi f_2 t, \text{ etc.}) \sin 2\pi f t \quad (1)$$

where f is the frequency of the radio frequency carrier wave, and f_1, f_2, etc. are the frequencies of the various musical notes being emitted. If we assume that the carrier wave is being modulated by a very high pitched note, we will be able to examine the effect of any distortion and see whether it will affect the carrier and side bands, because our high pitched note will give us side frequencies which are close to the outer limits of the side bands normally used for the transmission of music and speech. This assumption simplifies equation (1) to

$$i = (A + B \cos 2\pi f_1 t) \sin 2\pi f t \quad (2)$$

The physical significance of this equation is rather obscure, but we can juggle it into another form. The first step is simply to multiply it out. This gives

$$i = A \sin 2\pi f t + B \sin 2\pi f t \cos 2\pi f_1 t \quad (3)$$

The last term is now split into two pieces, each of half the size, thus

$$i = A \sin 2\pi f t + \frac{B}{2} \sin 2\pi f t \cos 2\pi f_1 t + \frac{B}{2} \sin 2\pi f t \cos 2\pi f_1 t \quad (4)$$

Now if we add $\frac{B}{2} \cos 2\pi f t \sin 2\pi f_1 t$ to both sides of equation (4) we have not changed the truth of the equation, but we can rearrange our terms and simplify by well-known trigonometrical identities. We then get

$$i = A \sin 2\pi f t + \frac{B}{2} \sin 2\pi (f + f_1) t + \frac{B}{2} \sin 2\pi (f - f_1) t \quad (5)$$

This equation obviously means that the current in the antenna is the sum of three currents, of frequencies f, $f + f_1$, and $f - f_1$. The important thing to note is that these three frequencies are all radio frequencies and are relatively close to each other in frequency, as f_1 is not over 1% of f, in the broadcast band.

Now that we have a clear idea of the currents that are actually present in the antenna, we look at the circuit of the amplifier itself to see in what elements distortion might be produced. Obviously, the only places where circuit conditions can affect the radio frequency currents are the tuned circuits and the tubes themselves. We shall consider these separately, taking up the tuned circuits first.

Attenuation of High Frequencies Through Resonance Effects

It is well known that excessive sharpness of tuning will result in muffled, "drummy" reproduction. This comes about from the fact that the amplification falls off very rapidly on either side of the point of resonance of the tuned circuits. When the circuits are tuned to the carrier frequency, only those frequencies which lie very close to the carrier frequency are amplified to any great extent. Referring back to equation (5), it is seen that the greater f_1, that is, the higher the frequency of the modulating note, the farther the side frequencies are from the carrier frequency. Hence, under conditions of too sharp resonance, those side frequencies representing the higher notes are sacrificed in favor of those representing the low notes, and it is the relative lack of high frequencies in the output of the set that gives rise to the muffled effect. One of the commonest causes of this excessively sharp resonance is the presence of too much regeneration in the amplifier.

BOOK REVIEW

We have received so many requests for detailed reviews of the prominent technical radio books that it seems only proper to present to the readers of RADIO ENGINEERING a resume of each of the volumes listed in our own library.

This general review, to appear in the May issue, will cover the following engineering works: *Radio Frequency Measurements*, by Moullin; *Thermionic Vacuum Tube*, by Van der Bijl; *Manual of Radio Telegraphy and Telephony*, by Admiral Robison; *Experimental Electrical Engineering*, by Prof. Karapetoff; *Vector Analysis*, by Coffin; *Theory of Vibrating Systems and Sounds*, by Crandall; *Principles of Radio Communication*, by Prof. Morecroft; and among the general publications, *Modern Radio Reception*, by Leutz; *Experimental Radio*, by Ramsey and *Wireless Pictures and Television*, by Baker.

Distortion Due to Rectification

As for the tubes themselves, it must be granted that distortion of the radio frequency currents is present whenever the tube conditions are such that the characteristic departs from a straight line over the working range of the tube. Let us see what these conditions are.

First, either an excess of "C" battery or too low a plate voltage will place the working point of the tube near the lower bend of the characteristic. This condition is what we strive to obtain with the so-called "'C' Battery Detector," or that detector circuit which utilizes the curvature of the grid-voltage, plate-current characteristic to produce rectification. Hence, if these conditions are present in the radio frequency amplifier, we will get rectification in the amplifier itself. Before considering whether or not rectification in the radio frequency amplifier will produce distortion in the musical output of the set, let us see what other conditions may give rise to distortion of the radio frequency currents.

The only other possibilities are insufficient "C" bias and too low a voltage on the filament. The former is not of great importance with a radio frequency amplifier, because of the relatively low impedance of the plate load. I refer, of course, only to its effect in producing distortion, as a positive grid raises havoc with the amplification and selectivity, because of the low input impedance of the tube under this condition. The other factor, viz., insufficient filament voltage, however, holds some interesting possibilities. As the filament voltage is reduced, the lower part of the characteristic curve remains about the same, but the point where the curve flattens off, representing saturation, comes lower and lower down on the characteristic, until finally the upper bend comes into the working range of the tube. In the early days of vacuum tubes, considerable use was made of the curvature of the characteristic at the upper bend to produce rectification. Hence, we must conclude that all of the important causes of distortion in the radio frequency tubes operate to produce the same type of distortion, namely, rectification.

Mathematical Delineation

Both the upper and lower bends in the characteristic curve can be represented quite approximately by a parabola. In general, however, different parabolas are required for the two cases, as the curvatures are rarely the same. This merely alters the value of the constants in the equations, however, so that a solution based on a general parabolic equation should hold for all cases.

The general equation for the plate current in a vacuum tube rectifier is

$$i = k(E_b + \mu e_g)^2 \quad (6)$$

Expanding,

$$i = kE_b^2 + 2k\mu e_g + k\mu^2 e_g^2 \quad (7)$$

The first term is a constant, and

merely represents the direct current flowing in the plate circuit; hence, we can disregard it in the mathematical treatment, as it has no bearing on the question in which we are interested. Inasmuch as we are after a qualitative solution only, we can also drop the constant multipliers of the other terms, and thus make the mathematical solution a bit less cumbersome. With these changes, equation (7) boils down to

$$i = e_g + e_g^2 \quad (8)$$

Of course, e_g is the alternating voltage applied to the grid of the tube; from analogy with equation (3),

$$e_g = k \sin pt + k^1 \sin pt \cos qt \quad (9)$$

where $p = 2\pi f$, and $q = 2\pi f_1$. Again we can throw away the constants without doing any violence to the qualitative solution. We then have

$$e_g = \sin pt + \sin pt \cos qt \quad (10)$$

Substituting this value in equation (8), we have

$$i = \sin pt + \sin pt \cos qt + \sin^2 pt + 2 \sin^2 pt \cos qt + \sin^2 pt \cos^2 qt \quad (11)$$

This is rather incomprehensible in its above form, but by making use of a pair of well-known trigonometrical relations, we can reduce it to a form where we can see just what it means. These relations are

$$\sin^2\phi = \frac{1-\cos 2\phi}{2}$$

and

$$\cos^2\phi = \frac{1+\cos 2\phi}{2}$$

Equation (11) then becomes

$$i = \sin pt + \sin pt \cos qt + \tfrac{1}{2} - \frac{\cos 2pt}{2} + \cos qt - \cos qt \cos 2pt + \tfrac{1}{4} - \frac{\cos 2pt}{4} + \frac{\cos 2qt}{4} - \frac{\cos 2qt \cos 2pt}{4} \quad (12)$$

Throwing away the constants and gathering terms, we have

$$i = (1 + \cos qt) \sin pt - (1 + \cos qt + \cos 2qt) \cos 2pt + \cos qt + \cos 2qt \quad (13)$$

Now that we have the result in an intelligible form, let us see what it means. The first term is the same as equation (2), so we have as one component of the plate current, an alternating current of the same form as the one we started with. The second term is seen to be of the same general form as the first term, that is, it represents a modulated radio frequency current. The carrier current is represented by the cos 2pt, which may be written cos 2π (2f)t. Hence this carrier is the second harmonic of the original carrier, and is a much higher radio frequency than the latter, so that it will not be passed on to the next tube through the intervening tuned circuit. We will therefore get no distortion from this term. It is interesting to note, however, that this carrier is modulated not only by the original audio frequency note represented by cos qt, but also by *its* second harmonic, represented by cos 2qt. This introduction of another modulating note would show up as distortion if this term were allowed to get to the grid of the detector tube. Fortunately, however, we have just seen that this is not possible with a tuned amplifier.

The last two terms of equation (13) represent audio frequency currents of frequencies f_1 and 2 f_1, respectively. These audio frequency currents, of course, will not be passed on through the radio frequency transformers, or tuned circuits.

Thus we see that of all the various components in the plate current of a tube which is operating under improper amplifying conditions, only one is passed on to the grid of the next tube through the intervening tuned circuit, and that one is of the same form as the current which was originally present in the input circuit to the tube. Hence, we are entitled to conclude that the only type of distortion which can originate in a tuned radio frequency amplifier is that which results from cutting off part of the side bands from excessive sharpness of resonance in the tuned circuits.

Methods of Volume Control

Let us see what this conclusion means from a practical standpoint. It is almost universally agreed that the proper place to control the volume of a receiving set is somewhere ahead of the detector, as this avoids the possibility of an overloaded detector tube. The three common methods of doing this are: filament rheostat, plate resistance, and potentiometer in the grid return. The first method lowers the filament voltage below the proper point when a loud signal is being received, the second causes too low a plate voltage, and the third results in improper grid bias. Inasmuch as we have just determined that none of these conditions will result in distortion of the audio frequency output, we must look elsewhere to find a choice between them. The last method, that of utilizing a potentiometer across the filament battery to vary the grid potential, is the least desirable for two reasons. One is that when the grid is even slightly positive, which is the case most of the time when listening to local stations, the plate current of the tube is excessive, resulting in shortened life for the tube itself and for the "B" batteries. The other reason is that a positive grid lowers the input impedance of the tube to such a point that the selectivity of the set is greatly impaired.

The method which uses a variable resistance in the plate circuit to reduce the effective plate voltage on the tube is very satisfactory on receivers where the radio frequency amplifier cannot be made to oscillate, but on other types the use of the plate resistance will cause the amplifier to go into oscillation with a terrific squawk. This is because the resistance is usually shunted with a fairly large condenser to minimize radio frequency losses when high sensitivity is desired, and the time constant of this circuit is usually in the audio frequency range. When the set goes into oscillation at radio frequency, this resistance-capacity circuit will charge and discharge at an audible frequency determined by its time constant, thus producing the aforementioned squawk.

Filament Control

The filament rheostat method is singularly free from disadvantages, and is to be highly recommended. The only precaution that needs to be observed is to keep the rheostat of sufficiently low resistance so that the desired range of filament voltage is just about covered by the full swing of the rheostat arm. In several of the older sets where this method was used the rheostat was of such a high resistance that the "low" position cut the voltage down to around two volts on tubes of the 201-A type. These tubes do not commence to give any appreciable filament emission until the filament voltage reaches about three and a half, so that over about half the range of the rheostat the tubes were inoperative, and the useful control was concentrated in less than half the rheostat range. This resulted in excessively critical control, especially if the amplifier was of the type where inherent regeneration was depended upon for sensitivity. A properly proportioned rheostat, however, will give a very smooth and silent control over the sensitivity of the radio frequency amplifier.

Filament rheostat control is not recommended for sets using the A. C. tubes in the radio frequency amplifier, however, since the filaments of these tubes are so heavy that they take an appreciable time to change their temperature when the filament voltage is changed. This results in a very annoying lag in the operation of the volume control. The plate resistance method is quite satisfactory with these tubes, however, as A. C. operated sets are not operated very close to the oscillation point, anyway, on account of the enormous increase in hum just before the oscillation point is reached.

The purpose of this article will have been realized if it causes the omission of "improper voltages on the radio frequency tubes" as a cause of musical distortion in future articles on tone quality.

The Problem of the Battery Set

Methods and Circuits for A. C. Conversion

*By Victor Greiff, E.E.**

PART III

NOW let us consider what to do when any set is presented as an electrification problem. First, it is still necessary to assure the average customer that you propose to give more than battery charging or even substitution; also it is well to bear this in mind.

The possibilities of the lamp socket are unlimited, and it is poor engineering to overlook any chance to obtain the best results from the set. It is not the same problem as designing a new set, because in the latter case many other means are possible to improve the tone or even, let us say, the salability of the set. However, in making a power application to a set already built, we are limited to design or selection of the additional equipment.

Power Units

Many thousands of the best informed set owners have been delighted by the performance of the 210 type tube substituted in the last stage of their sets by the earlier type of power unit, which also furnished "B" supply; but, of course, did nothing about "A" for the other tubes of the set, except a very few, which contained a trickle charger.

Analysis of the customer's return cards shows that they found their market with

(a) Builders of fine amateur sets—mostly over 6 tubes.

(b) Owners of the highest class manufactured sets.

(c) Owners of cheaper manufactured sets which have strong campaigns and merchandising behind them, and which are usually sold plus elaborate cabinets.

This is the answer to the question "Who will buy the expensive types of power units?" as well as an indication of when those types are satisfactory.

It will, of course, be evident that the reason for class (c) is that these owners have confidence in the value of their set, and also the price of the new equipment. There is no engineering reason against the less advertised set as a prospect for good equipment.

If this was true before the addition of complete battery elimination with the new tubes, it is now still truer, and the only real bar to the application of the 210 job is lack of appreciation, or inability to pay for it, which is usually a ridiculous argument, frequently given by set owners who have paid for a collection of inexcusable junk, selected by eye, enough money to finance a college education. However, the period of selection by ear is coming, if not squarely with us already. And it is power amplification that has brought it.

Application of Power Tube

The 210 is, of course, a good tube to keep out of the set. Its habits do not go well with set conditions.

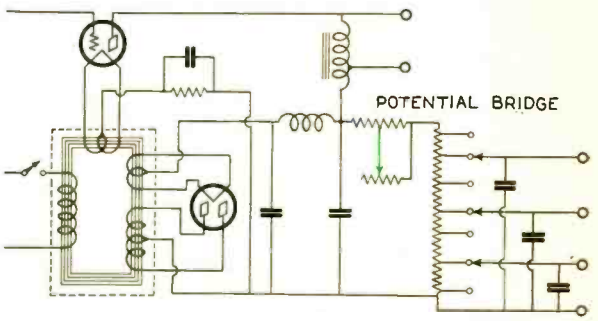


Fig. 1. Circuit of combined B-power unit and power amplifier. It will be noted that a low voltage, full-wave rectifier is used instead of a high voltage, half-wave rectifier.

The writer might go further and say that all audio amplification is better taken care of in a separate unit; but that is another story, as we have actual conditions to consider.

The method of operating the 210 in the power unit is probably familiar. The last tube of the set is replaced by a plug, permitting connection of the grid spring to a cord leading to the grid of the 210. This has been criticized as a long grid lead, and experimental work with grounded sheathing has been conducted; but except when ambitious amateurs sometimes insist on braiding it in with the loud-speaker cord, this has never produced any perceptible coupling effect.

By operating this tube in this way the high voltage plate is kept out of reach without the use of an automatic switch, all parts of this circuit being under the shelf in the unit.

The circuits of this unit are very similar to the previous unit, except the changes due to the higher "B" voltage. The 280 type full wave rectifier presents advantages which make it very desirable, and as it was not desired to go beyond its safe known voltage capacity; the 210 is operated somewhat under 400 volts, with a corresponding bias. See Fig. 1. It is found that the undistorted output is ample for any private use.

The output is tranferred to the speaker through a stepdown autotransformer, which by tone test appears to match the effective impedance with the operating impedance of

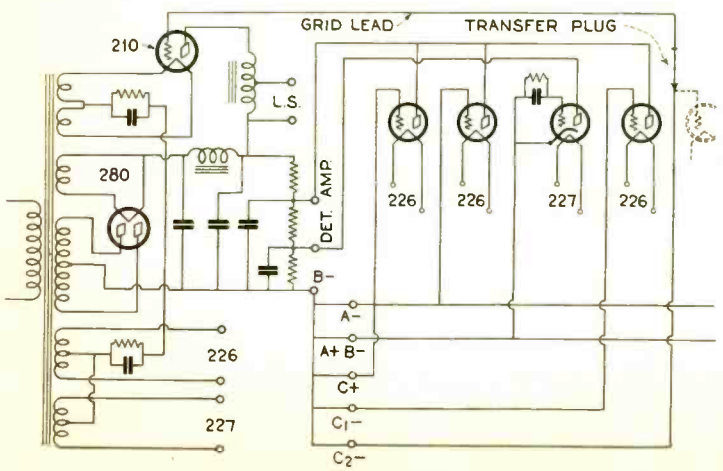


Fig. 2. Circuit of a complete "A.C." set, using A.C. tubes, and a combined "B" and "C" power unit and 210 power amplifier. This circuit illustrates the manner of conversion, from D.C. to A.C. operation.

* *Chief Engineer, Radio Receptor Co., Inc.*

the average speaker at the most desired range of frequencies.

The recent article contributed to the *Proceedings of the Institute of Radio Engineers*, by von Ardenne (Berlin) indicates the necessity of considering the live rather than the 'dead' characteristics of the speaker in calculations, and then determining the result by test.

"B" and "C" Voltage Provisions

Features of much discussion in this circuit are the "B" and "C" provisions.

The bias for the 210 is produced by its own plate current. This is a self-adjusting provision. If the applied voltage goes up, the resultant increase of plate current automatically increases the bias, limiting itself and keeping the grid properly biased for operation.

The bias for the 226 tubes is also obtained by the voltage drop through a resistance. If the number of tubes is increased, this bias tends to increase. Within the range of five to seven tube sets, this is found to do very well.

The fixed "B" amplifier and detector taps are found to operate excellently on a wide range of sets, partly assisted by the higher bias with increasing number of tubes.

The 226 tube has the widest sort of filament latitude and a moderate degree of "B" and "C" latitude. It is found that variations in "B" voltage applied to sets with the 226 tubes produce little effect within wide limits.

The writer designed a type of power unit called "Universal," which has an elaborate arrangement of "B" taps and a rheostat to compensate for variation in drain. Its principal application has been in the laboratory to prove that when an application is properly made, "B" voltages may all be taken from the same tap, identical with the general model. The circuit is shown in Fig. 2.

A feature which is very puzzling to the average person is the bunching together of -A, -A, -B, and a couple of C taps, all on one post of the unit. The explanation is, of course, that the transformer secondaries (filaments) have different D. C. potentials impressed on them, (positive) and all the grids are 'returned' to the common negative, giving the effective negative grid bias.

A. C. Adapter Harnesses

It is rapidly becoming common knowledge that the application of a unit of this kind with a harness, is practically universal. The manufacturers of the fittings seem to believe that with their harness once unpacked from its nest of paper boxes and linked up, the job is practically done, —just hook to the light socket. (Gas light is not yet recommended.)

This is largely due to the flexibility and success of the pioneer devices. The difficulties encountered with the complete unit described may be classified as follows:

(a) Oscillation caused by the increased energy of the new tubes. This is sometimes found in the R. F. stages, and in some three stage audio sets. The use of grid resistors has already been taken up. Re-neutralization of neutrodynes may be required, especially if neutralized for 199's.

In troublesome audio amplifiers a 0.1 megohm resistor across the next to last grid (to-C) will rob little, if anything, and in combination with the 210 tube will give the finest of tone.

(b) Complete misunderstanding of the control instructions. A mere shunting resistance will work, even connecting the ground to the slider will work, but the method given prevents abnormal R. F. conditions and oscillations. A mere series resistance is useless. Originality is not desirable at this point.

The antenna connections must be guarded against electrostatic and magnetic coupling with the higher R. F. stages, especially with the new tubes.

While it may be superfluous to speak of it, it will happen that someone will complain of 'hum' and blame the unit. The unit may be to blame, but this is comparatively rare, especially those units which generate a high voltage; as the reducing circuits act as capacity-resistance filter meshes, similar to a capacity-inductance mesh, and give very smooth "B" to the set. Hum is generally traceable to a wrong

Conversion Data

The following sets have been equipped with A.C. tubes and power amplifiers in the laboratory and in the field.

Make	*Type or model*	*Remarks*
Atwater Kent	10 (Open Bread Board)	Requires special UV adapters with 400 ohms in grid circuits of R. F. tubes.
Atwater Kent	20, 30, 32, 33, 35	No change is needed.
Bosch	Cruiser	Requires reneutralization.
Bosch	46	No volume control necessary.
Bosch	57	Special Harness. 700 ohms in grid circuits of R. F. tubes.
Bosch	66 or 76	Requires 400 ohms in grid circuits of R. F. tubes. Also requires reneutralization. No volume control necessary.
Bremer-Tully	Counterphase 6-37	Requires A. K type of Harness. Occasionally requires reneutralization or grid resistors.
Bremer-Tully	Counterphase 8	Requires harness with special distances between adapters. Reneutralization or the use of grid resistors. External volume control. A high resistance of 50,000 or 100,000 ohms should be shunted across the secondary of the 2nd audio transformer.
Crosley	Bandbox	Simply plug in harness. In some cases, reneutralization is necessary.
Day-Fan	6 Jr.	Simply plug in harness.
Fada	160 etc. (1926 models)	Use special UV harness.
Fada	Special '6'-265 A-RP 65	Simply plug in harness.
Fada	"7"-475-SF 45/75	Remove tube housing. Harness for seven tube set with distances between adapters slightly longer.
Fada	480 B-S. F. 50/80 B	Requires the use of 1,600 ohm resistors in the grids of all of the R. F. tubes. A high resistance in the order of 50,000 or 100,000 ohms should be shunted across the secondary of the 2nd audio transformer.
Federal	E-F	Use regular AK harness. Tube cups must be removed. 1,600 ohms in grids of 3rd and 4th R. F. adapters. Connect variable resistance across loop for volume control.
Freed Eisemann	201-A Battery Sets	Early 5 tube models require special harnesses. Later 5 and 6 tubes models require UX harnesses 7 and 8 tube models require special harnesses. Some sets may require reneutralization or the use of 700 ohm resistors.
Freshman	3 Dial Type	1,600 ohms in R. F. grid circuits. Special UV harness.
Grebe	MU-1 (5)	Requires slight reneutralization.
Grebe	7	Special distance harness.
Kolster	Model 6D or 6G	700 ohms in grids of R. F. tubes. Sensitivity control on set O.K.
Kolster	8-A etc	1,600 ohms in grids of 3rd and 4th R. F. adapters.
Radiola	20	Special harness. Reneutralize.
Sonora	'D'	Shunt 50,000 ohm resistance from grid of 2nd audio tube adapter to A- or B-.
Sonora	'E'	Requires 400 ohms in grid circuits of R. F. tubes. Also requires neutralization. No volume control necessary.
Sonora	'F'	Special harness. 400 ohms in grids of R. F. tubes.
Stewart Warner	525	No volume control other than one in set needed.
Stewart Warner	705	Special harness. No control needed.
Stromberg Carlson	501-A	Reneutralization required in some cases.
Stromberg Carlson	601-602	Special UX harness.
Zenith	VII, VIII, IX	Special UV adapters. 400 ohm grid resistors. No volume control needed. All 'C' batteries must be removed and gaps shorted.
Zenith	11 or 14	Special length harness.

connection, causing an open grid circuit, or to electrostatic pickup on an audio grid or transformer winding, which very often may be cured by grounding the metal parts of the set and unit. Wrong or defective bias resistors also cause abnormal operation, producing the hum.

The construction and treatment of power transformer windings are also a possible cause of hum. Dry windings are preferable to heavily waxed or impregnated windings for this reason, as the latter may have as high as 40 times the inter-coil capacity, as the former tests have shown.

There should be nothing within the unit to require the use of a balancing potentiometer across any of the tubes. This is becoming widely known, and it is believed that this item will gradually drop out of use. It will rarely be found that a displaced position of the potentiometer will give silence, unless there is a pick up of some kind in the audio amplifier, which should be otherwise removable.

The user is sometimes puzzled by the extreme energy available from the power unit, but soon, as a user wrote us,—"backs it into a corner and puts a halter on it." Exactly the expression—only this is power of another kind.

Mechanical Difficulties

The most serious difficulties are mechanical—in adapting the A.C. tubes to the various sets. One set seemed to require UV sockets, and then to present danger of ground; but it was found that a fake cover could be removed, and UX adapters used. In one case (the Radiola 20) angle adapters were required.

All the small tube Radiolas are difficult to convert. A rectifying circuit with a standard A.C. package was designed for the Radiolas 25 and 28.

The earlier six-tube Radiolas, with catacomb connected internally, are still an unsolved problem for adaptation of the new tubes; the best that can be done is to use an old type "B" eliminator, a power amplifier, plus an automatic trickle charger. An adapter device is in preparation, however, and is expected to be ready soon.

Intensive work in the laboratory has provided standard equipment for most common types of sets. Many not mentioned have just naturally followed the practice of their type—such as all ordinary neutrodynes. Of course, divergences from the 'dope' determined in the laboratory may occasionally be required in the field.

Sets with the last tube reflexed are the only ones presenting no hope of power amplification without extensive alteration.

In review, it may be said that of the various types of A.C. units, the poor set needs the best unit to bring it up to usefulness, while the fine set deserves the best auxiliary devices of every kind. Therefore, the 210 unit is the proper one to select.

The Relation of Condenser Ratings to Filter Design

An Explanation of Voltage Regulation in Power Supply Units and Its Effect on the Filter Condensers

*By Bert E. Smith**

IN the construction of Power Supply Units, many builders have been sadly disappointed by having their condensers short circuit after a few weeks of use, necessitating replacement of these expensive parts, frequently destroying the rectifier tubes, and sometimes even burning out the transformers or chokes.

This loss is peculiarly annoying, because it is so unnecessary. Usually the reaction on the part of the disgusted user is "Why the dickens don't these condenser manufacturers rate their condensers right. No more of that kind for me!"

Of course, there are some manufacturers who over-rate their condensers, as there are people in every trade who misrepresent their merchandise. And there are some who do not properly test their product. But let us presume that we are to consider only condensers made by manufacturers of proven integrity, whose ratings are conservative, and whose goods are properly tested before being used. Even in this case a condenser which to the inexperienced eye is correct, may blow up just in time to supply an interruption to a much anticipated program. Let us take a case in point:

Assume we have a transformer with a secondary tapped in the center and delivering 550 volts on each side. We are rectifying the current with two 81 rectifier tubes. Our filter is built with a pair of chokes and good 600 working voltage condensers connected in the customary way. And yet the thing blows up! Why? The transformer only turns out 550 volts; the rectifier tubes must have some resistance, and therefore there should be some voltage drop there; and the chokes should have resistance, again lowering the voltage, but it may be the last condenser which goes out! Only 550 volts to start, at least two voltage drops, and a six hundred volt condenser blows.

Under these circumstances, one can hardly blame the builder for using hard language. And yet, it is his own fault, for he has more than seven hundred volts across the condenser.

Peak Voltage

This seeming paradox is caused by the difference in nomenclature be-

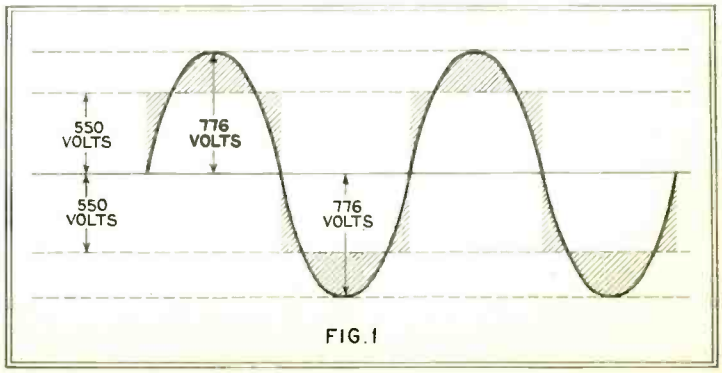


FIG. 1

Illustrating the variation of an alternating voltage through positive and negative values, and the "effective" voltage.

* *Aerovox Wireless Corp.*

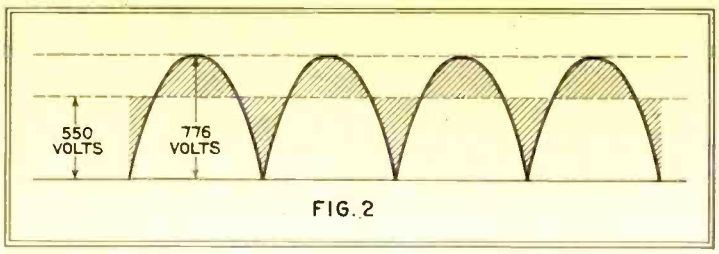


FIG. 2

Appearance of alternating voltage after rectification. The shaded portions represent the ineffective voltage.

tween A.C. and D.C. If we have 550 volts of pure D.C., we have just 550 volts—no more, no less. But when we have 550 volts of A.C., we have normally steadily varying voltages from +776 to —776 and back again. But it will only do as much work as its average value either plus or minus. So we take all its many instantaneous values, square them, add them up, and take the square root. In this case it is 550.

In other words, alternating current having maximum values of 776 volts will only do as much work as 550 volts of D. C. because its effective value is only 550 volts.

But if we rectify this voltage, and then store it in a condenser, it will build up to a value as high as the maximum value of the peak A.C. voltage. And hence, it is possible to blow 600 volt condensers in the filter with only 550 volts out of the transformer.

This brings up another question. If we have more than 600 volts to break up our condensers, why haven't we more than 600 volts to work our set? Is this high voltage some malificent wraith which is destructive but cannot be used?

Unfortunately the latter is true. We've got it—we can't get rid of it—but we can't make it work because we only have it a very small portion of the time. So we have to use condensers big enough to hold it even though they cost a little more money.

Root Mean Square Value

A reference to Fig. 1 will show what happens in our A.C. We have our voltage starting at zero and increasing through what is known as a "sine" curve until it reaches 776 volts, then falling back to zero and increasing again in the opposite direction. Due to the fact that at times there is only a very small voltage, this 776 volts maximum alternating current will do only as much work as its effective value which is 550 volts. That is, in Fig. 1, the shaded portions outside of the 550 volt line are useless because we require them to fill in the shaded portions inside the 550 volt line.

Now let us presume that we are to rectify this, using a theoretically perfect rectifier. Such tubes are not, of course, commercially practical, but it will simplify the explanation a great deal and detract in no way from it's correctness in general, if we ignore phase angles and transients in the explanation. After rectification, the current and voltage are approximately of the same values as before but they are now of one polarity only. In other words, if we were to cut Fig. 1 out of the book and fold it along the zero line, we should have the form which is shown in Fig. 2.

Our voltage will still have a maximum peak of 776 volts and twice in each cycle it drops to zero. It's effective or r.m.s. value is still only 550 volts, for the shaded portions of the peaks give still just sufficient to fill in the valleys to this value. Another way of getting at it is that we have here an alternating current varying from a maximum of 550 volts on one side to 227 volts on the other, super-imposed upon a direct current voltage of 550 volts.

Of course, we cannot use this kind of current as a supply for our tubes—what we want is the smooth 550 volt e.m.f. Therefore, we introduce into the circuit at this point a filter system in which the condensers, acting as reservoirs, charge when the voltage is above the average and discharge below this point.

But if we have no load across the output of our rectifier, the condensers will have no opportunity to discharge and the voltage will gradually build up to the peak value as shown in curve "A" of Fig. 3. This voltage is useless to us as far as operation is concerned for as soon as we put a small load across the output of the filter, the condensers will be given an opportunity to discharge and the voltage will not build up as high, following rather the form shown by curve "B" in Fig. 3. This condition is the one which obtains in most eliminators when the eliminator is turned on and some current is passing through the voltage distributing resistance, the receiver still being turned off. It is at this point that the maximum strain occurs in most eliminators, for usually the voltage is still above the average line by a considerable margin.

Current Drain and Voltage

For example, according to data issued by E. T. Cunningham, Inc., if the transformer output is 550 volts, the rectifiers are two CX-381s and the current load is 20 mils the voltage will be approximately 700. Now we turn the set on and increase the load to 40 mils. Due to the increase in load, our voltage drops to the value indicated by curve C. If we could keep it from varying beyond this point, we should be able to use condensers rated at the same working voltage as the nominal value of the alternating current output from the transformer but, unfortunately, it is impossible to avoid the condition shown in A or B at times and therefore, a sufficient margin must be allowed to give safety even though the voltage reaches the maximum peak value of the transformer output.

Curve "D" has been introduced to show roughly what happens when too heavy a load is put on the eliminator. So much current is being drawn that the condensers have insufficient storage room to effectively iron out all the ripples. During the time available for charging the condensers, they do not accumulate sufficient energy to supply the full load during the period when the rectifier is supplying little or no current at all, hence the voltage falls and in consequence a pronounced hum will be heard from the loud speaker. This condition can usually be cured by making the second and third condensers in the filter much larger.

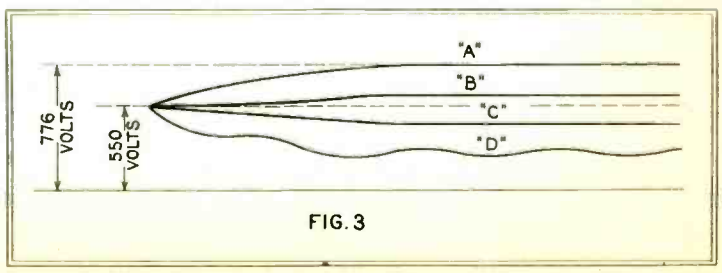


FIG. 3

A represents the peak voltage; B, voltage with small load; C, voltage with heavy load and D, the ripple introduced when the load is excessive.

The Mathematics of Radio

Capacity of Series and Parallel Connected Condensers and Their Relation to Applied Voltages

By John F. Rider, Associate Editor

PART V

WHEN condensers are connected in series the circuit arrangement differs from the parallel system. Compare Figs. 22 and 23. The former shows a parallel system and the latter depicts the arrangement of condensers in series. Contrary to the results desired when condensers are connected in parallel, the purpose of series connections is to reduce the resultant or effective capacity. Another purpose, which shall be discussed later in the text, is to permit the application of greater voltages.

Capacities in Series

The calculation of capacities in series is identical to that of resistances in parallel and the law governing this calculation is as follows:

The resultant capacity is equal to the reciprocal of the total capacity, which in turn is equal to the sum of the reciprocals of the individual capacities.

This is interpreted in the following manner when a formula expression is desired,

$$\frac{1}{C} = \frac{1}{C1} \text{ plus } \frac{1}{C2} \qquad (13)$$

If we substitute the values shown in Fig. 23, we have

$$\frac{1}{C} = \frac{1}{.006} \text{ plus } \frac{1}{.004} \text{ or}$$

$$\frac{1}{C} = \frac{1}{416} \text{ or}$$

$$C = .0024 \text{ mfd (approx.)}$$

One fact must be remembered when solving for capacities in series, and this is, that the resultant capacity will always be less than the smallest capacity value in the formula.

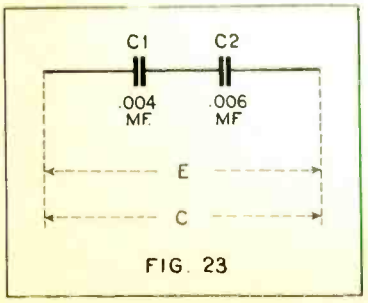


FIG. 23

Connecting condensers in series reduces the resultant capacity and increases the working voltage.

As in the case of resistances in parallel, another method of determining the resultant capacity of two unequal condensers in series, is available. It is identical to the system employed when calculating two resistances in parallel. It is

$$C = \frac{C1 \times C2}{C1 \text{ plus } C2} \qquad (14)$$

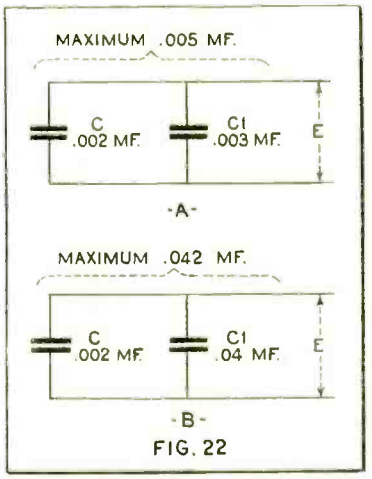


FIG. 22

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

Substituting the values employed in Fig. 23 and converting the values into micro-microfarads, so as to eliminate the need of multiplying fractions we have

$$C = \frac{6000 \times 4000}{6000 \text{ plus } 4000} \text{ or}$$

$C = 2400$, and since .001 mfd equals 1000 mfds.

$C = .0024$ mfd.

Sometimes several condensers of equal value are connected in series. The resultant capacity in this combination is determined by employing the following formula:

$$C = \frac{C1}{n} \qquad (15)$$

Where C1 is the value of one of the condensers and n is the number of condensers in series. For example, if we have four .006 mfd condensers connected in series as in Fig. 24. All have like values of capacity, say .006 mfd. What is the resultant capacity of the complete combination? According to the formula

$$C = \frac{.006}{4} \text{ or}$$

$C = .0015$ mfd.

Let us prove this by means of the first formula. We have

$$\frac{1}{C} = \frac{1}{.006} \text{ plus } \frac{1}{.006} \text{ plus } \frac{1}{.006} \text{ plus } \frac{1}{.006} \text{ or}$$

$$C = \frac{1}{664} \text{ or}$$

$C = .00151$ mfd (approx.).

Relation of Condensers to Applied Voltages

In direct contrast to the frequent use of paralleled condensers in receiver circuits, condensers in series connections are seldom employed. But because of the conditions existent when condensers are employed in series connection fashion, and because of the frequent use of paralleled condensers in power circuits, it is necessary to consider the relationship between condensers and applied voltages. We are not going to enter in the electrical design of the condenser, and discuss the factors which govern effective resistance, leakage, etc., but will dwell upon the voltage rating of the condensers in A.C. and D.C. circuits.

When a fixed condenser is to be designed certain items are decided upon. These are size, capacity and A.C. and D.C. voltage. The first is irrelevant. The second, third and fourth are closely related. After the capacity has been selected, the design uses materials which will withstand the potentials applied when the con-

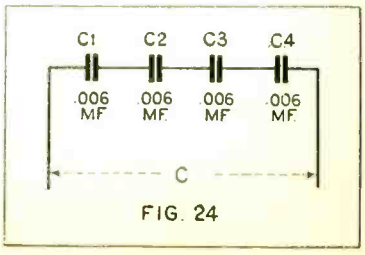


FIG. 24

The resultant capacity of this series group is approximately .0015 mfd. This example is worked out in the text.

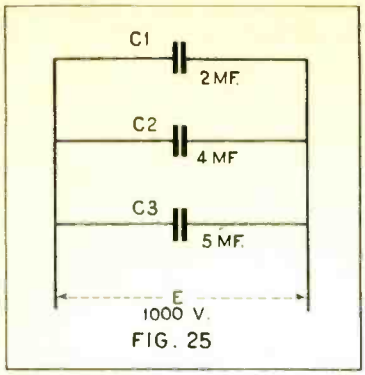


FIG. 25

Diagram used as an example of the relation of capacity to applied voltage.

denser is placed in operation. Since each condenser has a maximum A.C. and D.C. voltage rating, it stands to reason that condensers are not suitable for use at all voltages. The factors which govern the operating voltage are first the frequency and second the thickness and type of dielectric material employed. Since these are factors within the realm of the designer and outside of our scope, we will concern ourselves with the association of operating voltage rating and use in the receiver.

Fixed condensers of various values are usually marked with the voltage rating in addition to the capacity, and it is imperative that the operating potentials applied to the condensers do not exceed the voltage rating. Reference to Figure 22 A and B shows that when condensers are connected in parallel, the electrical charge is applied equally, that is, all condensers in the parallel combination are subjected to the same electrical potential. This does not mean that the same charge is carried by the condensers in the parallel combination, since the charge, usually designated as Q, is equal to the capacity C times the electrical potential E, hence a parallel combination of condensers C1, C2 and C3 as in Fig. 25 would carry charges equal to:

$Q1 = C1 \times E$

$Q3 = C3 \times E$

$Q2 = C2 \times E$

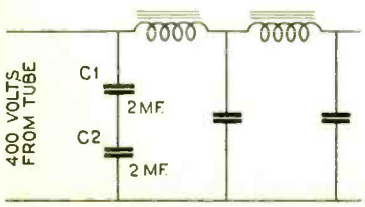


FIG. 27

Condenser C_1 and C_2 need not have a working voltage of 400 each, since they are connected in series.

The electrical charge carried by the condenser varies in direct proportion with the value of capacity, but the stress applied to the condensers is equal regardless of the value of capacity. See Fig. 25.

We have three condensers in parallel, C1, C2 and C3. The charging voltage is 1000 volts. The capacity of C1 is 2 mfd, that of C2. 4 mfd and that of C3. 5 mfd. The total capacity of the parallel combination is equal to

$C = C1 + C2 + C3.$

Since in parallel combination, the charge across each condenser is

$Q = C \times E$

the charge across C1 would be

$Q = 2 \times 1000$

$Q = 2000$

across C2

$Q = 4000$

across C3

$Q = 5000$

The voltage across each condenser is equal to the charge divided by the capacity or

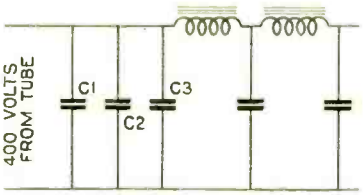


FIG. 26

Condensers C_1, C_2 and C_3 should have a 400 working voltage to withstand the strain.

$$E = \frac{Q}{C} \qquad (16)$$

therefore the voltage across C1 is

$E = 1000$

across C2

$E = 1000$

and across C3

$E = 1000$

Suppose we apply these facts to actual practice, as for example in a B-eliminator. Examine Fig. 26. We show a filter circuit, C1, C2 and C3 being the condensers connected in parallel fashion, and located adjacent to the rectifying tube. If we assume that the voltage from the rectifying tube is 400 and that in the initial layout only C1 of the bank of three parallel condensers was employed, this condenser would be subjected to the voltage strain of 400 volts. When we connect C2 and C3 we raise the value of the total capacity but we also subject all three condensers to the potential of 400 volts. Raising the value of capacity does not permit the application of a higher voltage or subjecting the condensers to a higher electrical stress, unless the voltage rating is greater than the potential obtained from the tube. If this is the case, it applies equally to each one of the condensers individually, and paralleling of the capacities to produce a higher capacity has no bearing upon the applied voltage.

Another fact which must be remembered when parallel capacities are concerned is that every one of the capacities if used individually must be able to withstand the electrical stress applied to the combination. That is to say, the minimum voltage rating of C1. C2 and C3 must be at least equal to the voltage output of the tube. Paralleling C3 with C1 does not permit the use of a 300 volt condenser for C3, simply because the voltage rating of C1 is 400 or 600 volts. Fig. 25 shows that the electrical potential is equally applied to each one of the condensers in the combination.

Division of Voltage in Series Combination

The above, however, does not hold true in series combinations. Here we find that the voltage divides between the condensers in the series, and that if we had two condensers such as C1 and C2 in Fig. 27, the actual voltage applied across each condenser is equal to one-half of the total voltage applied across the combination. The method of determining the voltage applied across each condenser is simple.

First the resultant capacity of the series combination is determined. According to the formula for equal values of capacity in series we have

$$C = \frac{2}{2} \text{ mfd or}$$

$C = 1$

The charge is equal to

$Q = C \times E$ or

$Q = 1 \times 400$ or

$Q = 400$

The voltage across a condenser is equal to

$$V = \frac{Q}{C} \qquad (17)$$

therefore the voltage across C1, whose capacity is 2 mfd, is

$$V1 = \frac{400}{2} \text{ or}$$

$V1 = 200$ volts and

$V2 = 200$ volts since the value of C2 is equal to that of C1.

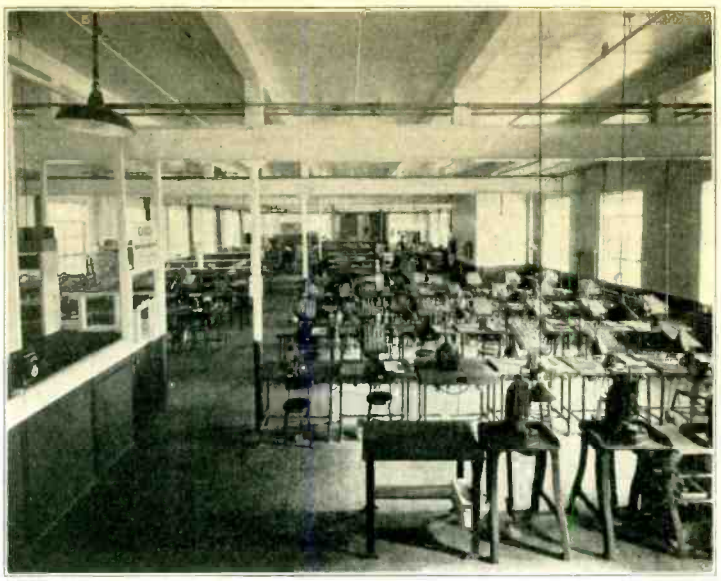
Under these circumstances we find that if the individual voltage ratings of the condensers are 400 volts, we can apply 800 volts across the series combination without impairing the life of the condenser, since the voltage applied across each one of these two equal capacities is only half of the applied voltage. Hence series condenser combinations permit the application of higher voltages. Two equal capacities of equal voltage rating per-

ment is one of the radio active element group properly known to the layman through its much heralded member radium which is often taken as a name for the marvelous and newest developments of scientific research. These radio active elements furnish the proof that all forms of matter are composed of nothing but electricity and energy and are constantly breaking down into simpler or more primitive elements, at the same time liberating vast quantities of free electricity and energy. This property has close connection with the use of thorium as a material employed in the filament of the radio valve. When heated, thorium emits a copious flow of electrons and these electrons are the process of the entire performance of the radio valve.

A tungsten filament is impregnated with as much thorium as it is possible to cause it to dissolve. The value of filament wire used in the present day radio valve depends to a great extent on the amount of thorium it carries as the exhaustion of this element marks the termination of the useful life of the valve. This is why a radio valve goes dead although the filament still lights and the other elements of the valve are to all appearances intact. This element is contained in solid solution and is accordingly not visible to the eye but forms a skin or layer whose thickness is only capable of being measured by such a fine instrument of measurement as the light ray over the surface of the tungsten filaments. This layer is constantly being replenished by diffusion of a fresh supply from the center of the filament as fast as the material is dissipated from the surface. This process is the reason why the filament should be burned at the proper temperature which is only to be secured by keeping the proper voltage on the filament, and the proper voltages on the grid and plate of the valve, as overloaded it is possible to rapidly deplete the available supply of thorium, and even completely exhaust it in a few hours' time. If the overload has been severe temporarily or only somewhat over a longer period, it is often possible to rejuvenate the filaments and this process is simply designed to restore to the surface of the filament the valuable thorium and only successful when the heart of the filament contains a still unused supply to draw upon.

Oxide Coated Filaments

Some of the newer types of tubes, namely, "alternating current," such as the -26 and -27 type—also the new ¼ ampere, tubes, use what is called an oxide coated filament or cathode. These oxides may be strontium and barium and others. The base metal may be nickel or some other similar material. The advantage of an oxide coated filament over a tungsten thoriated filament are the lower operating temperatures and higher saturation currents, giving to the public more



A view of a section of the general assembling department in a vacuum tube manufacturing plant.

efficient radio valves. Nickel is familiar to the average individual solely as a thin deposit placed on other metals to keep them bright and free from corrosion. Pure nickel is rarely seen in every day life because of the rather high cost and we are able to utilize some of its valuable properties by plating it on other metals, but when the radio valve comes into question we find it necessary to use only the purest of nickel. It possesses the valuable qualities of being only fusible at high temperatures and of being readily freed from the "occluded" gases, which are present in the pores of all metals and which were the bane of early experimenters of radio valves giving rise to the extremely erratic, soft valves of several years ago.

The Use of Molybdenum

Molybdenum is a name which may appear tongue twisting to the reader of this page and as a matter of fact, the every-day worker with this element usually alludes to it as "Moly." The use of Molybdenum as a metal has only been possible within the last score of years as previous to that time the metallurgist was unable to supply this element commercially in the form of a pure metal, but today the manufacturer of the modern radio valve calls for its extensive employment in spite of its extremely high cost. This element has all the good qualities of nickel and in addition the extremely valuable one of retaining its mechanical strength at such a high degree of temperature as is encountered in some types of radio valves. You will find the use of Molybdenum in transmitting tubes and a good many manufacturers use this material in the construction of their grids and hooks to support the filaments. Other material used in valves is bakelite for bases and in the case of bakelite it is essential that its electrical resistance be of proper value and the surface deterioration be negligible.

Magnesium, the Scavenger

Magnesium is used in practically every type of radio valve. This chemical element may be familiar to the reader in the form of flash light powder or ribbon of the photographer, which upon burning, leaves behind it a white powder known as magnesia. To day magnesium is also employed in both pure and alloyed form in aviation work, where great strength and lightness are needed, as this element is only about one-half the weight of aluminum which we probably think of as our lightest element. In the case of the radio valve, however, we are not concerned with the lightness of magnesium but with its chemical property of acting as a scavenger or "getter" as the phrase has arisen in the course of radio valve development. This means in every day language that all the slight traces of various gases that may still remain in the valve after it has been bombarded and exhausted during the course of manufacture can be cleaned up or caused to pass from the state of free gases to solid compounds with the aid of this almost magic element magnesium. When the valve is flashed this element, which has previously existed in the form of a small piece of metal welded on to the plate of the valve is suddenly released as a vapor or gas and performs at this moment the mission of making the valve one having a perfect operating vacuum. The magnesium vapor instantly condenses or deposits

itself on the inside wall of the glass bulb and imparts to it the familiar silver-like look, or mirror appearance. The presence of this deposit on the inside of the valve is thus seen to be purely incidental to the course of manufacture and represents simply the surplus or unused magnesium. Therefore, the quantity of this deposit or its position on the interior of the tube is absolutely no indication of the value of that particular valve. As a matter of fact unscrupulous or ignorant manufacturers of radio valves frequently use such an excessive quantity of this magnesium in order to obtain a radio valve having a mirror like appearance, that the metal deposits, not only on the inside of the bulb but also on the stem of the valve, and the last mentioned place is one where the presence of a metal, of course, is the last thing in the world desired, because it causes leakage of current from one element of the valve to another.

We find it necessary to employ metals which have been selected in accordance with the needs of the particular spot where they are to be employed. The lead-in wires of the valve furnish an example of this. At this point it is necessary to have a metallic conductor whose thermal coefficient shall accord with that of the particular glass employed at the same point, in order that leakage of air into the valve shall not occur when it is subject to a change of temperature as it is, of course, whenever the valve filament is lighted. Accordingly, it is found necessary to employ not a single chemical element or alloy at this point but a compounded metallic structure having a core which has this same thermal coefficient or rate of expansion with heat, as does the glass, and being covered with copper which actually wets the glass or makes a firm alloy with it when it is in the semi-molten state during the process of manufacture.

Solder Employed to Prevent Oxidation

Solder furnishes another example of this kind. It is necessary to employ solder with a high percentage of tin to avoid excessive oxidation of the contact points and consequent mysterious noises which may arise from this cause when the valve has been in use for some time.

We might proceed with every item concerning which, the most scrupulous care must be observed, down to the most minute detail, but the above outline is sufficient to give one an idea of the elaborate detailed precautions which must be observed in respect to every material entering into the composition of a radio valve. It is only by observance of each one of these fine details that a really good radio valve can be created and oft-times these very details add to the expense of manufacture. It is essential that the finest of laboratory equipment for testing be available, that skilled personnel be on hand to make tests and to check operations. This means an Engineering organization is necessary to insure the proper materials to be used, the types of tubes to be manufactured, the processes to be carefully guarded so that at all times uniform radio valves are produced, is a great problem. In addition to the testing of materials to be used in the valves it is essential that operating characteristics and life tests which show the probable life to be expected from a valve in normal use, will also have to be obtained. Tests are also made of radio valves under conditions where the filament is overloaded or the radio valve abused and all radio valves must be capable of standing a reasonable amount of abuse. This guarantees a margin of safety in actual operation. Many of the materials entering into the radio valve undergo treatments to aim at their further purification before they are actually sealed into the valve. For example, all the parts which are to be enclosed in the vacuous portion of the valve are given special treatments in furnaces at high temperatures while completely enveloped in an atmosphere of pure hydrogen gas. This treatment is of great importance when removing other gases, both free and combined, which might give rise to difficulty in securing a high degree of vacuum.

With all of the above precautions one can readily see that the complicated nature of the radio valve and its production in large quantities on an almost automatic basis is a feat which demands the highest engineering skill and supervision, and in spite of all this a certain small number of valves are still bound to come out of the process with some defects. Here an elaborate testing schedule enters and the tests should be so rigid that it is impossible for a valve in any way defective, mechanically or electrically, to leave the factory. The co-ordination of manufacturing care, inspection and testing of valves is essential if the valves are to be noted for their uniformity excellence.

Assembly and Inspection Operations

The usual sequence of the assembling of the average radio valve is as follows: That part of the valve observed inserted into the base is the flare, and it is the first step in the actual manufacture of a tube. This flare is now placed on a stem machine and the lead-in wires and the exhaust valve are placed inside of this flare. After these parts have been run through a series of fires, the completed stem is the result. The stem is now carefully inspected for cracks and strains and is then passed on to what is called the bending operation. This operation bends the support wires into shape in such a manner that the component parts, i. e. filament, plate, and grid can be assembled in a uniform manner.

Some organizations use specially designed jigs. If this is done a uniform mount is the result which in turn means uniform valves. After the mount has been completed, it is passed on to what is called mount inspection. At this operation all mounts are carefully inspected for alignment under powerful magnifying glasses and then are passed on to the sealing operation. The sealing operation joins the mount to the bulb and as in the case of the stem operation, this is done by passing the mount and the bulb through another series of fires.

The valve is now ready to be exhausted. This operation is performed on a very complicated piece of equipment and it is essential that high degree of vacuum be obtainable from this piece of equipment. After this operation the exhausted valve is again inspected to determine its degree of vacuum. The valve is now ready to be based. This is a comparatively simple operation but requires considerable technique on the part of the operators. After the basing operation the valves are aged. Different types of tubes require different aging schedules. These schedules may run from fifteen minutes to 24 hours. After the aging schedule the valve is now ready for a factory test. In the writer's opinion all tubes should be tested for grid current, saturation current, plate current, filament current, plate resistance and amplification constant and the manufacturer should have close limits and should abide by these limits.

Dynamic characteristics should also be taken on a certain percentage of the daily production. In this way better radio valves will be available to the public.

Jobbers' Statistic Check Dealer Survey

AN interesting comparison will be found between the dealers statistics and the jobbers statistics which were collected by the Electrical Equipment Division of the Department of Commerce in co-operation with the National Electrical Manufacturers Association, according to Louis B. F. Raycroft, vice president in charge of the Radio Division.

"The jobber statistics just released by the Department were obtained independently of the dealer survey but on a country-wide basis. A comparison of the two surveys show that the volume of business reported for 1927 by the radio dealers checks within five per cent with the volume reported by the jobbers for the same period when the proper allowance is made for the average dealers discount. This five per cent difference is accounted for in the apparatus which is sold directly by the manufacturer to the dealer.

What the Custom-Set Builder is Doing

A Survey of the Activities of Those Who Build Radio Sets to Order and An Appraisal of the Opportunities in This Field

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

THE oft-repeated sentiment with regard to the Presidency of the United States is that the office should seek the man. Devoutly to be wished though this may be, this ideal state of affairs generally has its whole life circumscribed by the mind of the dreamer. Within the last few years, however, there has arisen a group of highly skilled technicians who have more just claim to that distinction than any other class in society to-day. We refer to the custom-set builders, whose rise has been simultaneous with the growing demand on the part of the public for specially built receivers. These men, working unobtrusively and with little or no advertising save that voluntarily supplied by their enthusiastic customers, constitute one of the most powerful factors making for better, and consequently, in the last analysis, more radio. They have amply justified their existence, for, by giving to their clients nothing but the very best, they have revised the conception of many whose experience with radio had been limited to the agonizing sounds perpetrated by the cheaper sets.

We know of no better way of giving these experts the recognition they richly deserve than by citing a few concrete examples of men typical of the craft, showing how they came to be interested in custom-set building, how they work, and the unique strategic position they occupy. In addition, we hope to shed some light on the vast possibilities of this field, both present and future.

Outstanding Examples

H. Horneij, of the Schneider-Horneij Radio Research Laboratories, of New York City, is an outstanding example of what this profession offers the really competent radio expert. Mr. Horneij has lived with radio from its earliest days. In 1911, he went to sea as a commercial operator for the Marconi Company and remained with that organization for nine years, serving on some twenty-five different vessels. In 1920, he resigned, and after taking a brief fling at the manufacturing game, went into the custom-set business in which he has scored a marked success.

Mr. Horneij is assisted in his work by a corps of highly trained radio mechanics who supply that factor of careful production which is indispensable to the really good set. Approximately five hundred sets are constructed in the course of a year, which speaks volumes for the quality of the work turned out. All the receivers are built to meet the customers' requirements, and only after a careful consideration of the location factor, which is manifestly impossible with the manufactured set. Only the very best circuits are employed, and long experience has facilitated the work of properly co-ordinating circuit and location. Due to the fact that only the best of materials are employed, and that the assembling is done by experts, the servicing costs are practically nil. Each and every part is thoroughly tested before assembly, and the finished set is also subjected to rigid tests by Mr. Horneij himself.

Although he advertises on a small scale in the New York papers, Mr. Horneij freely admits that most of his business comes from the recommendation of satisfied customers, and has the satisfaction of seeing his business grow with each passing year. He does not suffer to any great degree from the low-priced manufactured sets offered, but when this point comes up, he tells his prospective customer to hear the cheaper set, examine the materials in it, and then compare it honestly with the one he is offering. "Nine times out of ten," says Mr. Horneij, (and we detect a bit of justifiable pride in his declaration), "he will buy my set." Needless to say, his profits are handsome, partly due to the excellence of his work, partly to the fact that, as he himself says, his overhead is small.

"In the Business to Produce the Best"

Another who has achieved a richly deserved success in building the custom set is H. C. Sherer. "In the Business to Produce the Best," is the motto of Mr. Sherer's Montclair Radio Laboratories where, for the past three years he has built broadcast receivers to order as a part time enterprise. The splendid financial return that has been his portion has convinced him that success awaits the custom-set builder who is willing to give his client more than an even break. Each year has added its bit to his growing business despite the fact that he does no advertising at all, depending upon his old customers for new ones. A desire for the best radio to be had, laid the cornerstone of his present flourishing business.

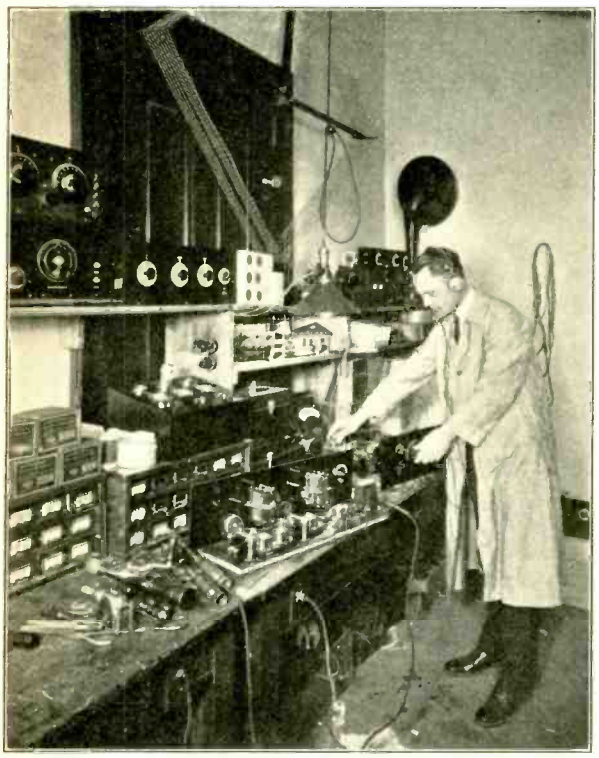
Recently Mr. Sherer installed a set in the Moose Home in Philadelphia, the contract being received as a result of other satisfactory installations made in the vicinity. A well known Philadelphia doctor, hearing the set in operation, immediately placed an order with him in spite of the fact that three months before he had had

Mr. H. Horneij, a successful custom-set builder, in his laboratory, in New York City. Note the array of testing equipment.

a nine hundred dollar radio installed in his home. Mr. Sherer has also made satisfactory installations in places as far distant as North Carolina, and modestly refuses personal credit, maintaining that the combination of a good circuit with the best parts to be obtained is the real reason for the successful performance of his sets under all sorts of conditions. He has never competed in the matter of price with the manufactured receiver, and never intends to. Most of his clients, he says, are discriminating buyers who know what they want, and also realize that a good set, though it may cost a bit more in the beginning, will ultimately prove more economical than the cheap one.

of such of his customers as considered themselves embryo radio engineers, taking the justifiable position that he knows more about such matters than they whose flights into the realms of radio technique are generally actuated by what they have heard or have seen on some other receiving set. In this way, he seeks to make his clients put their confidence in him, and is generally successful.

In addition to building receivers, Mr. Sherer also repairs them in the same careful, confidence-instilling way, and considers a set well overhauled a prospective client. "If our business is to flourish," he says, "quality, above all else, must be kept uppermost." That his sales, during



Another view of the quarters of the Schneider-Hornell Radio Research Laboratories, New York City, who specialize in custom - set building and servicing. This organization has been in the set building business for eight years and turn out about 500 sets yearly.

Ready to Meet Changing Conditions

Mr. Sherer does not keep a large stock of parts on hand, and in this connection makes the trenchant point that the manufacturer, with his elaborate stock of them which must be used up, is unable to make the desirable changes which can be effected by the professional set builder. For this reason, he expresses the belief that the custom built receiver is at least one year ahead of its manufactured brother. The best testimony which can be adduced in support of the excellence of his work is the fact that he averages just two service calls per month.

Mr. Sherer has consistently refused to incorporate in his sets the ideas

the past three and one-half months, have approached the four thousand dollar mark, would seem to prove that in this he has been uniformly successful.

Mr. John V. Kitchen of 277 Gates Avenue, Brooklyn, N. Y., is yet another who has found the field a lucrative one. Mr. Kitchen is a more recent devotee, beginning the study of wireless in England in 1917. He served as operator on various ships, always experimenting with apparatus which he himself constructed from odd parts lying about the radio room. The remarkable DX feats of his makeshift receivers spurred him constantly on to the construction of more elaborate sets incorporating all kinds of circuits, and when finally, after ten years on the high seas, he decided to lead the life of a landlubber, he gravitated naturally into the business constructing broadcast receivers to order. He was successful from the start, and has recently been forced to enlarge his working facilities because of increased business.

Honest with the Radio Public

W. H. Kuhlmann is a science teacher in the Junior Senior High School, of Lakewood, N. J., who has embraced custom-set building as a pleasant means of increasing his income. Four years ago he was sure he knew absolutely nothing about radio. However, he wanted a set and, upon the advice of a friend, built his own with such success that he was soon swamped with requests from friends to install receivers for them. Finding that he was able to produce one set per month in his spare time, Mr. Kuhlmann entered the field, and, needless to say, has achieved remarkable results which he ascribes to the fact that he has been perfectly honest with the radio public. Although he builds his receivers to meet individual requirements, he, like Mr. Sherer, employs only circuits and materials which experience has shown him to be superior. Consequently, his servicing costs have been, to use his own term, "negligible."

These examples could be extended almost without limit, but we believe that enough has already been said to convince the reader that here is a field whose possibilities are limited only by the ability of the individual. The radio public has indeed been fortunate as regards the quality of the men who have taken up this profession, and it is to be hoped that the recruits of the future will strive to maintain the high standard of manual and technical excellence established by their predecessors.

Cashing in on "Individuality"

In the course of this discussion, we have already touched on a few of the manifest advantages of the custom-built set. There is one, however, which, in our opinion deserves especial mention. This is in the matter of cabinets. Each one of us has that indefinable something that is called "individuality," and, if he is normal, is anxious to indulge it. It is this quirk of human nature that gives the custom-set builder a peculiarly strategic position in the radio market, for he can supply his customer with any sort of fittings he may desire, even to the placing of his radio in a cabinet costing hundreds of dollars. And so it follows as a matter of course that the person who really wishes his radio to reflect his own tastes will go to the custom-set builder rather than to the manufacturer who will supply him only with a limited choice of the styles in vogue at the moment.

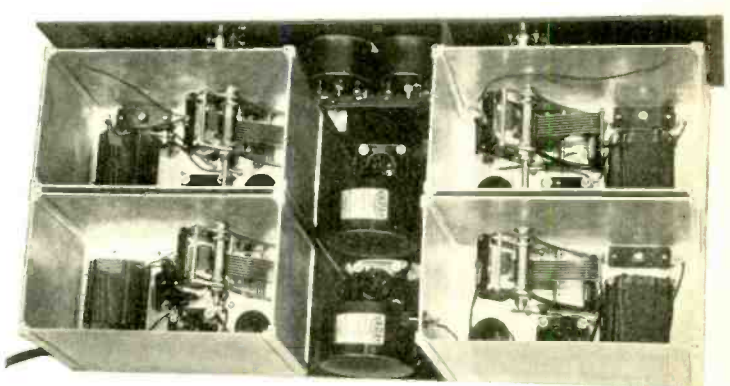
The Hagerman 210-A.C.-Six

By Lewis B. Hagerman

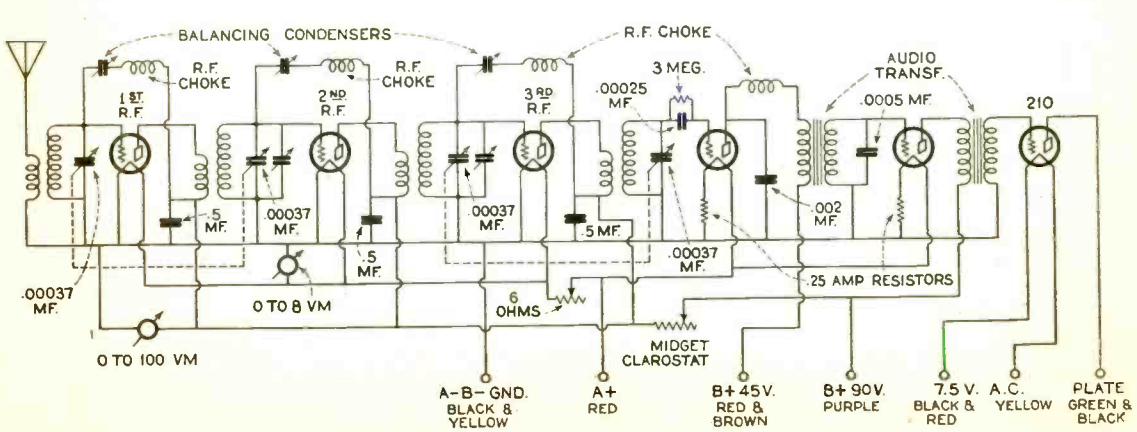
CUSTOM set builders have desired a complete receiver incorporating all of the recent engineering developments as well as a simple and efficient power unit for the operation of the receiver. The Hagerman 210-A.C.-Six was designed expressly to fill this need and incorporates the following salient features: Three stages of tuned radio frequency amplification provided with perfect balancing and stabilization, a two-stage transformer coupled audio frequency amplifier employing a 210 type power tube in the output stage, total shielding of all circuits handling radio frequency currents, and an individual power unit supplying all of the necessary A, B and C voltages.

It will be noted that socket operation is gained, not through the use of A.C. tubes, but rather by employing an A-eliminator having very efficient filtering properties. It is thus possible to use standard tubes and gain the advantages of perfect balancing, stabilization and high gain per stage of radio frequency amplification all of which at present are not possible to achieve to the fullest extent with A.C. tubes. Furthermore, this ensemble is "engineered" to the extent that voltage variations in the house lighting circuit can be readily compensated. The necessary compensation controls are incorporated in the receiver and power unit and to provide an indication of the voltage conditions two Jewell voltmeters are mounted directly on the panel of the receiver. The No. 1 voltmeter indicates the voltage directly across the filament terminals of the vacuum tubes and the No. 2 meter indicates the voltage across the plate circuits of the R.F. tubes. Any change in line voltage is immediately indicated by an alteration of the readings of the two meters.

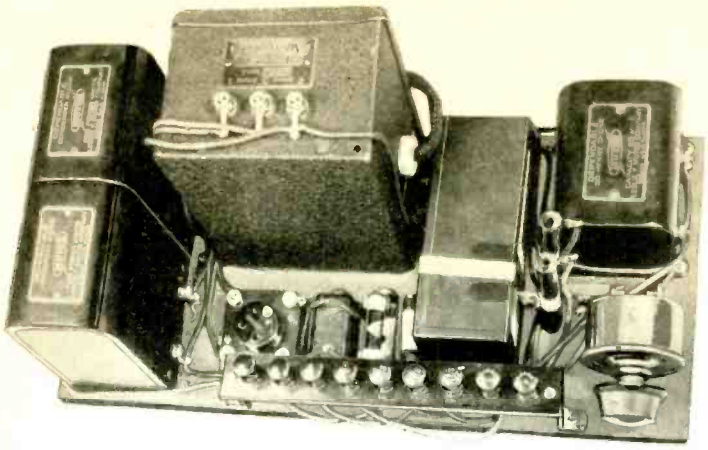
As already mentioned, the radio frequency stages are group tuned and completely shielded one from the other. The balancing employed is so accurate and delicate that it is possible to adjust the three circuits so that they will go into oscillation at exactly the same point or so that they will not oscillate at all. This system of stabilization allows the operator to provide at will excessively sharp tuning or fairly broad tuning by merely altering the adjustment of the Variodensers. This permits the receiver to be adapted to any location which is probably one of



Top view of the Hagerman 210-A.C.-Six receiver with the shield covers removed to show the layout of the R.F. stages and detector.



Schematic diagram of the Hagerman 210-A.C.-Six. The color code for the seven wire cable is given. The circuit is stabilized by R.F. chokes and small variable, balancing condensers.



General view of the Hagerman 210 A.C. Six "B" and "C" power unit. The output filter for the 210 tube, composed of an impedance and condenser, is included with this unit.

the most important considerations in the design of any receiving circuit. In other words, the set can be made extremely selective if it is to be employed in a congested area or it may be broadened out perceptibly if the locality is practically free from a large amount of station interference.

The coils employed in the radio frequency amplifier are of the space wound type which have a high degree of efficiency.

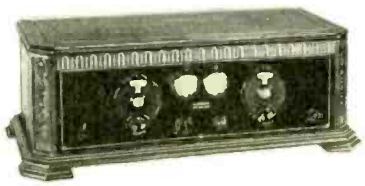
It will be noted from the schematic diagram that trimmer condensers are shunted across the variable tuning condensers of the second and third radio frequency amplifier stages. These condensers are employed for lining up the three radio frequency stages so that they all tune to exactly the same wave length at any given dial setting.

An interesting point in connection with this receiver is that the 210 power tube is incorporated in the set proper. This actually increases the efficiency of the audio frequency circuit, since in this manner the last audio stage is combined with the first audio stage and at the same time considerably simplifies the construction of the A-B-C power supply system.

All of the supply terminals of the receiver proper connect directly to a Belden seven wire fused cable. The wires in this cable are colored and this prevents any confusion existing regarding connecting the other end of the cable to the binding posts on the power supply unit.

Since a 210 power tube is used in the output of the audio frequency amplifier, it is necessary that the power unit supply a maximum potential of 450 volts for the plate of this tube as well as a grid bias of negative 40 volts and an A.C. filament voltage of 7½. The power unit supplies all of these voltages as well as the necessary plate, filament and grid voltages for the rest of the receiver.

That portion of the power unit which supplies the B and C voltages employs an R-81 half-wave rectifier tube. This tube delivers slightly over 500 volts direct current and this voltage is reduced by the output resistance bank so as to supply the three different plate voltages required for the operation of the receiver as well as the 40-volt C bias for the 210 type power tube. This voltage is obtained from the drop of voltage existing across the Muter 1,000 ohm resistor connected in series with the common connection or B minus terminal leading to the center tap on the 210 filament winding of the power transformer. It will be noted that the loud speaker terminals are included on the binding post strip mounted on the power supply unit as the protective circuit for the speaker, consisting of a 30 henry choke and a 2. mfd. condenser, is included on the same base with the power equipment.

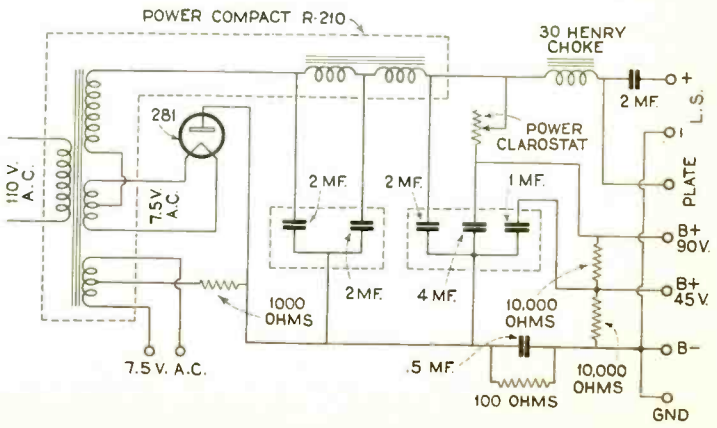


Front view of the receiver and cabinet. Meter No. 1, which indicates the filament voltage, is mounted on left center of panel.

The A supply unit is separate from the B and C power supply unit as it employs an individual circuit not requiring any direct connection to the parts in the B and C power unit.

Obviously, the A supply unit is a very important factor since any reduction in filament voltage is immediately noticeable by a considerable reduction in volume at the output of the receiver. As a matter of fact the greater the gain of a tuned radio frequency amplifier the greater will be the noticeable reduction in volume when the filament voltage is reduced. For this purpose the Abox "A" battery eliminator was chosen. This device consists of a step-down transformer, an electrolytic rectifier, and a filter system composed of a heavy duty filter choke and an electrolytic condenser with a tremendous capacity (approximately 200,000 mfd.). With such a large capacity the filtration is exceedingly good and the output can be considered as a pure direct current.

Since this receiver has a tremendous output and requires a power speaker capable of handling the great amplitude of low frequencies the Newcombe-Hawley long tone chamber type of console speaker was selected for use in connection with this ensemble. This speaker has an exceedingly long air column as will be noted from the accompanying illustration of the horn itself. Due to the length of this air column the speaker has very good low frequency response as indicated by the accompanying graph.



Schematic diagram of the power unit shown at the top of this page. The Power Compact houses the power transformer, with two filament heating windings, and the two filter chokes.

Assembling and Wiring

The assembling and wiring of the Hagerman 210-A.C.-Six ensemble is not complicated. Once the parts are properly laid out and mounted, the wiring can be accomplished in a single evening. The layout of the parts can be easily gained from the accompanying illustrations of the receiver and power unit.

The wiring is made very simple since the aluminum shields are employed as the common connection. The three tuned radio frequency stages are wired almost identically.

Wire the sub-base first before attaching to the panel or mounting the sides of the shields. It is advisable to make all the grid leads first, then all the plate leads and so on down to the filament.

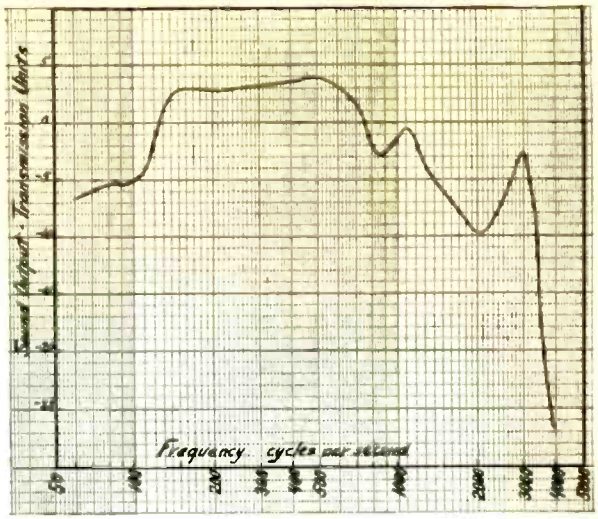
Operation

The Hagerman 210-A.C.-Six will operate satisfactorily with either an indoor or outdoor antenna. For an indoor antenna a length of wire 50 to 75 feet in length is sufficient. The outdoor antenna, which is the most desirable, should be from 35 to 50 feet in length in congested localities and longer where there are few nearby stations.

Placing the set in operation is a simple matter. Merely connect the seven wire cable from the receiver to the power supply unit and the A-eliminator, attach the loud speaker, and connect the power unit and A-eliminator to the light socket.

When the set is first turned on, the Jewell meters on the panel should show a deflection. Adjust the six ohm rheostat so that meter No. 1 reads about four volts and adjust the midget Clarostat so that meter No. 2 reads about 50 volts. Before making this last reading screw in the knob on the power Clarostat, on the power supply unit, until the reading, with the volume control all the way in, is about 100 volts. Then decrease this reading by adjusting the midget Clarostat to the desired 50 volts.

Adjustment of the receiver is comparatively simple. Adjust the trimmer condensers and the volume control for best results. Don't use the rheostat or filament control constantly. The best setting for this will vary for different tubes but once determined should be fairly constant.

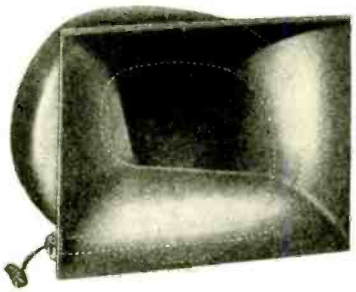


Frequency characteristic curve of the Newcombe-Hawley long horn speaker pictured below. It will be noted that the curve is moderately flat from 50 to 4,000 cycles, the latter being the cut-off frequency.

LIST OF PARTS REQUIRED

(Receiver)

4—Benjamin 2¼-inch r. f. transformers
6—Benjamin base mounting sockets



The Newcombe-Hawley long horn speaker. The length of the horn is clearly indicated by the dotted lines.

4—Karas .00037 SLF condensers, type 17
2—Karas audio transformers, type 28
1—Set Karas brackets
1—135 Jewell 0-8 d. c. voltmeter
1—135 Jewell 0-100 d. c. voltmeter
2—Carter .5 mfd bypass condensers
1—Muter .002 mfd fixed condenser
1—Muter .00025 mfd condenser and clips
1—Muter .0005 mfd fixed condenser
1—Muter 6 ohm rheostat
2—Muter ¼ amp. Tubestats
4—Aluminum Co. of America box shields 5x9x6-inch
1—Celoron 7x24x3/16-inch front panel
1—Celoron 10x23x3/16-inch sub-panel
2—Hammarlund midget condensers
3—X-L Variodensers, type N
1—American Mechanical Laboratories midget Clarostat
2—National illuminated vernier dials
1—Belden 7-wire fused cable with colored wires
1—Roll Belden Colorubber wire for wiring receiver and power unit
1—Muter 3 megohm grid leak
2—Brass ¼-inch shafts 10-inch long
1—X-L binding post
3—Ceco type K-r. f. tubes
1—Ceco type H detector
1—Ceco type AX tube.
1—Ceco type L-10 power tube

(Power Unit)

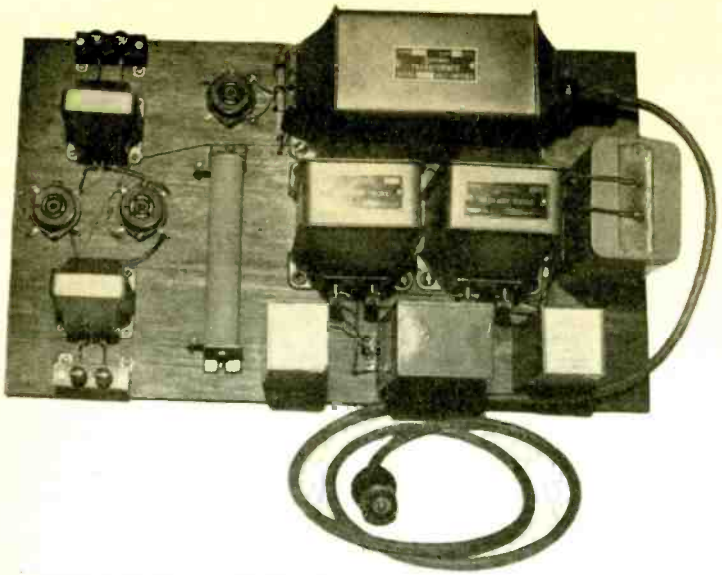
1—Abox 6 volt A unit
2—Muter power condenser blocks No. 598
2—Muter 10,000 ohm resistors No. 2910
1—Muter 1000 ohm resistor No. 2901
1—Muter audio power choke No. 3130
1—Muter 2 mfd power condenser 600 volt
1—Benjamin base mounting socket
1—Thordarson power compact Type R210
1—American Mechanical Laboratories heavy duty high range Clarostat
1—Ceco type R-81 rectifier tube
9—X-L binding posts
1—Amsco 100 ohm resistor and mounting
1—Muter ½ mfd condenser No. 507
1—Celoron strip 1x9x¾ inch
1—Newcombe-Hawley Speaker Console
1—Belden indoor or outdoor antenna kit

The Samson 350 Push-Pull Amplifier

By C. J. Brown

THE introduction of the 350 super-power tube marks a distinct advancement in the art of power amplification. This tube has even better characteristics than the 271 tube, i. e., the plate resistance is approximately 1,800 ohms at a plate potential of 450 volts as against a plate resistance of 2,000 ohms in the 271 at 180 volts and 5,000 ohms in the 310 tube at 425 volts. Due to this low plate resistance the amplification factor is only 3.8 as against an amplification factor of 8 in the 310 tube. The available power output, however, is close to four times that of the 310 tube. The important consideration, though, is the fact that this tube provides the excellent low frequency response obtainable from a 271, due to the low plate resistance, plus a much greater power output.

It was immediately realized that this tube offered an entirely new *degree* of reproduction. Considering the tremendous available output it would appear that a single 350 tube would fill all requirements. However, it must be remembered that irrespective of the power handling capacity of the output tube it is not possible to reduce appreciably the harmonic distortion created partly in the detector tube of the radio receiver and partly in the first stage of audio frequency amplification, without employing push-pull amplification. Since it was desired to obtain the best possible reproduction it was decided that a push-pull amplifier, using two of the 350 tubes, should be used. It will be evident later that the use of two of these tubes does not increase the total cost of the amplifier to any great extent.



The completed Samson 350 Push-Pull Amplifier. This is a self-contained unit, supplying its own power. Note the large filter chokes.

Automatic Grid Bias Control

By means of proper automatic grid bias control it is possible to obtain sufficient current at 450 volts plate potential for the operation of two 350 tubes, from a single 381 half-wave rectifier. Under normal operating conditions the combined plate current does not exceed 85 to 95 mils, depending on the uniformity of the 350 tubes. It is advisable to purchase matched tubes, that is, tubes drawing the same amount of plate current and to this end pick tubes drawing 40 to 45 mils. Some of these tubes draw over 55 mils. It will be noted from the circuit diagram that there is no shunt resistance network and that the effective output impedance of the two 350 tubes in push-pull is the only load introduced across the output of the filter. Any variation in the circuit is automatically taken care of by the grid bias resistor. If the plate voltage should increase, reproducing a hypothetical increase in plate current, the negative bias on the grids of the 350 tubes is likewise increased, and vice versa. This accounts for the good regulation.

Can Be Attached to Any Set

It is necessary to use two stages of audio frequency amplification in front of this amplifier in order to get the desired volume. Consequently it can be attached to the output of any receiving set without making any changes other than replacing the power tube in the output of the receiver (if one is used) with a 212, 212-A, or 301-A and slightly reducing the plate voltage and grid bias. Likewise, it can be used in connection with an electric pickup for the reproduction of phonograph music. It will be noted from the accompanying illustration that there are only four binding posts, two, marked "Input," which connect directly to the output of the radio receiver or two stage amplifier, as the case may be, and two, marked "output," to which the loudspeaker is connected. An amplifier of this sort can be connected up to any set, plugged into the light socket and placed into operation in a few minutes.

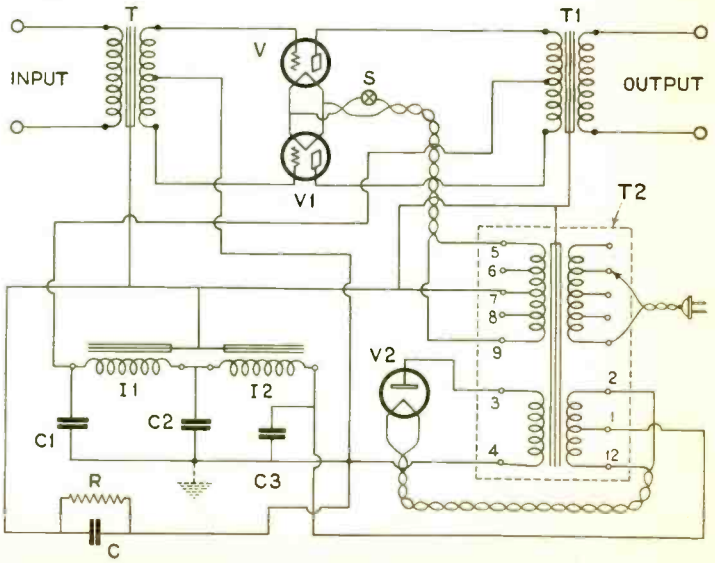
Special Chokes Used

Since the total plate current drawn by the 350 tubes is in excess of that which should be carried by the usual filter chokes supplied with 271 and 310 push-pull amplifiers, it is necessary to use chokes of a much larger current-carrying capacity so that the inductance will remain at the stated value. The chokes used will maintain an inductance of 30 henrys up to 120 mils, which is considerably more than the two 350 tubes draw. The output push-pull transformer is also of special design. The filter condensers have approximately the same voltage ratings as the condensers employed in any amplifier using a plate potential of 450 volts.

It will be noted that in the circuit diagram a small filament switch S is shown in one of the main filament leads supplying the current to the two 350 tubes. This switch is a necessary addition. The 350 tubes should not be turned on until the filament of the 381 reaches the point of full emission. Otherwise, the 381 tube may flash over.

In using this amplifier be sure that it is placed where all three tubes have good ventilation, as considerable energy is dissipated in the form of heat and it is important, as it is in every power amplifier, to provide good ventilation that the heat may be drawn off. It is also suggested that the amplifier should not be left on for any great length of time without signals passing through it. The plates of the 350 tubes will heat up under this condition as all of the energy is dissipated in the tube, while on the other hand when a signal is passing through the amplifier a large portion of the energy is dissipated in the loud-speaker instead and the tubes will run comparatively cool.

If the full output of the amplifier is to be used, employ a power speaker



Schematic-diagram of the 350 push-pull amplifier. Switch S is used to turn on the two 350 tubes after the 381 rectifier has reached the point of full emission. R is the grid bias resistor.

or two or more standard speakers connected in parallel.

LIST OF PARTS REQUIRED

T—Samson Type Y Input Push-Pull Transformer.
T1—Samson Type 0-4 Output Push-Pull Transformer. (Special.)
T2—Samson No. 162 Power Transformer.
I1, I2—Samson No. 312 Filter Chokes (30 Henry, 120 Mil.).
R—Hardwick-Field Type SE-8 Grid Bias Resistor (840 ohms, 100 watts).
C—Igrad 4 Mfd., 500 Volt, Grid Bias Condenser.
C1—Igrad 4 Mfd., 1,000 Volt, Filter Condenser.
C2—Igrad 2 Mfd., 1,000 Volt, Filter Condenser.
C3—Igrad 2 Mfd., 2,000 Volt, Filter Condenser.
S—Filament Switch.
V, V1—Cunningham CX-350 Super-Power Tubes.
V2—Cunningham CX-381 Half-Wave Rectifier Tube.
3—Eby UX Type Tube Sockets.
2—Eby "Input" Binding Posts.
2—Eby "Output" Binding Posts.
1—Roll Acme Celatsite Hookup Wire.
2—Binding Post Strips and Brackets.
1—Wood Baseboard, 12" x 20" x ½".
4—Rubber Feet for Baseboard.
Miscellaneous screws, bolts, etc.

A Screen Grid Power Amplifier

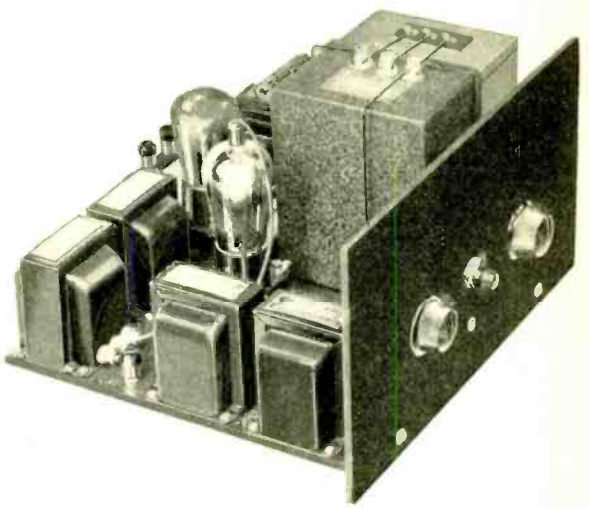
UP to the writing of this article the screen grid tube has been applied almost exclusively to the radio frequency side of the receiver. The amplifier described here, however, applies the screen grid tube in the audio end, thus making it possible to secure one stage of amplification which produces more kick than two, or even three ordinary stages. This is accomplished with no more chance for trouble than in a single stage using any of the older types of tubes. Now it is easily possible to take a mere whisper from the detector and step it up to a point that gives the power tube all it can handle in the way of signal voltage.

The chief line of attack heretofore has been in the use of more tubes and still more tubes in those parts of the receiver ahead of the output. We need not go into the difficulties attending that method other than to recall the fact that every added stage of amplification brings with it many more chances for distortion in the final circuit.

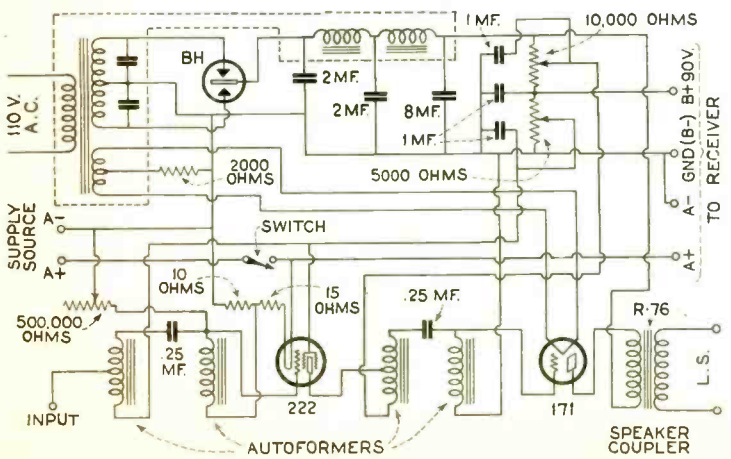
The full ability of the new method will not be appreciated on local and nearby stations because they provide enough strength for all the volume one wishes with any type of amplifier. But the first "DX" signal will be a revelation. Without pushing the radio amplifier anywhere near the point that means a howl and without taking any chance of an overloaded detector, it will be possible to listen to both speech and music with a clarity, tone quality and volume that give pleasure in the listening and not only in the thrill of knowing the station is far away.

The unit includes a complete two-stage audio amplifier, of the dual impedance type, and a complete plate power unit or B-supply unit. It may be used in connection with any radio frequency amplifier containing at least a detector and usually one or more radio frequency amplifying tubes. The only other part required is either an A-power unit, a storage battery or a set of dry cells for filament supply.

The input for the power amplifier is taken from the detector tube of the radio frequency amplifier through a single wire. Plate current or B-power for the radio frequency tubes and for the detector tube is furnished from the new unit, doing away with the need of any separate B-power supply or B-batteries. Grid biases are obtained through connections within the power amplifier so that no C-batteries are needed. There are three tubes; one the screen grid "voltage amplifier," another the power tube feeding the speaker and the third the rectifier tube for the plate power supply.



The completed screen grid power amplifier. The power equipment is mounted on the right hand section of the sub-base. The chokes, forming the dual impedance coupling units, are mounted on the extreme left and rear left of the sub-base.



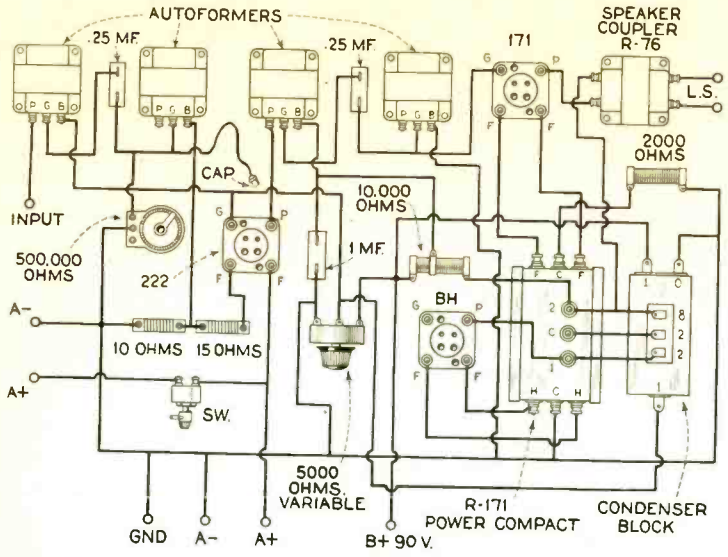
Schematic diagram of the screen grid power amplifier. It will be noted that provision is made for supplying the "B" voltage for the receiver as well. The switch in the positive "A" circuit turns on and off the filament current to both the receiver and amplifier tubes.

The secret of combining volume with tone quality at the output or speaker when working on an exceedingly weak signal is found in the novel method of impedance coupling used between detector and screen grid tube and again between this latter tube and the power tube.

Grid Biases

The required 40-volt negative bias for the power tube is secured by the voltage drop across the 2,000 ohm fixed resistance connected to the center tap of the power tube filament winding on the power compact.

The screen grid tube is given a 1.8 volt negative bias on its control grid by using the voltage drop across the 15-ohm resistance in this tube's negative filament line. This bias handles without danger of distortion the great-



Layout of parts and circuit wiring in the screen grid power amplifier. Note that the negative bias for the control grid of the screen grid tube is obtained from the drop in voltage across the split filament resistance.

est possible voltage which may be received from the detector.

Any grid biases for the detector and for the radio frequency tubes, are, of course, cared for in the radio frequency amplifier.

Volume Control

Control of volume in the audio amplifier is provided by a 500,000 ohm variable resistance mounted on the front panel. This unit is connected between the control grid of the screen grid tube and that tube's filament circuit.

This volume control has no effect whatever on the radio frequency amplifier and any control originally provided on that part of the receiver may be used as before.

Filament Supply

The filament of the power tube is heated by alternating current taken from a special winding in the power compact. The filament of the screen grid tube may be operated either from an A-power unit, from a storage battery or from dry cells, whichever may be convenient or originally used for the radio frequency portion of the receiver. The diagram shows the filament resistances arranged for operation on a 6-volt A-power unit or on a 6-volt storage battery.

Since the screen grid tube's filament takes only 3.3 volts and 0.132 ampere for normal operation, it may be handled easily with dry cells. Should dry cells be used, the only changes necessary from the arrangement in the diagram are to omit the 15-ohm filament resistance entirely and connect the grid return for this tube directly to the battery end of the remaining 10-ohm resistor. This grid return connection is the one made to a point between the 15-ohm and the 10-ohm resistances in the diagram. For dry cell operation this line is connected to the remaining 10-ohm resistance at the end farthest from the tube filament and nearest the binding post. These changes will provide the correct filament voltage and the correct grid bias with dry-cell operation.

The Plate Power Device

Building the plate power unit and the audio amplifier together has many advantages. Not the least of these is the elimination of eight external wires otherwise required between separate parts. This portion of the apparatus consists of the Thordarson Power Compact, the Tobe filter and bypass condensers, the Electrad resistors for voltage control and the rectifier tube.

The power compact contains within its housing a transformer having one secondary winding for the plate supply and a separate secondary for the filament of the power tube. Within the same housing are the two filter chokes and also the two buffer condensers required for the rectifier tube.

The Tobe B-block contains within a single case the three filter condensers and two bypass condensers. The bypass condensers are of one microfarad capacity each. The first two filter condensers are of two microfarads capacity each and the last one, connected to the output of the device, is of eight microfarad size. This large capacity connected directly to the plate circuit of the power tube provides a reservoir of energy more than ample to meet the demand for great volume on the lower notes in the musical scale.

The enclosing of several units in the power compact and several more in the B-block makes assembly and wiring of this part of the unit quite simple and easy. There is a third bypass condenser of one microfarad capacity carried under the base.

Four different voltages are supplied to the various plate circuits. The highest voltage, that for the power tube, is taken directly from a terminal at the top of the power compact. From this point connection is made to the Electrad 20,000-ohm fixed resistance. A movable tap on this resistance takes off 135 volts which feeds the plate of the screen grid tube. From the other end of this 20,000-ohm unit is taken the 90-volt line for the plate circuits of the radio frequency amplifier. On the front panel is mounted the Truvolt variable resistance, from the movable arm of which is taken the 45-volt line for the plate circuit of the detector and for the screen of the screen grid tube.

The movable tap of the 20,000-ohm resistance is set once for all at the desired voltage. The arm of the Truvolt is moved by means of its knob to obtain the best tone quality and volume.

LIST OF PARTS REQUIRED

4—Thordarson Type R-190 Autoformers.
1—Thordarson Type R-76 Speaker Coupling Tranformer.
1—Thordarson Type R-171 Power Compact.
1—Tobe Type R-171 B-block.
1—Tobe 1 Mfd. Filter Condenser (300-volt).
2—Tobe ¼ Mfd. Bypass Condensers (coupling condensers).
1—Electrad Truvolt T-50, 5,000 Ohm Variable Resistance.
1—Electrad Type E, 500,000 Ohm, Royalty Variable High Resistance.
1—Electrad B-100, 10,000 Ohm Fixed Resistance.
1—Electrad B-20, 2,000 Ohm Fixed Resistance.
9—X-L Push Posts, Bakelite type (2 A—, 2 A+, 2 Speaker, 1 B+ 90, 1 Ground, and 1 Input).
1—Yaxley No. 10 Battery Switch.
3—Benjamin No. 9040 Spring Sockets.
1—Carter 10-Ohm Filament Resistor.
1—Carter 15-Ohm Filament Resistor.
1—Base Panel, 9¾" x 12".
1—Front Panel, 7" x 12".
2—Base mounting brackets, 1 inch high. Necessary Screws, Wire and Solder.

The Ambassador DeLuxe Receiver

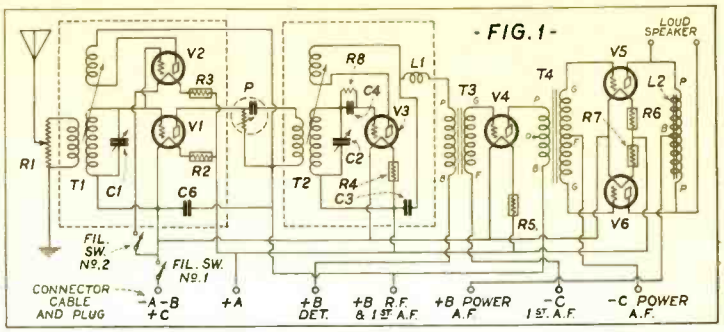
By John B. Brennan, Jr.

THE receiver whose construction is quite evident from the several sketches and circuit diagrams shown, consists of six tubes, two being used in a specially designed radio frequency amplifier, one as a detector, one as a first stage audio frequency amplifier and two in a final push-pull audio amplifier stage.

The receiver employs as a foundation the well-known Ambassador cir-

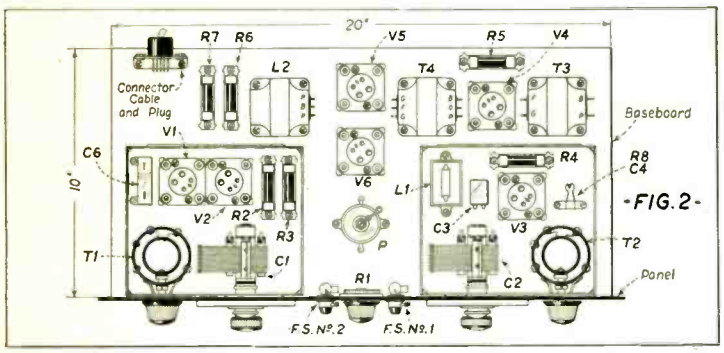
cuit. It will be noted from the circuit diagram that the extra tube employed in the R.F. circuit has its filament and grid paralleled to the filament and grid of the regular R.F. tube. Its plate, however, is coupled to the grid coil by means of a tickler. The filament circuit of the additional tube is controlled by a separate filament switch.

By connecting the additional tube as shown, regeneration of signals from distant stations is accomplished. The inclusion of the extra tube in the R.F. circuit in no way adversely affects the regular R.F. amplifier excepting when regeneration is so far advanced as to cause oscillation. In this condition, as is the case with other receivers employing regeneration, reception is not satisfactory. The secret of successful operation is to advance the regeneration control only enough to obtain satisfactory results. The regular R.F. tube and its associated circuits are stabilized by the use of a Phasatrol. Both tuning circuits, that is the R.F. and detector, are entirely housed in aluminum shield cans.



Schematic diagram of the Ambassador DeLuxe Receiver. Dual regeneration is employed, the first regenerative tube being paralleled with the R.F. tube. A push-pull audio amplifier is also used.

Two CeCo type K tubes are used in the R.F. stage, a type H in the detector, an AX in the first audio and in the final or push-pull stage may be used the type F, J-71 or L-10. If an adequate voltage supply is available it is recommended that the L-10 be used as it will result in the production of tone quality difficult to equal even in the higher priced manufactured receivers.



Constructional plan of the Ambassador DeLuxe Receiver. The symbols correspond to those given in the list of parts. Note that there are two filament switches. F.S. No. 2 controls the parallel regenerator tube.

LIST OF PARTS REQUIRED

C1, C2—Hammarlund Midline Condensers, .0005 Mfd.
C3—Tinytole Condenser, .001 Mfd.
C4—Tinytole Condenser, .00025 Mfd.
C5—Tobe By-pass Condenser, 1 Mfd.
T1, T2—Ambassador Three Circuit Tuner Coils.
T3—Samson Symphonic Audio Transformer.
T4—Samson Input Transformer, Type Y.
L1—Samson Radio Frequency Choke Coil, No. 85.
L2—Samson Output Audio Frequency Unit, Type Z.
R1—Electrad Royalty Potentiometer, 10,000 Ohms.
R2, R3, R4, R5,—Amperites, Type 1A.
R6, R7—Amperites, Type 112.
R8—Durham Grid Leak, 5 Megohms.
P—Electrad Phasatrol.
V1, V2—Ceco Type K R.F. Tubes.
V3—Ceco Type H, Detector Tube.
V4—Ceco Type AX, Audio Amplifier Tube.
V5, V6—Ceco Type J-71 Power Amplifier Tubes.
One Panel 7" x 21".
One Baseboard 10" x 20".
Two National Dials, Type B.
One Durham Grid Leak Mounting.
Two Yaxley Filament Switches, with Pilot Light, Type 210.
One Yaxley Cable Connector and Plug, Type 669.
Two Hammarlund Box Shields, Type As-1.
Three Boxes Corwico Braidite.
Six Benjamin Sockets.
Two K-K 1½-inch Knobs.
One Corbett Cabinet for Panel 7" x 21".

The "All-Wave Electric 9" Power Unit

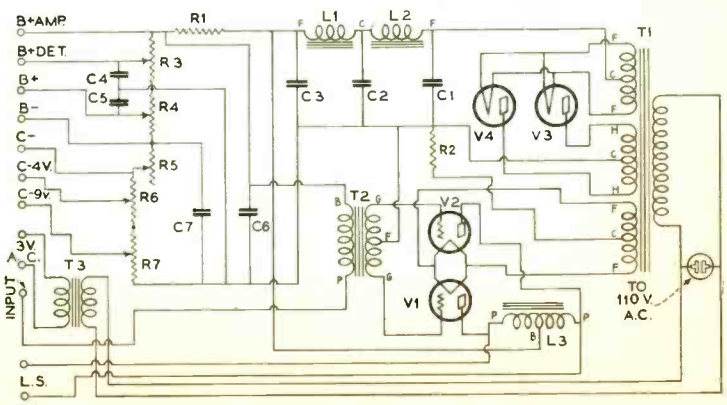
By R. E. Lacault

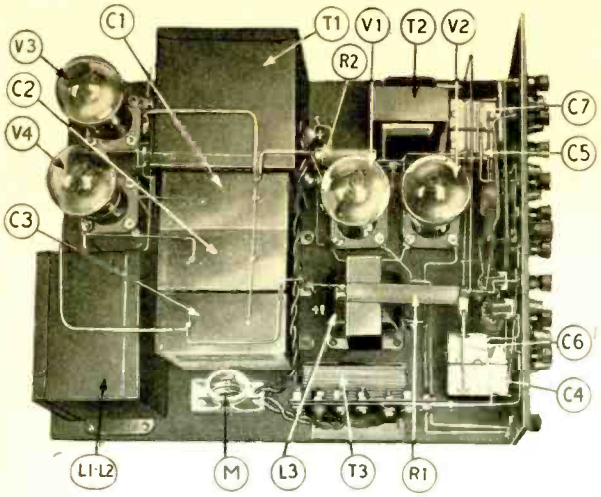
Schematic diagram of the combined "A,B,C" power unit and 210 push-pull amplifier designed for the "All-Wave Electric 9" receiver described in the March issue of Radio Engineering. Two half-wave rectifier tubes, connected in a full-wave circuit, are employed for supplying the "B" and "C" voltages.

THE Power Unit for the "All-Wave Electric 9" receiver which was described in the March issue of RADIO ENGINEERING, was designed specifically to meet the requirements of this eight-tube superheterodyne.

As will be seen from the schematic diagram the power unit consists of an A-B-C eliminator and a 210 push-pull amplifier. The first stage of transformer coupled audio frequency amplification is included in the receiver proper.

The power transformer T1, in the power unit provides the necessary B voltages for the plates of the two 210 power tubes as well as the A.C. tubes in the receiver. There are two sepa-





Top view of the completed "A-B-C" power unit and push-pull amplifier for the "All-Wave Electric 9" receiver. The transformer T_3 supplies the filament current for the A.C. tubes in the set. Tubes V_1, V_2, V_3 and V_4 receive their filament current from special windings in the power transformer T_1.

rate filament windings on this transformer for supplying filament current to the two power tubes, V1 and V2, and the two half-wave rectifier tubes V3 and V4.

The filter of the power unit is composed of the two chokes L1 and L2 and the three condensers C1, C2 and C3. The shunt resistance network, resistors R1 to R7, provide the correct B and C voltages for the receiver. The filament voltage for the A.C. tubes in the receiver is supplied by the filament transformer T3.

It will be noted that the push-pull amplifier unit employs an input push-pull transformer T2 and a push-pull output impedance L3. Since the output impedance has a center tap it is not necessary to use the usual blocking condenser associated with the common form of impedance filter.

LIST OF PARTS REQUIRED

T1—Thordarson 210 Full-Wave Power Transformer.
T2—Thordarson Push-Pull Audio Transformer.
T3—Transformer Corporation of America 3 Volt Filament Transformer.
L1, L2—Thordarson Audio Choke Unit.
L3—Thordarson Center-Tapped Audio Choke Coil.
C1, C2, C3—Acme Parvolt 2 Mfd., 1,000 Volt, Filter Condensers.
R1—Electrad 4,000 Ohm, 50 Watt, Wire Wound Fixed Resistor.
R2—Electrad 750 Ohm, 25 Watt, Wire Wound Fixed Resistor.
R3, R4—Electrad 10,000 Ohm Wire Wound Variable Resistors.
R5—Yaxley 60 Ohm Rheostat.
R6, R7—Electrad 500 Ohm Wire Wound Resistors.
C4-7—Acme Parvolt 1 Mfd., 400 Volt Fixed Condensers.
V1, V2—Ceco L-10 Power Tubes.
V3, V4—Ceco R-81 Half-Wave Rectifier Tubes.
4—Benjamin UX Type Tube Sockets.
12—Eby Binding Posts.
1—Formica Front Panel, 7" x 12" x 3/16".
1—Wood Sub-Base Panel, 15" x 12" x ½".
Belden Insulated Hookup Wire.
M—110-Volt Standard Porcelain Receptacle.

Testing and Adjusting Piezo Oscillators

BY order of the Federal Radio Commission broadcast stations are required to maintain their frequency within 500 cycles (0.5 kilocycle) of their assigned value. To maintain this accuracy of adjustment it is necessary to have special apparatus for checking the frequency of the transmitting set. The only satisfactory devices at present available for this are piezo oscillators, piezo resonators, and automatic piezo control. A piezo oscillator using a quartz plate is a very satisfactory device and can be purchased commercially. Specifications for a portable piezo oscillator are given in Bureau of Standards Letter Circular No. 186. The piezo oscillator described in these specifications does not provide for maintaining the quartz plate at constant temperature, which is desirable for the highest accuracy. These specifications do not include directions for cutting and grinding the quartz plate. A suitable plate can be obtained commercially. Letter Circular No. 223 describes the use of piezo oscillators in radio broadcasting stations. (Copies of these letter circulars may be obtained by persons having actual use for them by addressing the Bureau of Standards, Washington, D.C.)

When a piezo oscillator used as a standard to aid in maintaining the frequency of a station is tested by the Bureau of Standards, there are certain conditions which must be fulfilled. The bureau will undertake a test of a piezo oscillator only upon written request of the owner or operator of the transmitting station in which the piezo oscillator is to be used. This request must contain the following information: (a) Name of the owner of the station where the piezo oscillator is to be used. (b) location and call letters of the station, (c) licensed frequency of the station. (d) type of piezo oscillator and quartz plate used.

There is just at present an exceptional demand for radio tests of this kind which is greatly in excess of the capacity of the bureau for immediate service. For this reason it has been necessary to schedule pending tests and to notify each applicant for test of the approximate date the test will be made. Tests already scheduled will require about two months to complete. Every effort is being made to give much quicker service, consistent with accuracy, after that time.

Assignment of a date for test will be made only upon receipt of the written request from the owner or operator of the station giving the required information. The apparatus may be shipped at the time the test is requested or later in time to reach the bureau a few days before the assigned date. The test requires not less than two days to complete. It is necessary that the entire piezo oscillator except tubes and batteries be sent to the bureau. The type of tubes and the voltage should be specified in the letter requesting tests.

The quartz plate must have a frequency not more than 1 per cent below the licensed frequency. If it has a frequency higher than the licensed frequency, it can not be adjusted by grinding. The fee for adjustment of quartz plates with mechanical means for adjustment is $12. The fee for quartz plates which are not provided with a mechanical means for adjustment and which must, therefore, be adjusted by grinding is $20. In case it is desired to maintain the quartz plate at a constant-controlled temperature higher than room temperature, the work involved in the test is much greater. The fees for such tests are $25 and $50, depending on the type of adjustment required.

NEWS OF THE INDUSTRY

Automatic Electric Co. Enters Condenser Field

The Automatic Electric Company, Inc., of Chicago, Ill., long known as manufacturers of automatic telephone equipment, are now producing filter condensers covering a wide range of capacities and voltage ratings, for use with radio equipment.

The Automatic Electric Company has been manufacturing condensers for telephone equipment for the last forty years.

Dongan Electric Mfg. Company Absorbs Electrical Specialties Co.

Much interest is attached to the latest move of one of the radio industry's largest parts manufacturers. The Dongan Electric Mfg. Company, of Detroit, who has just purchased the business and equipment of the Electrical Specialties Company, Inc., manufacturers of fixed condensers.

Dongan is one of the few parts manufacturers who has persisted in limiting its activities to the production of parts alone. Since the advent of commercial radio, Dongan has designed and built all types of transformers, chiefly for set manufacturers. Many of the recent developments in AC transformer design originated in the Dongan laboratory.

C. Sam Swanson, Sales Manager, advises that Mr. C. Ringwald, former President of the Electrical Specialties Company, Inc., joins the Dongan ranks as Sales Engineer, in charge of condenser sales and engineering. Mr. Ringwald has had a most interesting career in his field dating back as far as 1908, when he was an engineer with Robins & Myers Company. After a number of years with this company, he continued his activities in electrical engineering as Consulting Engineer. In this capacity he did important work for such nationally known companies as the Remy Electric Company, Owen Dyneto Company, Paige-Detroit Company, Sur-Hit Products Corporation, R. B. M. Manufacturing Company and the Brown-Caine Company.

Long recognized as a condenser engineer, Mr. Ringwald in 1926 organized Electrical Specialties Company, Inc., of South Bend, Indiana. His success was almost instantaneous, and it rapidly became one of the important factors in the fixed condenser field.

Dongan plans to continue, as in the past, its policy of serving the manufacturer, and will expand its engineering department and laboratories to keep pace with this new addition to the transformer business.

Added space is being provided to the present Dongan plant for the installation of the machinery and equipment of the Electrical Specialties Company, Inc.

H. R. Fletcher Joins Racon Electric Co.

Harold R. Fletcher, nationally known radio merchandising authority and pioneer, has joined the staff of the Racon Electric Co., Inc., of New York,

H. R. Fletcher

as general sales manager, according to an announcement made by A. I. Abrahams, Vice-President of the concern. The new Racon official will shortly leave on an extended sales trip throughout the country in the interests of the special line of horns and loudspeakers manufactured under the Racon trade mark.

Mr. Fletcher brings to the new position a wealth of experience in radio fields, having at various times been associated with the Apco Manufacturing Co., Algonquin Electric Corporation, and other radio interests. He is a prominent member of the Radio Manufacturers Association and is actively identified with a number of its more important committees.

Mohawk and All-American Combine

Official announcemnt is made of the consolidation of two nationally known manufacturers of radio. The consolidation has been accomplished through a merger of the All-American Radio Corporation and the Mohawk Corporation of Illinois, born of Chicago. The two Companies are licensees of the Radio Corporation of America, Westinghouse Electric Manufacturing Company, General Electric Company and the American Telegraph and Telephone Company. In addition the Mohawk Corporation holds several valuable patents.

The newly formed Company is to be known as the All-American Mohawk Corporation, with factories and general offices located at 4201 Belmont Avenue, Chicago.

Timmons Speaker Company Bought by Philco

Confirming rumors that have been prevalent in the industry for some time, is the announcement by Philco that the Timmons Radio Products Corporation of Germantown, Penna., has been absorbed by the Philadelphia Storage Battery Company.

This is in keeping with the age of mergers, as for the past few years banking insritutions, railroads, public utilities and big business in general have realized the economic value of mergers, as it results in better production methods, better distribution and more productive selling.

While the Timmons Corporation will manufacture a new type of speaker which will be marketed under the Philco name, and which will be of an especially exclusive design for Philco, it will at the same time retain its own identity as a Division of Philco and will continue to manufacture and sell the Timmons Cone Speaker through jobbers and dealers as in the past. It will also build speakers for manufacturers of radio sets and cabinets.

The officers of the Company are: John S. Timmons, President; Sayre M. Rumsdell, Vice-President; John S. Thomas, Treasurer; Edward S. Peyton, Secretary.

Chicago-Jefferson Fuse & Elec. Co.

Announcement was recently made of the consolidation of the Jefferson Electric Mfg. Co. and the Chicago Fuse

Mfg. Co., the new organization to be known as Chicago-Jefferson Fuse & Electric Co., with offices at Laflin and 15th Streets, Chicago.

Jefferson Electric is well known to the radio, electrical and automotive trades for its high-grade line of radio transformers, rejuvenators and testers, its bell-ringing, signal, toy, sign, furnace and control transformers, its automotive coils and testers, and gas engine coils.

Chicago Fuse enjoys a vast following on its Union renewable and non-renewable fuses, Gem Powerlets, and its complete line of Gem Switch and Outlet Boxes.

The consolidation has many advantages to the trade: One reliable source of supply, greater facilities for helping to sell Chicago-Jefferson products, combined engineering experience, standardization of policies—all of which permits the new company to serve the trade better.

The following are officers of the new organization: President, J. A. Bennan, formerly President of Jefferson Electric Mfg. Co.; Vice-President, A. R. Johnson, formerly Secretary of Jefferson Electric Mfg. Co.; Vice-President, A. E. Tregenza, formerly Vice-President of Chicago Fuse Mfg. Co.; Treasurer, J. C. Daley, formerly Treasurer of Jefferson Electric Mfg. Co.

W. L. Woolf Brings Together the Baldwin and Amplion Companies

A trade deal of unusual importance was concluded the early part of March when Leslie Laurence, Chairman of the Board of Directors of Graham Amplion, Ltd., London, England, visited the American branch of the company, The Amplion Corporation of America, New York. On this visit, Mr. Laurence arranged with J. W. and W. L. Woolf, well known in the trade as a result of their activities in the horn, unit and loud speaker business as factory representatives of Nathaniel Baldwin, Inc., to purchase a substantial interest in the American Amplion concern.

The active management of the Amplion company will be under the direction of W. L. Woolf, who has become Treasurer. A. W. Harris will remain as President. He has also taken a financial interest in the business and in addition to dealing with problems of general administration, will be in direct charge of engineering and development. P. M. Dreyfuss, General Sales Manager of the company for the past few months, has resigned that position to enter into the manufacturers' representative business for himself.

The Woolf organization, headed by J. W. Woolf, which has maintained its headquarters at 227 Fulton Street, New York, for many years, will continue to represent the Baldwin interests in New York. This representation started in 1922 and is, to a great degree, responsible for the continued success that has favored the Baldwin products in the metropolitan area.

Mr. Laurence was attracted by the exceptional record made by Mr. Woolf in his field. Mr. J. W. Woolf stated that he became interested in the Amplion organization, not only because Amplion had maintained an excellent name with the trade, but also because of some new developments in progress in the Amplion laboratories consisting of the Amplion Revelaphone, a phonograph pickup employing a cobalt steel magnet, a new dynamic unit for public address use, which embodies new features in design, and a new dynamic unit for popular use which involves a construction entirely new to the radio industry.

Central Scientific Company to Market General Radio Instruments

The General Radio Company, of Cambride, Mass., manufacturers of electrical and radio laboratory equipment and precision measuring instruments, aside from the well-known GR line of radio parts, now announces a co-operative arrangement made with the Central Scientific Company, of Chicago, whereby the latter company will distribute GR laboratory and measuring instruments. Under this new sales policy, the General Radio Company will no longer sell through general supply houses of laboratory equipment, but only through the Central Scientific Company with the exception, of course, of sales made direct by the General Radio Company to its already large clientele of industrial and college laboratories.

The sales organization of the Central Scientific Company has exceptional contact with secondary schools and colleges. The new sales plan will enable the General Radio Company to utilize this specialized selling organization, while at the same time the Central Scientific Company will avail itself of the General Radio factory and engineering staff in producing the necessary equipment for the market.

The present sales policy is another in the series of steps being taken by the General Radio Company to make available to educational institutions, as well as industrial laboratories, apparatus associated with the rapid progress being made in the fields of audio and radio frequency measurements.

Zenith Secures "Automatic" Patents

Commander E. F. McDonald, president of the Zenith Radio Corporation of Chicago, announced recently that the Zenith Radio Corporation has acquired complete control of the H. N. Marvin Automatic Radio patents and has also purchased the A. J. Vasselli Automatic Radio patents.

It is the intention of the Zenith Radio Corporation to license its competitors under its Automatic Radio patents.

Newcombe-Hawley Licensed Under Magnavox Patents

A license agreement has been consummated whereby Newcombe-Hawley, Inc., large manufacturers of exponential horn type reproducers, will market a reproducer of the dynamic type under Magnavox patents. In this connection, Newcombe-Hawley has secured the services of Mr. V. Ford Greaves, who has been engaged in the development of dynamic cone reproducers with the Magnavox Company for the past several years.

Mr. Greaves has been active in research work in acoustics since 1910. He conducted important radio activities for the government during the war, and holds a Lieutenant-Commander's commission in the U. S. Naval Reserve. Since the war he has been associated with the Federal Telegraph Company, and later with the Magnavox Company.

Mr. Greaves' experience in pioneer development of the dynamic cone particularly fits him for his new duties with Newcombe-Hawley where he will be engaged in engineering sales service, solving the acoustical problems of Newcombe-Hawley's customers.

Through their connection with the Wallace Clement Sabine Acoustic Laboratory at Riverbank Geneva, Illinois, and a group of scientists and engineers, Newcombe-Hawley are developing many refinements in radio and phonograph reproducers of all types. They are bringing the benefits of their research work to the public in products manufactured in Geneva and St. Charles, Illinois.

H. Bobker Joins Cable Supply Co.

Mr. H. Bobker formerly connected with the Supertron Mfg. Co. has joined the forces of the Cable Supply Co., who manufacture radio tubes, transformers, condensers and neon tube signs.

Bert Smith Joins Aero Products

Mr. Bert E. Smith, formerly Advertising Manager of the Aerovox Wireless Corporation, of Brooklyn, New York, has joined the Engineering Staff of Aero Products, Inc., of Chicago, Ill.

Correction

In the article entitled "A Good B-Power Unit" appearing on page 43 of the February issue of Radio Engineering, mention was made of the new Raytheon R-9 full-wave rectifier tube. The type number of this tube is R-90.

NEW DEVELOPMENTS OF THE MONTH

R.C.A. 105 Super-Powerspeaker

A floor model cabinet loudspeaker employing the new super-power amplifier Radiotron UX-250 and two alternating current rectifier Radiotrons UX-281 is announced by the Radio Corporation of America. With ample

R.C.A. De Luxe Loudspeaker 105.

rectified and filtered energy, together with the latest super-power Radiotron, the amplifier of Loudspeaker 105 will handle three times the load of the 104.

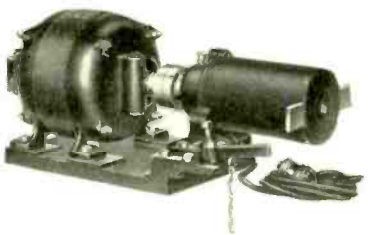
A new cone of the electro-dynamic type, is employed in the Loudspeaker 105. It is provided with corrugations and rendered moisture-proof, so as to eliminate "paper rattles" even at maximum power, as well as distortion due to climatic conditions.

In addition to supplying its own power requirements, Loudspeaker 105 will furnish "B" voltages up to 90 volts, as well as "C" potential. (or 135 volts at 3 milliamperes), for the radio receiver with which it is employed. The new loudspeaker operates only on 110-volt, 50-60 cycle alternating current. The wattage consumption is approximately 140 watts.

The mechanism is housed in an attractive two toned walnut cabinet measuring 41½ inches high, 23¾ inches wide and 16¼ inches deep.

Zierick Wire Stripper

The F. R. Zierick Machine Works, of 8 Howard Street, New York City, have introduced a very ingenious form



Zierick Wire Stripper.

of wire stripper which performs two operations simultaneously. By inserting the end of an insulated wire through the bushing of the wire stripper, shown in the accompanying illustration, and pushing the lever the machine will clean off the insulation and twist the strands of wire in one piece.

The machine is portable, taking approximately 7" x 12" of bench space and is practically noiseless except for a slight hum of the motor. It has an adjustable stop for gauging the length of insulation to be removed and will take wire up to ½". in diameter.

All of the working parts of the Zierick wire stripper are built-in thus eliminating danger of accidents.

Weston Model 537 Set Tester

The Weston Model 537 A.C.-D.C. Radio Set Tester is a complete outfit, most ingeniously designed and fully

Weston 537 Set Tester.

adaptable to the testing requirements of every set made, whether operated by direct current from batteries or battery substitutes, or by alternating current from socket power.

It will measure the various currents and voltages employed anywhere in the set, including those at the tube sockets. All tests can be made by using the regular voltages normally supplied to the set by its batteries or socket power without the necessity of changing connections. Nor is any auxiliary power required.

The set is provided with two instruments—an A.C. voltmeter and a D.C. volt-milliammeter. An ingenious system of switches and binding posts provides for automatically connecting the instruments to the circuits being tested. The A.C. voltmeter has three ranges—150/8/4 volts—the lower ranges being required for measuring the filament voltages of A.C. tubes, and the highest range is provided for measuring the line voltage. The D.C. volt-milliammeter has four voltage ranges—600, 300, 60 and 8 volts and two current ranges—150 and 30 milliamperes. All voltage ranges have a resistance of 1000 ohms per volt. The set is furnished with the necessary socket adaptors and a complete instruction book.

Manufactured by the Weston Electrical Instrument Corporation, Newark, N. J.

Rusco Band-Pass Filter

The Rusco Sales Company, of 360 East Grand Avenue, Chicago, Ill., have placed on the market a very efficient

Rusco Band-Pass Filter.

form of band-pass filter for use in connection with long wave or intermediate frequency amplifiers as used in superheterodyne receivers and special long wave circuits. The Rusco band-pass filter known as type 10KC consists of a network of inductance and capacity designed to pass a band of frequencies 10 kilocycles wide. It is claimed that this new unit has a very low and uniform impedance to all frequencies between 90 and 100 kilocycles and an

extremely high impedance to all other frequencies.

This band-pass filter has been designed to replace the usual form of tuned stage transformer and is used in connection with a regular I.F. amplifier. This unit provides the desirable selectivity without cutting the side-band frequency.

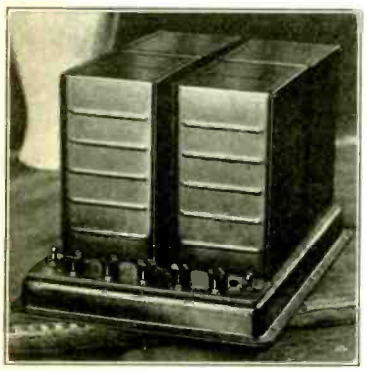
Rusco I.F. Transformers

The Rusco Sales Company has also placed on the market an I.F. transformer, known as Type 95KC, which can be used very effectively in connection with the Rusco Band-Pass Filter. These I.F. transformers are permanently tuned to a frequency at 95 kc. The transformer is of the air core type with a tuned secondary coil.

Rusco 95 KC. I.F. Transformer.

R.C.A. "B" Eliminator

The new R.C.A. "B" eliminator, which will be known as Model AP-1080, is of rugged construction, and employs no acids or liquids to be replenished; it has no mechanical parts or tubes to be replaced. The operating mechanism is enclosed and sealed in permanent steel containers. It is extremely compact, measuring 7¼ by 10¾ by 6½ inches high and will readily fit into the usual radio cabinet.



R.C.A. "B" Eliminator.

The device draws only 22 watts under average load. The power output is ample for any type of receiver up to the eight-tube circuit with power tube. The maximum potential has been limited to 135 volts.

A Bakelite Connector for Radio Speaker Cords

The Belden Manufacturing Company, 2300 South Western Avenue, Chicago, has developed a bakelite connector for attaching extension cords to radio speaker cords. The connector receives the standard pin type speaker tips. The tips of both speaker and extension cord are simply pushed into the connector. No tools are necessary.

A unique feature is that the tips are completely inside the bakelite connector. No metal is exposed.

Belden Speaker Cord Connector.

National Vernier Drum Dial

The National Company, of Malden, Mass., are now marketing a very attractive vernier drum dial known as the National Type F Velvet Vernier Drum Dial.

The dial proper has an engraved celluloid scale running from 0 to 200° behind which is mounted a small 6-volt light. The escutcheon plate is made of hammered silver and is attached to a metal frame which fits against the rear of the panel. Movement of the dial is controlled by a small bakelite knob. Instead of employing a series of gears or a friction arrangement, a series of metal pulleys carrying a flexible cord transmits the motion of the knob to the drum dial. This arrangement provides a very smooth and positive action.

National Velvet Vernier Drum Dial.

Belden Indoor Aerial Kit

The Belden Manufacturing Company, 2300 South Western Avenue, Chicago, has added an Indoor Aerial Kit to their complete line of radio accessories. This new kit contains a seventy foot spool of Indoor Aerial Wire, a twenty-five foot coil of Belden Colorubber Ground Wire, and a ground clamp.

The Indoor Aerial Wire consists of fine stranded copper wire inside a neat brown braid. The Indoor Aerial Wire is very flexible and can be readily run around a window frame, or over the molding. Its neutral brown color makes it easily concealed. The Colorubber Ground Wire is tinned copper, rubber insulated. A serve of cotton beneath the rubber makes it easily stripped for soldering.

Belden Indoor Aerial Kit.

Belden Weatherproof Aerial Lead-in Strip

A new contribution to radio, by the Belden Manufacturing Company, 2300 South Western Avenue, Chicago, is a rubber insulated aerial lead-in strip. The flat copper conductor is tinned. The flexible rubber insulation does not break at the sharp bends beneath the window.

It is also moisture and weather proof. The Fahnestock clips at both ends are soldered and riveted, assuring a positive contact of great strength.

Belden Weather-Proof Lead-in Strip.

"LMC" Vitreous Enameled Resistors

The Lautz Manufacturing Company, of 247 N. J. R. R. Ave., Newark, N. J., have gone into production on special type vitreous enameled resistors for the use in connection with radio equipment. These resistors can be obtained in practically any resistance value and wattage rating.

It is claimed by the manufacturer that these resistors are constant in

value, non-inductive and with a fairly low temperature coefficient. Since the element is thoroughly sealed with vitreous enamel the unit is non-hygroscopic. It is also claimed that the enamel will not easily chip off due to the process of manufacture.

CeCo L-50 Super-Power Tube

A new power tube known as the "CeCo" L-50 and a tube which is capable of delivering more than three times as much undistorted energy as the "CeCo" L-10 is now ready for the market.

The plate voltage recommended ranges from a minimum of 250 to 450 volts, with a negative bias of 45 volts when the plate voltage is 250 and a negative bias of 84 volts when the plate voltage is 450. The voltage amplification factor is 3.8. The filament requires 7.5 volts, 1.25 amperes.

CeCo L-50 Super-Power Tube

The L-50 is of the same size as the L-10 although it may ultimately be furnished with a larger size bulb. The base is the same as the L-10. The filament of the new power amplifier is of the oxide coated type, the wire being a development of the "CeCo" Engineering Department. This type of filament has great mechanical strength and a very long operating life. The plate of this tube is tall and narrow and has a slightly blackened color.

When used in a transmitting circuit the L-50 is rated at 25 watts as against 7½ watts of the L-10. As a power amplifier the maximum undistorted output of the L-50 is 4,650 milliwatts against 1540 milliwatts for the L-10.

The average characteristics of the "CeCo" L-50 power amplifier are as follows:

	Recommended Voltages				*Maximum*	
Plate Voltage	250	300	350	400	450	Volts
Negative Grid Bias	45	54	63	70	84	Volts
Plate Current	28	35	45	55	55	Milliamps
Plate Resistance (A.C.)	2100	2000	1900	1800	1800	Ohms
Mutual Conductance	1800	1900	2000	2100	2100	Micromhos
Voltage Amplif. Factor	3.8	3.8	3.8	3.8	3.8	
Max. Undistorted Output	900	1500	2350	3250	4650	Milliwatts

Filament 7.5 volts — 1.25 Amps.

CeCo RF-22 "Shielded Grid" Tube

The C. E. Manufacturing Company, of 702 Eddy Street, Providence, R. I., have introduced a new "shielded grid"

Ceco "Shielded Grid" Tube.

tube designed especially for use as a high gain radio frequency amplifier or audio frequency amplifier. This tube has an amplification factor of approximately 25 to 40 when used in a tuned R.F. circuit. The actual gain per stage is dependent on the type of coupling employed. When used in an audio amplifier of the resistance or impedance coupled type, the tube has a mu of approximately 60.

The new RF-22 tube has a thoriated filament requiring .132 ampere at 3.3 volts. The recommended plate potential is 135 volts with an attendant control grid bias of negative 1 to 15 volts and a screen grid bias of positive 45 volts.

The screen grid connects to the prong of the tube which is ordinarily the grid terminal. The control grid has its terminal at the top of the tube in the form of a small metal cap.

Radiall 622 Amperite

The Radiall Company, 50 Franklin Street, New York City, have introduced a new Amperite or automatic filament control designed for the new 222 type shield-grid tubes. This Amperite automatically adjusts the voltage to 3.3 volts at the filament terminals. It is designed to be used in series with a filament supply of six volts.

New Elkon Tapering Charger

The Elkon Works, of Weehawken, N. J., long identified with the manufacture of chargers have just announced a new type of Trickle Charger, which, on account of the Elkon principle is called The Elkon Tapering Charger.

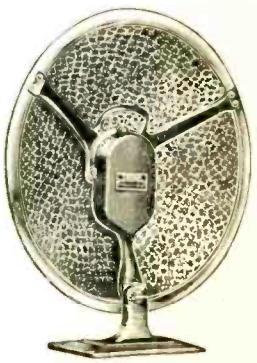
The new charger works in much the same way as the usual trickle charger except that the charging rate is automatically increased or decreased according to the condition of the storage battery.

Elkon Dry Tapering Charger.

The rectifying unit is the patented solid dry Elkon Unit which supplies a charging rate of 1 ampere when the battery is empty. Another feature is that instead of employing the usual glass tube fuse which is so difficult to replace, they use a small piece of 2 ampere fuse wire which is obtainable anywhere.

Trimm Concerto Cone Speaker

The Trimm Radio Manufacturing Company, of 847 West Harrison Street, Chicago, announce their new model

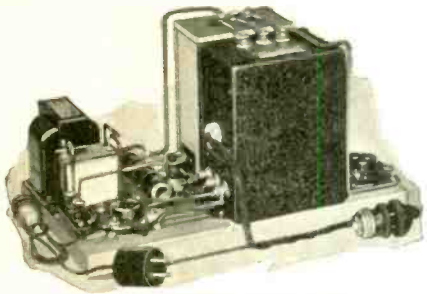


Trimm Concerto Cone Speaker.

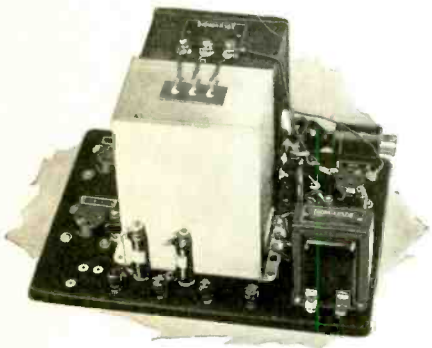
Concerto Cone Speaker, with a cone 14" in diameter.

The Concerto unit is built on the balanced armature principle with a forged chrome steel magnet. It is

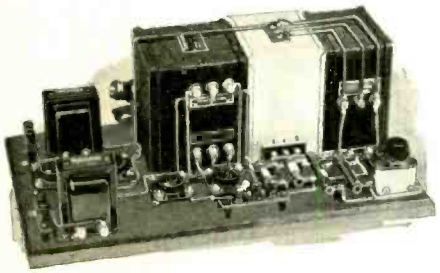
How's Your Old Audio Amplifier



THORDARSON 171 TYPE
POWER AMPLIFIER



THORDARSON 210 TYPE
POWER AMPLIFIER



THORDARSON 210 PUSH-PULL
POWER AMPLIFIER

A Home Assembled Thordarson Power Amplifier Will Make Your Receiver

A Real Musical Instrument

IMPROVEMENTS in the newer model receiving sets are all centered around the audio amplifier. There is no reason, however, why you cannot bring your present receiver up to 1928 standards of tone quality by building your own Thordarson Power Amplifier.

With a screw driver, a pair of pliers and a soldering iron you can build any Thordarson Power Amplifier in an evening's time in your own home. Complete, simple pictorial diagrams are furnished with every power transformer.

The fact that Thordarson power transformers are used by such leading manufacturers as Victor, Brunswick, Federal, Philco and Willard insures you of unquestionable quality and performance.

Give your radio set a chance to reproduce real music. Build a Thordarson Power Amplifier.

Write today for complete constructional booklets sent free on request.

THORDARSON

3572

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.

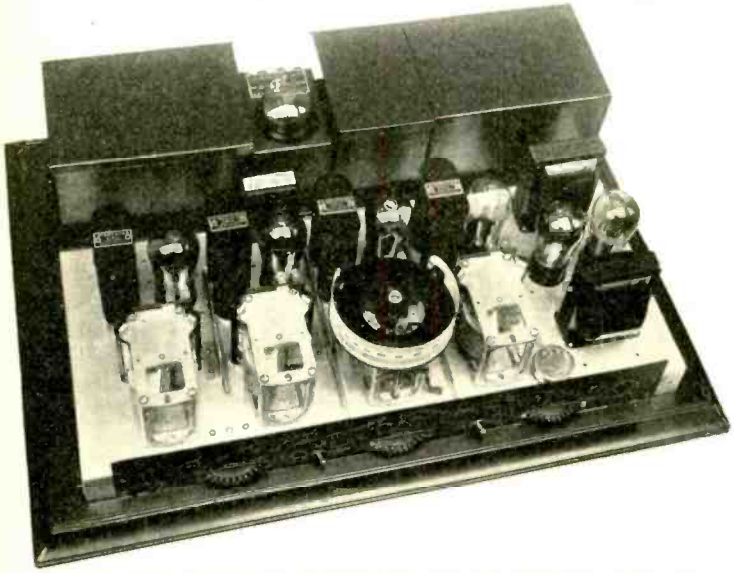
stated that this speaker is especially adaptable for operation with semi-power and power tubes and will handle the higher voltages and maximum amplification without blasting or distortion.

The edge of the cone is fully protected by a large metal rim and all of the metal parts are rust-proof.

The unit is equipped with a handy handle and has a removable base and separate attachment so that the cone can be mounted on the wall if desirable.

Grebe All-Electric Synchrophase A.C. Six Receiver

Arrangements for reception of either local or distant stations at the will of the listener; especially designed antenna compensation coil, enabling operation of receiver with any size of antenna and an input volume control ahead of the detector tube are a few of the unique radio developments inherent in the new Synchrophase A.C. Six, single dial, all electric, six tube radio receiver announced by A. H. Grebe & Co., Inc., of New York City, N. Y., and Los Angeles, California.



The new Grebe All-Electric Synchrophase A.C. Six Receiver. This set employs three tuned R.F. stages, has single tuning control and a special "Local-Distance" Switch.

The "Local-Distance" switch is a factor which contributes toward making for a large amount of undistorted volume; incidentally, one of the features of the new set. This unit functions so as to make it possible to obtain on the "Local" position a wider frequency band, thereby avoiding sideband cut-off of high frequencies, resulting in improved quality and greater undistorted output. When the new arrangement is set on the "Distance" position, the over-all selectivity of the receiver becomes as high as can be permitted.

The new Grebe receiver consists of four major units: The receiver proper, power unit; mounting frame for supporting the receiver, and cabinet.

Three stages of tuned radio frequency amplification, employing Binocular, Litz, space wound, coils with ruggedly constructed straight-line frequency tuning condensers; Grebe tube isolation circuits in each R. F. stage; detector, with A.C. heater type of tube and two stages of audio frequency amplification, the latter stage; of which is a 171-A power amplifier, form the main units in the receiver proper section.

The chassis, on which all the component parts of the receiver proper are mounted, is constructed of heavy aluminum with four reinforcing ribs which add immeasurably to its rigidity.

The mounting frame which supports the receiver proper, power unit, and cabinet is die-cast and of special construction. It is finished to match the cabinet. The mounting frame forms the base of the cabinet which fits over the set and attaches to the frame.

Selected mahogany veneers are used in the body of the cabinet, while the front panel is of stump walnut, finished in artistic design. Two sections of the panel are cut out to allow for an oblong inlaid bronz-metal control board, at the lower portion of the panel, on which are mounted the tuning control, antenna compensator, volume control, "Local-Distance" switch and the main "On and Off" switch, and a smaller space in the center of the panel near its top forms the second insertion in the panel through which the drum, graduated in kilocycles, may be viewed from the front. This drum is illuminated by a small six volt lamp.

The familiar Grebe tangent wheel vernier is employed for all movable controls on the new receiver.

New Powertone Speaker Unit

The Powertone Electric Company, of 220 Fulton Street, New York City, have designed a new loud speaker unit which is superior to their old model. This unit is being manufactured under United States patents No. 1,550,794 and No. 1,593,406.

The unit, which is of the electro-magnetic type, has a direct drive and uses 4" horseshoe magnets, the poles of which terminate at the ends of the laminated pole pieces.

The base of this unit is of molded aluminum. A 10-foot silk cord is supplied with each unit.

Stewart "A" Eliminator Kit

The Stewart Battery Company, of 119 No. Peoria Street, Chicago, Ill., have placed on the market an All-Dry "A" Eliminator kit designed for use in connection with the common 110-volt, 50 to 60 cycle A.C. lighting line. This unit is composed of a special dry disc rectifier, a dry electrolytic filter condenser, a step-down transformer and two large filter chokes. The whole unit when assembled takes up a very small amount of space and can be fitted without difficulty in the battery compartment of a radio receiver.

The Stewart All-Dry "A" Eliminator will supply sufficient current for operating receivers having from five to ten tubes.

Acme ABC Power Supply Units

The Acme Apparatus Corporation, 37 Osborne Street, Cambridge, Mass., have introduced three types of ABC Power Supply Units designed for use in connection with the new A.C. tubes.

The terminal panels are plainly marked for the various voltages and conveniently located at the top of the unit. There are over-size openings to permit with ease the entrance of as many wires as required to make the necessary connections to the receiving set.

The type R-280 employs a 280 type full-wave rectifier. This unit supplies "B" voltages up to 180 and has three intermediate taps and a minus 9 and minus 40-volt "C" tap. The "A" portion of this unit will accommodate four 226 type tubes, one 227 tube and one 171 or 112 tube.

The type R-BH is identical to type R-280 except that it employs a Raytheon BH full-wave rectifier tube.

The type A-BH is designed to use either the 280 type full-wave rectifier or the Raytheon BH full-wave rectifier. The "B" unit supplies a maximum of 180 volts. "C" voltages of negative 1.5 and negative 22 are available. The "A" unit will accommodate seven Arcturus A.C. tubes which have 15 volt filaments.

—About the June Show Number—

THE June issue of RADIO ENGINEERING will, of course, feature the Second Annual Radio Manufacturers' Trade Show and the Fourth Annual Convention of that organization.

The text section will cover, comprehensively, the engineering and production plans of the industry — will reflect the viewpoint of the technical minds of the industry — and will deal with the technical factors involved in the advances made during the past year and planned for the coming year.

The viewpoint of the executives and committee heads of the Radio Manufacturers' Association will be presented in statements which they are preparing for the June issue of RADIO ENGINEERING.

The advertising section will also be a valuable and interesting feature.

Advertising pages will be used to present engineering and technical facts in connection with the lines displayed at the show — facts which must be interpreted to the public during the following months.

Scores of material manufacturers who have advertised little, if at all, to the radio industry, have scheduled space in the June issue. It will be interesting advertising — covering processes, materials, machinery, parts, accessories and complete receiving units.

The June issue will be an active aid in determining sources of supply and in formulating buying plans.

Thousands of extra copies will be available at the RADIO ENGINEERING Booth—(Number 33).

Please accept this as a cordial invitation to stop in and see us during the week.

BOOTH NO. 33.

Announcing

the

DUPLEX CLAROSTAT

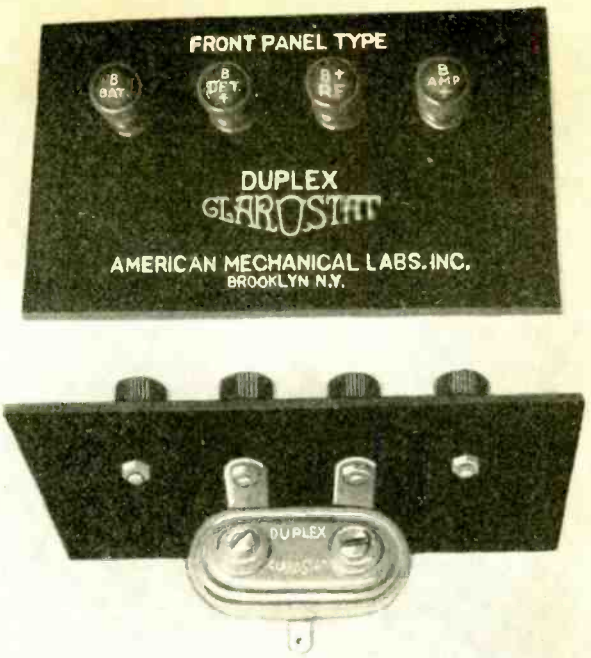
Reg. U. S. Pat. Off.

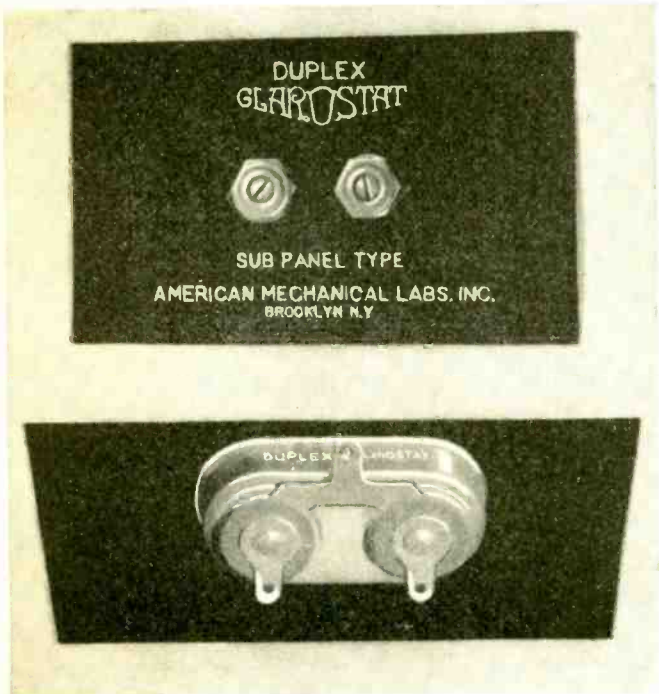
A radical departure in resistance technique. Two separate and distinct variable resistors in a compact, sturdy casing. Adjustments made by means of ordinary screw-driver engaging with slotted screw shafts recessed in decorating bushings. Resistors adjusted for specific conditions, and then left alone. No fussing; no chance for trouble; no unnecessary service calls!

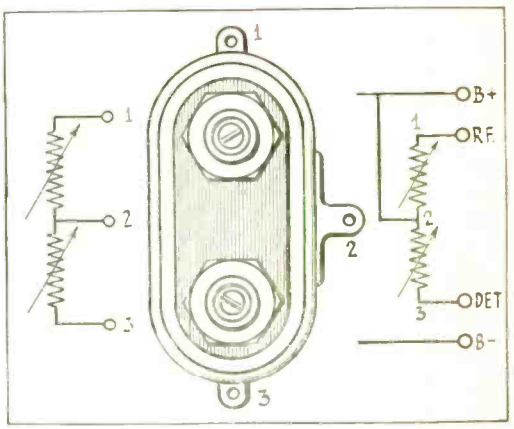
The Duplex Clarostat provides

(1) a total resistance of enormous range; (2) a tapped resistance with variable total and variable tap; (3) a potentiometer with variable total resistance and variable midpoint; (4) two separate and distinct variable resistors; (5) the simplest resistance network for a radio power unit.

The accompanying diagram tells the story.







In order to meet all mechanical requirements, the Duplex Clarostat is available in two designs: *Front Panel Type*, with combined terminals and mounting brackets, for use at rear of panel, with connections made directly to binding post screws. Adjustments made at rear of panel. *Sub-Panel Type*, with usual connection lugs at bottom, mounted by means of two threaded nipples that slip through holes and are held in place by decorative nuts. Adjustments made from top or front of panel.

The Duplex Clarostat is available in a wide range of resistances to meet general and special requirements.

Write for technical data regarding Duplex Clarostat as well as other types of Clarostat for every radio purpose. We shall be pleased to co-operate with you on any resistance problem.

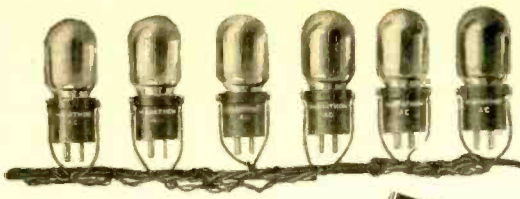
AMERICAN MECHANICAL LABORATORIES, INC.

Specialists in Variable Resistors

285 North Sixth Street : : Brooklyn, N. Y.

CLAROSTAT

Reg. U. S. Pat. Off.



Electrify Your Set

WITH THE

MARATHON AC KIT

Satisfaction Guaranteed

No need to wonder if the Marathon AC Kit will operate on your set—we guarantee it. If you have a 5, 6, 7 or 8 tube set using UX sockets and are now employing an "A" Battery (either drycell or storage) you can use the Marathon AC Kit—perfectly. Marathon AC Tubes are guaranteed for a year.

The Marathon AC Kit is complete

Nothing else to buy—everything is complete. For example the six tube kit includes 6 Marathon AC Tubes—a universal harness—a 6 volt, Transformer—a volume control—and an instruction sheet. Anyone, no matter how ignorant of radio can change his set from DC to AC.

Complete A B C elimination also by using the Marathon Power Pack instead of the Transformer. Prices for complete A B C Kits—5 or 6 tube—$59.50; 7 tube—$64.50; 8 tube—$69.50.

Jobbers — Dealers — Set Builders

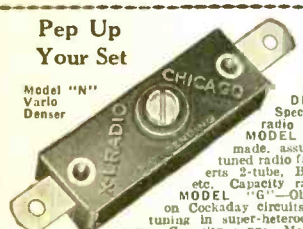
Write or wire for our sales proposition.

LIST PRICES
5 or 6 Tube Kit $30.00
7 Tube $35.00
8 Tube $40.00
COMPLETE

NORTHERN MFG. CO.
387 Emmet Street Newark, New Jersey

MARATHON A-C KIT

Pep Up Your Set



Model "N" Vario Denser

X-L PRODUCTS

Easier tuning—correct tube oscillation—more volume and clearness with an X-L VARIO DENSER in your circuit. Specified and endorsed by foremost radio authorities in all leading circuits. MODEL "N"—Micrometer adjustment easily made, assures exact oscillation control in all tuned radio frequency circuits. Neutrodyne, Roberts 2-tube, Browning-Drake, Silver's Knockout, etc. Capacity range 1.8 to 20 Mfd. Price $1.00

MODEL "G"—Obtains the proper grid capacity on Cockaday circuits, filter and intermediate frequency tuning in super-heterodyne and positive grid bias in all sets. Capacity range, Model G-1 .00002 to .0001 Mfd. Model G-5 .0001 to .0005 Mfd. Model G-10 .0003 to .001 Mfd. Price each with grid clips, $1.50.

X-L PUSH POST—NEW. Bakelite Insulated. Vibrations will not loosen, releases instantly. Price each 15c Also in strip of 7 on black panel marked in white. Price $1.50

X-L Push Post

FREE—New, up-to-date book of wiring diagrams showing use of X-L units in the new LOFTIN-WHITE constant coupled radio frequency circuit, and in other popular hookups. Write today.

X-L RADIO LABORATORIES 2423 Lincoln Ave. CHICAGO, Ill.

You Can Make Money

BUILDING & SELLING

R.E.L.-9

ALL WAVE ELECTRIC SETS

This proven circuit-electrified-and designed by R. E. Lacault, incorporates all the latest improvements known to the art. It is an A1 set in every respect for those who want the best.

Write for free Descriptive Pamphlet.

LOWEST PRICES ON THIS AND OTHER KITS

Write for List of Specials

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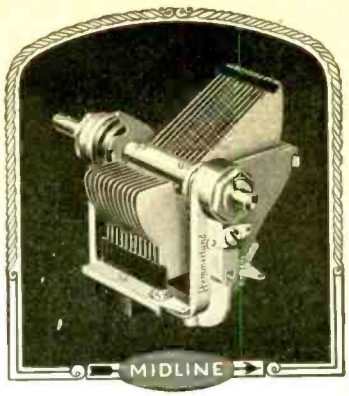

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Readers interested in products not listed in these columns are invited to tell us of their wants, and we will inform the proper manufacturers. Address Readers' Information Bureau.

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

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Westinghouse Elec. & Mfg. Co.

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Electrad, Inc.

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X-L Radio Labs.

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Copper and Brass Research Assn.
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CERIUM:
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CHOKES, RADIO FREQUENCY:
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COILS, IMPEDANCE:
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COILS, INDUCTANCE:
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Hammarlund Mfg. Co.

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COILS, RETARD:
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Automatic Electric, Inc.
Burt, A. G., Jr.
Dongan Electric Mfg. Co.
Electrad, Inc.,
Fast, John E. & Co.

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Aerovox Wireless Corpn.
Automatic Electric, Inc.
Dongan Electric Mfg. Co.
Electro-Chemical Co.
Fast, John E. & Co.

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Automatic Electric, Inc.
Burt, A. G., Jr.
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DIALS, DRUM
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Radio Receptor Co.

ELIMINATORS, B BATTERY:
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Radio Receptor Co.
Thordarson Electric Mfg. Co.

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Dongan Elec. Mfg. Co.
General Radio Co.
Grigsby, Grunow, Hinds Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.

ELIMINATORS, UNITS FOR:
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Dongan Elec. Mfg. Co.
Electro-Chemical Co.
General Radio Co.
Radio Receptor Co.
Thordarson Electric Mfg. Co.

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International Resistance Co.
Lautz Mfg. Co.

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Jewell Elec. Inst. Co.

KITS, TRANSMITTING:
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LACQUER:
Zapon Co., The

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Electrical Testing Labs.

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Electrad, Inc.,

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LUGS:
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Shakeproof Lock Washer Co.

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NUTS:
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Shakeproof Lock Washer Co.

OSCILLOGRAPH:
Burt, Dr. Rob't C.

OSCILLOSCOPE:
Burt, Dr. Rob't C.

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Tifft Bros.

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Formica Insulation Co.
General Plastics Co.
Westinghouse Elec. & Mfg. Co.

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Strype, Fred C., Co.

PAPER, CONE SPEAKER:
Seymour Co.

PHOTOELECTRIC CELLS:
(See Cells)

PLUGS:
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Saturn Mfg. Co.

POTENTIOMETERS:
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Central Radio Laboratories
Electrad, Inc.
United Scientific Laboratories

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Aerovox Wireless Corp.
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Ward Leonard Electric Co.
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Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
Hardwick, Field, Inc.
International Resistance Co.
Lautz Mfg. Co.
Ward Leonard Electric Co.
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Central Radio Laboratories.
Electrad, Inc.,
United Scientific Laboratories.
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Racon Electric Co.
Temple, Inc.
United Radio Corp.
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Formica Ins. Co.
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Saturn Mfg. Co.
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Jewell Electrical Inst. Co.
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Jewell Elec. Inst. Co.
TESTING INSTRUMENTS:
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Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
TESTING KITS:
Jewell Elec. Inst. Co.
TESTING LABORATORIES:
Electrical Testing Labs.
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General Radio Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
United Radio Corp.
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Acme Elec. & Mfg. Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.
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American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
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American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Samson Electric Co.
Thordarson Electric Mfg. Co.
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Northern Mfg. Co.
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TUBES, VACUUM:
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Northern Mfg. Co.
UNITS, SPEAKER:
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Peerless Radio Corp.
Racon Electric Co.
Temple, Inc.
VOLTMETERS, A. C.:
General Radio Co.
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Westinghouse Elec. & Mfg. Co.
VOLTMETERS, D. C.:
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
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Scovill Mfg. Co.
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Roebling, J. A., Sons, Co.
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Dudlo Mfg. Corp.
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WIRE, TINNED COPPER:
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To the attention of Chief Engineers—Laboratory Heads—Service Managers—Plant Executives:

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

WHY NOT START THIS CIRCULATING AS A ROUND ROBIN?

GROUP RATE—$1.00 A YEAR

THIS advertisement appeared in the March issue of RADIO ENGINEERING.

Twenty-four group subscriptions totalling 272 new subscribers had been received up to the time this issue went to press. One Group contained 22 names.

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QUALITY DONGAN PRODUCTS

Announcing

Dongan By-Pass and Filter Type Condensers

With the acquisition of the business and equipment of the Electrical Specialties Mfg. Company, Inc., Dongan now offers the manufacturers of radio receivers a line of fixed condensers comparable in quality and ingenuity of design to Dongan Radio Transformers.

Mr. C. Ringwald, an authority on condenser design and construction, will direct the condenser division of the Dongan radio line.

Just as Dongan has pioneered in transformer development, so will the Dongan laboratories strive to maintain front rank in fixed condenser design.

Thus the radio industry is assured additional permanency in the approved parts field.

Dongan will continue its policy as an exclusive source to set manufacturers.

—another Transformer Success

To meet the increased capacity of the new UX 250 power amplifier tube Dongan engineers have perfected two new Output Transformers. No. 1176 is Push Pull type, No. 1177 a straight power amplifier type.

A POPULAR A C TRANSFORMER

No. 6512 This is one of the best-liked AC transformers on the market. It is designed to operate with 4 UX 226, 1 UY 227 and 1 UX 171 power amplifier tubes. Mounted substantially in crystallized lacquered case, equipped with lamp cord and plug outlet for B-eliminator, also tap for control switch. $5.75.

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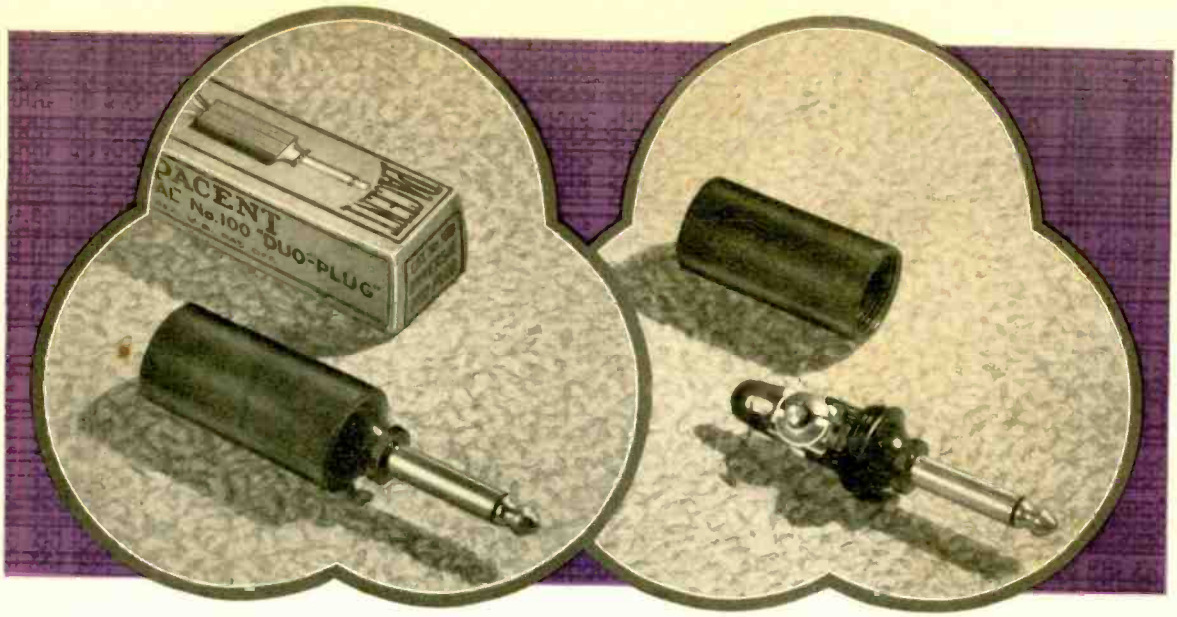
will be furnished with any desired information and engineering data on request.

DONGAN ELECTRIC MANUFACTURING COMPANY
2995-3001 Franklin St.
DETROIT, MICHIGAN

TRANSFORMERS of MERIT for FIFTEEN YEARS



Pacent Duo-Plug formed of Bakelite Molded. Pacent Electric Co., New York, N. Y., Manufacturers.

Note the fine threading and knurling of this Bakelite Molded plug

NO machining or finishing operations are required in producing the three Bakelite Molded parts of this Duo-Plug. Strong, durable threads are accurately formed in the mold, and likewise the knurled surfaces of both the plug and its protecting sleeve. The separator for the binding post is also formed of Bakelite Molded.

Multiple cavity molds are used and from six to ten finished parts are produced in one operation. Like parts are always interchangeable, a distinct advantage in assembling operations. The rich color and lustre of Bakelite Molded adds greatly to the appearance of the plug and makes it easier to sell.

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Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resins for radio uses provides a valuable background for the cooperation offered by our engineers and research laboratories.

BAKELITE CORPORATION

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