NOV.
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SHORT-WAVE CONVERTERS YOU CAN BUILD FROM $5 UP

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WORLD

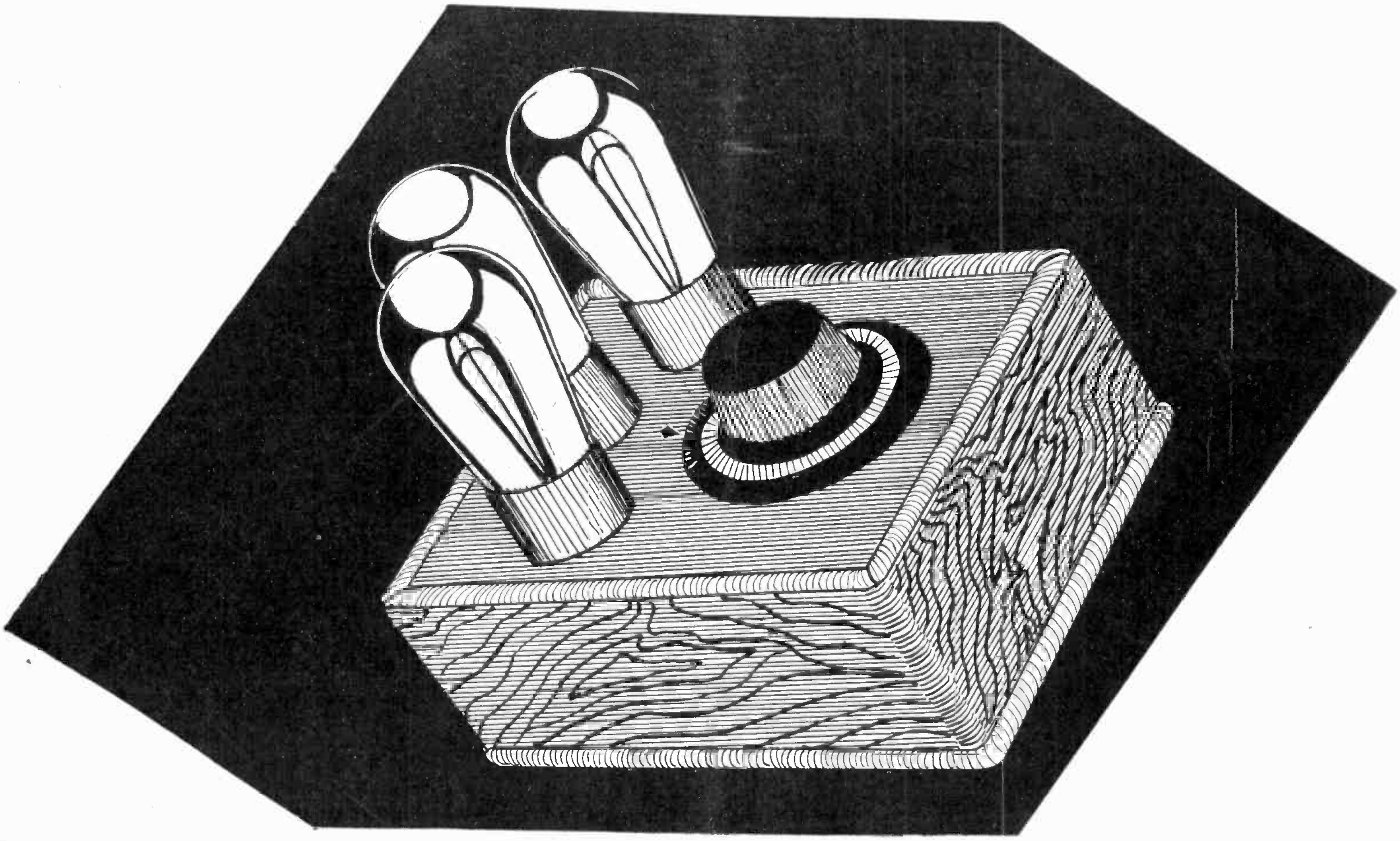
The First and Only National Radio Weekly
451st Consecutive Issue—NINTH YEAR

AN ALL-WAVE EXPERIMENTAL SUPER

TROUBLE-SHOOTING IN INDUCTOR SPEAKERS

DIAGRAMS OF NEW FADA AND STROMBERG-CARLSON

A ONE-DIAL CONVERTER—See Pages 8 and 9



RADIO WORLD, Published by Hennessy Radio Publications Corporation. Roland Burke Hennessy, editor; Herman Bernard, managing editor and business manager, all of 145 West 45th Street, New York, N. Y.

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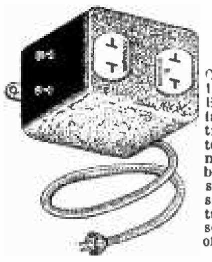

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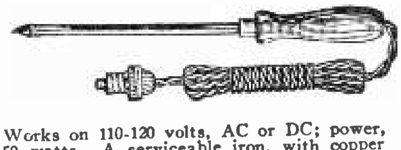

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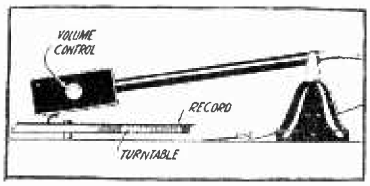

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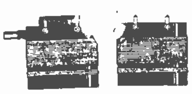

Antenna coil and three circuit tuner (single hole panel mount) for .0005 mfd. tuning. Wound on bakelite. Official coils for all models of Diamond of the Air. Pair for .00035 mfd. - - - $1.26

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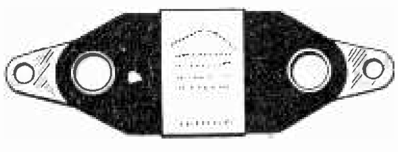

Dubilier Micon fixed condensers, type 642, are available at following capacities and prices:

.0001 mfd.	10c
.00025 mfd.	10c
.0003 mfd.	10c
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.001	17c
.0015	17c
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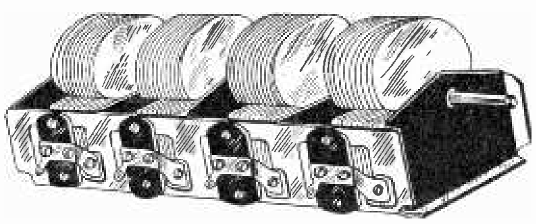

This condenser, each of four sections .00035 mfd., has aluminum plates that are removable and adjustable, also a ¼" diameter steel shaft that is removable. It is sturdy and is suitable for popular four-circuit screen grdi tuners. Trimming condensers are built in. The condenser may be mounted on its bottom or side. Total overall length, including shaft, 11⅞." Overall width, 4". The frame is steel Order Cat. 4-G @...................... $3.95

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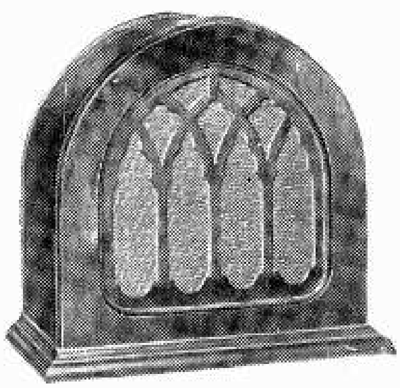

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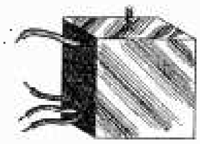

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Three Supertone non-inductive fixed condensers of 0.1 mfd. each, (250 v.) in steel case, provided with a 6/32 mounting screw, built in. The black lead is common to the three condensers, the three red leads are the other sides of the respective capacities. Size, 1½" square by ⅞" wide. Order Cat. SUP-31, list price, $1.00; net price, 57c.

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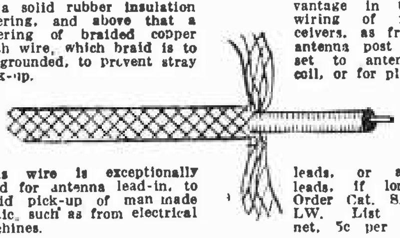

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Also used to advantage in the wiring of receivers, as from antenna post of set to antenna coil, or for plate leads, or any leads, if long. Order Cat. SH-LW. List 9c, net, 5c per ft.

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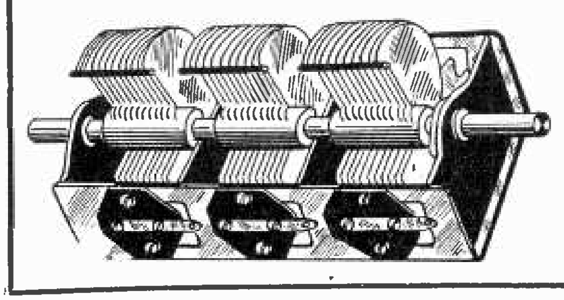

One of the best three-gang condensers made. Plates, utterly rigid and expertly aligned, are of brass, the most expensive metal used for this purpose. Capacity of each section, .0005 mfd. Shaft, ⅜" diameter, of genuine steel, protrudes at both ends. For ¼" diameter dial use an extension shaft (Cat. XS-4 @ 12c extra). Trimming condensers not built in, but mounting holes are provided for them. Condenser should be mounted on narrow side for drum dial operation. Rotor tension adjusters are built in. Frame is steel. Total shaft length overall 8½", total frame width overall, 4⅛". Order Cat. 3-G @ $3.20

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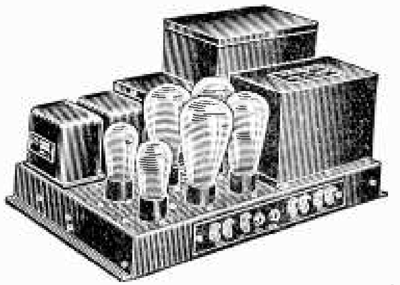
AMER-TRAN'S NEW POWER AMPLIFIERS



The American Transformer Company, makers of superb power amplifiers and components, has a new **and marvelous line of push-pull power amplifiers,** known as the "Series 80."

The six-tube power amplifier illustrated above is a three-stage system, with 227 first and second audio, and 250 push-pull output. Two 281 rectifiers are used, full wave. The first stage is transformer coupled, the second impedance coupled and the third transformer coupled. It is not intended this or any other "Series 80" power amplifier, supply any voltage to any other device, e.g., a tuner. The five binding posts are two each for input and output **and one for ground. The other posts are test jacks.** The input or primary of the first transformer has an impedance of 500 ohms, for general use, including microphone input. Input impedance of 2,000 or 4,000 ohms can be furnished instead, on request. The final output has an impedance of 15 ohms, for dynamic speaker voice coils, but 500-ohm impedance for line transformers and 4,000-ohm impedance for magnetic speakers can be furnished instead, on request.

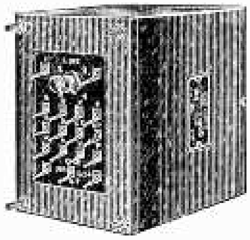
The three-stage 250 push-pull power amplifier is Cat. PA-86 and lists for $195, wired, less tubes. Net price, $114.66.

The three-stage product, with 245 push-pull output, has the same general appearance, audio circuit and impedance factors at input and output, but five tubes instead of six, due to the use of a 280 rectifier. This is Cat. PA-84, list price, $160, wired, less tubes; net price, $94.08.

The five-tube two-stage amplifier with 250 push-pull output, is Cat. PA-85, list price, $180, wired, less tubes; net price, $105.84.

The four-tube two-stage 245 PP output is Cat. PA-83, list price, $145, wired, less tubes; net price, $85.26.

These power amplifiers are highly suitable for theatres, auditoriums, clubs, public address and home use. They are licensed by RCA and associates.



Two types of power transformers by Amer-tran for those who want to build their own power amplifiers are Cat. PB-250 for 250 output, single or push-pull; and Cat. PB-245 for 245 output, single or push-pull.

Cat. PB-250 furnishes power for two 281s and for two 250s. Two B supply chokes are built in. No filament voltage for tuner is supplied.

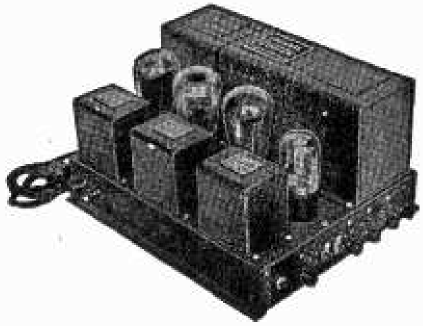
Cat. PB-250 lists @ $35; net, $20.58.

Cat. PB-245 furnishes power for a 280 and two 245s, besides 2½ volts AC for heaters of five tubes. Two B chokes are built in. List price, $32.50; net, $19.11.

Amer-Tran AF Transformers

First stage, de luxe, primary, in detector circuit, has 200 henrys inductance at 1 ma; turns ratio, 1-to-3. Cat. DL-1, list price, $8.00; net $4.70. Push-pull input transformer; turns ratio, 1-to-2½; single primary; two separate windings for secondary; Cat. 151, list price $12; net, $7.05.

National Co. Velvetone Power Amplifier



A 245 push-pull power amplifier especially suitable for powering AC tuners is the new model Velvetone. Uses one 280, one 227 and two 245. Furnishes 2½ volts AC for up to five other tubes, also plate voltages for tuner. Two stages of transformer coupling with output transformer. Cat. PPPA, list price, wired, $97.50, less tubes; net, $57.33.

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Enclosed please find $............. for which ship

☐ Cat. PA-86 @ $114.66	☐ Cat. PB-245 @ $19.11
☐ Cat. PA-84 @ 94.08	☐ Cat. DL-1 @ 4.70
☐ Cat. PA-85 @ 105.84	☐ Cat. DL-2 @ 4.70
☐ Cat. PA-83 @ 85.26	☐ Cat. 151 @ 7.05
☐ Cat. PB-250 @ 20.58	☐ Cat. PPPA @ 57.33

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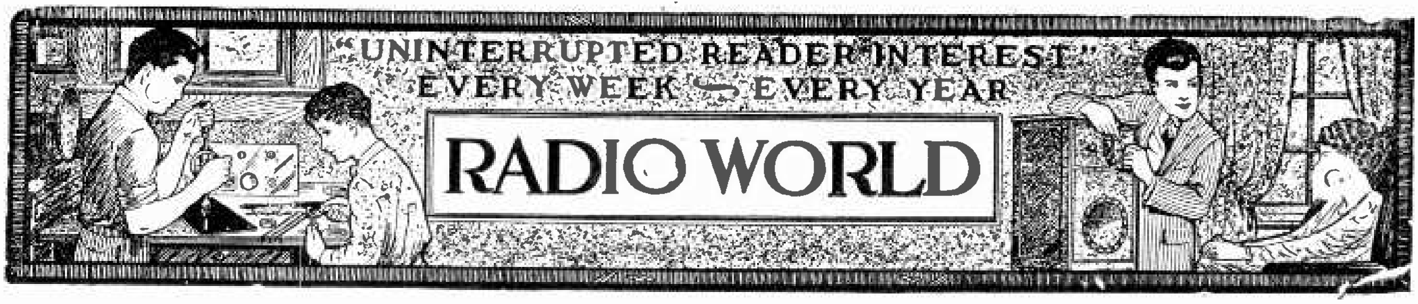

Vol. XVIII, No. 9 Whole No. 451
November 15th, 1930
[Entered as second-class matter, March, 1922, at the Post Office at New York, N. Y., under act of March, 1879]
15c per Copy, $6.00 per Year

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Technical Accuracy Second to None

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A De Luxe Converter

By Brunsten Brunn

IN order to get strong signals with a short-wave converter it is necessary to give the short waves a chance to come through. A converter is supposed to work in conjunction with any broadcast receiver, but the antennas used with such receivers are far from ideal for short-wave reception. Indeed, in many instances they are quite hopeless even if they are good enough to receive signals of broadcast frequencies. In such cases it is either necessary to erect a good short-wave antenna or else to make the converter more sensitive.

It is also desirable to provide at least one tuned circuit for the short-waves. Not only does this increase the sensitivity of the circuit but also its selectivity. One might think that for short-wave reception a high order of selectivity is not needed, but that is not so, for the short-wave bands are crowded more closely than the broadcast band.

In designing short-wave converters there is also the problem of coupling it efficiently to the broadcast receiver without making the receiver into an uncontrollable oscillator. While oscillation in the broadcast receiver is desirable for receiving continuous wave signals, the oscillation must be controllable so that it may be stopped when it is desired to receive other signals, such as spark and modulated signals. Therefore it seems desirable to add a stage of amplification which may be tuned to the intermediate frequency to be used.

Design of Four-Tube Converter

These points were kept in mind when the four-tube short-wave converter diagrammed in Fig. 1 was designed. It starts with an untuned radio frequency amplifier utilizing a screen grid tube. The purpose of this stage is to boost the signals to a receivable level despite the difficulties they have in getting through. Then follows a grid bias, screen-grid modulator with the coupling between the first tube and the modulator tuned to the incoming signal frequency.

The local oscillation is provided by a 227 tube oscillator coupled loosely to the modulator through the screen circuit of that tube. Loose coupling is essential because if the coupling is close the frequency changing oscillator will overload the modulator and there will be nothing but squealing and squawking in the set, especially when the two tuned circuits are set so as to receive a given signal most efficiently, and also when they are set in resonance with the same frequency. While the latter condition would not interfere with reception a raucous noise is not very pleasant. Moreover, when the coupling is close the squawking area may be so wide that it is impossible to receive clearly when the RF tuner is within 100,000 to a million cycles of the frequency of the oscillator. Loose coupling between the oscillator and the modulator is therefore essential. The pick-up coil in some instances has to be used for the purpose of bucking the stray coupling so as to leave the right amount.

Following the modulator tube is a circuit tuned to the intermediate frequency generated by the beating of the signal and the local oscillation. The condenser is connected from the plate to ground to provide a by-pass for the high frequencies at the same time it acts as a tuning condenser for the IF circuit. This tuned circuit is made variable so that different broadcast frequencies may be used as required. It is not necessary to make the tuning range of the coupling circuit equal to that of the broadcast receiver, but only wide enough to allow changes in the IF to avoid interference that may occur, such as image interference with another short-wave station or with a broadcast station that forces itself through.

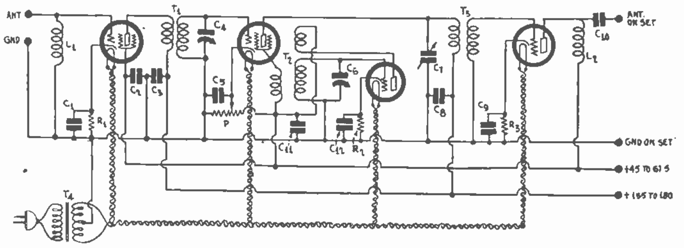

FIG. 1

THE CIRCUIT DIAGRAM OF A FOUR-TUBE SHORT-WAVE CONVERTER WITH ONE SCREEN GRID TUBE RF STAGE, ONE SCREEN GRID TUBE MODULATOR, ONE 227 OSCILLATOR AND ONE 227 INTERMEDIATE FREQUENCY STAGE.

Design of Coils

The coupling coil L1 is a specially made choke coil and consists of enough No. 32 double silk covered wire on a bakelite rod ⅜ inches in diameter to make a two-inch winding. This means approximately 166 turns. Other sizes of wire can be used provided not much heavier wire is used. The idea of this coil is to get an inductance with as little distributed capacity as possible, and it is for this reason that the coil is made long in comparison with its diameter.

T1 represents one of a set of coils of different number of turns wound on tube bases of the four-prong type. In winding the following connections should be observed: G on the coil socket should go to P on the tube socket ahead; P on the coil socket should go to G on the tube socket that follows; F plus on the coil socket should go to ground; and F minus on the coil

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LIST OF PARTS

L1—One small choke as specified
L2—One RF choke from 50 to 85 millihenries
T1 One set of plug-in RF coils as described
T2—One set of plug-in oscillator coils as described
T3—One one-to-one RF transformer as described
T4—One Polo 2.5 volt filament transformer with center-tapped secondary
C1 C2, C3, C5, C8, C9, C11, C12—Eight Supertone .1 mfd. condensers
C4, C6—Two Hammarlund .000125 mfd. short-wave condensers
C7—One Supertone 100 mmfd. trimmer condenser
C10—One .001 mfd. condenser
Five UY sockets (four for tubes and one for oscillator coil)
One UX socket (for RF coil)
R1—One 300 ohm grid bias resistor
R2, R3—Two 1,000-ohm grid bias resistors
P—One 30,000-ohm potentiometer with knob
Two dials
Six binding posts
Two grid clips
Two bakelite or hard rubber panels 7x12 inches

Sensitivity on Short Waves

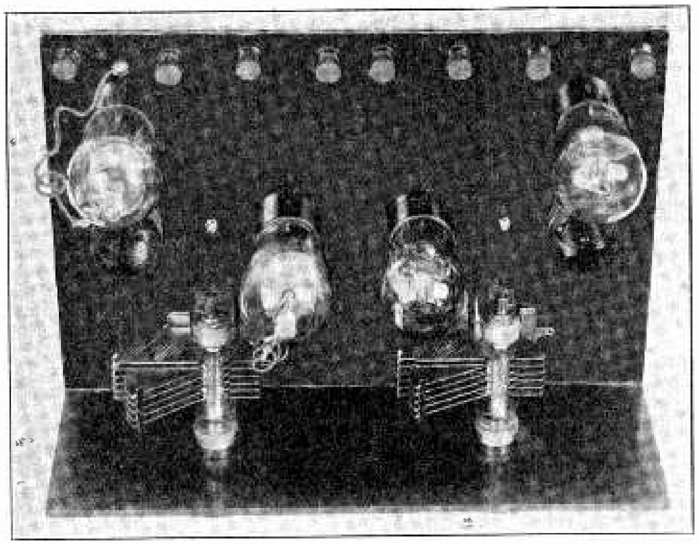

FIG. 2
A VIEW OF THE FOUR-TUBE SHORT-WAVE CONVERTER SHOWING THE LAYOUT

socket should go to B plus. This order of connection is recommended in order to make leads short.

T2 represents one of a set of coils of different number of turns wound on a tube base of the five-prong type. In winding these coils the following order is recommended: G on the coil socket goes to G on the oscillator socket; P on the coil socket to P on the oscillator socket; K on the coil socket to ground; HP on the coil socket to B plus, this prong picking up the terminals of two windings of the coil; HK on the coil socket should go to the screen, that is, to the G on the modulator tube. The use of the same voltages on the plate of the oscillator and the screen of the modulator makes it possible to use a five-prong tube base for the three winding coil.

T3 is an ordinary radio frequency tuning coil as used in broadcast receiver. For example, a coil wound on a 1.75 inch form with No. 28 wire should have about 80 turns for the primary and the same number for the secondary.

L2 is a radio frequency choke coil such as are used in broadcast receivers. It may have 50, 65 or 85 millihenries. All these are obtainable.

Turns for Plug-in Coils

The plug-in coils used in this converter for the oscillator and the modulator were identical with respect to the tuned windings. All were wound with No. 22 double cotton covered wire. The smallest had seven turns, the next eleven turns and the largest 16 turns. The primary of the RF coil and the tickler on the oscillator were also the same as to number of turns and wire. All were wound with No. 32 double silk covered wire. The smallest had six turns, the next nine turns and the largest twelve turns. The pick-up windings on the oscillator form were also of No. 32 double silk. Many coils were tried and the following worked satisfactorily: One turn for the smallest coil, three turns for the middle coil and six turns for the largest. To make the coupling loose few turns should be used and they should be placed as far as practicable from the tuned winding. Of course, there is no particular number or no degree of coupling which gives optimum results.

Correct phasing of the grid and plate coils of the oscillator is necessary. If the two windings are put on in the same direction, say in the direction of a left-handed screw, the plate and grid leads should be the extremes and the cathodes and the B plus leads toward each other. It is well to observe this rule, for it often saves reversing the leads in case oscillation does not result. If the leads are connected as specified above the phasing is right and if there is no oscillation it must be because the tube is not a good oscillator, because the tickler turns are not right, because the voltages are not high enough, or because there is too much loss from eddy currents. The most important condition for oscillation, correct phasing, can be determined by inspection, and it is just as well to dispose of this first so that in case of trouble attention may be given to other probable causes.

LIST OF PARTS

Bosch Model 60 Receiver

Diagram published in Oct. 25th issue

L1—1st RF Coil
L2—1st RF Coil
L3—2nd RF Coil (untuned)
L4—3rd RF Coil
L5—3rd RF Coil
L6—Detector Coil
L7—Detector Plat Choke
L8—Power Pack Filter Choke
L9—Speaker Field Coil .
L10—Speaker Voice Coil
T1—Main Power Transformer
T2—Audio Input Transformer
T3—Audio Output Transformer
C1—Antenna Trimmer Condenser
C2—1st RF Tuning Condenser
C3—1st RF Tuning Condenser
C4—1st RF Alignment Condenser
C5—3rd RF Tuning Condenser
C6—3rd RF Alignment Condenser
C7—3rd RF Tuning Condenser
C8—3rd RF Alignment Condenser
C9—Detector Tuning Condenser
C10—Detector Alignment Condenser
C11—1st RF Coupling Condenser.04 mfd.
C12—2nd RF Grid Return Condenser .5 mfd.
C13—1st and 2nd RF Screen Condenser .25 mfd.
C14—1st and 2nd RF Plate Condenser .25 mfd.
C15—3rd RF Coupling Condenser .04 mfd.
C16—3rd RF Cathode Condenser .5 mfd.
C17—3rd RF Screen Condenser .5 mfd.
C18—3rd RF Plate Condenser .5 mfd.
C19—Detector Grid Return Condenser .04 mfd.
C20—Detector Cathode Condenser 1. mfd.
C21—Detector Screen Condenser .5 mfd.
C22—Detector Plate By-pass Condenser .0001 mfd.
C23—Detector Plate By-pass Condenser .0001 mfd.
C24—Audio Coupling Condenser .006 mfd.
C25—AVC Plate By-pass Condenser .006 mfd.
C26—Buffer Condenser .1 mfd.
C27—Power Pack Filter Condenser 2. mfd.
C28—Power Pack Filter Condenser 2. mfd.
C29—Power Pack Filter Condenser 4. mfd.
C30—Power Pack Filter Condenser 2. mfd.
C31—Filter Choke Tuning Condenser .075 mfd.
C32—Tone Control Condenser .006 mfd.
C33—By-pass Condenser 2. mfd.
R1—Antenna Resistance 500 ohms
R2—1st RF de-coupling Resistor 1000 ohms
R3—Untuned Coil Resistor 50,000 ohms
R4—1st and 2nd RF Grid Resistor .5 meg.
R5—1st and 2nd RF Screen Resistor 20,000 ohms
R6—3rd RF de-coupling Resistor 1,000 ohms
R7—3rd RF Bias Resistor 1,000 ohms
R8—Detector Grid Resistor 1,000 ohms
R9—Detector Bias Resistor 50,000 ohms
R10--Detector Plate Resistor .5 meg.
R11--Volume Control .5 meg.
R12—1st and 2nd RF Center Tap Resistor
R13—Center Tap Resistor
R14—1st and 2nd RF Screen Resistor 20,000 ohms
R15—Resistor 10,000 ohms
R16—AVC Resistor .5 megohms
R17—Resistor 900 ohms
R18—3rd RF Screen Resistor 5,000 ohms
R19—AVC and Detector Screen Resistor 25,000 ohms
R20—Resistor 5,000 ohms
R21—1st AF Bias Resistor 2,000 ohms
R22—AVC Bias Resistor 2,000 ohms
R23—Voltage Divider Resistor 1,300 ohms
R24—Voltage Divider Resistor 2,380 ohms
R25—Voltage Divider Resistor 160 ohms
R26—2nd Audio Bias Resistor 950 ohms
R27—Tone Selector Resistor .5 megohm
R28—2nd Audio Center Tap Resistor

Switching in Short Waves

By Edward Torrey

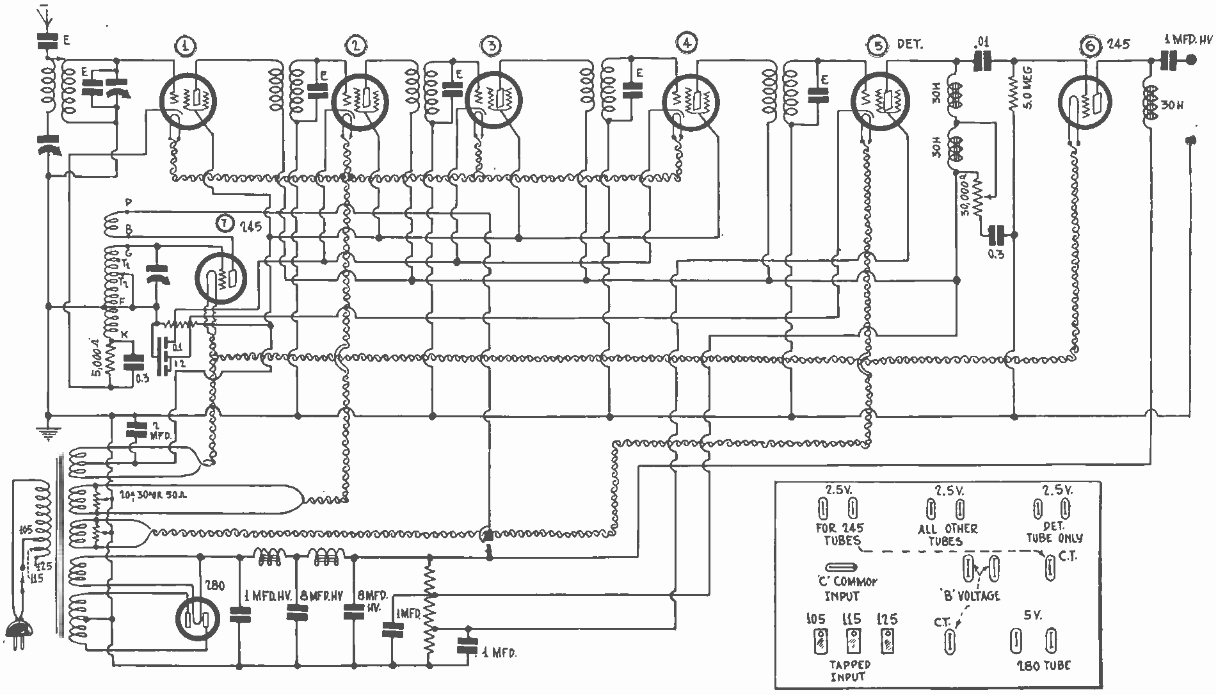

FIG. 1

Circuit using a 245 tube as oscillator, and providing a simple switching arrangement for bringing in short waves, besides broadcasts directly. This switching arrangement may be worked into other Superheterodynes. The two AF chokes potentiometer in the detector plate circuit are the network of a good tone control.

TWO points of especial interest are contained in the diagram of a Superheterodyne published herewith. One is the switching arrangement so that short waves may be received, the other is the use of a 245 tube as oscillator.

The switching arrangement is very simple and requires only a single pole single throw switch and a single pole double throw switch. It is possible to obtain bond and other panel type switches that will include both operations, or rather, all three. When the switch is off, broadcast reception is enjoyed. When the antenna arm is thrown to "on" position, the coil-condenser series circuit in the antenna system is paralleled with the modulator grid, and at the same time the oscillator grid winding is shorted sufficiently (at tap 2) to bring in stations starting at below 200 meters. Then when the switch in the oscillator grid coil is thrown to tap 1, the other switch, in the aerial circuit, is undisturbed.

Small Antenna Winding

The values chosen for the antenna circuit must be such as to render operation of the system practical. The antenna winding must be small. As the receiver will be very sensitive, this is all right. An idea of what is meant by a small coil may be gained from the fact that if the diameter is 2 inches the number of turns should not exceed five. This is about one-fifteenth of the number of turns on the secondary for .0005 mfd. tuning.

By the way, the coils in the modulator and oscillator circuits need not be shielded, except as a preventive of radiation that might be strong. If one coil is shielded the other must be shielded, for no other reason than to make uniform tuning possible with a three-gang condenser. The condenser has three sections, one section being used as a series condenser from the antenna winding to ground.

The use of the 245 tube as an oscillator in broadcast receivers and especially in short-wave receivers is novel. The power developed is great, and there would be danger of overloading the modulator even with a fraction of the oscillator's power, were leak-condenser detection used, hence the diagram shows negative bias detection, which will arise from 3 volts negative on the screen grid tube with 180 plate volts and 50 screen volts. This same 50 volts, turned about, is the negative bias on the 245s, the one in the oscillator socket, the other in the first and last audio stage (for there is only one stage of audio).

Works Loudspeaker

Enough volume will be obtained from this system to enable speaker reproduction with only one stage of impedance-resistance audio, provided the intermediate channel is high-gain. This channel is built to function at around 450 kc, and the coils may be any coils intended for broadcast tuning with screen grid tubes, which means a large number of primary turns, say a ratio of 1 to 2, primary to secondary. To attain 450 kc., use coils intended for .00035 mfd. tuning and put across their secondaries fixed condensers of .00035 mfd. capacity (not shown), and across in parallel, equalizing condensers E of 20-100 mmfd. capacity range. You can use the intermediate channel to tune in directly the lowest broadcast frequency, 550 kc. (545 meters), and set the condensers for resonance at this frequency by equalizer adjustment. Then when the circuit is completed and you are ready to work the Superheterodyne, turn the equalizers almost all the way down (full capacity), the correct position for each being determined by loudest response when a high frequency broadcasting station is tuned in, anything from 1,500 to 1,000 kc.

The same resistor that biases the oscillator must bias the output tube, due to the common filament winding. It would be possible to use a lower bias or higher bias on either by returning the grid of one or the other to higher than ground potential. However, if any difference is desired it is more readily obtainable in the plate circuit, so if the 245 oscillates too much (which it will do, rather than too little), you may reduce the plate voltage, which is shown as maximum, 250 volts for both. The oscillator plate voltage may be reduced even to 180 volts, by connecting the oscillator plate return to the same return as for the screen grid amplifier tubes and the detector.

Automatic Volume Control

The single resistor, or combination of resistances, is made to serve multiple biasing purposes: oscillator and output tube, intermediate frequency amplifiers and detector. The total resistance should be about 600 ohms, the tap for the intermediates being at 20 ohms and that for the detector at 200 ohms, leaving the remaining part, 380 ohms, or a 400-ohm commercial value is O. K.

Automatic volume control results from this system of biasing, as increased carrier intensity increases the plate current through the combination biasing resistor and thus increases the bias and reduces the effective amplification.

As for coil data, the modulator input uses a standard type of coupler with primary reduced to five turns. To wind your own on 1¾ inch diameter bakelite tubing, using No. 25, 24 or 22 size of single silk-covered wire, five turns and 70 turns would be right for .0005 mfd. tuning. The oscillator coil would consist of the following, assuming the same diameter and wire: PB, 12 turns; G to tap T1, 6 turns; tap T1 to tap T2, 6 turns; tap T2 to F (ground), 58 turns; F to K, four turns. The short wave spectrum will be for tap T1, about 28 to 65 meters, tap 2, about 55 to 120 meters, the principal reason for the large overlap being that strong signals may be tuned in at two places on the dial, 900 kc. apart (equal to twice the intermediate frequency).

Reason for Small Antenna Coil

The voltage divider ratio is approximately 2-to-1 between high voltage and 180-volt tap (1), and between 180-volt tap and ground (2). The tap for the detector screen grip about one-third the way up on the lower section. The total voltage divider resistance must exceed 15,000 ohms to keep the bleeder current from being too large. Around 20,000 ohms was assumed. A multi-tap voltage divider, 17,100 ohms, will serve the purpose nicely. The voltage points may be determined with the aid of a voltmeter of 1,000 ohms per volt resistance.

Construction of $5

By Herman

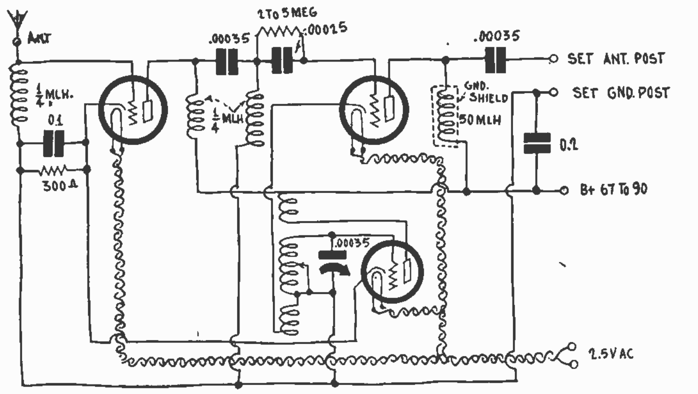

FIG. 8
THE AC MODEL CONVERTER THAT CAN BE BUILT FOR LESS THAN $5, NOT INCLUDING FILAMENT TRANSFORMER AND THREE 227 TUBES.

[In last week's issue, dated November 8th, the first instalment of this article was published. The text set forth the theory and practice of short-wave adapters that simply plug into the detector socket, stressing the possibility of non-operation being too great, due to differences in receiver detector plate load and voltages. Four adapter diagrams were printed. Then the short-wave converter, which makes a Superheterodyne of any broadcast receiver, was expounded. Six diagrams of these were printed, for AC or battery operation, emphasis being placed on one model for each type of operation, consisting of parts costing less than $5. Details of constructing these are given this week.—EDITOR.]

There are three unusual features of the converters shown in Figs. 8 and 9.

One is the use of a radio frequency choke coil of extremely low inductance in the plate circuit of the RF amplifier. It is generally considered proper to use a choke coil of around 5 or 10 millihenries, or thereabouts.

Taking a 10 millihenry choke coil has the example, in a circuit like the one shown, the natural period was computed to be slightly in excess of 400 meters. Now, that is a frequency we are not at all interested in, at present, and moreover the converter is robbed of its birthright of sensitivity by the introduction of such a high distributed capacity which acts as a shunt to ground for to very frequencies desired to be received.

The inductance value of the choke coil should be small, and one-quarter millihenry is suggested, although other values in that region are satisfactory, provided the distributed capacity is kept low. Since the distributed capacity is greater approximately in proportion to the diameter, a choke coil wound on a slender form would serve the purpose best. Such a choke is referred to as the pencil type, since the form has the shape of a short pencil.

Output Choke

A form of ⅜" diameter bakelite tubing may be used, and wire wound thereon so that the axial length is about 1 inch. The wire may be as fine as No. 40. Inductance depends on the number of turns of wire, so if larger wire is used, for the same winding space, the inductance will be less than if smaller wire is used. If you have No. 38, 36, 34. 32, or 30 wire you may use that. No. 40 enamelled wire winds 278 turns to the inch with an inductance of 234 microhenries for ⅜-inch diameter. The impedance is 4,225 ohms at 100 meters.

In the output circuit a regular radio frequency choke coil, as made for broadcast frequencies, may be used, say, 50, 65 or 75 millihenries, since here the frequency to be transferred is a radio frequency of broadcast proportions, and not the enormously higher frequencies of short waves.

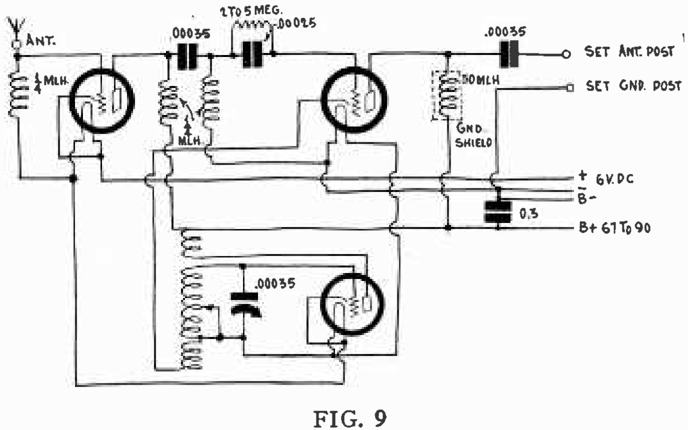

FIG. 9
THE BATTERY MODEL CONVERTER.

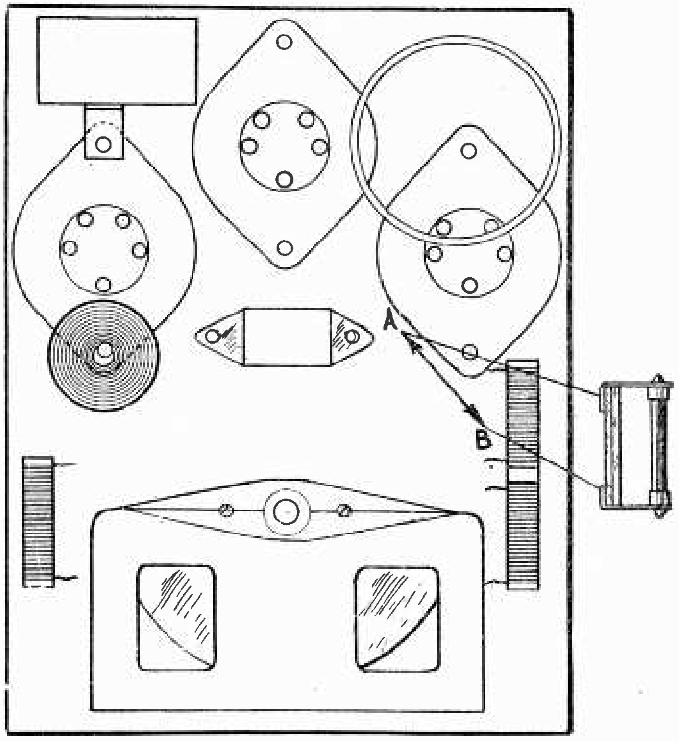

FIG. 11
LAYOUT OF PRINCIPAL PARTS FOR FIGS. 8 AND 9.

The second unusual feature is copper shielding of the output choke coil. This serves to reduce the effective strays the detector, since it is desirable to have the strays here at minimum.

The third unusual point is the method of coupling modulator and oscillator. The cathode lead of the modulator is interrupted on its way to ground by one of the windings of the oscillator coil. The modulator plate current flowing through this pickup coil sets up a magnetic field, and thus the interlink is established with the oscillator secondary, to which the pickup winding is in close inductive relationship.

Non-Critical Coupling

The coupling is not critical, and even the same degree of coupling may be used for the whole short-wave spectrum, say, 15 to 200 meters, although a little more sensitivity results when the coupling is made looser for the higher frequencies, or waves from 15 to 40 metres or thereabouts. Hence a movable coil, permanently placed in the converter and readily accessible, although not necessarily from the front panel, may be used.

Plug-in coils, is used, which go in turn in the same receptacle, need have only four prongs instead of five. If tube base type coils are used, the five-prong bases should be employed. Since two of the windings go to ground, use of the special six-prong base and special socket therefore is avoided.

In the simplified circuit recommended for use the plug-in feature is avoided, by the switching arrangement, and coverage from about 20 to 110 meters is obtained, which is a good working range, particularly in a device the parts for which cost $5 or less. Also, the coupling is fixed, between modulator and oscillator, at 2 turns. This worked well. The coupling is unity, anyway, as the modulator is not tuned.

Grid Leak Values

Nor is the value of the grid leak critical. The circuit diagram shows a grid condenser, intended to be of the type with the clips on it, so that a grid leak may be inserted between the clips. The values given are from 2 to 5 meg. Also, a 2 meg. leak may be substituted, from grid, condenser to ground and as the two leaks are in series, their resistance values add up. Hence the leak value actually used will be 2 meg. plus whatever value is inserted between the clips. Good volume and sensi-

Short-Wave Converter

Bernard

tivity are provided by 2 meg., although usually a few megohms more increase the volume. It is not possible to omit the leak between clips altogether, in this circuit, for then the grid would not be returned to grounded DC potential, the grid condenser serving to interrupt this return. This might not stop reception entirely, but certainly would impair it.

Panel Arrangement

The top panel for the converters discussed in connection with Figs. 8 and 9 last week, issue of November 8th, is 5 inches wide by 6½ inches long. The three sockets are arranged at top. You may provide four binding posts for the connections to aerial, B plus, antenna post of set and ground post of set, or, instead a four-lead cable may be used, for the AC model (six leads, if heater connections are cabled). For the battery model, instead of four binding posts, a six-lead cable is optional, also.

How most of the parts are arranged is shown in Fig. 11 herewith. The small radio frequency choke coils are placed as far from the top panel as possible. This places them about on the same plane as the rear frame of the tuning condenser. The object, of course, is to keep "hot" potentials away from the hand when tuning. A model was made with these chokes near the dial, and no body capacity was experienced except at wavelengths below 49 meters. However, it is just as easy to avoid body capacity down to the lowest wave that you can tune in.

Must Use Small Chokes

To be able to tune down lower than 40 meters it is imperative that small choke coils be used, except in the output. Hence there are three such small chokes, one in the antenna-ground lead, one in the plate circuit of the radio frequency amplifier and one in the grid circuit of the modulator. Two of these chokes for space reasons may be on the same form, adding a little inductive coupling to capacity coupling between the radio frequency amplifier and the modulator.

Considering the AC model converter, Fig. 8 of last week, reprinted herewith, the three small chokes are marked "¼ millihenry," and may be wound as specified. They need not be shielded. But the choke used in the output circuit has an inductance of 50 millihenries, since the intermediate frequency is involved here, and this choke has a shield, which shield should be grounded.

Be careful to connect ground wherever shown. The first precaution is to run a lead from the ground post of the converter to the frame or rotor connection of the tuning condenser, and this should be of heavy-gauge wire, no less than No. 18 solid, or its stranded equivalent.

Coil Data

One coil is used in the converter, and it is put in place permanently. Instead of plugging in two coils, a switching arrangement is used. When the switch is "in," the switch circuit is open, and the tuned secondary consists of eight turns. When the switch is pulled "out" the switch circuit is closed, and two of the eight turns are shorted out, leaving six turns effective, enabling tuning down to a little more than 20 meters. As stated previously, there will be no response at the lower wavelengths unless the three choke coils marked "¼ millihenry" have an inductance something in that neighborhood.

The coupling of the modulator and oscillator is effectuated by means of a two-turn winding. Thus when the oscillator coil is wound it will consist of a tickler, that provides oscillation; a tuned secondary with tap for switch to be cut in, and a pickup winding, which is a continuation of the winding that constituted the tuned secondary. Assuming the use of a 1¾-inch diameter bakelite tubing, 1 3/16 inches high, wind eight turns of No. 25 single silk covered wire for the tickler; leave ⅛ inch space or less, and in the same direction wind two turns of the same kind of wire; tap, wind two more turns; tap, and then wind the final six turns. Viewing the coil from top to bottom, the connections are, first to plate of the oscillator, next to be B plus, next to cathode of the modulator, next to ground and one side of the switch, next to switch tap and other side of switch; next to oscillator grid. Fig. 12 exemplifies the coil winding. If you haven't No. 25 single silk covered wire you may use No. 24 single silk or single cotton covered. The oscillation intensity is strong enough to support the use of any small diameter wire down to No. 28.

Coverage in Wavelengths

With a tuning condenser of .00035 mfd. capacity, the circuit will tune from about 110 meters to 20 meters. The range is much larger than would be expected, due to the high intermediate frequency recommended. This will be around 1,500, 1,600 or 1,700 kc., depending on the highest frequency to which your broadcast receiver will tune.

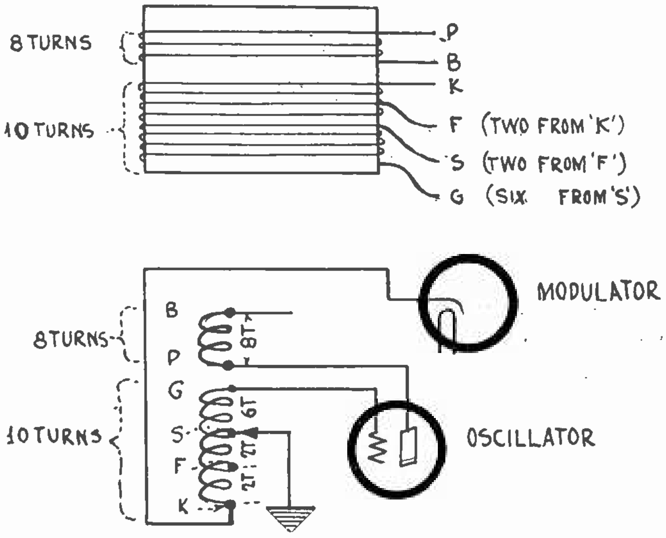

FIG. 12
ILLUSTRATED FACTS ON COIL WINDING. THE DIAMETER IS 1¾ INCHES. CONNECT SWITCH AS SHOWN IN FIGS. 8 AND 9.

The oscillator will bring in strong stations and some weak ones at two points on the dial. This fact enables wider wave coverage. The extension arises from the difference in the two settings of the oscillator being twice the intermediate frequency. Assuming 1,500 kc. intermediate, then W9XAA, the short-wave transmitter of WCFL, Chicago Federation of Labor, operating on 6,080 kc., or about 49½ meters, came in at 2 on the dial and again at 18. Hence 2 on the dial represented the higher oscillator frequency, using the oscillator frequency (F1) minus the incoming frequency. F1 = 1,500 + 6,080, or 7,580 kc., about 40 meters. The intermediate frequency was developed by subtracting the incoming frequency, 6,080, from the oscillator frequency, 7,580.

The lower frequency setting of the oscillator (F2) was established, using the incoming frequency less the intermediate frequency. Therefore the F2 was 6,080 — 1,500, or 4,580 kc., about 67 meters. The two are 37 meters apart.

It can be realized therefore that there will be a response when the oscillator frequency is subtracted from the modulator frequency or when the modulator frequency is subtracted from the oscillator frequency, and this double situation gives rise to the two repeat points.

Calibrating Set

Also, if you know the intermediate frequency, you are aided greatly in calibrating the only tuning dial used. The two repeat tuning points are separated from each other by twice the intermediate frequency, and since it is easy to find and use 1,500 kc., you know that the two points, 2 and 18 on the dial, constitute a difference of twice the intermediate frequency, or 3,000 kc. If you know the frequency of one point on the dial you can therefore tune in the station at the other point, and establish that frequency for calibration.

Not all stations can be brought in at two points, for the only point may be that where the oscillator setting is higher in frequency than the signal frequency, and near the zero end of the dial, and it is not possible to tune sufficiently higher.

There is more volume at one or the other of two oscillator settings, usually when the oscillator is tuned to the higher frequency (lower capacity of the tuning condenser, lower numerical reading of the dial). Hence you will tune for a station at the same dial setting all the time, unless interference develops, which may not show up on the other though weaker settings. Always use the same intermediate frequency so that the same dial settings of the converter will be applicable to the same short wavelengths.

No vernier dial is needed, since you can tune in a station on the converter dial, and for closer tuning use the dial of the broadcast receiver. The broadcast set's dial need be just barely touched to bring the converter and the set to resonance at the intermediate frequency. This slight vernier adjustment need not be considered as changing the intermediate frequency, as the change is so trivial, represented by perhaps one-eighth of a division of the broadcast set's dial.

Best Results on Full Coil

With the switch "out," the full eight turns used on the tuned secondary, most stations will be received, as most persons

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Repair of

By Wadsworth

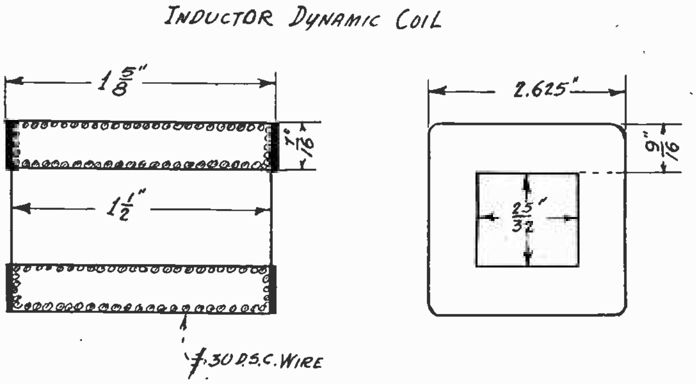

FIG. 1
DETAIL SHOWING HOW TO REWIND MAGNET COILS FOR REPAIR OF COMMERCIAL INDUCTOR SPEAKERS.

SERVICE MEN'S GUIDE

THERE are many who have a loudspeaker of the Farrand inductor dynamic type which has given excellent service, but of late may have lost volume, or developed some kind of defect that makes the quality of reproduction seem tinged with a rasp or rattling sound that was not there at first. The same general directions apply to magnetic speakers.

Strange as it may seem, the source of ill performance of either the magnetic or the inductor dynamic unit is frequently the presence of plain ,ordinary dirt, which usually lodges in the small spaces in the unit interior, in between the coils, or between the coils and casing, and sooner or later some of this gets in between the space in which the armature oscillates. If enough dirt accumulates the operation of the armature is seriously interfered with, and since the dust particles usually contain some magnetically constituted matter it is not hard to see why the dirt gets wedged in. It is only natural that the removal of these impediments to armature motion is imperative, but their presence might not be suspected, and usually is not.

Taking the Unit Apart

The only way out is to take the unit apart, an operation that is not difficult for anyone who has mechanical ability. The principal requirement is that you be careful in all that you do.

The first step is carefully to unsolder the phone cord terminals, which are usually differently colored, noting at the same time the posts to which they are attached, so that correct replacement is assured. Next unsolder the coil terminal wires. You will find that one of them is longer than the other, hence identification is easy. Finally, the connecting wires that join the two coils are to be separated, care being taken not to use too much heat, and not to subject the coil leads to excess mechanical strain.

Remove the magnets, which are usually held in place with one long screw, with a clamp nut to hold them tightly. In some units this is supplemented with hardened tipset screws. Magnetized particles held in place by the flux will fall away when the magnets are removed. Some of them will cling to the magnet poles, and are to be removed with forceful wiping with a dry cloth free of lint.

The remaining assembly, consisting of the pole shoes, armature and frame, is usually taken apart by loosening the armature clamp screws, removing them if necessary, and sliding out the pole shoes, which are in most models clamped by the same screw that holds the magnets in place.

The pole shoes are to be wiped with a dry cloth as before, and and magnetized particles adhering are to be picked off one by one if not removable by any other means.

Remove Rust

As the surface of the armature that fronts on the pole faces is likely to collect a coating of rust, especially if it is not coated with lamination varnish ,this coat of rust is to be removed with a fine flat file. Care must be taken not to file any of the armature metal. Merely remove the rust. If you have or can obtain some amyl acetate clear lacquer, you should coat the clean surface with a thin layer of this, which will prevent the formation of further rust. This pertains to the faces of the pole shoes, too, should they be similarly affected.

As a general precaution the frame of the unit may be cleaned off, and if any liquid cleaning fluid is used it is suggested that it be carbon tetrachloride (Carbona), as this substance is devoid of any deposit after it has evaporated.

The coils are usually free of stuff that clings, but they may be dusted with a camel's hair brush, preparatory to reassembly of the unit.

This operation is the reverse of the former, in most details, except that the necessity of cleanliness is paramount, and no vagrant iron chips are to be tolerated.

First loosely assemble the coils and armature and slip the pole shoes over them. Then place the whole on the frame.

Obtain some .005 inch bond paper that is smooth, and cut out four spacers that each just fit the width of the pole shoe. They are to project down over the pole shoe face. The purpose is to space the airgaps in which the armature oscillates. With four of these spacers the gaps will be all alike. If separate pole shoe clampscrews are provided, these are to be tightened, with the armature held tightly in position between the pole shoes by means of finger pressure.

Next the magnets are to be assembled to the unit frame, and the coil lead connections are to be resoldered. The phone cords are attached and lastly, the paper spacers are removed. The unit is ready to be tried out.

Unit Operation Improved

Some improvement will be found in the operation of the unit, but if the volume should be low, some further work will be necessary, and fortunately it is not difficult. The fruit of your work is immediate.

Permanent magnets suffer from a malady that is called fatigue and it is generally worse with a poor magnet than with a good one, a seemingly logical conclusion, but it is also dependent upon the air gap distance, a factor that introduces some leakage loss into the case. Since we have to have an air gap so that the unit will work, this form of leakage loss is always with us.

How to offset it, and what benefits accrue from the remagnetization of the magnets, is the subject of the following.

Re-magnetization Boosts the Volume

The inductor dynamic unit in mind is one that is equipped with two permanent magnets, which provides four legs on which exciter coils may be wound. These are to be left in place permanently, as the removal of the magnets after treatment merely will precipitate them to the same condition in which they formerly were.

The problem now is to decide what coils to wind, and what the exciting current shall be.

The first serious limitation that we run into is that there is not very much room in which to wind an exciting coil, and the

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Coil Performance On Short Wave

(Continued from preceding page)

will listen at night, when wavelengths of 35 to 120 meters come in strong. Below 35 meters there is little to be heard at night, and around 20 meters next to nothing, due to the peculiar behavior of the lower wavelengths at night. During daylight, however, stations on the lower wavelengths should be received.

Bear in mind the poor reception of the low wavelengths at night when testing to determine whether your converter functions at all on these wavelengths. Do not reach a negative conclusion until after several hours of testing during daylight.

The same coil winding data apply both to the AC and the battery model converters. Series connection of the heaters for battery operation enable the use of a 6-volt storage battery, giving each tube 2 volts, which is sufficient. The bias arrangement is taken care of by connecting the grid returns as shown in the diagram, Fig. 9.

Either the AC model, which will work on any set, battery-operated or otherwise, or the battery model, which likewise will work on any set, can be built of parts costing less than $5, which is a real invitation to get into the short-wave swing. In the one case a 2½-volt filament transformer, the secondary of which need not be center-tapped, is required, and in the other instance a 6-volt storage battery.

The $5 converter will give good performance. Foreign countries are better than the United States for short-wave reception. Caribbean Islands, Central and South America are particularly good, no converters will work to the Queen's taste. France, Britain, Germany are fertile fields. Canada is about on a par with the United States. The North America continent can be covered splendidly, television included in the reception. Once in a while a voice from Europe may be expected. But the most favored nations should hear regularly from **Europe.**

Inductors

C. Jamieson

next tem is that it is a toss-up as to whether we shall consider making four exciting coils of medium size or two larger ones, mounting one on each magnet leg. This question revolves around the room taken by the minimum number of turns necessary to create additional flux in the air gap, and one of the unknown factors in an equation that can help us to find out the number of turns required is the permeability of the steel of which the magnet is made.

Distances Defined

The distance between the two magnets of the inductor dynamic unit that is under consideration is 1 1/10 inches, and the maximum overall length of the coil can not exceed 1¼ inches. If the end insulation is 1/32 inch this leaves 1 1/32 inch, and if one wrap of insulation 1/32 inch thick is used the thickness of the insulating tube will be 1/16 inch on one side. The end pieces are made of 1/32 fibre stock and are 1 11/16 inch square.

Then there is the center cutout, dimensions obtainable from the foregoing, but the method of the cutout is to lay out the rectangle, in pencil, then draw cross lines from the corners so that they intersect at the center. Then cut out along these lines, and bend the resulting four flaps at right angles to the first surface. These flaps are to be glued to the fibre tubing that you form when you bend the flat 1/32 stock around the magnet leg. The result of this work is fibre spool, for which you make a little wooden form the same size of square as the magnet, but with 2-inch square end pieces, one of which is removable, and the other fixed so that you can slip the finished coil off when it's wound.

An additional prerequisite to a self-supporting coil is that you glue a piece of thin cotton tape on each side of the fibre tubing, leaving loose flaps on each end which you place in the turns of the coil during the winding process, in such a way that the effect is that of the tape being woven through the coil for self-support.

The finished coil is to be dipped in thin shellac and allowed to dry. Its use does not hamper the assembly of the unit in any way.

Two Coils Versus Four Coils

The extent of the stray field of the coils is what really influences the choice between two coils and four coils because when it is desired to increase the magnetic field of a permanent magnet, the two poles must be magnetized oppositely. The stray fields tend to neutralize each other to the extent that the various stray fields are coupled, and this depends on the proximity of the adjacent turns of the coils to each other.

In the case under consideration calculation or experiment will show that there are very definite limits to the radius of a coil that will provide the greatest magnetizing power, and it is not difficult to show that four coils provide less net magnetization due to the influence of the stray fields than do two, and as the space available for the windings is a not inconsiderable function of the separation of the poles of the magnet, it follows that here is another source of leakage. It need not be enhanced by a greater loss due to poor coil design.

FIG. 13
ONE DIAL TUNES THE $5 CONVERTER.

Making the Coils

The magnet is one of the U-shaped kind, and is 3 15/16 inch long. The poles are ¾-inch square. The center to center distance is 2¼ inches, and the available room for the magnetizing coil is 1 11/16 inch along the pole leg. Of course there is room for two coils on the legs of each magnet, of which there are two used in this unit, though we will use only one on each magnet.

From the foregoing it is understood that you are to make up a coil winding form of 1/32 fibre sheet. Indeed, it has been found that end pieces 1/16 inch each may be used, and they will help out because of the added support they provide.

The wire size selected is No. 30 D.S.C., whose mean outside diameter is .013 inch, and as the overall length of a layer is 1½ inches, there are 115.3 turns, but you will not wind so close, hence 115 will be about right, and the overall thickness of the coil is 7/16 of an inch. As 1/16 inch equals 62½ thousandths, the total thickness of the coil, per side, is 438 thousandths exclusive of the insulation tube, and therefore the total number of layers is 31, and the total number of turns is 115 times 31, or 3,465.

The resistance of the wire per foot is about .1 ohm, and the finished coil is around 20 ohms and therefore if the exciting voltage is 12 volts, the current per coil is .6 ampere, and the ampere turns are 3,465 times .6 or 2,079, and as two coils are used the current is cut in half, but the turns are multiplied by two, so the ampere turns are the same.

Connect the Coils Correctly

Since you are going to use a not inconsiderable power, care must be taken to assure the proper direction of flow of the magnetizing current.

The best way to do this is to make a simple test with a dry cell, holding a piece of lamination so that it is attracted by the magnet pole, and then close the coil-dry cell circuit.

If the polarity of the coil is correct there will be a slight attractive force felt, which indicates correct polarity, and the coil lead connections to the dry cell are to be noted and the positive lead of one of the coils is to be connected to the negative lead of the other, leaving a positive and a negative lead, which may be led to a terminal board, for subsequent connection to the exciting source.

If the lamination strip is repelled the polarity is wrong.

The two coils are to be placed diagonally opposite poles, that is to say, one on the north leg of the left hand magnet and the other one on the south leg of the right-hand one.

If you have a single magnet type of unit, it will be correct to use two coils and the dimensions may be the same if the magnet steel is of the same dimension as these just presented, but if the separation between the pole lgs is less by say ½ inch, the coils will have to be changed, and if the pole legs are less than an inch apart, and the overall length of the magnet is such that you cannot use more than an inch of the leg on which to wind a coil, the practical advantages of the use of a magnetization coil do not warrant its construction.

The coils previously described will increase the volume of all inductor dynamics considerably and if you have aligned the unit, and particularly the armature that drives the cone, taking care to see that it is parallel to the poleshoe faces, and also level with them, top and bottom, the reconstructed units' performance will repay you for your trouble.

Ordinary Magnetic Units

The foregoing instructions are for the inductor type of loudspeaker unit, but they also apply to the case of the plain magnetic unit, since the two are after all not so very different essentially.

The inductor has a two part armature that is made up so that the top and bottom bars are level with the upper faces of the poleshoe assembly whereas the plain magnetic units armature is one solid piece in most cases.

There was a tendency for the designers of these units to ignore the presence of Coucault currents in the armature structure and it is now known that this low potential, but high density current had a detrimental effect on the quality of reproduction, and the solution of the difficulty was to separate the armature into two parts, i.e., arrange it so that the flux reactions of the upper two poles would be quite distinct from each other.

This was accomplished in the design of the inductor unit.

But to return to our story, if you have a magnetic unit that is not providing the volume it once used to, you can rehabilitate it in much the same manner that the foregoing instructions provide, the only variations that you will find in practice are the length of the magnet poles, and the cross section of them.

The Birth

By *John*

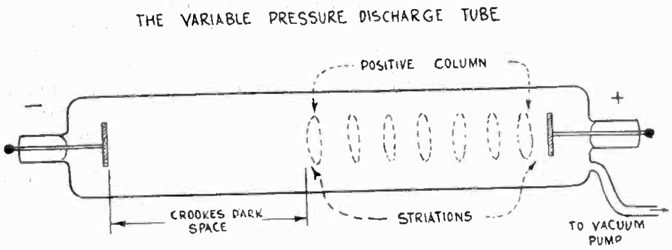


FIG. 1
THE VARIABLE LOW-PRESSURE DISCHARGE TUBE BY WHICH MEANS THE BEHAVIOR OF A GASEOUS DISCHARGE CAN BE STUDIED. A U-SHAPED PERMANENT MAGNET SLIPPED OVER THE TUBE DEFLECTS THE DISCHARGE AT RIGHT ANGLES TO THE POLAR AXIS.

THE progress of the various arts that contributed to telegraphic and radio communications systems is seen as a kind of shared responsibility that the various scientists assumed.

We have also seen that the outstanding contribution to the development of radio communication has been made by those who concentrated on the subject of radiation for a number of years, with the ultimate result that the foundations of all modern theory and practice were laid, and from this has sprung the diversified matrix of modern communications science.

The vacuum tube is a tool of forms and uses now believed to be limitless in application, and though the physicists of the years to come will achieve epochal distinction due to their labors in this field, the labors of those who laid the foundation should remain enshrined.

A resume of the last thirty years of the commercial development in radio transmission yields but a very small fraction of the history of the underlying principles of the art, largely, no doubt, because attention to the vast mass of detail would entail the publishing of a volume of stupendous size.

Radiation Is of Intense Interest

Ever since the laws of radiation weer successfully expounded and applied by Huygens, and later by Young, interest in the nature of the radiations of the heavenly bodies was stimulated, and when the time came when it was possible to duplicate the sun spectra by artificial means, still further impetus was added to the development of that subject which up to the present day remains one of the principal keys by which physics unlocks new realms of knowledge not only for the radio art, but other arts as well.

Radiation and Electrons

The reader has heard of electrons, but the subject of radiation is likely to be foreign, and on this account some explanation will be in order.

Mostly all substances, when at a temperature that we know as the absolute zero, i. e., minus 273 deg. Centigrade, are in a state of molecular quiescence, but at all other degrees of temperature above this one there is molecular activity that depends upon the chemical activity of the substance. The activity of various substances varies widely at temperatures not far removed from absolute zero.

This statement is relatively true of any comparison made between two substances in air, versus the same comparison in vacuo, though a comparison of the degrees of activity of the given two cases, one in air and the other in vacuo, would not necessarily provide the same conclusion.

Higher Temperature Increases Activity

But in general the activity of a substance increases as the temperature increases above the absolute zero, so that some substances at, say, normal temperature, are very unstable, an example of which is the metal sodium, which exists naturally only in combination with some other substance, but the most common form of which is sodium hydroxide.

Metallic sodium is usually prepared, and will keep only when submerged in gasoline or kerosene, hence you can gain some idea of its activity.

There are some other metallic substances that display the activity which, though not as great as that of sodium, is controllable, and hence available for our study in connection with the vacuum tube.

Molecular activity at room temperature also means that the components of molecules are also subject to motion, and, in fact, are in a state of transit, as is provéd in the case of metallic substances that readily conduct a current of electricity under these conditions. Molecular activity is now regarded as a wave motion.

With suitable detecting means ,then, it is possible to detect, as the temperature goes up, the presence of some of these components of colecular activity about the exterior of the sample, which may be a wire.

And in accordance with the foregoing, the type of activity around the wire is dependent upon some chemical constants.

But to find out where radiation fits into the vacuum tube story, we will have to consider a wire we are slowly heating. We find that as the temperature is increased a point is reached where the effect of this increase is registered suddenly on the detecting device, and the nature of the registration is such that whatever produced the effect is a negative charge, a fact of fundamental importance. Scientists first tried to obtain the opposite effect, of positive charge, with the result that nothing happened, and it was afterward proved that the positive charges did exist, but were outnumbered by the negative ones which neutralized them, and hence the positive charges did not get far enough away.

Why Vacuum Was Used

In other words, there was a dense cloud of negative charges through which the positive charges could not penetrate, so the positive ones fell back upon the surface whence they came, and the net observable effect was zero. All of the above was carried on in air initially, and the experiments had to be made at voltages low enough to forestall atmospheric breakdown, and the magnitude of the effects was of a low order, so it was considered as a next step to use a part vacuum.

When it was found that the electrical constitution of matter was the combination of a definite arrangement of electrical charges, which had mass, and had a velocity that depended upon the acceleration imparted to them, it was realized that the distance through which these charges travelled in air was limited. Before the charge had travelled very far it would meet an air molecule and thus would be stopped, this distance being of the order of perhaps a hundredth of a millimeter.

This meant that the mean free path of a charge in transit very likely would be considerably less, and, in fact, the previous experiments made in air were now known to be erroneous, due to this, hence it was decided to make use of a glass envelope that would enable the visual observation of interelectrode phenomena, as well as to form an insulating support for the two electrodes that projected into the envelope interior. So a long tube was made that looked somewhat similar to the one of Fig. 1. It consisted of just what you see, plus an appendix through which air was withdrawn by the vacuum pump to the desired pressure.

The Low Pressure Discharge Tube

If we can imagine the tube void of any visual discharge effect, and with an operative voltage of say 2,000 volts applied between the electrodes, with the polarity as shown, and the tube full of air, we are ready to start.

We start the vacuum pump exhausting at a slow rate, and observe the tube in a darkened room, and as the pressure reduces to a certain value, suddenly the tube interior becomes suffused with an almost uniform blue glow.

If we examine a series milliameter in the tube exciter circuit we find that the reading of this meter coincides with the appearance of the blue glow. As the pressure is still further reduced the uniformity of the glow begins to alter. At the same time striations which form tend to crowd over to the positive end of the tube, producing what is known as a positive column.

But near the negative end of the tube there appears a space in which there is no glow at all. As the pressure is reduced the width of this negative dark space increases, coincidentally with the shortening of the positive column. The intensity of the glow around the positive electrode increases. All the while the current indication of the milliammeter has increased. The appearance of a glow ring around the negative electrode, the cathode glow, as it is called, also increases in intensity as the length of the dark space increases.

Path of Charged Particle

To understand the formation of the glow in the first instance let us trace the path of a charged particle through the tube, which may consist of a particle that has a negative charge, and an associated positive one also, this combination of charges being called an atom. There are many hundreds of them in the tube even at the reduced pressure at which we are working.

The negative charge under the attractive force of the positive electrode is pulled from the surface of the negative plate at incredible speed, and after traveling a certain distance collides with another atom with sufficient force to knock the second atom apart. This impact produces light, and also a certain amount of heat, but the charges of the impacted atom, now being separated, tend to move in opposite directions. The positive charges move to the negative end of the tube and the negative charges, still under the influence of the positive electrode, are again accelerated after impact, and a short distance further on, an-

f the Tube

Williams

other impact of these negative charges produces a second light emanation, and the second atomic split-up has occurred. As this process builds up at almost instantaneous rate the tube is not long in lighting up.

Therefore when the positive column extended to the negative electrode it was made up of ionized gas particles, and as the pressure was lowed the mean free path of the negative charges grew longer and these negative charges bombarded the positive neuclei with greater energy, driving them back to the positive end of the tube, and with still further lowering of the pressure the negative-charge stream increased in length, until it extended practically the whole length of the tube.

Glow Discharges Observed

Various glow discharges peculiar to the cathode and the anode were first observed by Faraday, and other effects observed by Crookes, and so paradoxically the places where there is no glow at all have been selected in honor to the physicist whose work on that region of the discharge is historic. Thus we have the comparatively long space in front of the cathode, devoid of visual emanation, called the Crookes dark space, while there is a dark space between the cathode glow and the electrode that is called the Faraday dark space.

From the foregoing then we can easily surmise that there are two energy streams in this tube and they are oppositely directed, and it is also possible that if they are properly directed that they can be segregated or otherwise individualized in some form of tube so that the two different kinds of rays can be studied.

Sir William Crookes studied the properties of light waves in addition to the foregoing and made some very interesting experiments which at the same time were conclusive. The result of them was among other things the radiometer, a form of which is diagrammed herewith, not because of its direct connection to the radio vacuum tube but rather because its operative principles were the subject of proponents of two schools of thought, represented by Dr. Oswald Reynolds, on the one hand, and Sir William Crookes on the other.

The Radiometer

The controversy concerned the method by which the radiometer operated, and the view of Dr. Reynolds was that impinging heat rays drove the vanes in much the same way that a stream of water drives a water motor, that is, the effect was due to the repulsion of the vanes, and that the straight conduction of heat through the wall of the tube was involved. Dr. Crookes was able to prove that this mechanism disregarded the effect obtained when the tube interior was pumped out to a low pressure, of say I millimeter of mercury, when alternate heating and cooling of the gaseous contents no longer could be effective in driving the vanes.

The Crookes theory of atomic bombardment proved to be more in line with the observed effects, and its application to the radiometer is of interest.

If white light falls upon the radiometer, and the pressure within the enevelope is reduced, thereby increasing the mean free path of the gaseous particles within the tube, a condition is prepared whereby the inpinging radiation is absorbed by the side of the vane that appears as a large clear surface. This surface is in reality coated with lampblack, while the shaded side of the vane is a smaller but polished reflecting surface. When the aforesaid absorption takes place the temperature of the absorbing surface is increased and an atom is shot off.

The recoil drives the vane in the opposite direction and as the same thing happens at the surface of the other vanes, the cumulative effect is rotation of the four arms.

Polished Surface Offers Little Resistance

Since the other sides of the vanes are polished, any atoms that impinge here are reflected without sensible absorption. Consequently there is no work done against the vane on this side, in opposition to what is being done on the other side. The vanes rotate counter clockwise, as arranged in the sketch, and the rotational effect is seen to be the result of a reaction between the vanes and the atoms that are displaced from the surface of the absorption surface.

Rotation of the vanes can be accelerated if the light falls on the vanes in such way that one of them is in the shadow of the others for a brief period, this plan permits the displaced atoms to realign themselves faster near the blackened surface of the shaded vane.

The vane arms are made of a bit of straw, and the vanes are of polished aluminum foil, coated on one side.

Since light waves can do mechanical work it should follow that the reverse is true. The low pressure tube experiment showed this to be the case, since the mechanical impact of atoms has been shown to be capable of producing light.

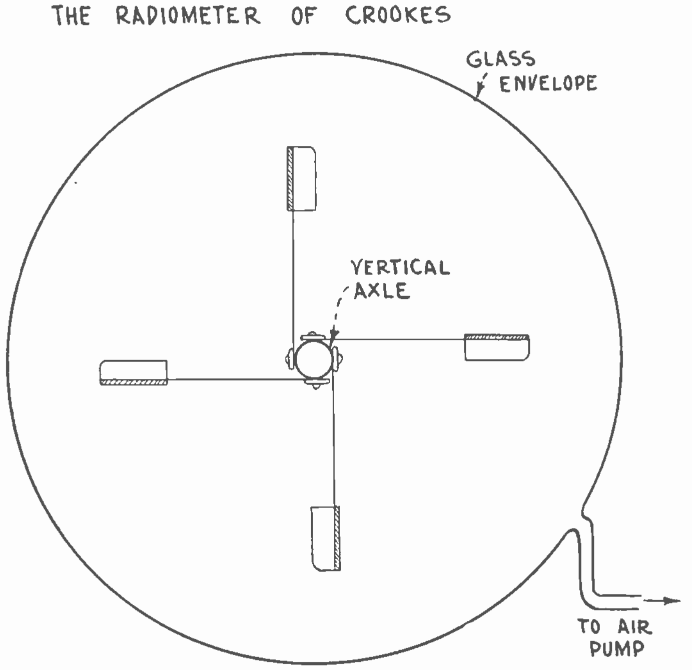


FIG. 2
THE RADIOMETER OR LIGHT WAVE REPULSION MOTOR.

The Practical Adoption of Negative Radiation

The largest single contributor to the fund of intelligence regarding the nature of radiation from hot surfaces, particularly that from hot wires, is Dr. O. W. Richardson, whose treatise on "Radiation from Hot Bodies" contains expositions of principles and laws that are a standard reference. In this connection it will be remembered that it was Dr. Richardson who made the first investigations of radiations from hot platinum, which were proved to be negative charges, and subsequently these were named electrons, and the associated positive charge was the proton.

Dr. Thomas Alva Edison, of Orange, N. J., who at the time was interested in the development of the incandescent lamp, also noticed that the outer surface of an illuminated lamp assumed a negative charge. The phenomenon of this radiation was called the Edison effect. Shortly afterward the same experiment in different form was performed by Dr. Fleming, who suspected the unilateral conductive property of the negative radiation stream. But it was not until he had performed his classic experiment that he was able to verify the theoretical conclusions that ultimately led to the invention of the Fleming valve, a sketch of which appears next week. The means employed to prove the existence of the unilateral effect are shown.

Fleming's Valve

The first true electron emitter of a form that began to approach the kind of tube we use today was this valve of Fleming, and though the tubes that you now see are all sealed off, the first tube was operated while still connected to the exhaustion pump, so that the effect of the gradually reducing pressure might be noted. The anode potential was kept constant, while the hot cathode also was kept under constant potential, though an increase of temperature was noted as the pressure was reduced, due to the observation of the increase in brightness of the cathode electrode. As the pressure reduced the indicating instrument at the left deflected.

In the first experiment the attempt was made to find the relationship between the anode current and the pressure. The anode potential was kept constant and the current increase noted as the pressure was reduced. This test was repated with successive increases of anode potential with the final result that it was found for the various potentials used the knee of the current-pressure curve occurred at practically the same pressure, which means that the maximum anode current flow occurred at the same pressure.

The second experiment related to the unilateral conducting property of the hot cahode radiation, determined by reversing the terminals of the anode battery at their point of connection. It was suspected that there would be an anode current of some consequence, but on closing, this circuit there was a slowly decreasing deflection, which soon reduced to zero, and the application of higher potentials yielded negative results, so the unilateral conductivity of the negative radiation was established. Incidentally the answer to several questions regarding the behavior of the ionization stream in the low pressure tube was given.

(Continued Next Week)

The New Stromberg-Ca

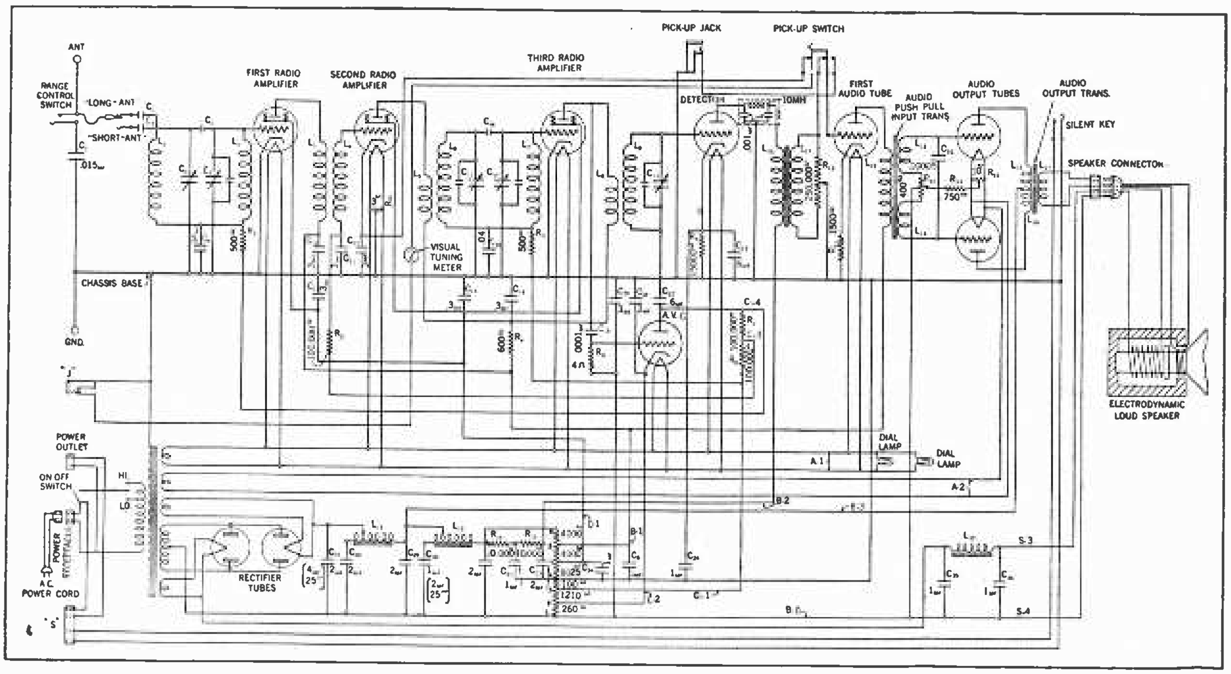
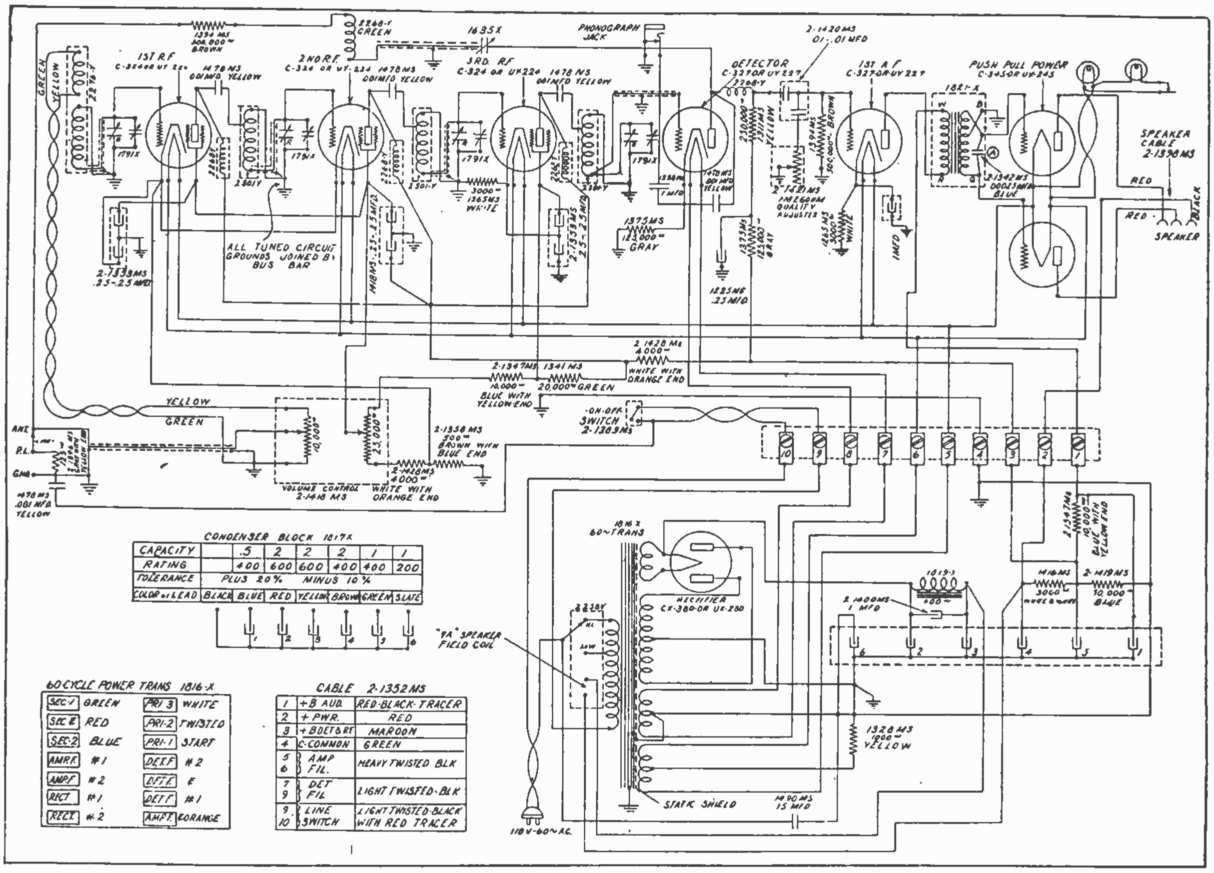


FIG. 1

THE COMPLETE CIRCUIT DIAGRAM OF THE STROMBERG-CARLSON MODELS 12 AND 14 RECEIVERS IN WHICH PROVISION IS MADE FOR TWO PHONOGRAPH PICK-UP UNITS, AND IN WHICH AN AUTOMATIC VOLUME CONTROL IS INCORPORATED. A SPECIAL ARRANGEMENT WITH SEPARATE FILTER IS USED FOR THE CURRENT SUPPLY FOR THE FIELD WINDING OF THE LOUDSPEAKER.

IN the October 25th issue we published information on the Stromberg-Carlson Models 12 and 14, giving a simplified diagram of the automatic volume control and a curves showing the effectiveness of this control, and in the Nov. 1st issue we gave a simplified diagram of the B supply part of the receiver. Herewith we reproduce a complete diagram of the receiver, which shows in detail the design of the receiver.

The method of manual volume control is of interest. The first adjustable feature is a range control switch by means of which a .015 mfd. condenser is cut in across the first tuned circuit.



CONDENSER BLOCK 1617X

CAPACITY		.5	2	2	2	1	1
RATING		400	600	600	400	400	200
TOLERANCE	PLUS 20% MINUS 10%						
COLOR of LEAD	BLACK	BLUE	RED	YELLOW	BROWN	GREEN	SLATE

60 CYCLE POWER TRANS 1816-X

SEC-1	GREEN	PRI 3	WHITE
SEC E	RED	PRI-2	TWISTED
SEC-2	BLUE	PRI-1	START
AMP.F.	#1	DET.F.	#2
AMP.F.	#2	DET.F.	E
RECT	#1	DET F.	#1
RECT.	#2	AMP.F.	E ORANGE

CABLE 2-1352 MS

1	+B AUD.	RED-BLACK-TRACER
2	+ PWR.	RED
3	+ B DET & RF	MAROON
4	C-COMMON	GREEN
5 6	AMP FIL.	HEAVY TWISTED BLK
7 9	DET FIL	LIGHT TWISTED-BLK
9 10	LINE SWITCH	LIGHT TWISTED-BLACK WITH RED TRACER

FIG. 2

ONE OF THE 1930 MODEL FADA RECEIVERS INCORPORATING THREE SCREEN GRID TUBES, RESISTANCE COUPLING AND PUSH-PULL AMPLIFICATION. NOTE THE SPECIAL DUAL VOLUME CONTROL COMPRISING A 10,000-OHM POTENTIOMETER IN THE ANTENNA CIRCUIT AND A 25,000-OHM POTENTIOMETER IN THE SCREEN CIRCUITS.

rlson and Fada Circuits

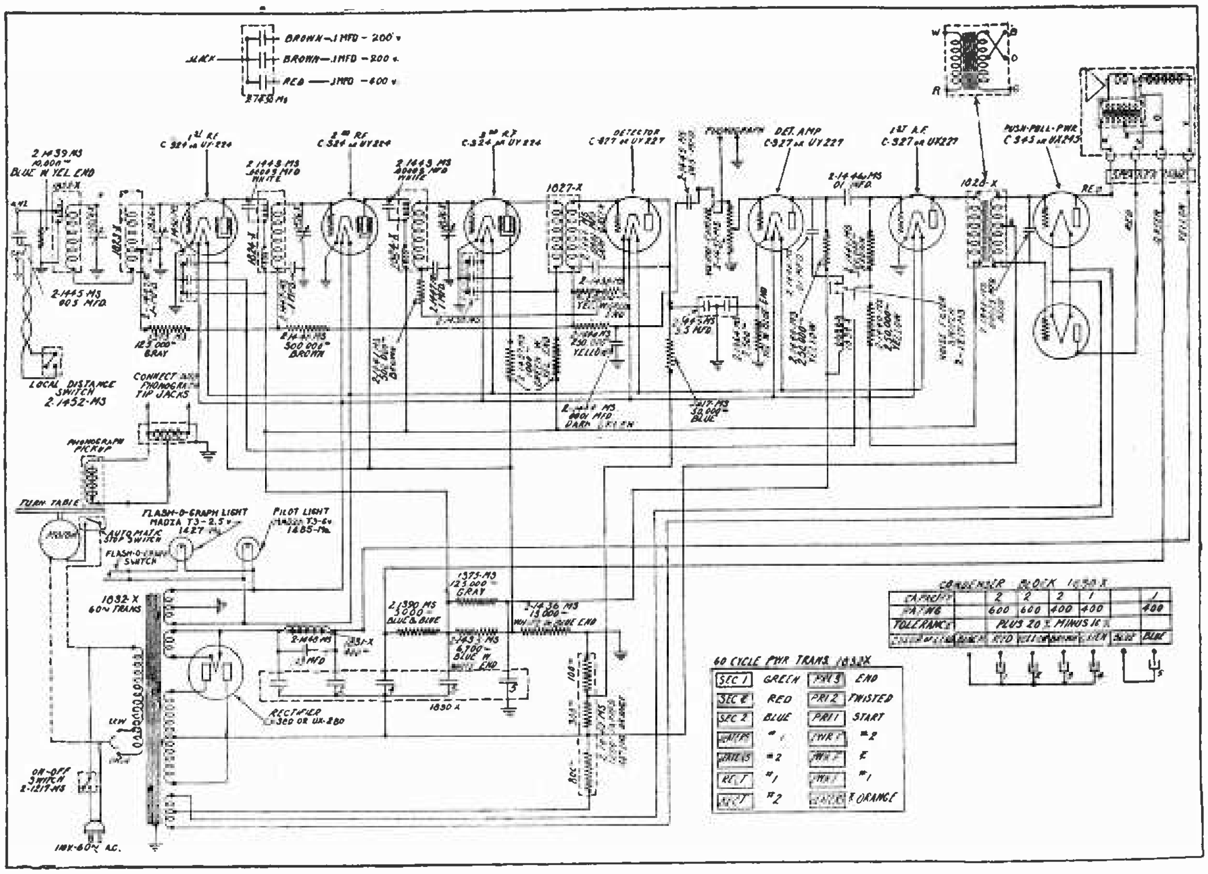


FIG. 3

THE CIRCUIT OF ANOTHER 1930 MODEL FADA RECEIVERS IN WHICH THERE ARE TWO STAGES OF RESISTANCE COUPLED AUDIO IN FRONT OF THE PUSH-PULL POWER AMPLIFIER. NOTE THE SPECIAL COUPLING ARRANGEMENT BETWEEN THE DETECTOR AND THE FIRST AUDIO AMPLIFIER.

This, of course, by-passes to ground the greater part of the signal so that this control should be used only when receiving local, high-power signals. When receiving weak signals the condenser circuit should be open.

The next feature is the provision for adapting the circuit to either long or short antennas. By means of a "Long-Short" switch the antenna may be connected to the first tuned circuit either through a small or a large condenser. These condensers are proportioned so that the "Short" position of the switch should be used for antennas having capacities up to 75 or 100 mmfd. and the "Long" position should be used for antennas having higher capacities. Since the capacity of any antenna cannot be known without measurement and, further, since there are so many conditions that the capacity cannot be approximated by the antenna length, a practical method for selecting the better position is needed. A simple method is to tune in a very weak station at the high frequency end of the range and then testing with both positions of the switch. The one giving the stronger signals should be retained.

The controls in the antenna circuit govern the volume in steps which may be too large to suit most conditions. For this reason a 250,000 ohm potentiometer is connected across the secondary of the first audio frequency transformer, by means of which the volume may be varied in minute steps or continuously, that is, without any appreciable steps.

The tuners in the receiver are of the bi-resonator type. That is, each tuner is made up of two tuned circuits coupled together so as to form a band pass filter of suitable width. There are two of these, one between the antenna and the first tube and the other between the second and third tubes. The first tuned circuit contains coil L1, condenser C4, and condenser C6. The second contains inductance L2 and condensers C5 and C6. Thus condenser C6, which has a capacity of .04 mfd., is common to the two circuits and provides the coupling between them. There is an additional bond between the two circuits in C7, which is a capacity of the order of one micro-microfarad.

The coupling between the two circuits is closer the lower the frequency because as the frequency decreases the impedance of the coupling condenser increases. This automatically decreases the selectivity as the frequency decreases, thus keeping the effective selectivity constant on a percentage basis. In other words, the change in the coupling with frequency keeps the sideband admission at the same level throughout the tuning scale. An inductance coupling in the position of C6 would work in the opposite direction.

The function of C7 is to increase the coupling between the two circuits at high frequencies to a value slightly higher than that afforded by C6 alone.

The resistance R1 associated with the bi-resonator serves two purposes. It broadens the peak of the tuning characteristic at the low frequencies and serves as a filter in the grid bias lead.

There are two 280 rectifier tubes in the circuit, one to supply the plate current for the receiver proper and the other for supplying the field current for the loudspeaker. There is only one high voltage winding for the two rectifiers, but there are two filament windings. One is used for the positive of the supply for the receiver and the other for the positive for the field current.

There are also two filter circuits. The one for the field current contains one choke, L20, and two 1 mfd. condensers. Since the field winding itself is a choke, the filtering of the field current is adequate.

One of the 1930 model Fada receivers consists of three stages of tuned radio frequency amplification, utilizing 224 screen grid tubes, a high signal detector using a 227 tube, one stage of resistance coupled audio, also using a 227, and one stage of push-pull using two 245 tubes.

A 125,000-ohm filter resistor is used in series with the 250,000-ohm coupling resistor to eliminate motorboating, and this filter resistor is by-passed to ground with a .25 mfd. condenser. The grid leak is a 0.5 resistance and the stopping condenser has a value of .01 mfd. From the grid to ground are connected another .01 mfd. condenser and a 1.0 megohm variable resistance, in series. This series circuit across the line serves as a tone control. When the entire 1.0 megohm resistance is used there is practically no by-passing of the high audio frequencies while when the resistance is set at minimum there is a strong by-pass effect. Since the resistance may be set at any value less than 1.0 megohm, a wide range of tone is available to the listener.

The volume is controlled manually by means of a 25,000-ohm potentiometer which varies the screen potential applied to the first two screen grid tubes. There is another potentiometer, one of 10,00 ohms, in the antenna circuit for making volume adjustments. This is connected across the primary of the input transformer and is arranged so that the entire resistance is across the primary all the time, thus leaving the damping constant, but so that various proportions of the voltage in the antenna circuit may be impressed on the primary.

Data on the 280 Tube

By J. E. Anderson

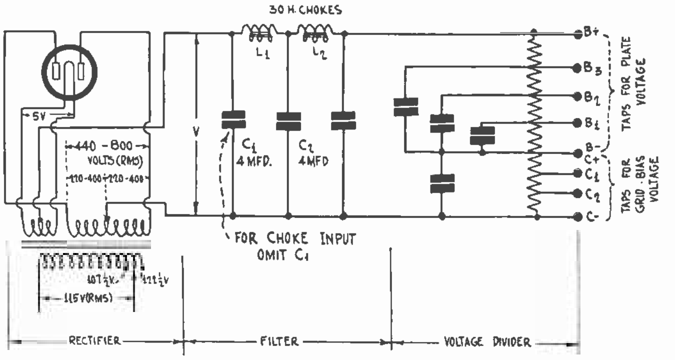


FIG. 1

A TYPICAL CIRCUIT DIAGRAM OF A FULL-WAVE RECTIFIER UTILIZING THE 280 TUBE. THE FILTER CONSISTS OF TWO SECTIONS OF TWO 30-HENRY CHOKES AND THREE BY-PASS CONDENSERS. THE VOLTAGE DIVIDER IS ARRANGED TO GIVE BOTH PLATE AND GRID BIAS VOLTAGES.

THE 280 is a full-wave rectifier tube for use with receivers requiring a maximum rectified voltage of 350 volts or less and a current of 125 milliamperes or less, or a maximum rectified voltage of 400 volts with a maximum current of 110 milliamperes. It has a five-volt filament winding requiring a current of two amperes.

CHARACTERISTICS OF THE 280 RECTIFIER

Filament voltage	5.0
Filament current, amperes	2.0
AC voltage per plate (RMS)	350.0
Max. load milliamperes for 350 volts on plates	125.0
AC voltage per plate (RMS)	400.0
Max. load milliamperes for 400 volts on plates	110.0

Maximum overall length, 5 5/8 inches.
Maximum diameter, 2 3/16 inches.
Socket, standard UX.

The power transformer used with this tube should have two secondary windings, one of high voltage for the plates and one of low voltage for the filament. The high voltage winding should be accurately center-tapped so that both plates get the same voltage. The filament winding need not be center-tapped but a center-tap is desirable if the tube is to deliver a high current. If the load current is taken off on one side of the filament that side will be operated at a higher temperature because more of the rectified current will flow through this side. When a center-tap is used the load current is divided equally between the two legs of the filament and the heating will be uniform.

Line Voltage Variations

The primary should be wound for 115 volts but should preferably have taps for 107.5, 115 and 122.5 volts so that compensation may be made for line voltage fluctuations. If the primary is not tapped, it should be wound for about 115 volts and a variable resistance should be put in the primary circuit to cut the voltage down to that required in case the line voltage should rise above 115 volts.

The actual effective voltage across the high voltage secondary depends on the DC voltage desired, and may vary from 220 to 400 across each half of the winding, that is, from 440 to 800 volts across the entire winding.

In Fig. 1 is shown a typical rectifier circuit incorporating the 280 tube, together with the filter circuit and the voltage divider. The average output characteristics of such a circuit are shown in Fig. 2. These curves show the variation in the DC output voltage with changes in the load current for different values of RMS input voltage per plate of the rectifier tubes. The output voltage is as measured at V in Fig. 1. The full lines are for condenser input to the filter and the dotted lines for choke input. The difference between these inputs is indicated on the diagram in Fig. 1.

These curves may be used to estimate the maximum output voltage when the current drain and the input voltage are known. Suppose, for example, the effective AC voltage per plate is 350 volts and we wish to draw a current of 100 milliamperes. The 350-volt curves, tell us that the voltage is 345 volts at V, with condenser input, and that it is only 250 volts with choke input. The curves do not take account of the drop in the choke coils so that the useful voltage will be less. Suppose the total resistance of the two chokes is 400 ohms. If the current is 100 milliamperes the drop will then be 40 volts. This leaves 305 volts for the case of condenser input and only 210 volts for choke input.

Condenser Requirements

As indicated in the rectifier circuit, the capacity of the first condenser is 4 mfd. If the capacity of this condenser is increased, the voltage will be slightly greater, and if the capacity is less the voltage will be less, but changes in voltage with the condensers ordinarily used are so small that they may be neglected.

The capacities and resistances associated with the voltage divider are not specified because they would depend on the circuit with which the rectifier is to be used. This is especially true of the resistances. It may always be stated that the capacities of the condensers should be as high as practicable and that not less than one microfarad should be used in any position.

In selecting condensers it should be remembered that the voltage may rise to the peak of the voltage applied to each plate of the rectifier tubes and that the condensers must stand this voltage for brief periods. The peak voltage is 1.41 times the RMS voltage, so that if the applied voltage per plate is 400 volts, the voltage across the condensers might rise to 564 volts. This would occur when the load is removed without turning off the power to the transformer. Even when there is a bleeder current which remains when the load is removed, the voltage will rise, although not to the same value. This rise in voltage is indicated on the curves in Fig. 2. At 10 milliamperes, for example, the voltage across the first condenser, when the voltage per plate is 400 volts, RMS is 510 volts. Only the first three condensers will be subjected to the maximum voltages.

Surges

This voltage rise does not take surges into account, but only the rise due to regulation. When there are surges the voltage may rise to much higher values instantaneously, and surges will occur when there is a sudden change in the current. For these reasons the voltage rating of the condensers should be at least twice as high as the highest steady operating voltage. Moreover, care should be taken that the power is always turned off before any change is made in the circuit, such as removing a tube or changing the position of some lead on the voltage divider.

It would seem that the condenser next to the rectifier tube would be subject to the greatest stress, but in most instances it is the third condenser that breaks down first, if the three condensers across the entire line are of the same rating. This rupture, no doubt, is due to high voltages generated in the amplifier due to static crashes and other disturbances of a similar nature, and is superinduced by the heating of the condenser by the constant flow of normal signal current through it.

While it is customary to put the two filter chokes in the positive side of the line, as is done in Fig. 1, they could also be placed in the negative side. This is sometimes done in commercial sets. Or one could be placed in each side of the line, and this method, too, has been adopted by some manufacturers.

When the load current is high it is common practice, especially when push-pull amplification is used, to tap the current for the power tubes from the junction of the two chokes. This diverts the larger part of the load from the second choke so that it becomes more effective in filtering the remaining current.

(Continued next week)

Dial Requirements

By Goodnow Burroughs

THERE are dials that read counter-clockwise and others which read clockwise. There are also tuning condensers that increase in capacity when turned clockwise and others that increase when turned counter-clockwise. Should a dial and a condenser which run in the same direction be used together or should a clockwise of one be used with a counter-clockwise of the other? Some will answer this question one way and others in another way, and both are right. But both may be wrong.

There is another factor entering into the problem which has not yet been mentioned, and that is whether the dial moves over a fixed index or the index moves over a fixed dial.

If the index remains fixed and the dial moves with the condenser, the dial and the condenser should be of opposite sense, but if the dial remains fixed and the index, or pointer, moves with the condenser, the dial and the condenser should be of the same sense. These facts can easily be verified by looking at the dial scale reproduced herewith and imagining that a variable condenser is back of it.

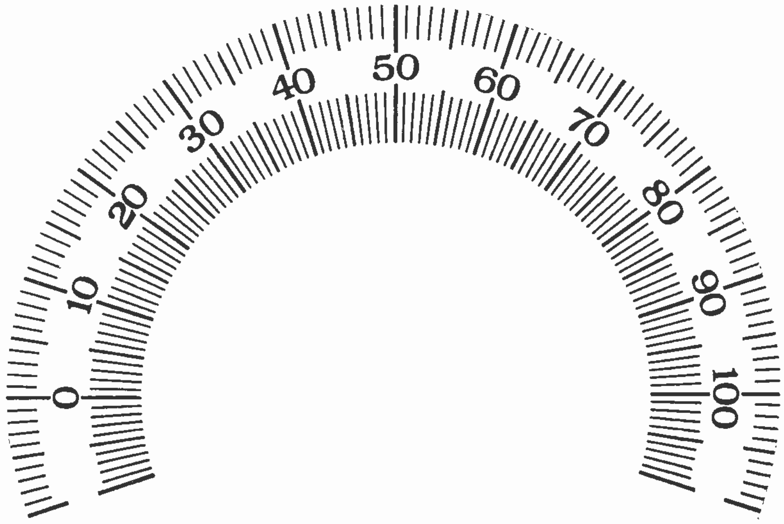


FIG. 1
A TYPICAL CLOCKWISE, LINEAR DIAL SCALE WHICH SHOULD BE USED WITH A COUNTER-CLOCKWISE CONDENSER IF THE SCALE IS ATTACHED TO THE CONDENSER AND WITH A CLOCKWISE CONDENSER IF THE INDEX IS ATTACHED TO THE CONDENSER.

Calibrating Dials

The dial in Fig. 1 is laid out on a linear scale, that is, so that all the divisions are equal. If the condenser back of it is of the straight line frequency type, stations in the broadcast band will always appear on the dial on a linear scale, or they will appear at distances proportional to the frequency separation between them. If the condenser is of the straight line wavelength type, stations will be crowded at the low end but stations differing by the same number of meters will appear at equal distances apart. If the condenser is of the straight line capacity type, the stations will be crowded together at the short-wave end and they will be spread out at other.

Practically no condenser is strictly of any one of these types, most of them being a compromise between straight line frequency and straight line wavelength. Hence a linear scale will read neither wavelengths nor kilocycles and it becomes necessary to calibrate the scale in terms of one or the other, or both. This is done very easily if a few stations can be tuned in and a list of frequencies and stations is available.

Suppose WEAF comes in at 80 on the dial. Its frequency is 660 kc and therefore an arrow is drawn pointing to 80 with 660 written at the end of the arrow. A similar arrow with WEAF at the end may be drawn on the opposite side of the scale. The same is done for all other stations that can be tuned in and identified as to call letters and frequency.

The number of kilocycles is written in, instead of call letters, because there may be two or more stations operating on the same frequency. These would all come in at the same point, and in some instances there may be so many on one setting that all the call letters could not be written. The call letters of only the popular stations should be written to avoid cluttering up the dial. Call letters may change from one position of the dial to another, for the Radio Commission may make changes any time, but the frequencies will always remain, provided that the set is not changed.

Auxiliary Dial

The dial in the receiver may not be accessible for calibration. In that event a dial like that shown herewith may be used as a calibration chart. All the desired call letters and all the frequencies obtained on the receiver are entered on this dial in the manner mentioned above, and then it is used as a handy key to the tuning of the receiver.

In some instances it may be possible to mount the dial on top of the dial in the set and then calibrate it. This can be done without in any way mutilating the set.

The dial in the picture extends through an angle of 216 degrees, or through 120 divisions, from minus 10 to plus 110. It is extended beyond the usual 180-degree range in order to make readings easier at the two extreme positions of the 180-degree condenser.

Right or Wrong?

QUESTIONS

(1)—If the chokes in a B supply unit are placed in the negative side of the line, there is no filtering action because the chokes are on the grounded side of the circuit.

(2)—A two-tube short-wave converter that acts as a volume booster for broadcast signals but does not receive any short-wave signals can be made to do so by treating the oscillator circuit so that it oscillates at the high frequencies.

(3)—Scratchy noises in a receiver are often due to dust between the armature and the pole pieces. This applies to all common types of loudspeakers.

(4)—A short-wave adapter built on a metal sub-panel in such a manner that the oscillator coil is close to the metal does not work because no oscillation can be induced in the circuit.

(5)—A tone control is a device for making the quality worse than it normally is.

(6)—Electric waves travel on a wire at the speed of light.

(7)—Electric current travels in the same direction in every portion of an electrical transmission line at every instant.

ANSWERS

(1)—Wrong. It makes little difference in which side the chokes are placed provided they are placed so that the rectified current flows through them. Some B supply units have the chokes in the negative line because under certain conditions less hum results from the arrangement.

(2)—Right. When the circuit acts as a volume booster it simply means that the modulator tube acts as an amplifier of the frequency to which the broadcast receiver is tuned, or to all frequency in the broadcast band. It will also act as a detector or modulator and the only condition for short-wave reception is that the oscillator function, which it will do if the coils are connected correctly and if the voltages are high enough.

(3)—Right. Even if ordinary dust gets between the armature and the pole pieces, scratchy noises are likely to appear, and if tiny particles of iron get between there is likely to be much noise. The magnets attract iron filings and hold them. Usually when iron filings have lodged between the armature and the pole pieces it is necessary to remove the armature and remove the dust by force.

(4)—Right. At least it is correct in most instances. If the sub-panel is of metal the oscillating coil should be raised above it so that the windings are at least one inch from the metal.

(5)—Right. The way sets are designed the quality at normal is usually as good as engineering can make it, with the material at hand. A tone control in most instances makes it worse, although in many instances it may make the quality more pleasing to the listener who wants plenty of bass.

(6)—Wrong. It travels with a speed considerably slower than the velocity of light. Just how much more slowly it travels depends on the distributed inductance and capacity of the wire, or on the inductance and capacity per unit length of the wire.

(7)—Wrong. Current may travel in opposite directions at the same time and does so at distances equal to half a wavelength.

A Question and Answer Department conducted by Radio World's Technical Staff. Only Questions sent in by University Club Members are answered. Those not answered in these columns are answered by mail.

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Use of Plate Filtering

WOULD you recommend the use of a filter in each plate circuit for the purpose of keeping the DC plate current out of the primary of the transformer windings? I have first rate transformers but it seems that I am not getting the quality out of the amplifier that I should. If the trouble is due to saturation of the cores I should like to try the filter scheme to remedy the condition. Can you suggest chokes and condensers to use?—G.W.F.

With the best transformers it is necessary to use the filter scheme, for the direct current through the winding would saturate the core so that the transformer would degenerate into one which could be obtained for a small fraction of the price of the good one. You might use a 245 Polo choke in the plate lead and a 2 mfd. condenser in series with the primary to stop the DC current. The opposite side of the primary may then be grounded or it may be connected directly to the cathode of the tube preceding.

* * *

Shielding of Live Leads

IN a short-wave receiver is it advisable to use shielded wire for the grid and plate leads to prevent coupling between the stages? If not, what are the objections to it?—H.A.W.

It is not advisable to shield the live leads because the capacity between the leads and ground would be very high, for short waves. One effect would be a high minimum capacity in the tuned circuits and another would be the shunting of the signals to ground and thus decreasing the sensitivity of the circuit. The low potential leads should be wound with shielded wire to prevent coupling, for here the capacity to ground that is added is beneficial.

* * *

Grounding of the Loudspeaker

I HAVE noted in several circuits that the loudspeaker is grounded. That is, the secondary of the output transformer has one side connected to ground, which also connects one side of the speaker to ground. How is it that this does not kill the signals?—D.B.C.

One point in any circuit can be grounded without affecting adversely the operating properties of that circuit. In fact, one point should be grounded to stabilize the circuit. Hum is often due to induction between live conductors or parts and the speaker hanging in the air, so to speak. Grounding one side of the speaker often eliminates this entirely.

* * *

Loading Coil in Antenna Circuit

WOULD is be of any advantage to use a loading coil in the antenna circuit for short-wave converters? I recall that in the early days loading coils were used in broadcast receivers when the antenna was too short.—L.B.W.

Whether or not any advantage could be gained by using a loading coil would depend on the length of the antenna and on the frequency to be received. The object of the loading coil would be to add to the self-inductance of the antenna until the total inductance and the capacity of the antenna would resonate with the frequency to be received. To gain any advantage both the capacity and the inductance would have to be adjustable. It would hardly be practical. For some waves in the short-wave range the loading coil would have to be used and for others a series condenser.

* * *

Capacity and Inductance of Antenna

ABOUT what is the capacity and the inductance of an antenna 150 feet long, of which 50 feet are vertical and 100 feet horizontal? What would be its natural wavelength?—H.C.

The capacity varies with the position of the antenna with respect to other objects, especially metal objects. For the inductance 17 microhenries is an average and for the capacity approximately .0003 mfd. These constants would make the natural wavelength of the antenna 135 meters. If we add to the inductance a 20 microhenry primary the total antenna inductance would be 37 microhenries, and this would make the natural wavelength 198.5 meters.

* * *

Short-Wave RF Does Not Tune

I HAVE built a short-wave converter using two tuners, one for the oscillator and another for the radio frequency amplifier. The oscillator tunes all right but the radio frequency tuner does not seem to behave right. For some stations I get loudest signals when the RF tuning condenser is set at zero and the oscillator about midway, and for other stations I get loudest signals when both are set about the same. What is the cause of this variation in the radio frequency tuner?—W. A. C.

This apparent trouble is due to the fact that any given frequency comes in at two points on the oscillator dial. Suppose the intermediate frequency is 1,500 kc. The two points are then located 3,000 kc. apart on the oscillator dial. One may lie in the middle of the dial and if it is the higher frequency setting the RF tuner may not reach it and hence it has to be set at zero for loudest signals. Another station less by 3,000 kc. than the first may also lie close to the point on the oscillator dial where the first came in and this station may come in on the RF tuner dial near the middle. When you tune circuit set the RF tuner at zero and then tune with the oscillator. Having brought it in with the oscillator as loud as possible, tune the RF condenser. If the signal does not become very much louder at some setting away from zero plug in a smaller coil in the RF socket and try again.

* * *

Receiving on Harmonics with Converters

WITH a short-wave converter which I have built I am able to tune in certain short-wave stations at several points on the dial of the oscillator. I understand why it should get each station at two points, since the circuit is a superheterodyne, but I don't understand why I should get some of them at more settings. Please explain.—J.C.F.

As we have explained in RADIO WORLD several times, any station of given frequency can be received on an infinite number of points on the oscillator dial, theoretically at least. This reception is possible because of harmonics generated in the radio frequency tube and in the oscillator. At all but a few points the signals are so weak that it cannot be received audibly, but in many instances four or eight are strong enough to be heard. Possibly you are receiving on the second harmonics as well as on the fundamentals. For example, you may be able to set the oscillator so that its frequency is about one-half of the frequency of the signal. This will account for two extra points where a signal comes in.

* * *

Tuning to Light Waves

IF light waves and radio waves are of the same nature, it should be possible to construct a tuner by means of which certain light waves could be brought in. Can you suggest such a tuner?—E.L.B.

Such a tuner would have to be of atomic or electronic dimensions. We cannot suggest how you might construct one. Selective transmission of colors through certain substances may be a resonance effect in the material. For example, a piece of red glass, which transmits red light only, may be resonant to the red wavelengths. That is to say, the atomic structure may be such that the atoms vibrate only when subjected to red light. This would be equivalent to a large number of series tuned circuits. There is also selective absorption in certain substances. Such materials transmit all but one wavelength of light. This would be equivalent to parallel resonance. Thus it may not be possible to construct a tuner for certain light waves but you might hunt around until you find one in nature already constructed for you. Investigate color filters.

* * *

Condenser for Short-Wave Set

WHICH is better, to use a large condenser and one or two coils or a small condenser with many coils in a short-wave set? Will you kindly discuss the relative merits of the two systems?—G.W.K.

When a small condenser is used the band covered by that condenser and a given coil is small and the stations in that band are spread out over the entire 180, or 270 degrees of the dial. This in a way converts the tuner into a vernier or fine adjustment tuner. This is a great advantage when the circuit is very selective. Moreover, when a small coil and several coils are used, each coil may be designed to work efficiently in that narrow band. When a large condenser and a small coil are used to cover a wide band, the coil can be designed to work efficiently only over a portion of the band covered by the combination.

* * *

Requirements of Short-Wave Oscillator Coils

IN a short-wave converter must the oscillator be wound with heavy wire in order to obtain satisfactory selectivity just as the RF tuner must be wound with heavy wire?—K.L.W.

The only requirement of the oscillator coil is that it will

(Continued on next page)

oscillate. Its design has nothing to do with the selectivity because in the converter the greater part of the selectivity is obtained in the broadcast receiver and none at all in the oscillator. A coil wound with fine wire may not oscillate so readily as one wound with heavy wire. In one case two coils were wound with No. 32 double silk and No. 22 double cotton and when used in the same circuit there was no difference in the result. Both coils oscillated when 67.5 volts were applied to the plate of the tube and neither when only 45 were used. If it required more voltage for the fine wire coil the difference was less than 22.5 volts.

* * *

A Squawking Set Silenced

I BUILT one of the short-wave converters which you described a while ago, a two-tube circuit with an RF stage in it. When I tune in there is a loud squawking noise which entirely drowns out the signals. Sometimes this occurs all over the oscillator dial and at other times only in certain regions. The noise also depends on the position of the other tuning condenser and on the coils I use. Can you suggest the cause of this trouble and the remedy?—W.H.J.

Such squawking is usually due to overloading of some kind, and should occur when the oscillator and the RF circuits are set at the same frequency, or nearly the same. The first thing to suspect is an open grid lead in the RF stage or lack of sufficient leakage in either grid circuit. Another thing that sometimes causes it is the grid bias resistor. It acts as a grid leak even though it is not directly in the grid lead. However, this does not happen very often. In one circuit which squawked in this manner the cause was found to be due to insufficient current on the heaters of the tubes. The filament transformer did not have sufficiently good regulation so that when the load was put on the current fell. This in turn reduced the cathode emission so that the tubes overloaded very quickly. As soon as a good filament transformer was substituted the circuit behaved normally on all settings of the condensers, even when the two-tuned circuits were exactly in tune.

* * *

Three Taps for Phonograph Pick-up

IN my receiver there are two tip jacks for a pick-up unit on an insulated mounting and there is another, apparently not insulated, which is marked "Common Phono." The two insulated jacks are marked "Low impedance" and "High Impedance." Will you kindly explain why three terminals are provided and which two to use when the phonograph pick-up is connected to the set?—G.A.P.

One side of the pick-up unit should always be connected to the "common" terminal. If this is not insulated it must be grounded so that the pick-up unit is always connected to ground. One of the other two is for the live side of the pick-up unit, the one to use depending on the impedance of the pick-up unit, which may be either high or low. Presumably there is a matching transformer back of the three terminals and the "low impedance" terminal goes to a tap on the primary of this transformer.

* * *

Getting Europe

WHAT is the chance of getting the European short-wave stations with a good short-wave converter and a modern radio receiver? Do the European stations fade as badly as the American?—A.L.F.

The chance is very good, provided that you listen at the proper time of the day. The proper time is in the afternoon.

* * *

Link Circuits Cause Coupling

WHICH is better, to use a metal sub-panel in a short-wave set or converter or a heavy wire ground running around the set? Will you kindly point out some advantages of both as well as disadvantages?—J.C.F.

A metal sub-panel is probably better because the ground is available wherever needed, and it would be a good ground. A disadvantage of it is that there might be serious losses due to eddy currents. However, the losses could be minimized by keeping the coils away from the metal as far as practicable. A ground made of a heavy wire is all right provided that it is not made into a link circuit, for this link would cause undesired coupling. Moreover, this form of ground is not as effective or as convenient as the chassis ground. If the coils are kept away from the metal and if no loops are formed of the wire ground, there is little difference between the two and the choice would be determined on availability of sub-panel material.

* * *

Screen Grid Tube Amplification

WILL you kindly tell what the conditions of operation should be when the 224 tube is used as an audio frequency amplifier in a resistance coupled circuit? That is, I wish to know the voltages and the resistance values in the circuit.—C.B.F.

There are many combinations of voltages that may be used but the following may be considered as average and satisfactory. Grid bias, 1.5 volts negative; screen voltage, 22.5 volts positive; plate voltage, not less than 180 volts and preferably 225 volts. The plate coupling resistor should be 250,000 ohms, the coupling or stopping condenser, .01 mfd., and the grid leak about one megohm.

* * *

Comment on Rectifier Design

IN some rectifiers the positive lead is taken at the center of the filament winding of the rectifier tube, while in others it is taken on one side of the 5-volt winding. Is there a disadvantage in using one side? I like this because it makes the transformer simpler and also the wiring of the rectifier circuit. Is there any reason why I should not?—L.C.W.

There is no important reason why you should not use the simpler connection. When the lead is connected to one side of the filament more rectified current will flow in one side than in the other, but this is so small in comparison with the total filament that no ill effects result.

* * *

Connection of Plate Returns

IN the Nov. 1st issue you published a double push-pull amplifier utilizing two 245 tubes in the output stage. The plate return of the power stage goes to the top of the voltage divider, which makes the total plate current flow through the second choke. Is there any reason why the plate return of the output tubes should not be connected to the junction of the two chokes and then use a choke of less current capacity and higher inductance in the second position?—F.C.

There is no reason why this should be done. Indeed, it would be all right to connect the plate return of the two 227 tubes there too and use the second choke for only the detector and the radio frequency amplifier, if one is powered from this circuit.

* * *

Loftin-White Amplifier

IF the voltage drop in the plate coupling resistor between the two tubes is greater than the bias needed for the power tube, is there any way of arranging the circuit so that the high DC drop in the coupling resistor may be retained and still permit the proper bias to be applied on the power tube?—A.C.

There is a very simple way. Just connect the plate return of the voltage amplifier to a point on the voltage amplifier higher than the point to which the filament center tap of the power tube is connected. By connecting the return at a point of suitable voltage any desired bias can be given to the power tube. The resistance between the connection of the power tube filament and the plate return of the other tube should be by-passed with a large condenser, for if it is not the signal input voltage will be reduced to the same extent as the bias on the power tube.

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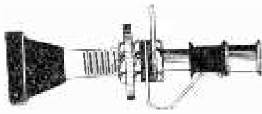

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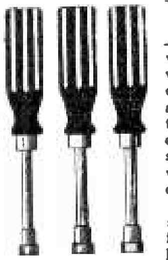

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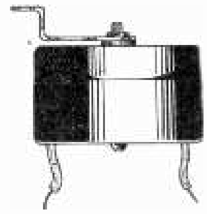

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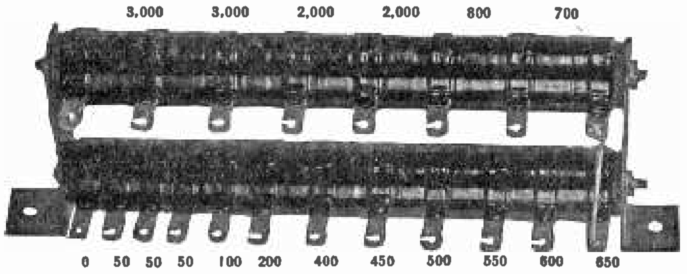

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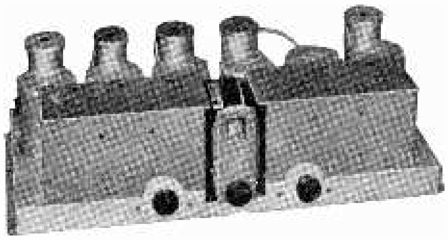

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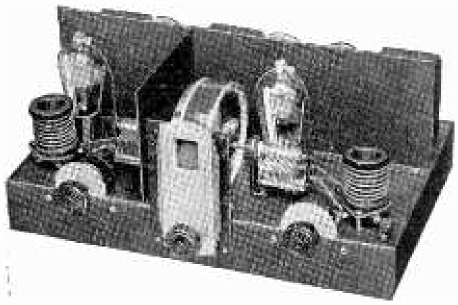

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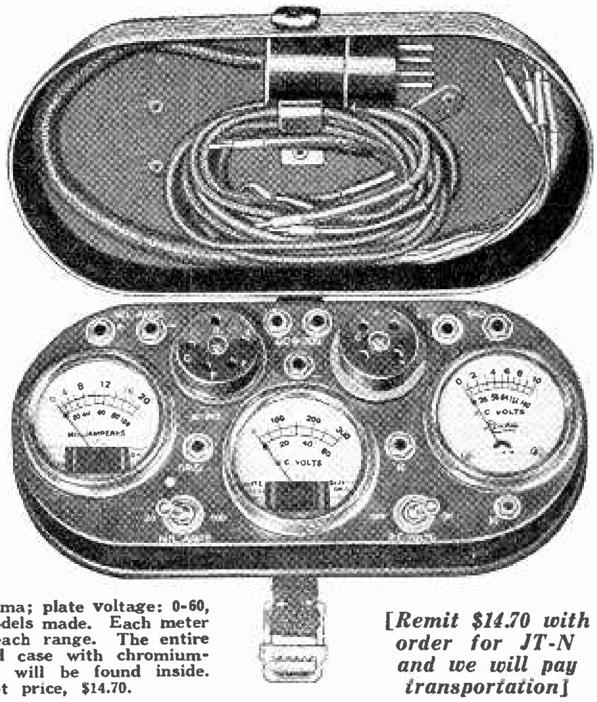

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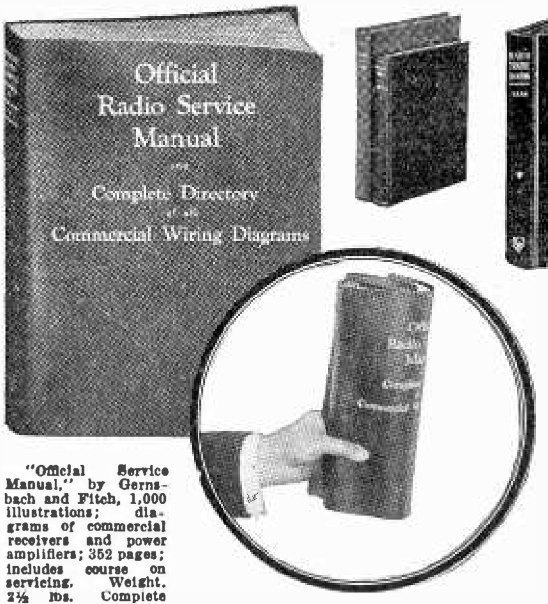

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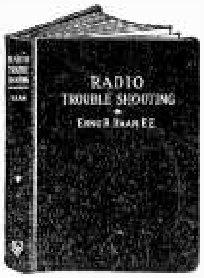

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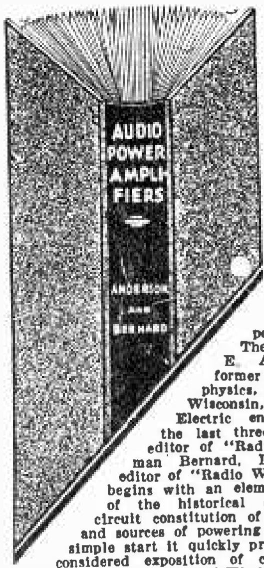

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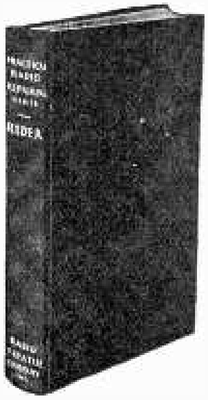

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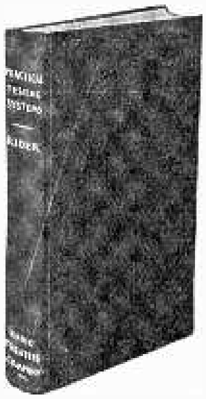

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