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THE BREATHING BATTERY

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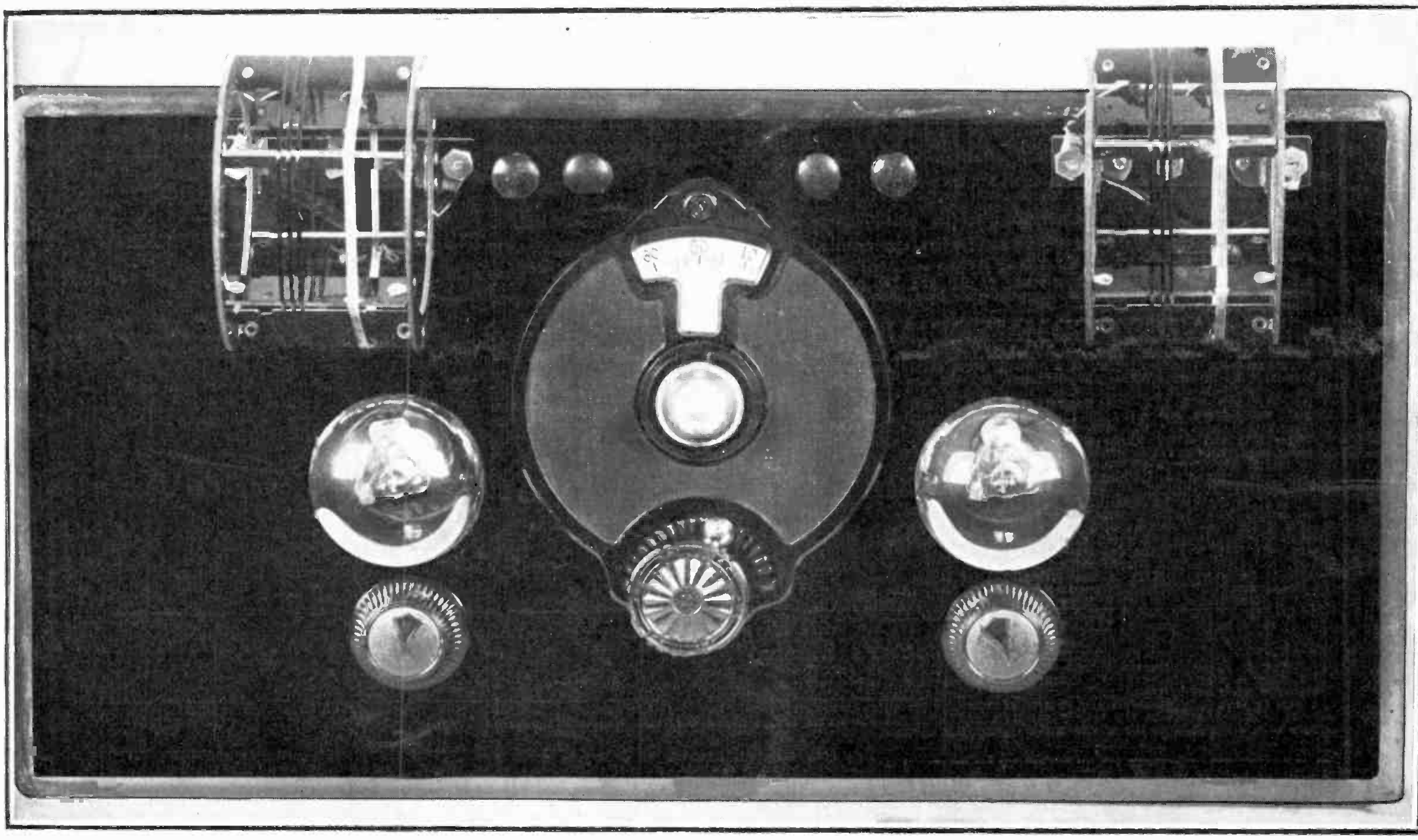
448th Consecutive Issue—NINTH YEAR

BATTERY SET, USING NEW 230, 231, 232

HERTZ RADIATED 28 HORSE POWER ON SHORT WAVES

TWO-TUBE SHORT-WAVE CONVERTER



The Simplest Short-Wave Converter, for Use With Any Broadcast Receiver, Illustrated Herewith, and Described on Pages 5, 6 and 7.

Automatic Volume Control Circuits of New Stromberg-Carlson and Bosch Receivers

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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"AUDIO POWER AMPLIFIERS"—Anderson and Bernard

"Audio Power Amplifiers" is the first and only book on this important subject. The authors are:

J. E. Anderson, M.A., former instructor in physics, University of Wisconsin, former Western Electric engineer, and for the last three years technical editor of "Radio World."

Herman Bernard, LL.B., managing editor of "Radio World."

The book begins with an elementary expositon of the historical development and circuit constitution of audio amplifiers and sources of powering them. From this simple start it quickly proceeds to a well-considered exposition of circuit laws, including Ohm's laws and Kirchhoff's laws. The determination of resistance values to produce required voltages is carefully expounded. All types of power amplifiers are used as examples: AC, DC, battery operated and composite. But the book treats of AC power amplifiers most generously, due to the superior importance of such power amplifiers commercially.

CHAPTER I. (page 1) General Principles, analyzes the four types of power amplifiers, AC, DC, battery-operated and composite, illustrates them in functional blocks and schematic diagrams.—CHAPTER II. (page 20) Circuit Laws, expounds and applies Ohm's laws and those known as Kirchhoff's laws.—CHAPTER III. (page 35) Principles of Rectification, expounds the vacuum tube, both filament and gaseous types, electrolytic and contact rectifiers, full-wave and half-wave rectification, current flow and voltage derivation. Regulation curves for the 280 tube are given.—CHAPTER IV. (page 62) Practical Voltage Adjustments, gives the experimental use of the theoretical knowledge previously imparted. Determination of resistance values is carefully revealed.—CHAPTER V. (page 72) Methods of Obtaining Grid Bias.—CHAPTER VI. (page 90) Principles of Push-Pull Amplifier.—CHAPTER VII. (page 98) Oscillation in Audio Amplifiers, motorboating and oscillation at higher audio frequencies.—CHAPTER VIII. (page 118) Characteristics of Tubes, tells how to run curves on tubes, how to build and how to use a vacuum tube voltmeter, discusses hum in tubes with AC on the filament or heaters and presents families of curves, plate voltage-plate current, for 240, 220, 201A, 112A, 171A, 227 and 245, with load lines. Also, plate voltage-plate current characteristics of 220, 200A, 201A, 112A, 171A, 222, 240, 226, 227, 224, 245, 210, 250, full data on everything. There is a composite table (II) of characteristics of Rectifier and Voltage Regulator Tubes, and individual tables, giving grid voltage, plate current characteristics over full useful voltage ranges for the 220, 201A, 112A, 171A, 222, 240, 227, 245 and 224.—CHAPTER IX. (page 151) Reproduction of Recordings, states coupling methods and shows circuits for best connections.—CHAPTER X. (page 161) Power Detection.—CHAPTER XI. (page 121) Practical Power Amplifier, give AC circuits and shows the design of a sound reproduction system for theatres. A page is devoted to power amplifier symbols.—CHAPTER XII. (page 183) Measurements and Testing, discloses methods of qualitative and quantitative analysis of power amplifier performance. Order Cat. **APAM.**

"FOOTHOLD ON RADIO"

In simple English that any one can understand, the technical side of radio is presented by Anderson and Bernard in their book, "Foothold on Radio." Any one who can read English can understand this book. It is intended for the sheer novice. The treatment is non-mathematical. The origin of the broadcast wave, its radiation, reception, amplification and rectification are set forth in clear language. Side bands are explained simply. The types of receiving circuits are illustrated, described and contrasted. A chapter is devoted to loudspeakers, explaining the different kinds and the principles of their operation. Performance is compared. Audio coupling is fully explained, also the action of the vacuum tube, with a special analysis of plate current and its behavior. Those who have been thirsting for a book that readily reveals the marvels of the radio science will appreciate this little volume. Paper cover 60 pages, fully illustrated. Published May, 1930. Order Cat. **FOR.**

"THE SUPERHETERODYNE"

This is a new volume by Anderson and Bernard dealing with the principles and practice of the Superheterodyne method of receiving. It explains the function of the oscillator, the modulator, the pre-modulator selector, and the intermediate frequency amplifier. It explains the cause of repeat points and gives methods for avoiding them or minimizing their effect. It expounds the relative advantages and disadvantages of high and low intermediate frequencies, and shows the effect of selectivity on the quality.

It illustrates various forms of oscillators and tells of the advantages of each. Different types of modulators and pick-up systems are explained and their advantages stated. Different methods of coupling in the intermediate frequency amplifier are shown.

Image interference is discussed in detail and methods given by which it may be reduced.

A special method of ganging the oscillator to the radio frequency condensers is explained, a method which allows either the high or the low oscillator setting to be selected by means of a variometer in the oscillator circuit.

One section is given over to coil design for the radio frequency tuners, the oscillator, and the intermediate frequency filter.

Audio amplifiers suitable for superheterodynes are also described. These include transformer, resistance, and push-pull amplifiers both for AC and DC.

While the book is primarily intended to expound the principles of the Superheterodyne, the practical phase has not been neglected. Detailed descriptions of AC and DC superheterodynes, designed in conformity with best practice and sound applications of the principles, have been included in the book. These descriptions are well illustrated. Order Cat. **ABSH.**

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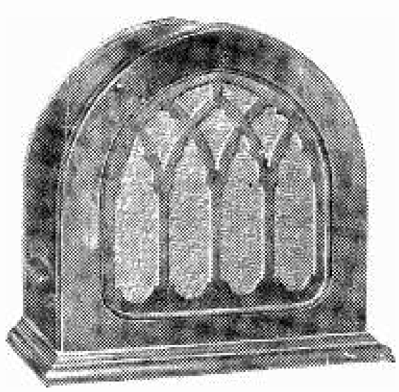

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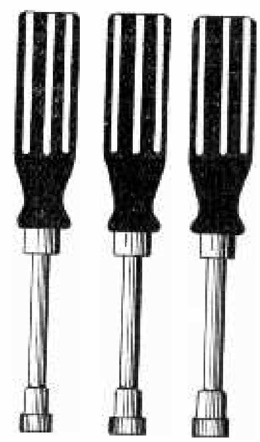

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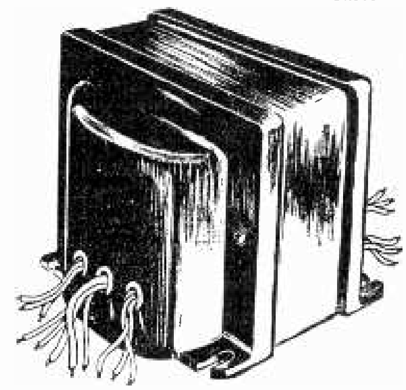

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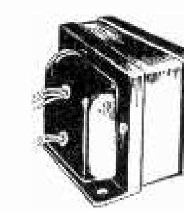

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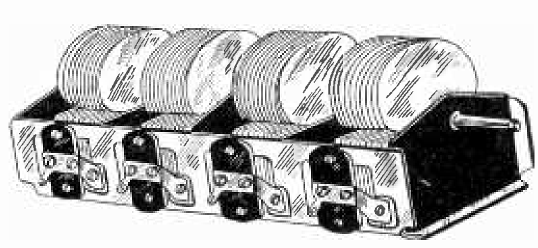

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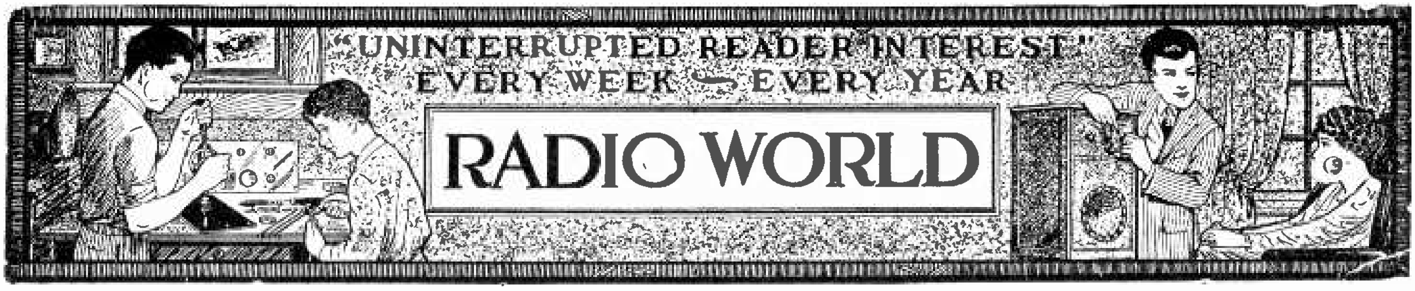

Vol. XVIII, No. 6 Whole No. 448
October 25th, 1930
[Entered as second-class matter, March, 1922, at the Post Office at New York, N. Y., under act of March, 1879]
15c per Copy, $6.00 per Year

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The Simplest Converter

By Herman Bernard

THE simplest short-wave converter that can be built is one that consists of a modulator and an oscillator. If an AC model is desired, then a filament transformer should be used, rather than placing reliance on a broadcast receiver to furnish the heater power, since an additional current of 3½ amperes would be imposed by two 227 tubes, used in the converter.

However, it is permissible, and in no manner dangerous to the receiver, to obtain the B voltage therefrom, so a binding post would be included for connection to whatever voltage is handiest or best, from 45 volts to 180 volts. The only modification is that the B voltage must be high enough to insure oscillation of the oscillator. Around 135 volts will afford this guarantee, unless the tube used in the oscillator socket is dead or very sick.

Principle of Operation

The short-wave converter operates on the principle of tuning in short waves at their original wavelengths, by the tuned modulator circuit, then the establishment of a different frequency in the oscillator, and the coupling of modulator and oscillator, whereby the modulator thus obtains an output frequency equal to the difference between the two other frequencies. This difference frequency is the one to which the broadcast receiver should be tuned, so that the radio frequency amplifying stages of the broadcast receiver become the intermediate frequency amplifier, the detector of the receiver is the detector (so-called second detector) of the system, and the audio channel performs its usual function. You then have a Superheterodyne. Therefore short-wave stations may be received on the loudspeaker, and at an outlay of less than $20 for parts, with two 227 tubes constituting the only extras. You can double the usefulness of your broadcast receiver, and increase greatly the pleasure derived from radio reception.

The converter is therefore the mixing circuit of a Superheterodyne, of which the broadcast receiver is the intermediate frequency amplifier, detector and audio amplifier. The converter as diagrammed furnishes its own heater power but takes its B voltage from the receiver.

Performance Depends on Your Set

Receivers built within the last year or two are sensitive instruments, as a rule, and particularly the AC type receivers, so that the radio frequency amplification, for which you depend almost exclusively on the RF channel of the receiver, is abundantly high. The performance, with such a mixer as shown, and with a good receiver, with sensitivity of even only 50 microvolts per meter, will be reliable and steady. The performance depends on your receiver.

A particularly attractive feature of a converter is the combined absence of body capacity, due to grounded rotors of tuning condensers, and of difficult and irksome tuning owing to the freedom from trickiness and to detuning effects caused by adjustable regeneration. Single dial tuning control is quite practical, and if a trimmer is placed on the front panel, there is no less of sensitivity involved by single control, although the precaution must be taken to have the trimmer capacity of sufficient range so that when identical coils are used the capacity divergence between the two tuned circuits always will be enough to establish the desired difference frequency.

Assuming that the highest possible frequency to which the receiver can be tuned is used as the intermediate frequency, which in modern receivers will be higher than the broadcast

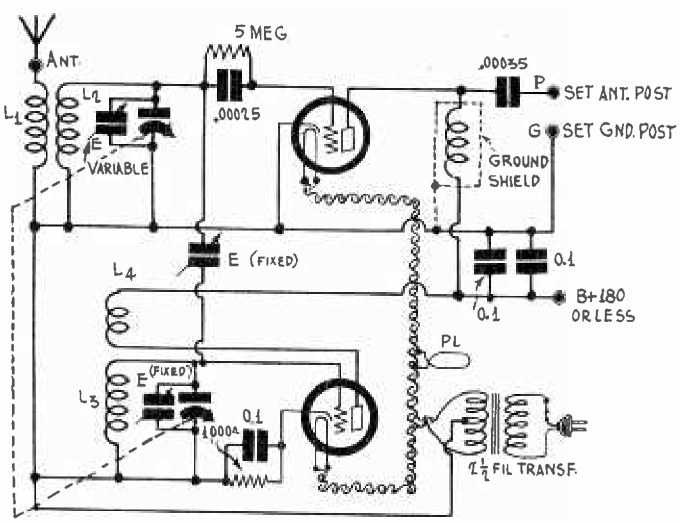


FIG. 1.
CIRCUIT DIAGRAM OF THE 2-T CONVERTER, THE SIMPLEST CIRCUIT FOR A SHORT-WAVE SUPERHETERODYNE.

maximum, a difference frequency of, say, 1,700 kc would be established. This will be done if the trimmer has a maximum capacity of .0001 mfd., and it may have a relatively high minimum, say, .00002 mfd. These values in mmfd. are 100 and 20 respectively.

The difference frequency of, say, 1,700 kc is a high frequency

(Continued on next page)

LIST OF PARTS

Two sets of Precision Short-Wave coils wound on air dielectric forms, two coils to a set; total number of coils, four.
Four binding posts.
One .00025 mfd. fixed condenser with clips.
One .00035 mfd. Dubilier Micon fixed condenser.
Three 0.1 mfd. Supertone fixed condensers in one case.
Three Hammarlund equalizers. 100 mmfd.
One two-gang Scovill .0003 mfd. condenser.
One 1,000-ohm wire-wound biasing resistor, 20 ma rating or higher rating.
One shielded radio frequency choke, 50 millihenries.
One 2½-volt filament transformer, for 110 volts, 50-60 cycles.
One 5 meg. grid leak.
One wooden cabinet, walnut finish.
One National VBD velvet vernier dial with pilot lamp and bracket.
One Hart & Hegeman AC switch, shaft type.
One 7 x 14 inch bakelite panel, with two tube sockets, and two coil receptacles built in; drilled for National VBD dial, for switch, for trimmer and for the binding posts.
One bakelite bushing to mount modulator trimmer, and one shaft to engage trimmer.
Two ¼ inch knobs.

How to Avoid Dead

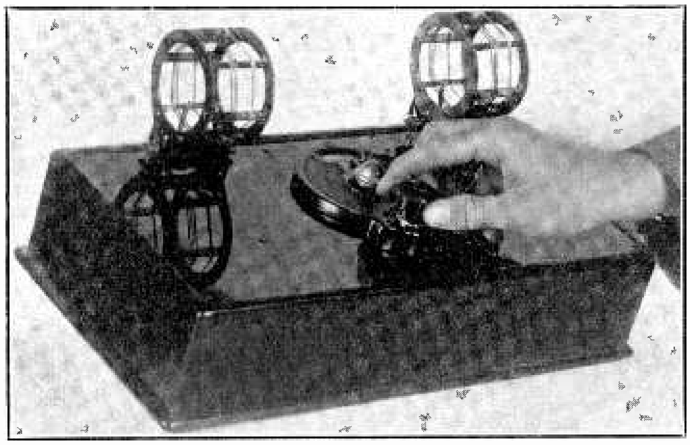


FIG. 2.
A SHALLOW CABINET IS USED FOR ACCESS FROM THE TOP. THE PANEL IS 7x14 INCHES AND THE CABINET IS 3 INCHES HIGH.

(*Continued from preceding page*)
in the language of broadcast frequencies, but in the short-wave spectrum it is a relatively low frequency. For instance, not much difference in capacity would be required when you are tuning in on 30 meters (10,000,000 cycles), since 1,700 kc is only about one part in 7,000 under those circumstances. Because of the small difference, and the peril of not being able to meet it otherwise, an extra capacity is used across the modulator as well. Hence the two circuits may be adjusted to zero beat, and when the trimmer across the modulator is at a low capacity setting. Then the adjustable trimmer is bound to be effective.

The coupling between modulator and oscillator is effected through a small condenser. Use of a capacitance of the equalizing type will permit the choice of any desired degree of coupling within the capacity range of the condenser. In the grid-to-grid position shown, 100 mmfd. is close coupling indeed, and most experimenters will want to use less, and may do so, but once the capacity is selected on test basis it need not be changed.

The Small Condensers

There are three small condensers marked E, but it must not be assumed there are several knobs to manipulate. The condenser uniting the modulator and oscillator circuits and the one across the oscillator tuning coil are set for a position of optimum results and not molested thereafter.

The other condenser of this small capacity range, across the modulator's tuned circuit, is a manually operated trimmer mounted on the panel, and if a suitable shaft and bushing are provided, the same model condenser may be used here in a variable manner as is used in a fixed fashion in the two other positions.

Considerable simplicity in wiring and construction results from the unison of the mixer circuits by the capacity method. First, two similar or identical coils may be used in the modulator and oscillator circuits, and a three-winding coil for the oscillator is avoided.

Plugging in three-winding coils is not always handy, particularly as one may have bases that contain only four coil socket connections, and three-winding coils normally require six connections. If one winds his own coils the construction simplicity is heightened, and also the wiring of the converter itself is made easier and long leads completely avoided, since the coupling condenser is mounted on the two-gang tuning condenser, from condenser stator lug to stator lug.

Coupling Precaution

The condenser method of mixer coupling has been used in popular circuits only occasionally, but is gaining greater favor. The new line of commercial screen grid Superheterodynes uses it with good results. In short-wave work it has additional advantages, as outlined, only the precaution must be severely taken not to utilize too high a capacity. Bear in mind that 100 mmfd. is high indeed. Around 30 to 50 mmfd. usually work well.

With this method of loose coupling there is also less likelihood of dead spots on the dial. The subject of dial silence in short-wave work is a delicate one, and most writers on constructional topics prefer to avoid the discussion. It is a fact that in any short-wave receiver, converter or adapter there is always the possibility that, with reception excellent over most of the dial, with a given coil in the receptacle, there will be a dead space, or blind spot, or "skip," where nothing is heard or can be heard.

This situation is not to be confused with failure to hear anything over part of the dial, when that failure is due simply to absence of stations on the air or their operation outside your sensitivity range. It is hard to distinguish between the two, except that if you do considerable listening in a suspected dead spot area of the dial, if your suspicions are unfounded you will hear something some time, whether code, voice or music.

Cures for Dead Spots

In converters or any other circuits using the Superheterodyne principle it is always possible that this silent effect is due to the two circuits pulling together, so they act as one, where the capacity is doubled and the inductance halved, as in any parallel connections of these two types of constants. This is merely another reason for not using a high coefficient of coupling beween modulator and oscillator.

Assuming loose coupling, the next subject to consider is the effect of the B supply inpedance on the tuned circuit, or the effect of the B plus lead. It has been found that low capacities, of the order of 0.01 mfd., from B plus to ground, when increased considerably, removed dead spots in other circuits, so here the capacity used is 0.2 mfd., or twenty times as great.

The odd capacity of 0.2 mfd. is obtained by parallel connection of two units of a three-section fixed condenser. This part contains in one aluminum case three 0.1 mfd. capacitances, from which case emerge four leads. One lead is black and is common ground for all three condensers. The three red leads connect to the respective opposite plates of the three condensers, so unite two of the red leads and connect them to B plus in the converter. The third red lead goes to the cathode of the oscillator tube.

If a shielded radio frequency choke is used in the plate circuit of the modulator, ground the shield.

Also, if a suspected dead area of the dial comes to life when the oscillator plate voltage is raised, make this increased voltage permanent, even though it heightens the modulator voltage to a greater potential than is usually recommended for detector circuits.

Detectors and Modulators

Moreover, the modulator circuit is not a detector in the sense in which the word detector is commonly used, that is, reduction of radio frequency modulated carriers to audio frequency values, or carrier-elimination. The modulator does contribute a frequency change, to be sure, but it is simply the reduction of the carrier frequency to another radio frequency, on a much smaller ratio scale than prevails in what are commonly known as detector circuits.

The construction of the converter is easy enough, as there are only a few wires to connect, and the points of connection are readily accessible.

A good vernier dial must be used, as otherwise you would skip past an amazing number of stations without hearing them, and might complain of total dead spot over the dial on all coils. The National VBD velvet vernier dial is an excellent one. It mounts flat on the outside of the panel and actuates a condenser with shaft at right angles to the panel. It is well worth the few cents extra to use the pilot bracket and lamp, so that dial illumination will be provided. Also, this serves as a pilot light to warn you the converter is turned "on," when you might have supposed you'd turned it off. Either a 2½-volt or a 6-volt lamp may be used, despite the 2½-volt source, since not much brilliance is needed, and both will light, the one intensely, the other moderately, on this voltage.

Heater Power

To the left of the tuning dial's knob is a small knob for the trimming condenser across the modulator's tuned circuit, while

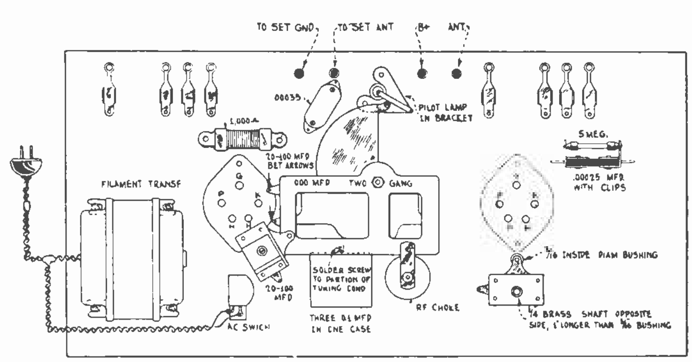


FIG. 3
LAYOUT OF PARTS FOR THE CONVERTER. THIS IS A VIEW OF THE BOTTOM, WHICH ACCOUNTS FOR PLATES AT LEFT AND CATHODES AT RIGHT IN THE SOCKET DETAIL.

Spots on Short Waves

at right a corresponding knob actuates the shaft-type AC switch. The panel, which is 7 x 14 inches, fits onto a cabinet that is shallow in depth, because the outfit is tuned from the top, instead of from the front. Also on top are the two sockets for the 227 tubes, and the two coil receptacles.

The filament transformer, if used, would be placed, naturally, next to the switch, and room is provided for such location, with inside panel mounting.

If you have 2½ volts AC independently accessible, as from a power pack, then the filament transformer well may be omitted, and both heater and plate voltages obtained from the pack. Special precaution should be taken, however, to obtain authoritative assurances that the extra 3½ amperes drawn by the two heaters, in conjunction with the heater drain of the broadcast receiver, will not overtax the winding that is intended to furnish this power.

With broadcast receivers proper, it is unsafe to try to use the heater voltage on the converter, but where you have a broadcast tuner with a separate audio power amplifier, it is frequently permissible to make this double use of the pack. If the power transformer in an audio power amplifier has a 16-ampere winding, you may feel perfectly safe in assuming that the winding will "pull" a total of eight tubes, so if it serves six tubes or less, including radio frequency amplifiers, detector and audio amplifier, you may power the heaters of the two tubes of the converter from the same winding as well.

External Connections

The method of making external connections, after the converter is wired, is indicated in the diagram, Fig. 1, but is stated textually herewith:

(1) Remove the aerial wire connection from the antenna post of the broadcast receiver, and instead connect the aerial wire to the antenna post of the converter. Use any kind of wire for this prpose, preferably insulated.

(2) Connect the B plus post of the converter to a source of B voltage, obtainable from the receiver. This voltage is not critical, and anything from 67 to 180 volts will work the converter, except that if a tube used as oscillator is in a weak condition, higher voltage than 67, but not higher than 180, will be required. Use insulated wire of any kind for this connection.

(3) Connect a wire from the ground post of the receiver to the binding post of the converter marked "Set Gnd. Post."

(4) Connect the remaining post of the converter, marked "Set Ant. Post" to the antenna post of the broadcast set.

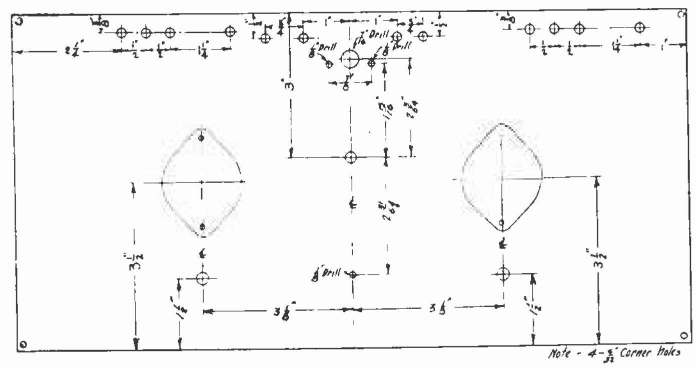


FIG. 4
DIMENSIONAL DIRECTIONS FOR DRILLING THE TOP PANEL OF THE CONVERTER

When the converter is worked, as it must be, in conjunction with the broadcast set, by turning the dial of the broadcast receiver it will be possible to tune in broadcast stations on their regular wavelength, unless shielded wire is used for connection between the antenna post of the set and the corresponding binding post of the converter.

Broadcast Pickup Avoided

It is of no particular disadvantage that this is true, since the set itself is tuned to a fresuency higher than that of the highest broadcast frequency, and the setting is not changed on the set at any time. In fact, to insure the same dial settings for the same stations time and again on the converter, the same setting of the set dial should be used all the time.

However, if one likes to try out different intermediate frequencies, he may do so, but will encounter direct broadcast reception because the lead from the converter to the antenna post of the set constitutes an aerial for the set. Locals will come in on a sensitive receiver, even some distance. So if it is desired to avoid this, use shielded wire. Solder an extra piece of other wire to the shield of the shielded wire, and the other end of the extra piece connect to the ground post as the set. The shielded wire method will reduce sensitivity a little.

One device is to use the mesh of the shielded wire as the ground lead from set to converter, and the inside wire of the lead as the antenna connection.

Right or Wrong?

QUESTIONS

(1) Interrupted continuous waves can be received with a short-wave receiver without making the radio frequency amplifier oscillate and without using any oscillator except that in the converter.

(2) The best way of getting the proper screen voltage is to connect a suitable resistance between the plate voltage tap and the screen return lead, because this holds the screen voltage in a constant ratio to the plate voltage.

(3) Heat and radio waves are the same fundamentally and differ only in wavelength

(4) If comfortable room volume only is desired there is no advantage at all in having two 245 tubes in the output stage because the maximum undistorted output is not utilized.

(5) When two power tubes are used in push-pull the grid bias resistance should be made up of two resistors connected in series, each having the resistance required for a single tube.

(6) A tuning fork oscillator maintains a constant frequency regardless of the temperature and the amplitude of vibration of the fork.

(7) Silicon steel is inferior to permalloy type steels for cores in audio transformers and chokes because it gets saturated much more quickly.

(8)—The effective voltage on the plate of a tube at any instant is equal to the difference between the applied plate voltage and the drop in the load impedance.

ANSWERS

(1) Wrong. While it is possible to locate such stations on the dial it is very difficult to read the signals because no clear note is produced. In order to have the signals come through as a musical note it is necessary to provide an oscillator which generates a frequency which differs by about 1,000 cycles from the intermediate frequency. Either the radio frequency amplifier must be made to oscillate or else an auxiliary oscillator must be provided and adjusted to a suitable frequency.

(2) Wrong. This is a very poor way because the screen voltage should be held constant and this method yields a screen voltage which depends on the screen current.

(3) Right. Both are electro-magnetic waves and travel with the same speed in space. The only difference is one of wavelength, or what amounts to the same thing, frequency. Light waves are also of the same nature. In fact, light waves are heat waves of very short wavelength.

(4) Wrong. Maximum undistorted output contains relatively much more harmonic distortion than the volume which is just comfortable to listen to, if both come from the same receiver. Hence there is a decided advantage in using high power output tubes in push-pull.

(5) Wrong. If the bias resistors were connected in series the bias would be practically four times as great as it should be because the current is doubled by the fact that the plate currents from both tubes is flowing and also by the fact that the resistance is doubled. The resistors should be put in parallel, or what amounts to the same thing, the bias resistance should be one-half as great for two tubes as for one.

(6) Wrong. The frequency generated varies considerably with variations in temperature and also with variations in the amplitude of the fork.

(7) Wrong. A core made of silicon steel does not saturate as quickly as one made of high permeability steel, other conditions being equal. The superiority of the permalloy type steels lies in the fact that their permeability is high. They saturate more quickly and this is a disadvantage of these steels.

(8)—Right. The effective voltage on the plate is equal to the drop in the internal resistance of the tube, and this must be equal to the applied voltage less the voltage drop in the external circuit.

Adaptation to New Tubes

By Neal Fitzalan

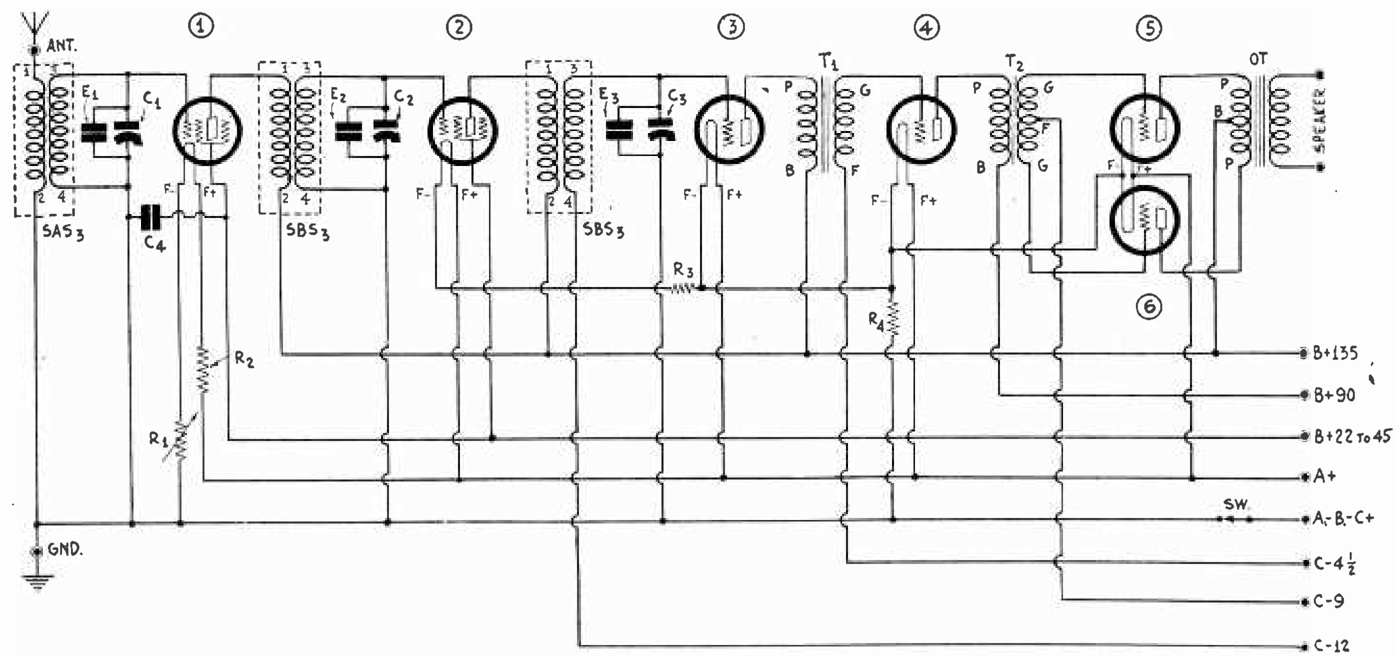


FIG. 1
A SIX-TUBE BATTERY RECEIVER THAT MAY BE ADAPTED TO THE NEW 2-VOLT TUBES WITH ONLY A FEW CHANGES IN THE VOLTAGES.

INTEREST in receivers built around the new 2-volt tubes is increasing because many people living in sections where no electric power is available are rapidly learning the advantages in using the low voltage tube. Few circuits have been described utilizing these tubes, but this should not be a deterrent to building receivers with these tubes because almost any circuit designed for battery tubes can be converted with little change to accommodate the new tubes.

Suppose a circuit has been designed so as to employ two 222 screen grid tubes, a three element detector, a similar audio frequency amplifier, and a stage of push-pull using any of the battery type power tubes. Such a receiver can be changed to the new tubes with very few alterations in the filament, plate and grid voltages. Of course, a circuit of any different make-up can also be changed just as easily, but we single this out because it is an excellent circuit both with regard to sensitivity and output volume. This six-tube circuit to which we refer is shown in Fig. 1.

Tubes and Voltages

This receiver employs two each of the three new 2-volt tubes. The first two are 232 screen grid tubes and are used as radio frequency amplifiers. The next tube is a 230 and is used as grid bias detector and the fourth tube is also a 230 but is used as audio frequency amplifier. The two tubes in the push-pull output stage are the 231 power tubes.

The filament terminal voltage of each of these should be two volts. Let us see what changes are necessary in the filament circuit to insure that each tube gets 2 volts. To decide what to do we have to inquire into the filament voltage source and the current taken by all the filaments. First, the first four tubes require a current of 0.24 ampere, since each takes 0.06 ampere. The power tubes require a current of 0.26 ampere for each takes 0.13. Therefore the total current will be one-half ampere. Now a No. 6 dry cell deliver one-fourth of an ampere and it is not economical to draw more from it for any length of time. Hence if we put two such cells in parallel we can get enough current to supply the tubes, provided that we use enough voltage. Each cell has a voltage of 1.5 volts. Therefore we have to use two in series and we have a total voltage of 3 volts, one volt more than that required. Accordingly, we use four No. 6 dry cells in series-parallel. We cannot use less but we could well use more in parallel so as to cut down the current drawn from each cell.

In the diagram all the positive ends of the filaments are connected to the positive of the battery without the intervention of any ballast, with the exception of the first tube in which there is resistance, R2. Remove it and make the connection direct as for the other tubes. There are also the resistors R3 and R4 in the negative leads. Remove these also and make the connections direct to the negative binding post for the filament battery.

Now we have no ballast resistance for any of the tubes but we do have a rheostat in the negative lead of the first tube. More about this in a minute. We have to make a provision for getting rid of the extra volt in our filament supply. Cut the positive lead just to the left of A plus and insert therein a low resistance rheostat. Let us see how much resistance we need. The current through it will be half ampere and we want to drop one volt. Therefore we need just two ohms. Hence if we use a six-ohm rheostat we will have ample resistance and still we can set the rheostat so that the current will be just one-half ampere.

Volume Control

Rheostat R1 is used as a volume control, and an effective one. As more resistance is cut on the filament current is reduced, thus decreasing the amplification, and at the same time the grid bias is increased, contributing still more to the reduction in sensitivity. To determine what value we should use we have to take account of the current flowing through it and the current reduction necessary. If the current is cut down to .04 ampere the tube will not be very effective and if we cut it down to .03 it is practically dead. When the current is cut down to .03 ampere the voltage across the filament is one volt and we have to cut down one more in the rheostat. Therefore we have a voltage of one volt and a current of .03 ampere. Hence the maximum resistance should be about 33 ohms. Since 30-ohm rheostat may be obtained one of them can be used. Even a 25-ohm rheostat would control the volume sufficiently.

There is a new battery available, an account of which is given on the opposite page, which has been designed especially for the new tubes. It has a voltage of 2.5 volts which remains constant for a long period. This is preferred to the use of dry cells. No change is needed in the circuit from the above except that now the voltage drop in the 6-ohm rheostat should be only one-half volt and the resistance used should be only one ohm. In view of the fact that the new battery maintains a constant voltage, even the rheostat could be dispensed with and a fixed resistor of one ohm used in place of it. This new battery is known as the "breathing cell" or "air cell" battery.

Voltage Changes

No change is needed in the plate and screen voltages specified in the diagram because the same values are used for the two-volt tubes. The grid bias on the power tubes, C9, should be changed to 22.5 volts. The bias on the detector should be changed to about 9 volts, but the exact value should be determined by experiment to find that which gives best detection.

The bias on the grid of the first audio tube, when the plate voltage is 90 volts, should be 4½ volts, just as marked on the terminals. The two screen grid tubes should have a bias of 3 volts but there is no provision for this, now that the ballast resistors have been removed. Therefore the two leads running from the first two tuned circuits to ground should be cut, joined together, and then connected to the 3-volt point on the grid battery, the positive of which is connected to A minus.

The Breathing Battery

THE new constant-voltage "breathing battery" named the Eveready Air Cell is expected to confer popularity on the new 2-volt tubes, 230, 231 and 232. Already several large manufacturers have started production of Air Cell receivers designed around this battery-tube combination.

There is, and always has been, according to the National Carbon Company, a large, untouched market for battery-operated receivers, conservatively estimated at 2,000,000 families, mostly rural, so located that radio can come to them only by way of battery sets, but who, so far, have refrained from buying because industry has been unable to make the kind of receiver these folk must have.

The only kind of battery-operated receivers the industry has been able to offer has been the so-called storage battery set and the dry battery set. The storage battery set uses a type of tube which demands such heavy filament current that only a storage battery can meet the demand. The storage battery set has proved itself to be better and more practical than the dry battery set, but it can not be used by these 2,000,000 or more persons because they either will not or they can not go to the trouble and expense involved in keeping a storage battery charged.

A Flash and a Flop

The dry battery set, so named because it uses a type of tube so sparing in its consumption of filament current that its demand falls within the current-producing ability of the dry cell, at one time promised to be the solution of the rural radio problem.

The eagerness with which the first dry battery sets were snapped up by the trade and the public is evidence of the existence of a large market for a battery set which does not require a storage battery. In spite of its initial enthusiastic acceptance, however, the dry battery set failed to achieve commercial success. The failure of the dry battery set left a large part of the rural radio market high and dry.

The company's analysis continues:

The vacuum tube and the dry cell are not compatible. Either alone is perfectly satisfactory, but nature never intended them to get along together. This was not well understood in the early days of radio, and is not generally understood now, but it really is the cause of all the trouble the industry experienced in its efforts to exploit the dry battery set idea.

The vacuum tube demands, and must have, its filament current delivered to it at practically constant voltage; the dry cell, by nature, is incapable of meeting this demand, being inherently a variable voltage device.

If the voltage applied to a tube filament is only slightly above the rated value, the tube loses emission, or may actually burn out. On the other hand, if the applied voltage falls slightly below the tube's rated value, the tube ceases to function well for as long as the voltage is below normal. The upper safe voltage limit, above which burnout occurs, and the lower satisfactory voltage limit, below which the tube ceases to operate, are rather close together, the permissible leeway between them amounting to not more than 5 per cent of the rated voltage of the tube, in most cases.

In contrast with this exacting demand for constant voltage, the initial voltage of a good dry cell is at least 50 per cent. higher than the final voltage at the end of life.

The tube, then, any tube, as a matter of fact, including the new 2-volt tube, is essentially a constant-voltage device; any dry cell is inherently a variable-voltage device. These directly opposing traits are responsible for the failure of the dry battery set, not the reputed fragility and general unsuitability of the tube.

To get right down to the fundamentals of the thing, the dry battery set failed because of an unsuitable battery-tube combination.

Many devices intended to bring these opposing traits into line have been tried, but without permanent success. A few of the more familiar of such devices are: the filament rheostat, the indicating filament voltmeter, the ballast resistor, and the automatic voltage regulator.

Renewals Get One's Goat

When it is considered that none of these devices was successful, it is evident that any effort to invent still another device intended to reconcile the difference in the dry cell and the tube would be wasted. Then, too, there is still another weakness of the dry battery set which should be overcome, if possible, and that is the frequency with which even the recommended, most economical combination of dry cells must be renewed.

Depending on the number of 199 tubes in the set, the best dry-cell A battery consists of six, nine or twelve dry cells, hooked up in a complicated series-multiple connection, a form of connection extremely difficult for the average set owner to make, and one which has resulted in the ruin of numerous cells and tubes, through wrongly made connections. Even assuming that the set owner gets his dry cells hooked up correctly, he has to go through the whole procedure again in two, three or four months. To be completely acceptable, the new sets should be free of this nuisance, inconvenience and expense.

This leads to the inescapable conclusion that the dry cell is not a satisfactory source of filament power for radio receivers. It never has been; its variable voltage characteristic kills it for that. It is perfectly satisfactory for a host of other uses, and is daily demonstrating its fitness to serve devices not requiring constant voltage, including the "B" circuit of the vacuum tube, but it is now evident that nature never intended it to serve as an A battery for a radio set. We must seek elsewhere for a suitable source of filament power.

On AC Set Plane

Since an unsuitable battery-tube combination was at the root of the dry battery set failure, it is logical to conclude that the way to go about making a successful set would be to develop a suitable battery-tube combination; a battery and a tube in which the essential electrical characteristics would harmonize, rather than oppose each other.

And, in addition, the tubes should be as sparing as possible in the consumption of B battery current, to prolong the life of that important adjunct, and the A battery should have large capacity, to the end that it will last much longer than the best combination of dry cells hitherto available, and thus make it possible for the user to obtain satisfactory reception for unusually long periods from one installation of batteries.

The Research Laboratories of National Carbon Company, in other words, set out to develop a battery receiver which would look like, act like and be operated like the now universally familiar AC set; a battery receiver which would afford its owner the simplicity of operation, the dependability, the quality of reception, the economy of upkeep of an AC set, but which would not require a storage battery and which would not require manually adjustable controls, which, through accidental misadjustment, could cause damage to the tubes, the batteries, or both.

No Recharging

The most important characteristic of the new battery, and the one which makes it an inseparable companion of the 2-volt tube, is its constant voltage feature. Unlike most primary batteries of the past, the voltage of this battery remains practically at full initial strength throughout its enire life, without recharging.

This important feature is the result of a development by National Carbon Company Research Laboratories in the form of a special carbon electrode, by means of which the essential, life-giving oxygen is drawn into the battery as required, directly from the air.

In all other forms of batteries the oxygen is supplied in the form of some chemical or mineral built into the battery. The oxygen carrier in the dry cell, for example, is manganese dioxide, a natural mineral occurring at widely separated points in the earth's crust. In the dry cell, as the oxygen, which is the depolarizer, becomes used up, the working voltage falls as a consequence.

In the Air Cell battery, with an unlimited supply of oxygen always available, the voltage-reducing hydrogen can not accumulate within the battery, but is converted into harmless water as fast as it is generated by the flow of current through the cell. Thus the voltage remains well up until all the active, electricity-producing ingredients in the battery have been consumed.

Old Idea, But New Feat

The idea of using the air itself as the depolarizer is almost as old as the primary battery. Probably every scientist, every research man, every physicist who has had anything to do with batteries, has made serious attempts to use the air we breathe to depolarize them instead of oxygen-bearing minerals which must be obtained at considerable labor and cost. But this is the first successful application of this principle.

The Eveready Air Cell A Battery has a rated capacity of 600 ampere-hours. A 2-volt receiver, using seven tubes, two of them being output tubes, consumes approximately .55 ampere from the A battery. This means that the new battery will run such a set for well over 1,000 hours, or on the basis of three hours per day, a whole year.

The battery consists of two cells, built in one container and permanently connected in series. The nominal voltage of the battery is 2.5 volts. While the voltage is not absolutely constant in the strictest sense of the word, the decline in voltage from beginning to end of life is only a fraction of the decline in the dry cell, and is well within the permissible leeway between the tube's upper safe voltage limit and its lower satisfactory operating limit. Consequently, an Air Cell receiver requires no adjustable rheostat. A fixed resistor built into the set will cut the 2.5 volts of the battery down to the 2.0 volts required by the tubes.

The only filament control required by such a set is a simple off-on switch, just like an AC set. With such a set, the power from the Air Cell battery can be snapped on without danger of damaging the tubes when the battery is new, and with full working filament voltage available at the tubes until the battery has delivered practically all of its rated capacity.

Automatic Volume Con and Stromb

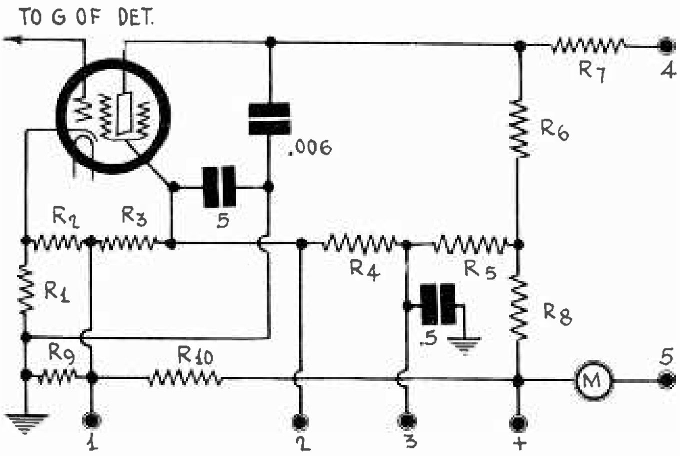


FIG. 1
A DETACHED AND SIMPLIFIED DRAWING OF THE AUTOMATIC VOLUME CONTROL USED IN THE BOSCH MODELS 58 AND 60, WHICH ARE NEW 1930-31 MODELS.

[Herewith is the first of a series of articles under the general topic, "Service Men's Guide," discussing technical features of 1931 model commercial receivers. It is planned to publish complete diagrams of the latest commercial receivers and power supplies, for the help of service men in their work, and also for the general engineering interest in these circuits. Diagrams of circuits prior to the 1930-1931 crop will be found in Rider's "Trouble Shooter's Manual," and his "Supplement No. 1," which supplement contains 115 diagrams alone. Also Gernsback and Fitch's "Official Radio Service Manual" contains diagrams prior to the present season's aggregation.—EDITOR.]

SERVICE MEN'S GUIDE

AUTOMATIC sensitivity controls, usually referred to as automatic volume controls, are now incorporated in most commercial radio receivers of the advanced type. The object of these devices is to maintain the output constant within certain limits, regardless of the strength of the signal at the antenna. Two noteworthy advantages result from their use. One is that when the signal is subject to fading the output remains practically at the same level, and the other is that when the circuit is being tuned and the controls are moved through a strong local signal there is not so much increase in the volume as compared with the output when the controls are moved through a weak station.

When the automatic sensitivity control is really effective it is difficult to tune in a station by the sound-intensity method, that is, by tuning for loudest sound, because there is comparatively little increase as the tuning controls move through the point where the carrier comes in. For this reason it is customary to insert a visual resonance indicator which is placed so that there is a decided peak in the deflection of the needle at resonance. However, not all automatic sensitivity controls are made 100 per cent. effective, so that in some receivers having them it is still possible to tune by the sound-intensity method.

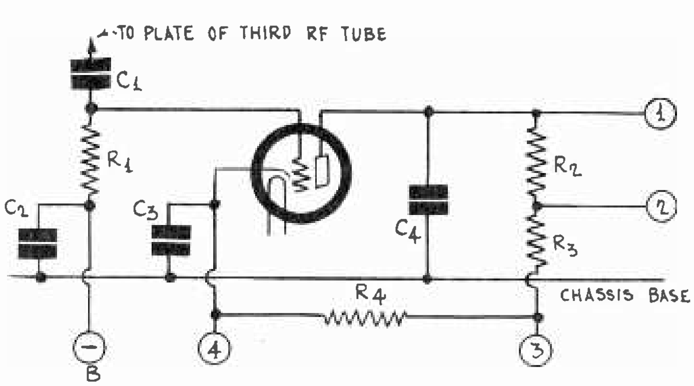


FIG. 2
A DETACHED AND SIMPLIFIED DRAWING OF THE AUTOMATIC VOLUME CONTROL USED IN THE LATEST STROMBERG-CARLSON MODELS, 12 AND 14. THIS METHOD INTRODUCES TAPERED BIAS.

In principle, all automatic sensitivity controls are practically the same. In details, they differ considerably. In brief, the principle is that the radio frequency signal after considerable amplification is impressed on the grid circuit of the sensitivity control tube which has been adjusted so that it acts as a plate bend detector. The DC component of the plate current in this tube varies as the intensity of the signal voltage impressed on the grid, and this current is passed through a resistance which is used as grid bias resistor for some of the radio frequency amplifiers in the receiver, usually the first and the second tubes. Thus as the intensity of the signal increases, the grid bias on these tubes increases, and the amplification decreases. Therefore there is an automatic check on the amplification, and the degree of the check is proportional to the intensity of the signal at the antenna. If, for example, the signal swings due to fading, the sensitivity increases as the signal fades out and the sensitivity decreases as the signal comes in strong. The net result is that there is not much change in the intensity of the sound output.

The same thing happens when the circuit is tuned through a carrier. When the tuner is far off resonance the input to the sensitivity control tube is small and the bias on the tubes controlled is low. Hence the amplification is high. As the tuning approaches the resonance point the input to the sensitivity control tube increases and so does the bias on the controlled tubes, which in turn reduces the amplification. Hence there is not a great deal of difference between the outputs when the circuit is in exact resonance and when it is considerably off tune.

Lover Limit Set

If the check were complete and if there were no limitations to this action there would be no apparent selectivity regardless of the selectivity of the resonant circuits. Therefore it is necessary to set a lower limit, which may be at any signal strength desired.

When the input to the sensitivity control tube is less than this the sensitivity control has no effect. It is possible to arrange the constants so that this occurs at 5,000 or 10,000 cycles off resonance on some selected signal intensity at the antenna. The upper limit of effectiveness of the arrangement depnds largely on the overload point of the sensitivity control tube. This, too, is within the control of the designer of the receiver since it depends on the plate and grid bias voltages on the sensitivity control tube.

Different sets employ different arrangements of the sensitivity control tube, but the differences are in detail rather than in principle. In Fig. 1 is a simplified drawing of the arrangement used in the new Bosch models 58 and 60, which are 1930-31 models. As will be observed, a screen grid of this tube is controlling the sensitivity. The control grid of this tube is connected to the grid of the detector tube in the receiver proper and grounds are common in the two tubes. R1 is a resistance of 2,000 ohms, which gives a permanent bias to the control tube.

Voltages Obtained

Suitable screen and plate voltages are obtained for the control tube by means of a voltage divider, which is also used to supply other voltages in the amplifier, as will be pointed out in detail later. The automatically variable grid bias for the first two radio frequency amplifiers is the drop in resistances R6 and R8 because (4) is connected to the grid returns of these two tubes and (5) to the cathodes of the same tubes. Since the control tube is operated as a grid bias or plate bend detector, increase in the signal voltage impressed on this tube increases the drop in R6 and R8 which in turn increases the grid bias on the two amplifier tubes and decreases the amplification. R6 has a value of 0.5 megohm and R8 a value of 900 ohms. Therefore the bias is really determined by R6 alone, since the resistance of the other is negligible in comparison.

R7 is also a 0.5 meg. resistor but it does not enter into the automatic volume control. Its function is to stabilize the circuit by preventing feedback. It is part of a resistance-capacity filter, the condensers of which are not shown. The object of R8 is only to aid in establishing the proper voltages on the various elements connected to the voltage divider. The various numbered taps go to different points in the circuit and they will be given in detail later.

The 0.006 mfd. condenser between the plate of the control tube and ground serves the purpose of shunting the radio

trol in the New Bosch erg-Carlson

frequency currents around the output resistances R6 and R8 and so to keep these currents out of the automatic bias. It is a filter which prevents alternating current feedback. Pure DC feedback is what is desired

LIST OF RESISTANCES FOR FIG. 1

R1—2,000 ohms	R6—0.5 megohm
R2—2,000 ohms	R7—0.5 megohm
R3—5,000 ohms	R8—900 ohms
R4—25,000 ohms	R9—160 ohms
R5—5,000 ohms	R10—2,380 ohms

LIST OF CONNECTIONS FOR FIG. 1

(1)—To the cathode of the first audio frequency amplifier.
(2)—To the screen grid of the detector tube.
(3)—To the screen grid of the third radio frequency amplifier.
(4)—To the common grid return of the first and the second radio frequency amplifier tubes, both of which are screen grid tubes.
(5)—To the cathodes of the first and the second screen grid tubes in the receiver.
(+)—To a positive point on the voltage divider in the B supply unit which gives the desired voltages on the elements on the control tube.

Tracing these connections and remembering that most of the grid returns are made to ground, we see that the drop in R9 is the grid bias on the first AF tube, that the drop in R1, R2 and R3 is the screen voltage on the detector tube, measured from ground, that the drop on R2 and R3 is the screen voltage on the control tube, measured from the cathode of that tube, that the drop in R1, R2, R3 and R4 is the screen voltage on the third RF tube, measured from ground, and that the drop in R2 to R5, inclusive, is the applied plate voltage on the control tube. We also note that the drop in R6 and R8 is the automatically variable portion of the grid bias on the first two radio frequency amplifier tubes.

The meter M in the cathode lead of the first two radio frequency tubes is a visual indicator of resonance.

Stromberg-Carlson Control

In Fig. 2 is a different version of an automatic sensitivity control, and is a simplified diagram of that used in the new Stromberg-Carlson models 12 and 14. In this the control tube is a 227, the grid of which is connected through a 0.0001 mfd. condenser to the plate of the third radio frequency tube, which is a 224 screen grid tube. The grid return is connected to B minus, the most negative point in the circuit, and the cathode (4) is connected to a point on the voltage divider which is positive with respect to B minus but negative with respect to ground. The voltage between B minus and (4) in Fig. 2 is the steady bias on the control tube which makes it a grid bias, or plate bend detector.

The signal voltage impressed on the grid varies the direct current component in the plate circuit of the control tube and the drop in the resistors R2 and R3. Point (1) is connected to the grid return of the first screen grid radio frequency amplifier, point (2) to the grid return of the second, and point (3) to the grid return of the third tube. It is only the bias on the first two tubes that is varied automatically, the first by the amount of drop in the two resistors R2 and R3 and the second by the amount of drop in R3 alone. Thus the degree of control varies for the two tubes, being greater for the first tube than for the second. This is called tapering of the bias.

A condenser C4 of 0.6 mfd. is connected across the plate circuit of the control tube to filter the carrier from the direct current component. Other by-pass condensers to aid in the filtering are C2 and C3, each of which has a value of 0.3 mfd.

LIST OF PARTS FOR FIG. 2

C1—One 0.0001 mfd. condenser
C2, C3—Two 0.3 mfd. condensers
C4—One 0.6 mfd. condenser
R1—One 4 megohm grid leak
R2, R3—Two 100,000-ohm resistors
R4—One 1,210 ohm resistor in the voltage divider

LIST OF CONNECTIONS FOR FIG. 2

(1)—To the grid return of the first radio frequency amplifier tube.
(2)—To the grid return of the second radio frequency amplifier tube.
(3)—To a point on the voltage divider 3 volts negative with respect to the chassis and the ground. The resistance between (3) and ground is 100 ohms and is in the main voltage divider.
(4)—To a point 1,210 ohms below (3) on the main voltage divider.
(B—)—The negative side of the B supply circuit, which is separated from (4) by 260 ohms.

In order to show more clearly the connections of the sensitivity control tube to the voltage divider in Fig. 2, next week Fig. 4 will show the B supply used in the receiver, stripped of that part which is used exclusively to supply the field current for the dynamic speaker. The various taps on the voltage divider, (B—), (3) and (4) are marked to correspond in the two drawings.

B1 is the high voltage tap that is connected to the plate returns of the two 245 output tubes, B2 goes to the plate return of the detector, B3 goes to the plate returns of the first audio amplifier directly and to the plate returns of the screen grid radio frequency amplifiers through resistors of various values, and B4 goes to the screens of the radio frequency amplifier tubes. K connects to the cathode of the detector tube.

A point to observe in this control arrangement is that the most negative point is not grounded as is customary, but the ground is placed at a point 1,570 ohms higher up. This is done so as to get the proper voltages on the control tube with reference to the voltages applied to the tubes in the amplifier.

The voltage between any two taps depends, of course, on the current taken from the various taps, and the circuit is not applicable without suitable change to any receiver. The receiver in question contains three 224 screen grid radio frequency amplifiers, one plate bend 227, high signal detector, one 227 audio frequency amplifier, and two 245 power amplifiers in push-pull, transformer coupling being used throughout the audio amplifier.

Effectiveness of Control

It is interesting to note the effectiveness of this automatic sensitivity control over a wide range of signal intensities. Fig. 3 gives the relationship between the relative output and the input measured in microvolts. Both the ordinates and the abscissas are plotted on the logarithmic scale in order to include the wide range. It will be observed that the output remains practically constant at 100 between inputs from 100 to 5,000 microvolts. Below 100 microvolts the output drops rapidly and that therefore 100 microvolts has been set as the input at which the control tube "takes hold." At 5,000 microvolts the output begins to rise rapidly as the input increases, but even at 10,000 microvolts the output has not yet doubled.

The advantage of the automatic feature is obvious. A signal of 100 microvolts is a very weak signal and one of 10,000 microvolts is a comparatively strong signal. Yet the variation in the output does not vary as much as two to one. If normal signal intensity of a station is around 2,000 microvolts there is practically no variation in the output even if the input falls as low as 100 microvolts and rises as high as 5,000. Fading under these conditions will practically be absent and the only effect that the fluctuations would have on the received signals would be a rise and fall in the proportion of stray noises. They would rise as the signal faded out and they would fall as it came back.—J. E. ANDERSON.

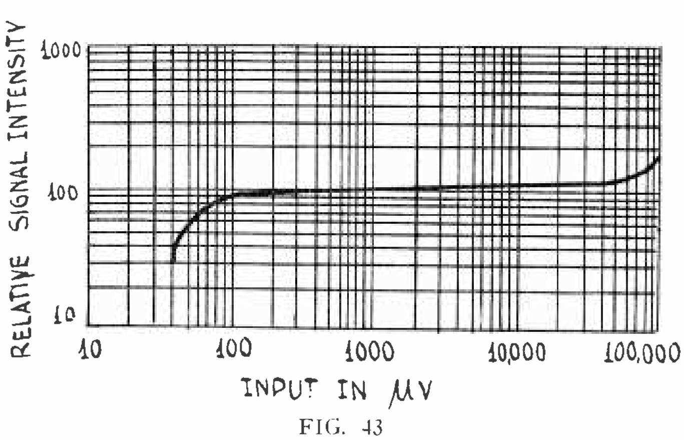


FIG. 43
A GRAPH SHOWING THE EFFECTIVENESS OF THE AUTOMATIC VOLUME CONTROL IN THE NEW STROMBERG-CARLSON RECEIVERS, MODELS 12 AND 14.

Hertz Radiated 28 H

By John

GIGANTIC HERTZ OSCILLATOR

[This article is the third of a series dealing with the historic aspect of radio transmission and reception, as well as the discoveries that were made at an early date, and later applied successfully. The first article appeared in the October 11th issue and presented a condensed resume of important scientific steps that culminated with the successful commercial experiments of Guglielmo Marconi in the years 1899-1901. *The second article appeared in the October 18th issue and consisted of a brief review of the early telegraphic systems, including data on the first photo-electric work and short-wave transmissions with mirrors, the earliest stages in the development of the beam transmission system. Progress was traced from the sixteenth century to the eighteenth century.*—EDITOR.]

THE early development of the art of telegraphy by means of system of signalling was successful to a degree, but this period of development was followed by a long span of years in which little work was done on an electrical method of communication, but there certainly was scientific research which the events of later years justified fully.

One of the many important early experiments was the discovery of the Leyden Jar in 1720, by Musschenbroek, who was seeking some way of increasing the value of the charge imparted to a metal plate by a neighboring charged rod. He found that the sparks obtainable from the plate increased as the rod was brought closer to the plate, but also found that if the rod touched the plate, the charge disappeared, and so he reasoned that if the rod could be brought very close to the plate without touching it at all, the sparks should be of great strength.

Improved Results

This was tried and, though the results did in a measure confirm the effect did not please the philosopher. He reasoned that as men in battle who are more nearly of a size expend a far greater amount of physical energy in conflict, so two charged conductors of a similar size will also react with greater vigor under the given condition. So he chose two larger conductors, and charging one beheld the evidence of a larger charge on the other. On bringing the two plates to within two centimeters of each other he obtained a big spark. Encouraged, he used larger plates, and though the sparks obtained were bigger it was noticed that a large repulsion force was developed when the biggest plates were brought together. He reasoned that there must be some connection between the appearance of the larger spark and the manifestation of the repulsion force. It was assumed that if the force became beyond the strength of man, and as a larger spark was required, as it most certainly would be, then the only recourse was to fasten the plates to some "non-electric," a term due to William Gilbert, (1540-1603).

Used Glass for Transparency

Preferably a transparent "non-electric," for observational reasons, was sought. so, with a seperation of five millimeters, he chose to use glass. The plates being charged, the approach to the completion of the discharge circuit was made. "A spark 'like thunder' was both seen and heard," Musschenbroek wrote, telling of his experience in which an assistant shared, "and though we were both frightened we tried the discharge-rod again, and to our surprise obtained another spark, not quite as big as the first one, but considerably larger than the ones we had been obtaining during the past year."

Later Musschenbroek tried the same experiments with glass jars, and that is how the Leyden Jar was begun. Not long afterward the Leyden Jars appeared in various part of Europe and later in the United States.

The invention of the Leyden Jar was hailed as a most important contribution to science, and was used in the famous kite experiment of Benjamin Franklin (1706-1790) in connection with the invention of the lightning-rod.

Hertz and many others used the Leyden Jars as a high-tension battery, even though its discharge rate was very rapid. Thus Musschenbroek worked out the Leyden Jar, an apparatus with which electricity could be placed within a confined space.

but Hertz about a century later was keenly interested in ele trical manifestations that related to unconfined space, or radi tion, including short waves. Hertz used, among other thing mirrors or both concave and parabolic contour. He used tv metal balls and a focusing device, so the mirror would send o plane or parallel waves.

Must Keep Surfaces Clean

It is essential that the sparking surfaces of the balls be ke clean, and further precautions be taken to prevent the likeliho of the danger when illumination of the polished surfaces these balls by lateral discharges takes place, otherwise no oscill tion will take place.

In other words, if a back-and-forth reflection occurred at t spark-ball surfaces the resulting interference would nullify t wave's emission. The spark is produced by a small Rhumkor type coil, and the high voltage is carried to the gap by tv heavy wires, each covered by gutta percha, and they termina at the balls which form a gap of 3 millimeters, although t spart-length capacity of the coil is at least 4.5 centimeters.

"The additional evidence of electric force in space wheth due to aberration of the reflected wave or not," he wro "seems to be evidenced by the appearance of small spar exhibited by a secondary conductor placed at the side of t path of the reflected beam, and this secondary conductor of the collapsible type, hence its period of oscillation can readily adjusted to the wave frequency present in the pa in which the oscillator is placed."

But it was later found that the observed oscillation peri was a function of the primary circuit's period, and so t effect due to the circular collapsible conductor gave only differential effect.

This secondary oscillator was made of a circular copp tubing that had a diameter of 7½ millimeters, and the so copper conductor that slid within the tubing was 2 millimete in diameter. The end that faced the metallic sphere that w mounted on the hollow tubing, was sharply pointed. The tv parts thus formed a loop, in other words the effects observ with this secondary conductor were not due to resonan as it was afterward found out that the sparks were obtain in the gap, with the oscillator placed in the focus of t beam, at any adjustment at all, this system constituting circuit that had no period of its own and thus it was abandon

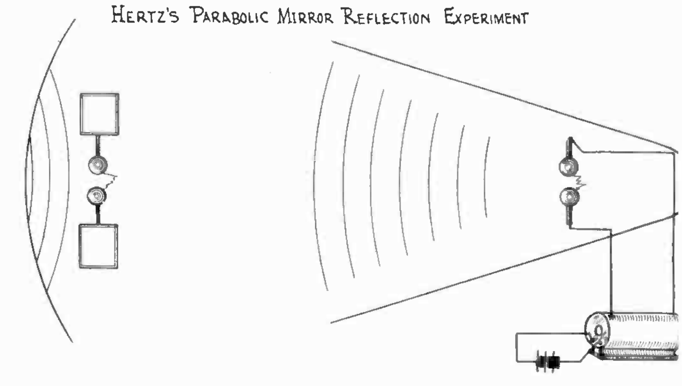
But even though Hertz did not at the time perceive t full import of his discovery, had his death not been so sudd no doubt he would have found a place for such perception.

Other Transmission Effects

Various other sizes and shapes of responsive circuits we tried, and from the observations that were made mathematic formulae were evolved to fit each case, and Hertz gave sever lectures at the Berlin Academy, as well as several of a popul nature in Germany and elsewhere, and was enthusiastica received.

Hertz's previously outlined experiments were continued, a some additional transmission effects were found by arrangi two parallel wires of heavy stock, 50 centimeters high, wi a right-angled bend of about 5 centimeters, the wire bei 5 millimeters in diameter. The short ends being inserted in fixed terminals attached to two wings of the oscillator syste and with the primary oscillator-driver in operation it w possible to observe the effect of induction potential relative excitation potential without the excessive influence of reso

HERTZ'S PARABOLIC MIRROR REFLECTION EXPERIMENT



rse-power on 30 Meters

. Williams

ance. The arrangement did not admit of ready alteration of the sparking distances, a defect that was remedied by bending the tops of the vertical wires apart, in a somewhat exponential shape that opened up a new field of inquiry.

How Electric Waves Were Produced

The influence of reflecting surfaces, as an aid to the concentration of oscillatory electric waves, was demonstrated augmented by the addition of several highly-polished copper mirror surfaces whose curvature, though mathematically correct and fixed, could be varied, if necessary.

If the primary inductor be excited in a large free space, it was found that the greatest distance at which the sparks could be readily distinguished was 1.5 to 2 meters, without the use of the mirrors, but if a plane mirror be set up about 15 centimeters from the inducing spark gap, and carefully adjusted, and the experiment repeated it was found that the intensity of the spark at the secondary gap had increased. If at the same time the secondary spark gap be moved toward or away from the exciting source there would be a series of places where the spark intensity was maximum. Also a definate separation of the spark balls provided the strongest spark. This gave rise to the conclusion that the primary oscillation wave was one-half plus the distance from the inducing spark-gap to the mirror surface that reflected the wave, namely 30 centimeters. This relationship was found to agree with Maxwellian calculations so fully that it resulted in the world-wide recognition of Hertz. The type of radiation that he discovered was subsequently named in his honor.

Distance Increased

The above experiment was repeated, but with a parabolic mirror placed behind the inducing spark-gap. The result was that the original response distance of 2 meters was increased to 15 meters, bearing out the predictions of Hertz, who declared that he expected to obtain a considerable increase of distance, especially with the spark balls placed just ahead of the principal focus of the mirror, and also that it is advantageous to have a reflection focal distance short enough so as to not produce interference with the reflected wave, in other words to avoid quenching it.

This recognition of the possible effect of interference by Hertz is evidence that he had done considerable research in this subject, to which much knowledge of the most fundamental character had been contributed by Christian Huygens (1629-1695) and by Thomas Young, an early adherent of the undulatory theory later known as the electromagnetic theory of light as propounded by James Clerk Maxwell (1831-1879).

Hertz also found that it made quite a difference whether electric waves were reflected by conductors or insulators, as did Lodge, but the priority of discovery of nodes and loops belonged to Hertz. Waves reflected by conducting surfaces were found to be alternately weakened and strengthened at certain points while at other points there was no spark at all, at least none visible in a darkened room, but there were found to be at least four very distinct points in the focal path of the parabolic mirror. He obtained a strong image of the source at the distances of 33, 65, 98 and 136 centimeters, hence he used as short a wave as half a wave length, an oscillation period of one one-thousand millionth of a second, assuming the velocity of light for the velocity of radiation.

The velocity in wires was less, as the oscillation had a wavelength of 29 centimeters, but a different kind of experiment was necessary to show just why this was true.

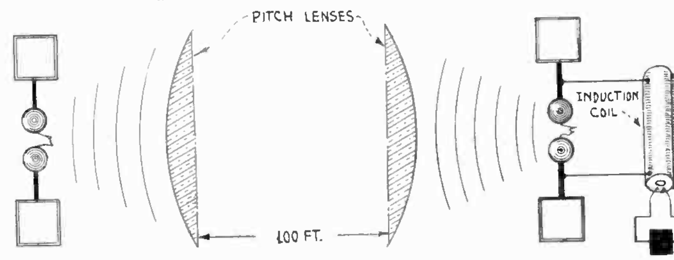
Electric Waves Versus Light Waves

Hertz was familiar with the theory and experiments of the production of polarized light, having been acquainted with William Nicol, who invented the prism that bears his name, and knew about other means of producing polarized light. He determined to try to polarize electric waves by reflection, as Young did light many years earlier, and though there are some references to it in "The Annalen der Physik," which also deals with refraction of electric waves, it is certain that the untimely death of Hertz stopped the recording of what would have been classical experiments.

At this point Lodge took up the series of experiments and succeeded in producing a concentrated wave path of over 100 feet in length.

Foundation research was due to Hertz, who made a very complete record of the indices of refraction of a lot of insulating substances, such as glass, gutta percha, rosin, pitch and

DR. LODGES ELECTRIC WAVE REFRACTION EXPERIMENT



hard rubber. The index of refraction of a substance is defined as the ratio of the sine of the angle of incidence to the sine of the angle of refraction. Lodge after consulting in the matter decided to try first the pitch, and later the glass, which by the way was optical glass, as this kind has a much higher refractive index than the common lead glass.

The layout of the apparatus used in the Lodge experiment is shown herewith in condensed form, nothing essential to its operation having been deleted.

The large scale on which the experiment was worked necessitated a considerable amount of preparation, not the least of which was the casting of the large pitch lenses, a job that had to be done at least twice before a perfect lens was obtained, as in the early stages the patterns were not equal to the enormous weight of the pitch, and broke easily.

Difficulties Overcome

A further difficulty was that differences in the constitution of various samples of the substance led to differences in degree of solubility of parts of the lens, which could only be corrected by remelting and recasting. But in the end two satisfactory lenses were set up in a long corridor, with their flat faces about 100 feet apart, on support stands, the finished lenses being 25 centimeters thick and 75 centimeters in diameter.

The oscillator shown at the left in the accompanying sketch is in reality the biggest one that had been used up to this time, it having a radiation output of 28 horsepower, the operative voltage being in excess of 25,000 volts. The plates were of copper, one-eighth of an inch thick and 120 centimeters square. The horizontal connecting bars were 230 centimeters long, spark balls were 2 centimeters in diameter and their separation was 1.5 centimeters.

The frequency employed was 10,000,000 cycles per second, and the dissipation resistance was 22,500 ohms. So you can form an idea of the amount of power used, as well as that which was radiated.

Lodge found that if any great degree of precision in electro-optical experiments was to be attained it would be necessary to have a strongly converging beam, which is more readily attained with lenses than with mirrors, for physical reasons.

Interested in Distances

In contrast to the results obtained by Hertz, Lodge found that a well-defined point existed for the principal focus of the second lens, while the presence of secondary radiations to either side of the beam was almost wholly absent, although there was some slight glow effect noticed from the surface of the brick walls, which was not explained immediately.

But the experiment had sufficed to show that if any great distances were to be covered the signal-carrying beam would have to be concentrated either in the form of an image of the source, as had just been done, or in the form of a parallel-beam, in much the same manner as the searchlight beam penetrates the fog, because of the way its rays are focused by the glass lens.

The 245

By J. E.

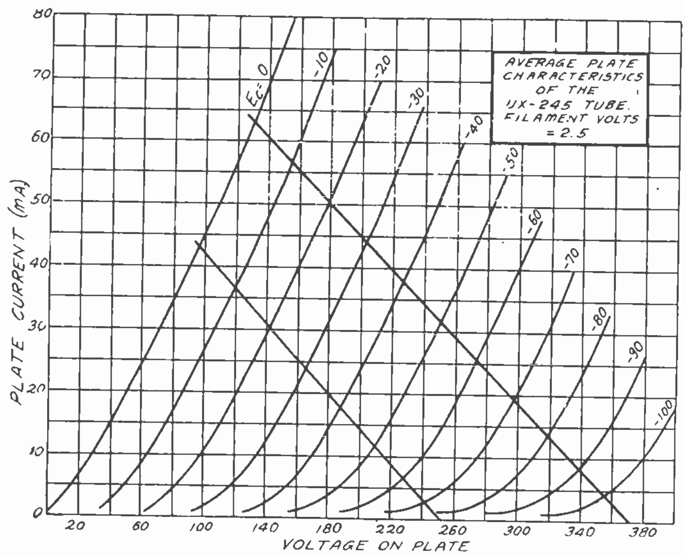


FIG. 89

A FAMILY OF PLATE VOLTAGE, PLATE CURRENT CURVES FOR THE 245 POWER TUBE OVER THE USUAL RANGE OF GRID BIAS VALUES, TOGETHER WITH TWO LOAD LINES DRAWN FOR 3,800 OHMS.

[*This is the twelfth instalment of "Modern Radio Tubes," a series of articles which began in the August 9th issue and has been running weekly since then. Past instalments have dealt with the small receiving tubes, both AC and DC, as well as some of the power amplifier tubes. In coming instalments special purpose tubes, such as rectifiers, voltage regulators and transmitting tubes will be discussed.*—EDITOR.]

THE coupling between the power tube and the speaker may be by a choke coil and a condenser or an outpu transformer. The choke-condenser method is preferable when the impedance of the loudspeaker to be used with the receiver is equal to or greater than the impedance of the tube. This method of coupling also has the advantage that the signal current in the plate circuit of the last tube may be kept out of the B supply. The transformer method of coupling has the advantage that the impedances of the tube and the speaker may be matched by choosing the proper ratio and primary and secondary impedances. These two methods are shown in Fig. 88, the transformer at left and the choke-condenser at right.

In the transformer drawing of Fig. 88 the core is grounded. This ground also applies to the case of the transformer since in all cases the core and the case are connected together. While grounding the core is optional, usually some improvement in stability and the reduction of hum results from doing it. One side of the loudspeaker circuit is also indicated as grounded. It is not necessary to ground one side of the speaker circuit but it is good practice to do so.

There are several variations of the choke-condenser output circuit, but the diagram in Fig. 88 shows the one that seems to include the largest number of advantages. One side of the speaker is connected to a condenser of from 2 to 8 mfd., the other side of which is connected to the plate of the tube. The other terminals of the loudspeaker is connected to the center-tap of the 2.5 volt filament winding, and not to B minus as it is sometimes done. The choke coil through which plate the current is supplied to the tube prevents the signal current from flowing into the B supply while the signal current flows through the condenser, the speaker and back directly to the filament.

Plate Current Curves

Plate voltage, plate current curves for the usual range of operating grid bias are shown in Fig. 89. These curves may be used for estimating the grid bias, the plate current, or the plate voltage when any two of these are known. They can also be used for calculating the output power of the tube, and it is for this purpose that they have been drawn.

The two load lines across the curves have been drawn for 3,800 ohms, the resistance which gives the maximum undistorted output, and for two different applied plate voltages. The upper curve fits the case when the plate voltage is 250 volts. Let us calculate the output power when the grid bias is 50 volts and the plate voltage is 250 volts, assuming that the signal peak is 50 volts.

When the grid bias is zero the plate current is 63 milliamperes and the effective plate voltage is 130 volts. When the grid voltage is 100 volts, the plate current is 4 milliamperes and the effective plate voltage is 355 volts. Thus we have a current change of 59 milliamperes and a voltage change of 225 volts. The product of these is 13,275, which is eight times the output power in milliwatts. Hence the maximum undistorted power is 1,660 milliwatts. The rated value is 1,600 milliwatts and the agreement is as good as can be expected.

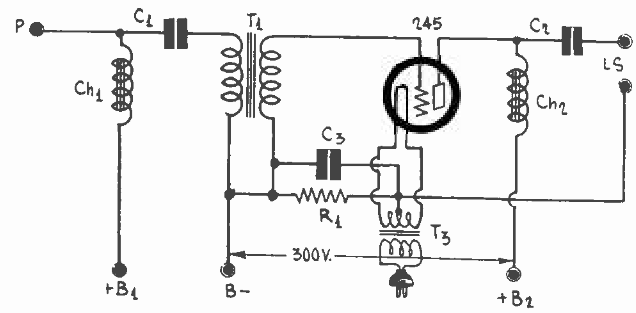


FIG. 90

A DIAGRAM OF A 245 TUBE POWER STAGE IN WHICH FILTERS ARE USED TO KEEP THE DIRECT CURRENT OUT OF THE PRIMARY OF THE COUPLING TRANSFORMER AND ALSO OUT OF THE LOUDSPEAKER.

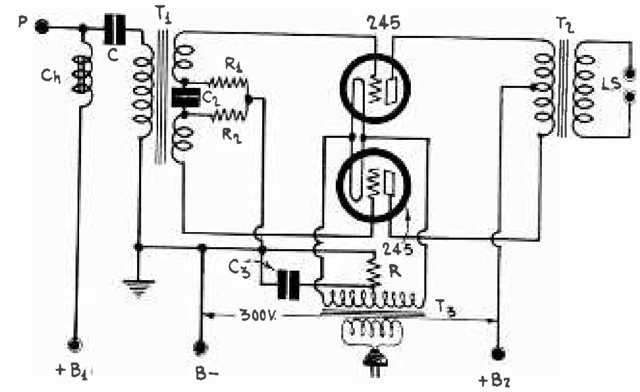


FIG. 91

A DIAGRAM OF A PUSH-PULL POWER STAGE UTILIZING TWO 245 TUBES. AN INPUT FILTER IS USED TO AVOID CORE SATURATION OF THE INPUT TRANSFORMER AND RESISTANCE-CAPACITY FILTER IS USED IN THE SECONDARY TO AID IN BALANCING THE CIRCUIT.

IN Fig. 90 is a diagram of a single-sided, transformer-coupled power amplifier utilizing a 245 power tube, showing the preferred input and output circuits when high quality signals are desired. Transformer T1 is supposed to be wound with a very high inductance primary on a core of special high permeability steel. In order to prevent saturation of the core and consequent reduction in the impedance, the direct current component in the plate current of the preceding tube is filtered out and only the signal component is admitted to the transformer. The direct current component of the plate current flows through the high inductance choke Ch1, which should be designed so that it can carry the current without appreciable saturation.

The signal component flows through the condenser C1 and the primary. If the inductance of the primary of R1 is very high, as it is in the best modern audio transformer, the capacity of the condenser C1 need not be higher than 2 mfd. The other side of the primary winding is connected to ground, or to B minus, so that the signal current is kept out of the B supply circuit. This has an important bearing on the quality as well as the separation of the DC and the signal currents. An optional connection of the low voltage side of the primary of T1 is to the cathode of the tube preceding, in case that tube is of the 227 type, or to the mid-point of the filament, in case it is of the directly heated type.

Bias Provision

The grid bias for the 245 tube is provided by the drop in R1, a resistance which should have a value of 1,550 ohms. A condenser, C3, which should preferably not be smaller than 4 mfd., is connected across the bias resistor to insure that no reverse feedback will occur in the tube on essential audio frequencies.

The output circuit of the 245 is essentially the same as that of the preceding tube. That is, a choke, Ch2, is used for the direct current component and a condenser C2 to prevent it from flowing into the loudspeaker. The choke should have an inductance of at least 30 henries and a current carrying capacity well in excess of 32 milliamperes. The capacity of C2 depends on the impedance of the loudspeaker, or of the primary of the loudspeaker input transformer. However, a capacity of 4 mfd.

and the 250

Anderson

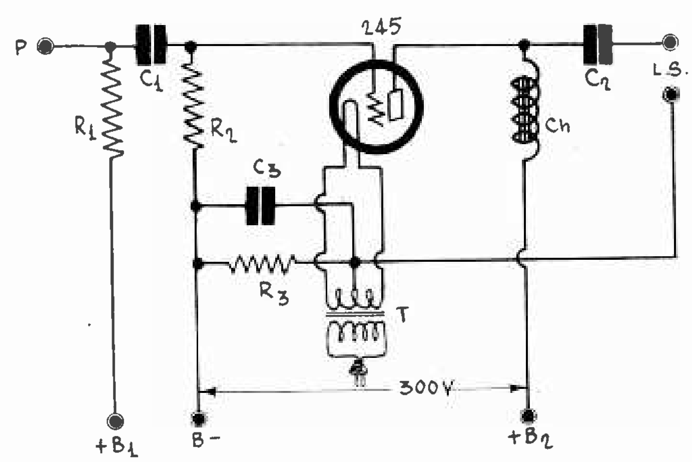


FIG. 92

THIS ARRANGEMENT SHOULD BE USED WITH A 245 OUTPUT TUBE WHEN THE COUPLING BETWEEN THIS TUBE AND THE PRECEDING IS OF THE RESISTANCE-CAPACITY TYPE.

is sufficient in most instances, but larger values may be used if strong emphasis on the low notes is desired.

An important point in the circuit is that the low voltage side of the speaker be connected to the mid-point of the 2½-volt winding of transformer T3.

A Push-Pull Amplifier

Fig. 91 gives a diagram of a push-pull amplifier utilizing 245 power tubes. It employs a push-pull input transformer T1 and a push-pull output transformer T2. A filter circuit like that used in Fig. 90 is also used in this circuit, Ch being the high inductance choke through which the direct current component flows, and C the stopping condenser which prevents the flow of direct current into the primary of the transformer. The values of Ch and C are the same as those of Ch1 and C1 in Fig. 90.

The secondary of T1 is divided into two equal parts in order to permit the use of the filter circuit comprising the 2 mfd. condenser C2 and the two 50,000 resistances R1 and R2. The objects of this filter are to equalize the inputs to the two tubes and to clear up the quality of the output.

The bias resistor R in this case is only one-half as large as in Fig. 90 because twice the current flows through it, that is, it should be 775 ohms. It is permissible to use either 750 or 800 ohms, both of which are standard commercial values.

While a by-pass condenser C3 is connected across the bias resistor in Fig. 91, this condenser is not necessary in all instances, for if the circuit is accurately balanced there will be no signal current flowing in the resistor and hence there would be nothing to by-pass.

The output circuit is a simple push-pull transformer T2 wound to match the tubes and the speaker used. Since the circuit is balanced, it is not necessary to use any output chokes to keep the direct current out of the primary of this transformer, for the direct currents from the two tubes tend to magnetize the core in opposite directions, and therefore there is no saturation effect.

Resistance Coupling

When the power tube is coupled to the preceding tube with a resistance coupler, the connections should be as in Fig. 92. The value of R1 would depend on the type of tube ahead of the power tube. If it is of the 227 type, 100,000 ohms will be right, but if it is a high mu tube or a screen grid tube, a value of about 250,000 ohms is better. The applied plate voltage at B1 should not be less than 180 volts.

The stopping condenser C1 and the grid leak R2 should have such values that their product, when they, are expressed in farads and ohms respectively, is not less than 0.02 second. This will insure a high amplification on the low notes. For example, if the capacity of the condenser is 0.01 mfd., the resistance of the leak should be 2 megohms, and if the capacity is 0.02 mfd. the resistance may be one megohm. The second combination is preferable.

The other elements of the circuit should have the same values as the corresponding elements in Fig. 90.

When the amplification ahead of the power stage is not sufficient to load up a push-pull stage, the 245 tubes may be connected in parallel as shown in Fig. 93. The input voltage

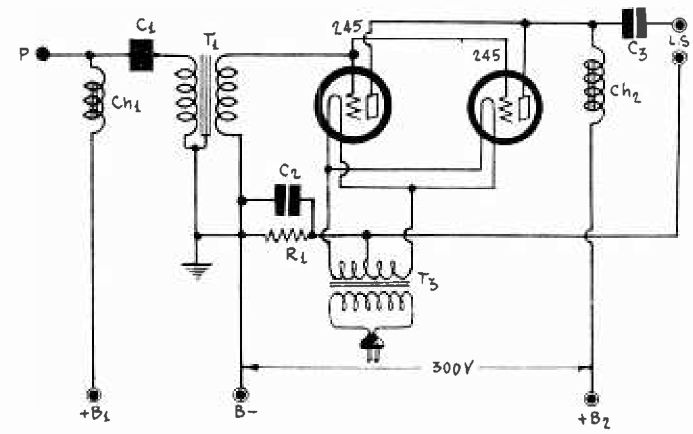


FIG. 93

WHEN MORE OUTPUT POWER THAN A SINGLE 245 WILL GIVE IS DESIRED AND WHEN THE AMPLIFICATION AHEAD OF THE POWER STAGE IS NOT SUFFICIENT TO SUPPORT A PUSH-PULL STAGE, THE TUBES MAY BE CONNECTED IN PARALLEL AS SHOWN IN THIS DIAGRAM.

required in this case is the same as the input to a single tube and the output power is approximately doubled. The output circuit in Fig. 93 is the same as that in Fig. 90 or in Fig. 92, but the choke coil Ch2 must be designed to carry twice as much current. The grid bias resistor R1 should be the same as that in the push-pull circuit, namely, 775 ohms. The condenser C2 across this resistor should be 4 mfd. or higher, and it must be used because there is no balancing of currents in this circuit as there is in the push-pull amplifier.

If the filter output is used the matching between the amplifier and the speaker will be better than in the single-tube circuits because the output impedance is only one-half as great.

250

THE 250 is the largest of the power tubes used in receiving sets. It requires a filament terminal voltage 7.5 volts, which may be either alternating or direct, and a filament current of 1.25 amperes. It may be operated with a plate voltage as high as 450 volts, at which voltage the grid bias should be 84 volts. The normal plate current under these operating conditions is 55 milliamperes and the maximum undistorted power is 4.65 watts, which is approximately three times the maximum undistorted power given by the 210 or the 245.

CHARACTERISTICS OF 250

Filament voltage	7.5
Filament current, amperes	1.25
Plate voltage, maximum	450
Grid bias, volts	84
Plate current, milliamperes	55
Plate resistance, ohms	1,800
Mutual conductances, micromhos	2,100
Amplification factor	3.8
Maximum undistorted output, watts	4.65
Overall height, inches	6.25
Maximum diameter, inches	2 11/16
Base, standard UX.	

PLATE CHARACTERISTICS OF 250

Plate voltage	*Grid bias*	*Plate current*	*Plate resistance*	*Mutual conductance*	*Power output*
250	45.0	28.0	2,100	1,800	900
300	54.0	35.0	2,000	1,900	1,500
350	63.0	45.0	1,900	2,000	2,350
400	70.5	55.0	1,800	2,100	3,250
450	84.0	55.0	1,800	2,100	4,650

If the grid bias voltage be divided by the plate current for each of the plate voltages in this table the value of the grid bias resistance that should be used is obtained. A different value is obtained for each case but the average is nearly 1,500 ohms, and this value can be used whatever the plate voltage may be. If two of the 250 tubes are used in parallel or in push-pull the grid bias resistance should be one-half of this value, namely, 750 ohms.

Circuits for the 250

Fig. 94 depicts a power stage utilizing the 250 tube. The circuit is the same as that in Fig. 90 except that 1,500 ohms are used for the grid bias resistor R, a 7.5 volt step-down transformer for T2, and a heavy duty choke for Ch2. Both the resistance and the choke must be able to carry the plate current.

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Power Tube Circuits

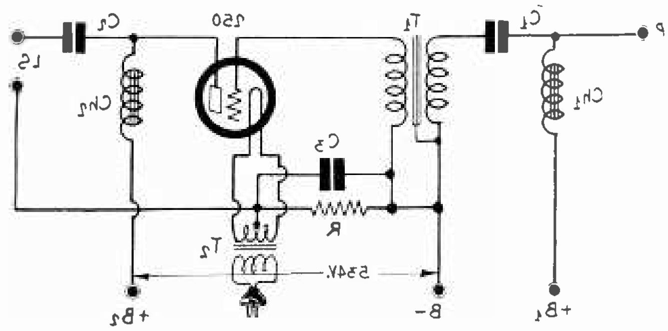


FIG. 94

A 250 TUBE POWER AMPLIFIER WITH TRANSFORMER INPUT AND CHOKE-CONDENSER OUTPUT.

(*Continued from preceding page*)

of 55 milliamperes continuously without heating excessively, and the choke should be proportioned so that it does not saturate on this current. The other parts may be exactly the same as the corresponding parts in Fig. 90, except that condenser C2 must have an operating rating of at least 600 volts.

Fig. 95 is the same circuit except that it has an output transformer instead of a choke and condenser. A condenser C2 is used in this circuit to shunt the alternating current that flows in the primary of T3 directly to the filament. This condenser, also, must be rated in excess of 600 volts working DC voltage. The output transformer must have been designed for the heavy duty that it is called on to perform in the output circuit of a 250.

Fig. 96 is a circuit similar to that in Fig. 92. The same output choke and condenser must be used as in Fig. 94, and the secondary voltage of T must be 7.5 volts. The grid bias resistor R3 should be 1,500 ohms and the condenser C3 across it should be not less than 4 mfd.

Fig. 97 corresponds to Fig. 91 and all the parts preceding the power stage should have the same values as those used in the 245 tube push-pull amplifier. T2 should have a secondary voltage of 7.5 volts and R3 should have a value of 750 ohms. The condenser C3 across R3 may be omitted if equal tubes and well-balanced input and output transformers are used.

In Fig. 98 is a power amplifier circuit like that in Fig. 93, that is, the two power tubes are in parallel. In this case the grid bias by-pass condenser C3 must be used and it should have a capacity not less than 4 mfd. The larger the condenser is the better the circuit will function and an electrolytic condenser of high capacity can be used to advantage. The bias resistance should be 750 ohms and it must be designed to carry at least 110 milliamperes.

Voltage Requirements

The choke coil Ch2 must also be able to carry 110 milliamperes without appreciable heating and with negligible saturation. The requirements of this choke are much more severe than those of the choke in any of the single-tube circuits of similar structure.

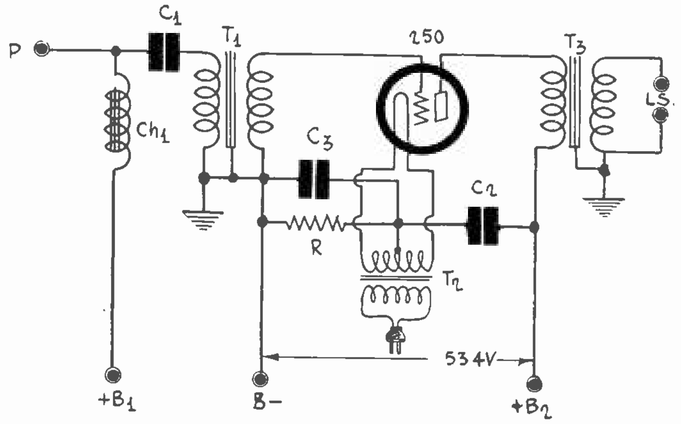


FIG. 95

A 250 TUBE POWER AMPLIFIER WITH TRANSFORMER INPUT AND OUTPUT.

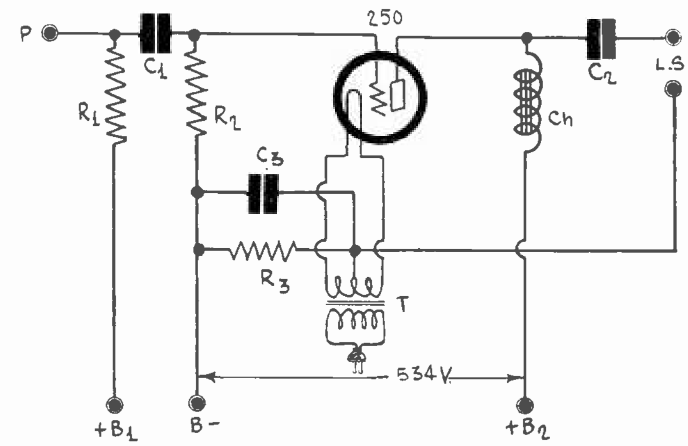


FIG. 96

A 250 TUBE POWER STAGE WITH RESISTANCE-CAPACITY INPUT AND CHOKE-CONDENSER OUTPUT.

In each of the circuits in Figs. 94 to 98, inclusive, the voltage between B minus and B2 plus is 534 volts, which is the sum of the required plate voltage of 450 and the grid bias of 84 volts. The grid bias resistance and the internal DC resistance of the tube divide the voltage so that each element gets the proper voltage. This holds even if the applied voltage is different from 534 volts so that it is not necessary to make any change in the grid bias resistance when the applied plate voltage is changed.

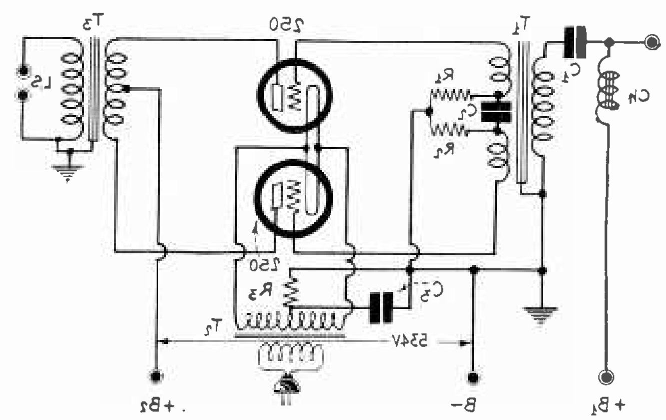


FIG. 97

A PUSH-PULL AMPLIFIER UTILIZING THE 250 TUBE. WELL-BALANCED INPUT AND OUTPUT TRANSFORMERS AS WELL AS EQUAL TUBES ARE NECESSARY TO TAKE FULL ADVANTAGE OF THE PUSH-PULL ACTION.

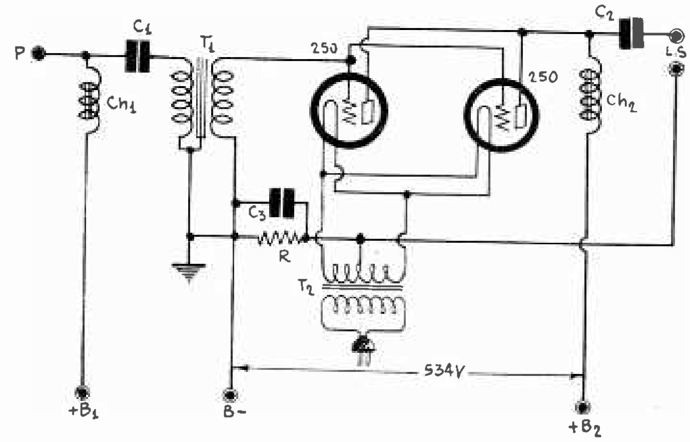


FIG. 98

A POWER STAGE UTILIZING TWO 250 TUBES IN PARALLEL. THE AMPLIFIER HAS TRANSFORMER INPUT AND CHOKE-CONDENSER OUTPUT.

An Impedance RF Set

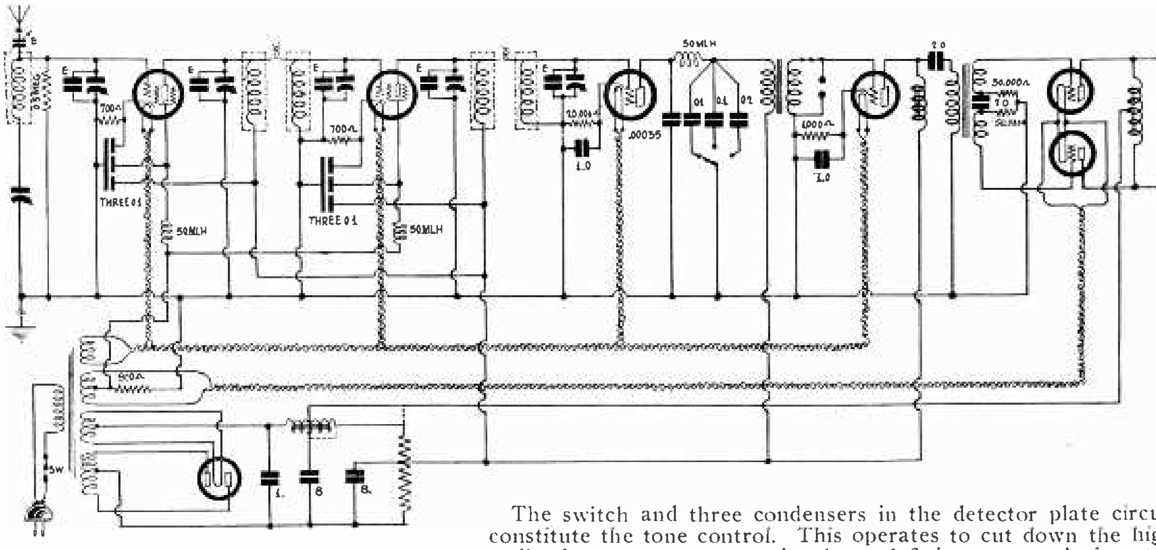


FIG. 1
A receiver with two stages of screen grid radio frequency amplification, highly selective, however, due to the special coupling method and five selector circuits. The other tubes are detector, first audio, push-pull output and rectifier. Total, seven tubes.

LOOSE coupling between radio frequency stages, as by the use of a small capacity, say around 1 mmfd., enables the tuning of both plate and grid circuits in screen grid receivers. While the diagram, Fig. 1, shows a complete AC receiver, the radio frequency method is applicable to battery-operated screen grid receivers as well.

Since wire leads are brought out from the grid and plate tube connections, by virtue of the soldering to coil terminals, these leads may be insulated and twisted around each other, so that the plate of one tube thus couples to the grid of the next. The method was explained last week, in the October 18th issue, to which the above diagram applies in reference to the complete receiver. The coupling method as used in a tuner (less audio and B supply) was shown then.

There was some confusion as to the diagrams last week, but Fig. 1 herewith clears that up.

The circuit in Fig. 1 this week uses a pair of three-gang condensers, one unit on one side, the other on the other side of a drum dial. Therefore there are six capacities, all governed by the one dial, and if we resort to two stages of tuned radio frequency amplification, as well we may, the input to the first tube, the output of the first tube, input to the second, the output of the second and the input to the detector would be tuned. This accounts for only five of the six sections of the pair of three-gangs, but the sixth section is used as a variable capacity to ground the antenna choke coil, so that at the higher broadcast frequencies the pickup will be less, while at the lower broadcast frequencies it will be more. As this direction is opposite to the rising characteristic of tuned radio frequency amplification, the tendency is to produce a levelling effect, or a constant output for a constant input, regardless of the broadcasting frequency. Such levelling is advisable, especially in conjunction with relatively high values of biasing resistors for the radio frequency amplifying tubes, which tend to level the divergent amplitudes of carrier frequencies, or radio frequency intensities, of the different stations.

The combined system creates an automatic volume control.

Grid Return for First Tube

Due to the interruption of the grid return of the first tube by the levelling condenser, the grid of this tube would be unbiased, so a high value of resistance, around 50,000 ohms, may be used to establish a grid return to ground. Greater resistance values may be interposed at this point without any appreciable difference in results, although values much smaller than 50,000 ohms must be avoided, because of their partly short-circuiting effect on the radio frequencies.

The choke coil in the antenna-ground circuit has a DC resistance of 1,000 ohms, compared with the recommended 50,000 ohms, and while this fact does not state the circuit impedance relationship to radio frequencies, which changes in the coil-condenser series circuit, but not in the resistor, it gives a rough idea of the parallel resistor being large in respect to the coil and condenser it is across.

The tuning value of the first selector condenser, in the grid circuit of the first tube, would be negligible, were it not for the antenna series condenser E (upper left), which effectuates loose coupling between antenna and first grid, and permits the establishment of resonance among the respective sections of the tuning devices. This antenna series condenser is an equalizer that is set at a chosen position and left thus. Under no circumstances omit it.

Other features of the radio frequency circuit were discussed last week in the consideration of the tuner, and may be referred to by any reader desiring fuller facts on this aspect.

The switch and three condensers in the detector plate circuit constitute the tone control. This operates to cut down the high audio frequency response in three definite steps. A four-tap switch should be used, although no wire is connected to the fourth tap. This tap should be the left-hand one as you regard the switch from the front panel. It simply provides an "off" position, so that the volume control is then out of circuit. The response at this position may be referred to as "brilliant." It is the position to use when speech is being heard, for the hissing consonants that render speech most intelligible then come through strong, whereas when the .01 mfd. condenser is cut in, these audio highs are attenuated, and when 0.1 mfd. is used, the effect on the extreme highs approaches full cutoff, while .02 mfd. for a certainty eliminates these highs, and the response is "deep," that is, the lows gush forth with intense accentuation, which some desire when dancing, as the rhythm seems to be much more pronounced.

At all hazards, the "off" position of the switch should be included, because it affords a method of not using the tone control at all when such use is not desired.

The "off" position may be assumed to be the "natural" one, since it produces no change in the tonal values. The permanent .00035 mfd. fixed condenser from plate to ground, which is there simply to offer a low impedance to radio frequencies and high impedance to audio frequencies, is a by-pass condenser therefore for radio frequencies and improves the detection without affecting the audio response more than trivially.

The Audio Amplifier

The detected signal is put into a high-class audio amplifier that consists of two stages of transformer coupling, the final stage being push-pull 245's. The transformers are Amertran de luxe, first stage, and No. 151 second stage. Therefore No. 151 is a push-pull input transformer. It has two separate windings for the secondary. They establish an effective of 1-to-2½.

By this separate-coil method it is possible to use a preferred resistance-capacity filter in the grid return circuit, whereby a 50,000-ohm resistor is connected to the "low" sides of the coils (Nos. 2 and 3 on the transformer terminal strip), the other sides of the resistors to ground. Between points 2 and 3 is connected a 2 mfd. condenser of low-voltage rating, say, 200 volts DC.

The plate circuit of the first audio tube is filtered, resulting in parallel plate feed. This method upholds the inductance of the primary of the push-pull input transformer. Since the core is a special alloy in each transformer, first and second stage, the inductance will drop fast with current increase. In the detector plate circuit the draw, due to power detection, is only about 1 milliampere, so no parallel feed method is needed there, but in the plate circuit of the second audio tube some 10 milliamperes will flow, and this is entirely too much to let go unfiltered.

Speaker Connections

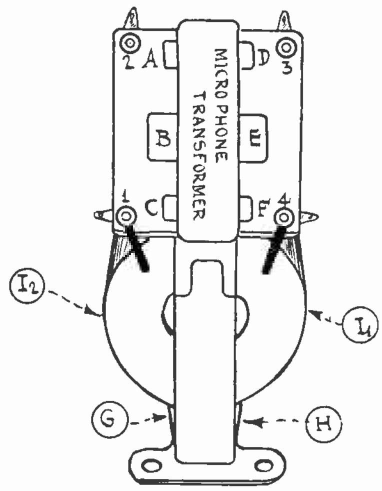
Any type speaker may be connected to the output, between plates of the 245 tubes. No direct current will flow in the windings of a magnetic or inductor speaker to cause injury.

If a dynamic speaker is used, the primary of an output transformer may be connected to the output posts of the receiver. This transformer usually is built into the speaker. A standard power transformer is used, with two 2½-volt windings, one of which is to carry high current, the other to be used for the filaments of the 245s; one 5-volt winding for the 280 rectifier, and one high-voltage winding, around 700 volts AC at 85 milliamperes, to afford a total potential across the voltage divider of 300 volts. Of this voltage, 50 is devoted to negative bias of the 245s, through the 800-ohm resistor at left in Fig. 1, while 250 volts are effective on the center-tapped output impedance.

Tuning Fork Oscillator

By Wadsworth Adams

FIG. 1
Unsolder and remove binding posts 1, 2, 3 and 4.
Unbend lugs A, B, C, D, E and F from beneath terminal strips.
Lift out shields I_1 and I_2.
Spring out clamps G and H.
Slide core and coil upward.
Remove washers W_1 and W_2.



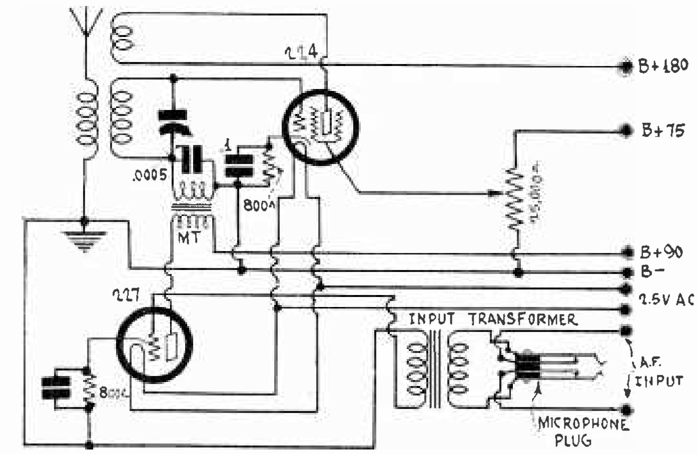


FIG. 2
DIAGRAM OF THE CONNECTIONS THAT INCLUDE A MICROPHONE-TRANSFORMER AS AN INPUT TO THE MODULATOR CIRCUIT

[The following is the third and final consecutive instalment of an article describing the construction of a tube-operated tuning fork, with modulation process.—EDITOR.]

WE are to consider now the necessary item in connection with the modulating circuit of the oscillator of Fig. 2, in other words the microphone transformer. A Gold Bond 1 to 3 audio transformer was converted to this use. The primary winding is easily removable from the secondary coil by careful heating that does not injure the primary winding.

It is almost surprising what one can do with the secondary winding of an audio transformer in the way of building adjuncts to sound-intensity measuring apparatus. For instance you can obtain comparative sound-output indications of your dynamic speaker in your home, and thus have the means right at hand for correcting tonal deficiencies to a nicety. And in these days when a slight difference in the registered tone of a receiver influences the sale, or your friends' opinion of your set, the utility of a simple means of making comparisons will be appreciated.

Modifying the Audio Transformer

The chief object attained by making over the present transformer is that a special microphone transformer retails for a figure substantially higher than the combined cost of the one in mind, plus the cost of wire necessary to make the change. Besides all this the reader who enjoys making over a device which when it is finished possesses some useful application, will find that the modification will increase his stock of electrical knowledge by a definite amount.

The primary winding of most plain audio transformers has an impedance that equals that of the plate impedance of the most commonly used tubes, but for our purposes this value is too high. Also the accompanying ohmic resistance is much too high, and so we will merely remove the primary winding.

This involves a little skill with the soldering iron. The procedure is to heat up your iron first to the temperature at which it will melt solder, then unsolder the primary and secondary leads, next unbend the aluminum lugs that hold the primary and secondary terminal boards in place, then carefully pry this cap off, which holds the laminations in place. You will be able to remove the shield pieces at the sides. After this the rest of the lamination clamp is easily slid off, leaving the coil assembly in view, within the laminations, which are now removed carefully, one at a time, until the coils are loose.

Shake Out Laminations

The rest of the laminations are shaken out, leaving the coils, and next you insert the hot soldering iron within the axis of the primary coil, gently warming the coil. You will be able to press out the coil easily, leaving the secondary winding with a hole of about one inch diameter, the central hole of the primary coil being ¾ inch, leaving about ⅛ inch for the overall thickness of the primary coil just removed.

Inspection has just shown that this central hole could be a trifle smaller or 11/16ths inch, so the substitute primary coil that we will make up will have an overall thickness of just 3/16ths inch.

The next problem is, what size and insulation-covering of magnet wire shall we select? The safe current carrying capacity of the old primary was 10 milliamperes. As there are 3,200 turns of wire in the primary coil, there are for the aforesaid current flow, 32,000 milliampere turns, or 32 ampere turns in the coil. As the transformer does not get hot when in continuous service, this rating may be taken to be conservative and may be slightly exceeded.

As a starter it is suggested that double silk covered wire be used, whether it be enamelled or plain, and in addition that a little wooden coil-winding form be made that is collapsible, with flanged ends that are 1 1/16 inches apart, the depth of the winding slot 3/16 inch. You are to provide a lead hole at the bottom of the slot that permits the starting lead to be brought into the coil.

Current Measured, Voltage Selected

Consulting a standard wire table listing double silk covered wire we find a number of sizes to select, and since the size we will choose will be between No. 22 and No. 32, suppose we look at the carbon grain microphone with a view to finding out what DC it draws. To do this we take four dry cells and connect them in series, then connect the negative terminal of an ammeter, also a voltmeter of appropriate respective scale ranges each, the microphone circuit being traced from the negative terminal of the dry-cell battery through the low-range ammeter to the microphone, and from here to a contact-key, and thence on to the positive terminal of the battery.

But the positive lead is not permanently connected to the 6-volt post of the battery, but rather is long enough to reach to any one of the four cells. If no low range ammeter is available, a 0 to 400 milliammeter may be used. The voltmeter may be a 0 to 8-volt instrument. The experimental carbon grain microphone, when measured at a variety of voltages, from 1.5 to 6 volts, showed some interesting results from our present point of view, as follows:

Applied Volts.	Measured Current.
1.5	.005
3.0	.080
4.5	.080
6.0	.160 initially but dropped to .080

From the above then it is apparent that it would be wrong to use a microphone voltage in excess of 6 volts, and probably the lowest satisfactory voltage is 3 volts. The large initial reading at 6 volts is seen to be 50% higher than the final value, an indication that heating in excess of the safe current-carrying capacity is taking place, which if continued will ultimately end in the destruction of the microphone, to say nothing of uneven reproduction and blasting. Let us decide to use 3 volts and the current will be 80 milliamperes. The additional resistance of the transformer will limit this current value a little, but the original value can be restored with a slightly increased applied voltage, not in excess of the limits already prescribed.

Winding the Substitute Primary

The wire size chosen for this new primary is not one that is irrevocably interchangeable, but it is one that with the average transformer of a 1 to 3 ratio has produced good average results in countless previous cases, and it is No. 28 DSC magnet wire.

The table quoted the external diameter of No. 28 DSC wire as .0164 inch, but it is safer to allow a limit of .017 inch in the winding. The coil thickness, overall dimension, is to be 3/16 inch, but the first paper layer is to be .010 inch, and in

(Continued on next page)

Widening a Set's Scope

By Brunsten Brunn

A TIME comes in every home equipped with a radio receiver when the programs no longer appeal so strongly to all the family. The receiver may be running all day without any-one being aware of it, or it may be silent for weeks at a time without anyone missing it. This perhaps is due to standardization of programs and procedure. The same announcers speak all the time, the same performers do their familiar pieces every day, the sponsors of programs inflict the same blurbs and play the same tunes every time they sponsor, the continuity actors get into the same situations every time.

Anyone who has had a receiver for a year knows exactly what is going on in broadcasting without taking the trouble to turn on the set or to listen if it is turned on. It is this sameness that kills all interest in the radio receiver. If there is a gem scheduled for a certain hour, a great deal of publicity is required to make it stand out from the mass of sameness.

Change is Needed

The owner of a radio receiver needs a change, some new method of getting entertainment out of his equipment, and there are ways in which he may get it. Then the broadcast programs, by contrast, resume their former importance. For example, he may get a phonograph attachment and play his favorite records any time he likes to, and he will get better reproduction and better entertainment than if he played the same record in the old way.

Then, again, he can get a recording device for making his own records, and this is one field which is practically unlimited. He can record the voices of his children, his wife, himself and his friends, or he can record the occasional gem that comes over the radio. He may even put the recording device to detective uses. He can "talk" letters into the microphone and mail the records to the addressee and get a "back talk" reply.

The entertainment possibilities of home recordings are obvious to everyone. Is there a mother who would not like to hear the voices of her children after these children have grown up? Would not a record of their early prattle be an even better memento than the first shoes or the first stockings? Would not such a record be just as interesting as a snapshot?

Television Soon, Let's Hope

Television is another ally of radio, and it ought not to be long before it has reached the stage where it can be classed as entertainment. Even now, many find television a pleasant pastime. Promise of the arrival of television as a branch of entertainment is given by the fact that in many laboratories throughout the world feverish activity is going on along developmental lines.

Home talkies are also closely allied to the radio receiver, for every such device needs a good audio amplifier, and in every modern set there is an amplifier as good as the amplifier used in theatres, and in some cases much better.

Equipment for showing talkies in the home is now available and it will not be long before apparatus for making them in the home will also be available.

A talking movie history of every child in the family would be a dandy memento for mother and father.

A short-wave converter, to be used with a broadcast receiver, opens the possibility of bringing in foreign stations directly on the loudspeaker.

A Tube-Operated Tuning Fork

(*Continued from preceding page*)

addition to this there are to be layer insulation strips of .005-inch wax paper, which makes a total for the insulation thickness of 660 thousandths of an inch. As the coil depth is 187.5 thousandths the net depth left for windings is 127.6 thousandths, and if you will leave .001 thousandth for error in winding, the job will come out all right.

There will be seven layers, and sixty-two turns per layer, or a total of 434 turns, and as the length of a mean turn is 2.7 inches, the resistance of the finished coil is found to be around 5.8 ohms.

This coil will give a sufficiently close approximation on an ampere-turn basis, to the original coil, and the microphone is to be spoken into in the familiar way, but if you should plan to have some one sing, it will be necessary to have the artist placed at a distance of three feet or so from the microphone, principally to avoid echo-effects.

The same rule obtains if you operate a phonograph.

As each successive layer of the coil is wound, coat it with a layer of liquid collodion, which is allowed to dry, then the paper insulator is put on and also collodion-cemented. The coil made up in this way is finally finished off with two coats of collodion, making a hard and self-supporting job which will slip off the winding form easily. The paper ends may be coated also, and when the coil is dry it will insert into the secondary easily. The microphone operative voltage may be derived from the B voltage supply circuit incorporated with the tube-operated tuning fork.

The capacity of the B voltage supply system is more than adequate to supply the plate voltages required, as well as those due to the added tubes, and since these are a UY-227, and two UX-245's, the plate voltage required are known, as well as the correct values for grid-bias valtage, and the manner in which they are customarily obtained.

It is likewise intended that transformer-coupling shall be used, and in order to insure the purest output tone the use of Amertran input and output transformers is advocated, but if you should wish to consider cost somewhat, an output choke for the 245's may be substituted, although it will be at least twice the size of the transformer.

A convenient switching arrangement, say a speaker-relay, would permit you to "pipe" the output of your favorite phonograph record to the loudspeaker either via the amplifier, or via the oscillator, and then you can test the operation of the RF circuit you are building, with almost any kind of modulation you may desire.

WMCA, Improving Plant, Seeks Unlimited Time

Washington.

WMCA, with transmitter at Hoboken, N. J., has applied to the Federal Radio Commission for permission to cease sharing a channel with WNYC, the municipal broadcast station of New York City, and to use the 570 kc channel unlimited time.

The New York station had applied for the same authority previously but its application was denied by the Commission, which was later upheld by the courts. However, the station has renewed the application and it is expected that a hearing will be held at an early date on both petitions.

WMCA, which is owned and operated by the Knickerbocker Broadcasting Co., Hoboken, N. J., has been granted a construction permit to make changes in the equipment and power. The improvements will include automatic frequency control and 100 per cent. modulation, and the new equipment will be for a maximum power of 1,000 watts instead of 500 watts.

Radio Waves Held Diphtheria Relief

Pittsburgh.

Dr. Waclaw T. Szymanowski and Dr. Robert Alan Hicks, of the Pennsylvania Hospital Institute of Pathology, assert that they have been able to weaken slightly the poison of the diphtheria bacillus by means of radio waves. They hope that the ultimate result of the research in which they are engaged will be the development of an irradiated toxin as an immunizing agent.

These scientists are continuing experiments which were first made several months ago in the laboratories of the General Electric Company at Schenectady, N. Y., to test the effect of short radio waves on temperature in fever. Experimenters in these laboratories found that artificial fever could be induced by exposing the patient to radiation of short waves.

A number of different frequencies have been used in this new field of research.

Schilling in New Position With Trade Paper

Walter A. Schilling, radio pioneer and trade magazine expert, has been appointed editor of "Furniture World," New York, and assistant to the president of the company that publishes it. Mr. Schilling will also direct the new radio division planned by the furniture magazine.

Mr. Schilling was editor of "Radio Dealer" for some years, resigning the post to be public relations counsel to several of the leading organizations in radio, industrial and civic fields.

Weekly Anxiety

I AM always waiting for Tuesday of each week to come, as that is the day that RADIO WORLD arrives. An interest in the different layouts and hook ups is of vital moment to the experimenter and the advanced layman of the craft. Let us hope that the good articles will continue to be published, as the battery and electric go hand in hand.

FRED C. JAMES,
302 S. Miami Ave., Miami, Fla.

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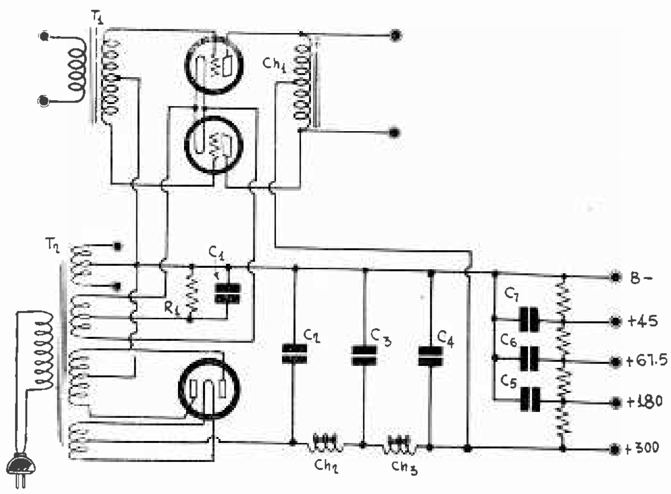

FIG. 858
THIS CIRCUIT CONTAINS A 245 PUSH-PULL AMPLIFIER AND A B SUPPLY CAPABLE NOT ONLY OF SUPPLYING THE POWER STAGE BUT ALSO THE RADIO FREQUENCY AMPLIFIER AND THE FIRST AUDIO STAGE

AC on Battery Tubes

IS IT practical to build a complete receiver with tubes like the 199 and the 230 and heating the filaments with alternating current? If it is not practical will you kindly suggest a way of operating such a receiver without the use of storage batteries?—P. C. W.

It is not practical because these tubes have not been designed for alternating current operation and the hum would be excessive. You might use AC on the power tube but that is all. However, it would hardly be practical to use AC on one of the tubes when DC must be used on the rest. One way of operating these tubes without the use of a storage battery is to hook up an A battery eliminator which gives enough current at the proper voltage. Another way is to use dry cells.

* * *

Design of Compact Receiver

WOULD it be all right to use trimmer condensers of the Hammarlund type for tuning? I realize that it would not be practical to calibrate the tuners, but that does not matter.—G. W. K.

A receiver could be built compactly with these condensers but, of course, the sensitivity would not be so great as if air condensers were used because these condensers have somewhat greater losses. Moreover, the tuning range would not be so wide because the minimum capacity is comparatively larger in these than in air condensers. But they can be used.

* * *

Station Interference Elimination

I LIVE close to several broadcasting stations which interfere with some of the stations I wish to receive. One of the interfering stations is so close that its signals spread out over half the dial. Can you suggest an inexpensive method of getting rid of the interference? I do not want to add more tuners to the circuit and I can't afford to get a more selective receiver.—W. H. J.

The simplest way to minimize the interference is to put in a wavetrap in the antenna circuit. Tune this trap to the station that interferes the most. First tune in the station that causes the interference and then tune the wave-trap until the signals are as weak as possible. Then leave the wave-trap alone and tune the set to the station you want. If there is only one station which interferes regularly leave the wave-trap adjustment set all the time.

A very good wave-trap can be made of a variable condenser of .0005 mfd. and a coil of 160 microhenries. Wind 43 turns of No. 22 double cotton covered wire on a 3-inch diameter and connect the condenser across this winding. Also put on about five turns on the same form about one-fourth-inch from the large winding. Connect the five-turn winding in the antenna circuit of your set, above the antenna binding post.

* * *

Blasting of Loudspeaker

MY SPEAKER blasts on certain notes when I turn the volume up. Could you recommend a speaker which does not do this? In this respect, is a magnetic preferable to a dynamic speaker? Mine is of the latter type. Possibly it is not the speaker that is at fault. If so please explain what might cause the trouble.—B. F. L.

If a loudspeaker is not loaded up with a large cone, diaphragm, or baffle board, any speaker may blast on certain notes due to defects in the speaker, and there is no difference in this respect between magnetic and dynamic speakers. The cause of the blasting is most likely the amplifier and the B supply, or in the combination of the two. Blasting is due in most instances to extremely high amplification on certain notes, and this high amplification is usually due to regeneration. If there were a little more regeneration on those frequencies, or a little more amplification in the set, the circuit would probably howl on some frequency where blasting now occurs. The remedy lies in so treating the amplifier that there is no regeneration, or so that there is no tendency to "motorboat." The blasting is really an indication of incipient motorboating. The cure for motorboating is to use much larger condensers across the B voltage taps in the B supply or across equivalent points in the amplifier. Individual choke coils in the plate return leads will help. A choke in the plate return of the detector is usually very effective. If a choke is used a condenser of 2 mfd. or more should be connected from the plate side of the choke to the cathode of the tube preceding, or to the filament of that tube.

* * *

Operation of 210 Amplifier

I HAVE a 210 power tube which I wish to use in a power amplifier, but my B battery eliminator does not give more than 300 volts. I wonder if I could use this tube advantageously with this low voltage? If so, what should the grid bias be?—D. F. W.

The 210 can be used advantageously on any voltage between 180 and 425 volts. If you use 300 volts on the plate the bias should be 22.5 volts. This will be provided if you use a 1,500 ohm grid bias resistor. The maximum undistorted output will be over one-half watt.

* * *

Principle of Selenium Cell

DOES the selenium photo-electric cell work on the same principle as the vacuum tube photo-electric cells? If not, what is the principle of the selenium cell?—G. F. W.

The two work on entirely different principles. In the vacuum tube photo-electric cell light entering the cell releases electrons from the metal coating on the inside wall of the glass envelope. The electrons are then attracted the positive electrode usually mounted in the center of the bulb. The resulting current is called the photo-electric current and it is proportional, for a given voltage between the metal coating and the anode, to the amount of light entering the cell

The principle of selenium cell is not so well understood but it is known that its resistance varies according to the amount of light that falls on the selenium. In the dark the resistance to electric current is very great while in daylight it is comparatively low.

The photo-electric cell responds to changes in light intensity without any measurable lag, but the selenium cell is very sluggish. It is because of this sluggishness that selenium cells are useless in television work.

* * *

Measuring DC Plate Resistance of Tube

IS there any way of measuring the DC resistance of an amplifier tube at different grid bias values? If so, please outline method.—H. B. W.

There is a very simple way, indeed. Just connect a milliammeter in the plate circuit of the tube and note the current. Measure the voltage applied in the plate circuit, or assume that it is equal to the nominal voltage of the plate battery used. Divide the plate voltage by the plate current and the result is the DC resistance of the tube. This can be repeated for different values of grid bias. To get the true DC resistance of the tube alone there should be nothing in the plate circuit other than the battery and the milliammeter.

* * *

Resistance of Parallel Resistors.

YOU have shown how to determine the resistance of two resistors in parallel when the resistance of each is known, namely, to multiply the two resistances together and dividing the product by their sums. Will you kindly show a similar formula for calculating the resistance of several resistors in parallel? Is it generally true that you can get the resistance by dividing the product by the sum of all the resistors?—L. W. C.

There is a general formula of this kind that holds for any number of resistors, but it is rather a formula for writing out a specific formula. The formula given for two resistors does not hold for any other number. However, the old formula which states that the resistance of several resistors in parallel is equal to the reciprocal of the sum of the reciprocals of the resistances holds for any number. To apply it divide unity by the resistance of each resistor and thus get the reciprocal. Add all the reciprocals. Then divide unity by the sum and the result is the desired resistance. This holds for two or a million resistors. It might be mentioned that the simple formula applying to two resistors can be used several times to obtain the resistance of several resistors in parallel. Take any two of the resistors and find the resistance of the two by the simple formula. Then using this result in combination with another resistor find the combined resistance of three. Keep this up until all resistors have been taken into account.

* * *

Ballast Resistor Calculation

I HAVE an RCA set using seven 199s and one 120 tubes. This set works all right when the filament supply voltage is 4.5 volts. But I want to use a six-volt storage battery. If this is all right, please give me the value of the extra resistance that must be connected in series with the battery to cut the voltage down to 4.5 volts.—J. B.

Each of the 99 tubes takes 0.06 ampere and therefore the seven take 0.42 ampere. The 120 tube takes 0.12 ampere. Hence the total current drain is 0.54 ampere. Since the voltage of the battery is six and the required voltage is 4.5 volts, the drop in the resistance should be 1.5 volts. Therefore the resistance should be 1.5/.54, or 2.78 ohms. A six or ten ohm rheostat may be used since either can be adjusted to the desired value, yet giving an ample margin to take care of overvoltage.

* * *

Principle of Tuning Fork Oscillator

HOW is it possible for a tuning fork to maintain the oscillation in an amplifier? In what way does feed-back take place? Is there any connection between an oscillator built with a tuning fork and an amplifier and an oscillator using the ordinary tuned circuit and a tickler?—F. W. C.

The feed-back takes place through the fork and the fork is also the equivalent of a tuned electric circuit. The fork is driven by the output of the amplifier by means of some electromagnetic arrangement. A pick-up coil is also put on the fork, or a telephone electromagnet is mounted close to one of the vibrating prongs of the fork. A voltage is induced in the pick-up coil and this voltage is impressed on the grid of the amplifier. If the phase of the voltage is right the tube will keep the fork vibrating once the vibration has been started, just as an ordinary oscillator keeps oscillating once it has been started.

In most instances the fork oscillators are self-starting. That is, it is not necessary to strike the fork to start the oscillation. The impulse needed to start the fork is extremely small and it is possible that a gust of wind or a minute jar in the building starts vibration.

* * *

Condensers in Series

HOW can the capacity of a number of condensers in series be determined from the capacities of the condensers so connected. What are the advantages of the series connection over the parallel?—G. M. W.

The capacity of a number of condensers connected in series is determined in the same manner as the resistance of a number of resistors connected in parallel, that is, the reciprocal of each capacity is found first, then all the reciprocals are added together, and then the reciprocal of the sum is taken. The result is the capacity sought.

When condensers are connected in series the resultant capacity is always less than the smallest condenser in the series. An advantage of connecting condensers in series is that the voltage rating of the resulting capacity is higher. For example, suppose we have two condensers of 2 mfd. each having a voltage rating of 600 volts. When they are connected in series the capacity is only one microfarad but the voltage rating is 1,200 volts.

* * *

Use of 2-Volt Tubes

WOULD you recommend the construction of a radio frequency amplifier with the new 2-volt tubes, the 232 for amplifiers and the 230 for detection? The amplifier would precede an audio amplier of two push-pull stages.—P. T. B.

The new tubes are very good and this scheme should be quite all right. It has the advantage that the radio frequency amplifier can be built into a compact form and also that it takes very little filament current. However, the question arises as to how to supply the current. A single cell of storage battery of the lead plate type would do nicely, but perhaps a better arrangement would be to rig up a rectifier of the copper oxide type. This could be done without great expense.

* * *

Amplifier and B Supply

WILL you kindly supply a circuit diagram of a push-pull amplifier utilizing the 245 powers together with a B supply that will not only operate the amplifier but also a medium size radio frequency amplifier?—L. W. S.

Fig. 858 gives such a diagram. R1 should have a value of 750 ohms and the condenser across it should be about 2 mfd. The design of the filter is standard in every respect. The high voltage winding should be center tapped and the total voltage, R. M. S., should be 600 volts. The transformers, single chokes and the center-tapped output chokes used in this circuit were Polo. C4 and C3 were electrolytic condensers of large value.

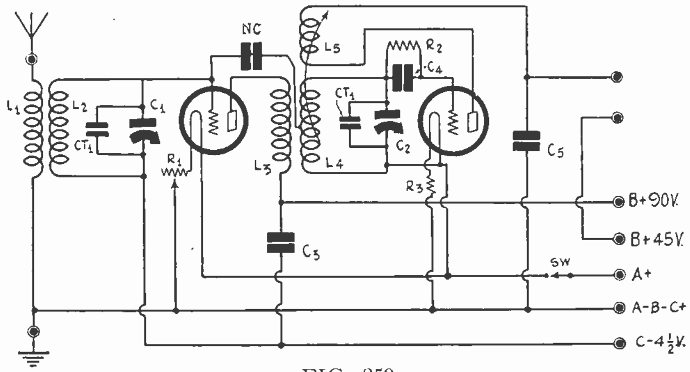

FIG. 859
THIS ILLLUSTRATES THE CONNECTION OF A NEUTRALIZING CONDENSER BETWEEN THE GRID OF THE RF AMPLIFIER AND A TAP ON THE TUNED WINDING OF THE COUPLING COIL

* * *

The Lost Cause of the 226

WHAT is the reason that the 226 tubes have practically been abandoned in favor of other tubes? Are they not good amplifiers?—C. W. C.

They are inferior to the 227 and the 224 tubes. They amplify no better than 227s and not nearly as well as 224s. Then there is the difficulty with hum which is not experienced with the heater type tubes to nearly the same extent. Moreover, they require the use of neutralizing condensers when used as radio frequency amplifiers which the 224 tubes do not. It was really the 224 tube which crowded the 226 out.

* * *

Method of Neutralization

IF you have a circuit showing how to neutralize a radio frequency amplifier, will you kindly publish it, or else give a sketch showing the position of the neutralizing condenser.—B. D.

Fig. 859 illustrates the method although it contains only one RF amplifier. The neutralizing condenser NC is connected between the grid and a point on the secondary of the tuned coil following the tube. The tap on L4 should be placed so that the number of turns below it is equal to the number of turns on the primary L3.

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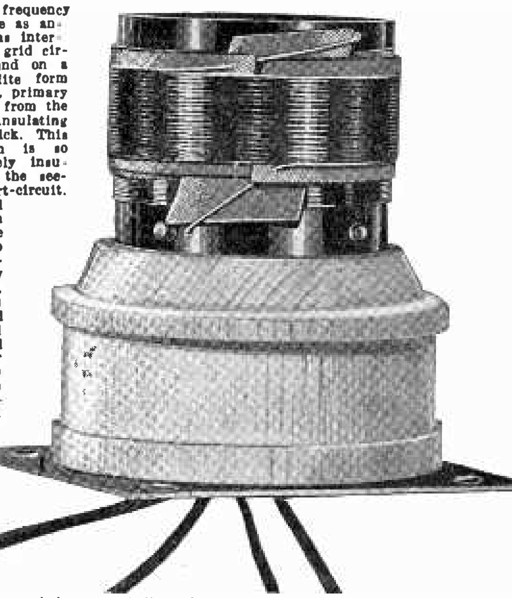
High-Gain Shielded Coils

A SHIELDED radio frequency transformer for use as antenna coupler or as interstage coupler, for screen grid circuits. The coil is wound on a 1¾-inch diameter bakelite form with No. 28 enamel wire, primary on the outside, separated from the secondary by an insulating wrapper 42/10,000-inch thick. This moisture-proof insulation is so shaped that it completely insulates the primary from the secondary, preventing short-circuit. The coil form is mounted on a wooden base, which base has the removable shield bottom fastened to it. The drawn aluminum shield fits snugly over the wooden base, and coils remain always erect and amply spaced from the shield wall in all directions. The shielded coils are suitable for baseboard or metal chassis mounting. The four leads emerge through an insulated hole in the shield bottom.

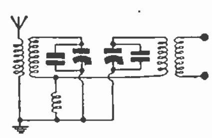


The coil comes already mounted on a shellacked wooden base, which is fastened at the factory to the shield bottom. Series A coil is illustrated.

The external appearance of the shield, with four 6/32 machine screws and nuts, which are supplied with each coil assembly.

Precisely Matched for Gang Tuning

ONE primary lead-out wire from the coil, for antenna or plate connection, has a braided tinned alloy covering over the insulation. This alloy braid shields the lead against stray pick-up when the braid alone is soldered to a ground connection. The outleads are 6 inches long and are color identified. The wire terminals of the windings themselves, and the outleads, are soldered to copper rivets. Each coil comes completely assembled inside the shield, which is 2¾ inches square at bottom (size of shield bottom) and 3¾ inches high. High impedance primaries of 40 turns are used. Secondaries have 80 turns for .00035 mfd. and 70 turns for .0005 mfd.



BP-6 is the coil at bottom.

EXTREME accuracy in winding and spacing is essential for coils used in gang tuning. These coils are specially suited for gang condensers, because the inductances of all are identical for the stated size condenser. The coils are matched by a radio frequency oscillator. The color scheme is as follows: shielded wire outlead is for antenna or plate; red is for ground or B plus. (These options are due to use of the same coil for antenna coupling or interstage coupling.) Blue is for grid and yellow is for grid return. For .00035 mfd. the Cat. No. is A-40-80-S. For .0005 mfd. the Cat. No. is A-40-70-S.

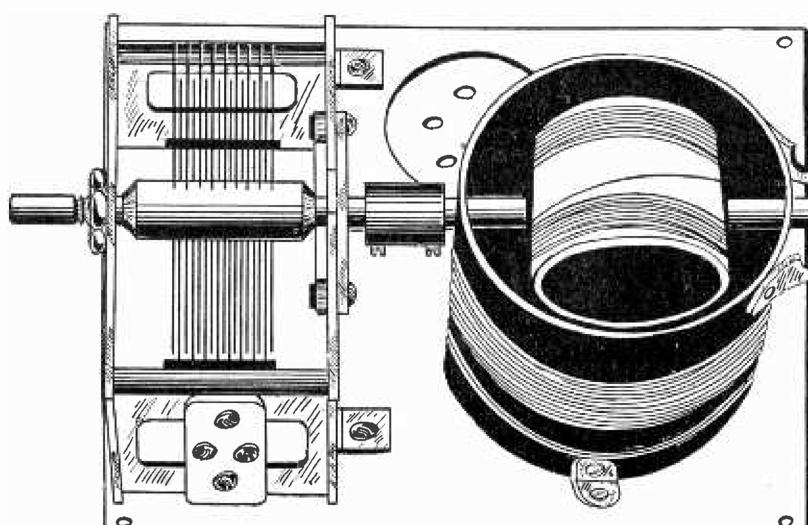
Where a band pass filter circuit is used the small coupling coil to unite circuits is Cat. BP-6. The connection is illustrated herewith.

Junior Model Inductances

The Series B coils have the same inductance and the same shields as the series A coils, but the primary, instead of being wound over the secondary, with special insulation between, is wound adjoining the secondary, on the form, with ¼-inck separation, resulting in looser coupling. No wooden base is provided, as the bakelite coil form is longer, and is fastened to the shield bottom piece by means of two brackets. No outleads. Wire terminals are not soldered. Order Cat. B-SH-3 for .00035 mfd. and Cat. B-SH-5 for .0005 mfd.

Coils for Six-Circuit Tuner

Series C coils for use with six tuned circuits, as in Herman Bernard's six-circuit tuner, are wound the same as type A shielded coils, but the shields are a little larger (3 1/16-inch diameter, 3¾ inches high), and there are no shield bottoms, as a metal chassis must be used with such highly sensitive cricuits. Fasten the brackets to the shield and then, from underneath the chassis, fasten the other arm of the two brackets to the chassis. Order Cat. C-6-CT-5 for .0005 mfd. and Cat. C-6-CT-5 for .00035 mfd. Five needed for Bernard's circuit. If band pass filter coupling coil is desired order Cat. BP-6 extra.



For a stage of screen grid RF, either for battery type tube, 222, or AC, 224, followed by a grid-leak-condenser detector, no shielding is needed, and higher per-stage amplification is attainable and useful. This extra-high per-stage gain, not practical where more than one RF stage is used, is easily obtained by using dynamic tuners. Two assemblies are needed. These are furnished with condensers erected on a socketed aluminum base. Each coil has its tuned winding divided into a fixed and a moving segment. The moving coil, actuated by the condenser shaft itself, acts as a variometer, which bucks the fixed winding at the low wavelengths and aids it at the high wavelengths, thus being self-neutralizing and maintaining an even degree of extra-high amplification throughout the broadcast scale.

Two assemblies are needed. For AC operation (224 RF and 224 or 227 detector), use Cat. BT-L-AC and BT-R-AC. For battery or A eliminator operation (222 RF and any tube as detector), use Cat. BT-L-DC and BT-R-DC.

Screen Grid Coil Co., 143 West 45th Street, New York (Just East of Broadway):

Enclosed please find $.. .... (Canadian must be express or P. O. Money Order), for which send me prepaid the following:

- ☐ A-40-80-S, each $2.25
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- ☐ B-SH-3, each $1.00
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- ☐ B-SH-5, each 1.00
- ☐ Matched set of four B-SH-5........... 4.00
- ☐ BT-L-AC and BT-R-AC, assembled, with condenser, link, socket and base, per pair....... 6.00
- ☐ BT-L-DC and BT-R-DC, assembled, with condenser, link, socket, base, per pair.......... 6.06
- ☐ C-6-CT-5, .0005 mfd. shielded coil for six-circuit tuner...........each $2.25
- ☐ C-6-CT-8, .00035 mfd. shielded coil for six-circuit tuner...........each $2.25
- ☐ BP-6 .... .25
- ☐ EQ-100, equalizer of 20-100 mfd. capacity, made by Hammarlund.............. .35

(Note: All coils come with shields, except BP-6 and BT-L.)

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BT-L for the antenna stage and BT-R for the detector input. BT-L consists of a small primary, with suitable secondary for the .00035 mfd. condenser supplied. BT-B has two effective coils: the tuned combination winding in the RF plate circuit, the inside fixed winding in the detector grid circuit.

The moving coils must be "matched." This is done as follows: Turn the condensers until plates are fully enmeshed, and have the moving coils parallel with the fixed winding. Tune in the highest wavelength station receivable—above 450 meters surely. Now turn the moving coils half way round and retune to bring in the station. The setting that represents the use of lesser capacity of the condenser to bring in that station is the correct one. If gang tuning is used, put a 20-100 mmfd. equalizing condenser across the secondary in the antenna circuit and adjust the equalizer for a low wavelength (300 meters or less).