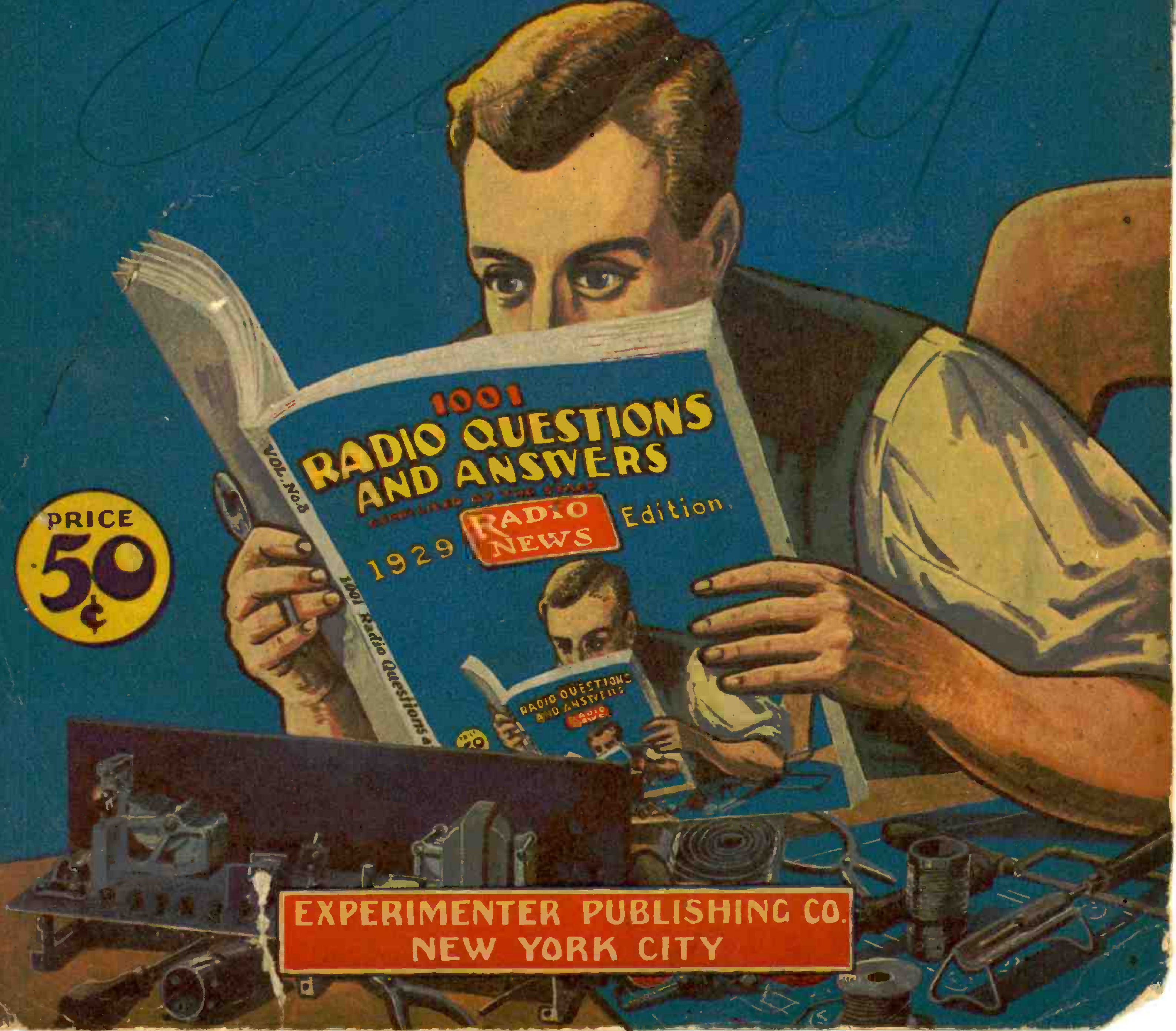
1001 RADIO QUESTIONS AND ANSWERS

COMPILED BY THE STAFF OF

RADIO NEWS

1929 Edition



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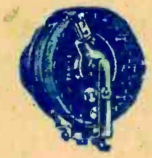
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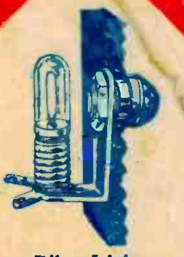
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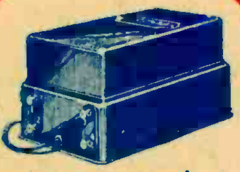
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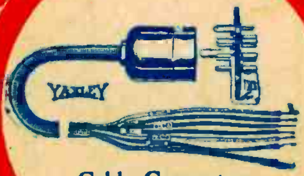

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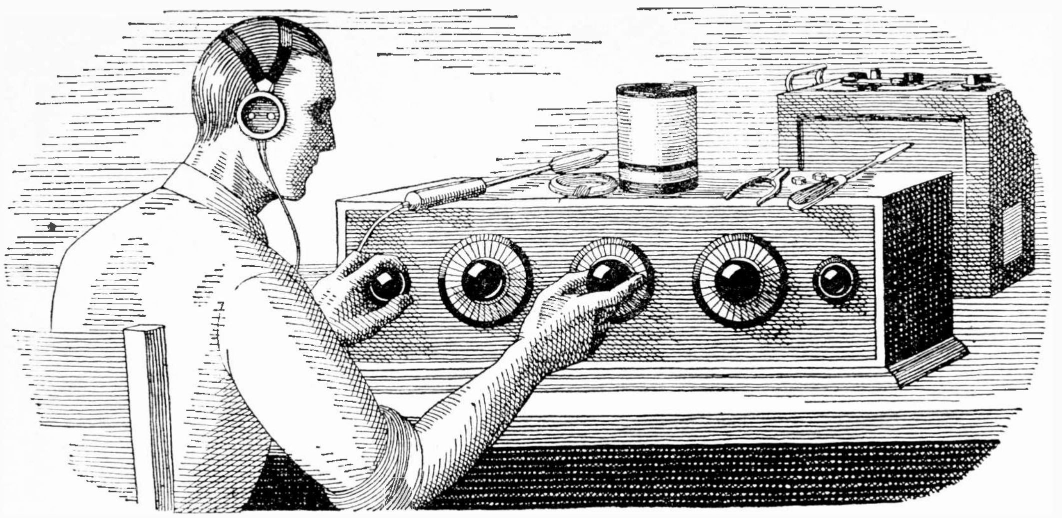

If all the Radio sets I've "fooled" with in my time were piled on top of each other, they'd reach about half-way to Mars. The trouble with me was that I thought I knew so much about Radio that I really didn't know the first thing. I thought Radio was a plaything—that was all I could see in it for me.

I Thought Radio Was a Plaything

But Now My Eyes Are Opened, And I'm Making Over $100 a Week!

$50 a week! Man alive just one year ago a salary that big would have been the height of my ambition.

Twelve months ago I was scrimping along on starvation wages, just barely making both ends meet. It was the same old story—a little job, a salary just as small as the job, while I myself had been dragging along in the rut so long I couldn't see over the sides.

If you'd told me a year ago that in twelve months' time I would be making $100 and more every week in the Radio business—whew! I know I'd have thought you were crazy. But that's the sort of money I'm pulling down right now—and in the future I expect even more. Why only today—

But I'm getting ahead of my story. I was hard up a year ago because I was kidding myself, that's all—not because I had to be. I could have been holding then the same sort of job I'm holding now, if I'd only been wise to myself. If you've fooled around with Radio, but never thought of it as a serious business, maybe you're in just the same boat I was. If so, you'll want to read how my eyes were opened for me.

When broadcasting first became the rage, several years ago, I first began my dabbling with the new art of Radio. I was "nuts" about the subject, like many thousands of other fellows all over the country. And no wonder! There's a fascination—something that grabs hold of a fellow—about twirling a little knob and suddenly listening to a voice speaking a thousand miles away. Twirling it a little more and listening to the mysterious dots and dashes of steamers far at sea. Even today I get a thrill from this strange force. In those days, many times I stayed up almost the whole night trying for DX. Many times I missed supper because I couldn't be dragged away from the latest circuit I was trying out.

I never seemed to get very far with it, though. I used to read the Radio magazines and occasionally a Radio book, but I never understood the subject very clearly, and lots of things I didn't see through at all.

So, up to a year ago, I was just a dabbler—I thought Radio was a plaything. I never realized what an enormous fast-growing industry Radio had come to be—employing thousands and thousands of trained men. I usually stayed home in the evenings after work, because I didn't make enough money to go out very much. And generally during the evening I'd tinker a little with Radio—a set of my own or some friend's. I even made a little spare change this way, which helped a lot, but I didn't know enough to go very far with such work.

And as for the idea that a splendid Radio job might be mine, if I made a little effort to prepare for it—such an idea never entered my mind. When a friend suggested it to me one year ago, I laughed at him.

"You're kidding me," I said.

"I'm not," he replied. "Take a look at this ad."

He pointed to a page ad in a magazine, an advertisement I'd seen many times but just passed up without thinking, never dreaming it applied to me. This time I read the ad carefully. It told of many big opportunities for trained men to succeed in the great new Radio field. With the advertisement was a coupon offering a big free book full of information. I sent the coupon in, and in a few days received a handsome 64-page book, printed in two colors, telling all about the opportunities in the Radio field and how a man can prepare quickly and easily at home to take advantage of these opportunities. Well, it was a revelation to me. I read the book carefully, and when I finished it I made my decision.

What's happened in the twelve months since that day, as I've already told you, seems almost like a dream to me now. For ten of those twelve months, I've had a Radio business of my own. At first, of course, I started it as a little proposition on the side, under the guidance of the National Radio Institute, the outfit that gave me my Radio training. It wasn't long before I was getting so much to do in the Radio line that I quit my measly little clerical job, and devoted my full time to my Radio business.

Since that time I've gone right on up, always under the watchful guidance of my friends at the National Radio Institute. They would have given me just as much help, too, if I wanted to follow some other line of Radio besides building my own retail business—such as broadcasting, manufacturing, experimenting, sea operating, or any one of the score of lines they prepare you for. And to think that until that day I sent for their eye-opening book, I'd been wailing "I never had a chance!"

Now I'm making, as I told you before, over $100 a week. And I know the future holds even more, for Radio is one of the most progressive, fastest-growing businesses in the world today. And it's work that I like—work a man can get interested in.

Here's a real tip. You may not be as bad off as I was. But think it over—are you satisfied? Are you making enough money, at work that you like? Would you sign a contract to stay where you are now for the next ten years—making the same money? If not, you'd better be doing something about it instead of drifting.

This new Radio game is a live-wire field of golden rewards. The work, in any of the 20 different lines of Radio, is fascinating, absorbing, well paid. The National Radio Institute—oldest and largest Radio home-study school in the world—will train you inexpensively in your own home to know Radio from A to Z and to increase your earnings in the Radio field.

Take another tip—no matter what your plans are, no matter how much or how little you know about Radio—clip the coupon below and look their free book over. It is filled with interesting facts, figures, and photos, and the information it will give you is worth a few minutes of anybody's time. You will place yourself under no obligation—the book is free, and is gladly sent to any one who wants to know about Radio. Just address J. E. Smith, President, National Radio Institute, Dept. 9E8, Washington, D. C.

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1001 RADIO QUESTIONS and ANSWERS

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Vol. No. III **1929 Edition**

COMPILED
BY THE STAFF
OF

RADIO NEWS

EDITED BY
ALLAN K. ROSS

Price 50c

A Classified, Comprehensive Collection of Radio Questions and Answers, of Practical and Everyday Value to Everyone Interested in Radio

How To Use This Book

IN response to popular demand we present the 3rd edition of this book, which has found a place in the heart and mind of the home-set builder, the experimenter and the radio listener.

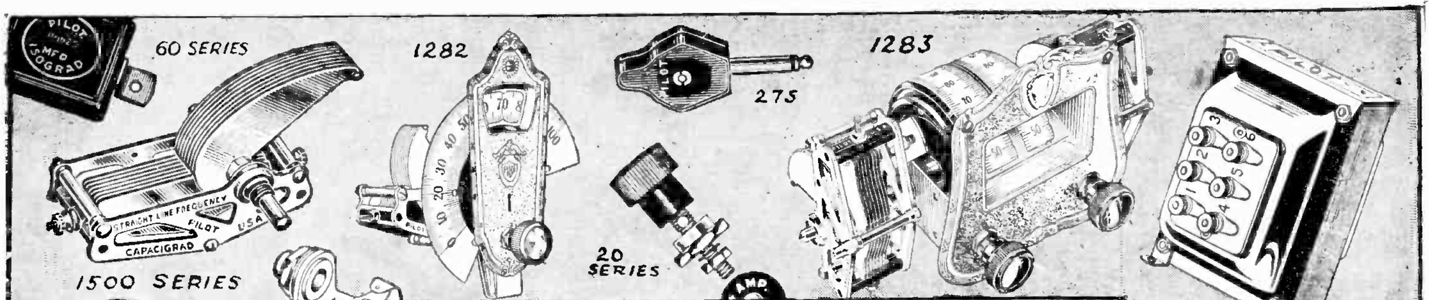
In connection with any new science there are always many problems which puzzle the more advanced experimenters as well as the beginners and it is, therefore, the purpose of this book to answer as many of these questions of both classes as possible. The questions appearing in this edition were selected from more than 2,000 received since the publication of the previous edition and it is hoped that the information contained herein will prove of even greater value than those that have gone before.

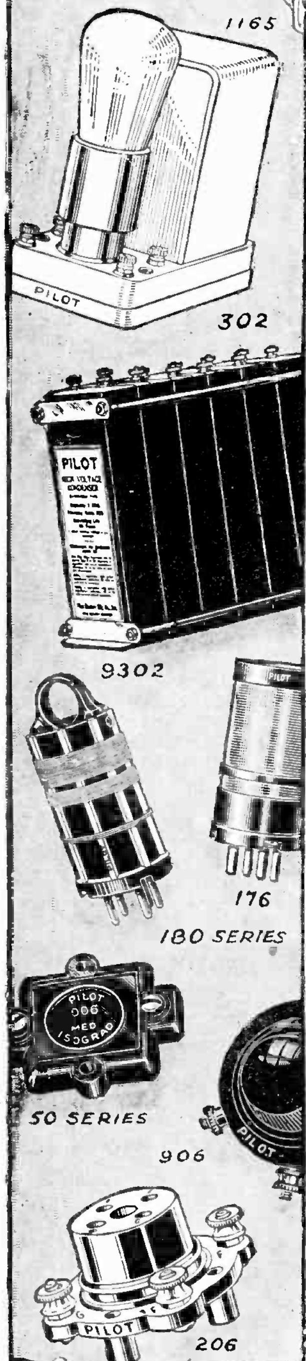
It has been the aim of the publishers of this book to classify the questions and corresponding answers in such a way that they are available for ready reference. They include the actual queries of hundreds of radio experimenters in all parts of the world, covering practically every phase of radio reception and amateur transmission, including an entire chapter devoted to the consideration of the construction and use of short-wave receiving sets, on which there is as yet comparatively little accurate information available, but which give promise of being one of the most important developments of the year.

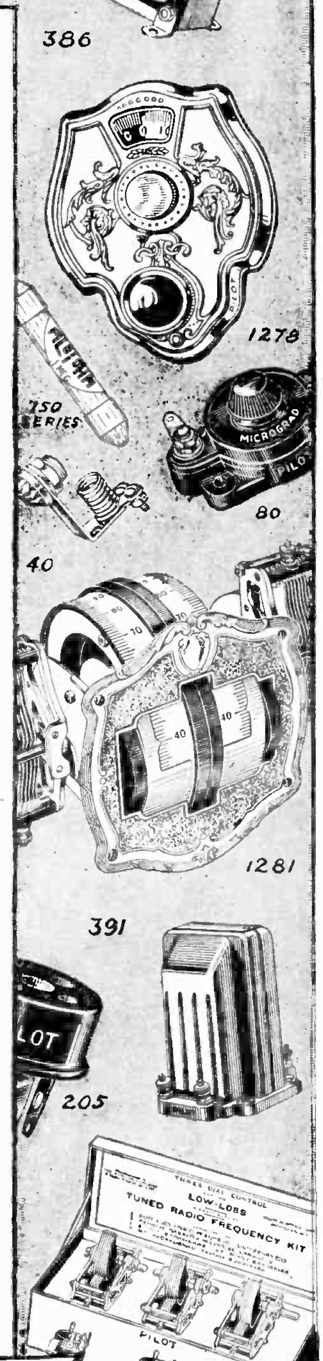
An outline of the various subjects covered in this edition will be found on page 2. The reader will note that considerable space has been devoted to the use of the new screen-grid type of vacuum tube, also to the use of A.C. tubes and the various methods of adapting existing sets for their use.

A complete index of every question and answer will be found in the alphabetical list appearing on page **106.** The reader will find this of value in obtaining answers to his own questions as well as in gaining a knowledge of the various subjects covered by this book.

—EDITOR.







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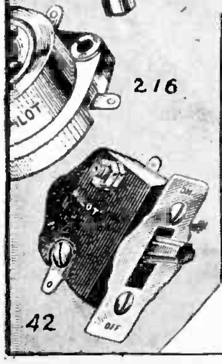

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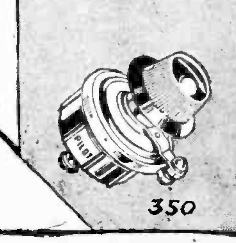

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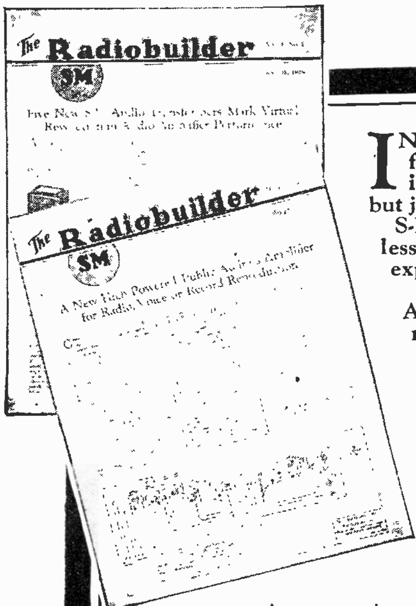

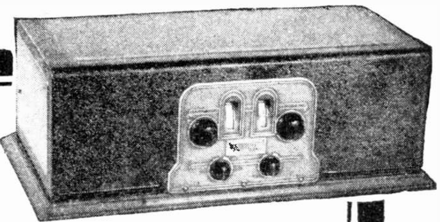

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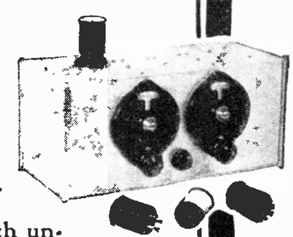

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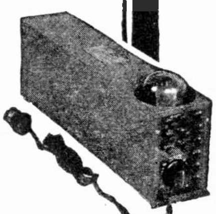
Never has there been a design which so perfectly fulfills the requirements of the setbuilder as does the new Silver-Marshall 720 Screen Grid Six—successor to the famous Shielded Grid Six of such unparalleled popularity during early 1928. The 720 Screen Grid Six is a six-tube dual control screen grid receiver using three screen grid tubes in individually copper-shielded r. f. stages and two audio stages with the marvelous new S-M transformers—a set absolutely unequalled at the price.

On a summer evening test in Chicago, 41 stations (two on West Coast) were logged, 5 of which (in N. Y., N. J., Fla., Ga., and La. respectively) were on adjacent channels (only 10 kc. apart) to locals then on the air. The 720 Kit, complete without cabinet, is priced at $72.50. Custom-built complete in cabinet as illustrated, it costs $102.00.

And at $51.00 S-M offers the 740 "Coast to Coast" Screen Grid Four—a kit that is a revelation in four-tube results. Type 700 metal shielding cabinet as illustrated is but $9.25 additional, for either set, finished in duo tone brown; it marks a new standard of style and distinction.

The Sargent-Rayment Screen Grid Seven, type 710, is the wonder set of the season, and S-M offers, exclusively, the approved kit at $120.00. It is complete with aluminum shielding cabinet and will bring in 100 stations on any average evening.

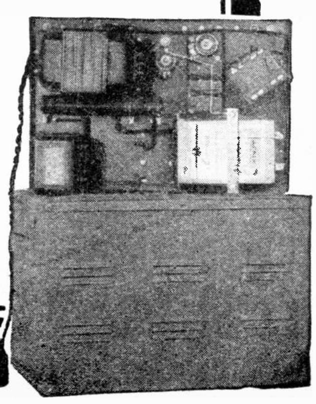


The S-M "Round the World" Short Wave sets are the trimmest, most efficient short wave sets yet, priced from $36.00 to $51.00 complete with shielding cabinet. New S-M condensers are marvels of rigidity and flexibility in Universal single, and triple types. The 685 Public Address Unipac—the first really high-powered amplifier yet offered—is priced at only $160 wired, or $125 for the kit. It will turn out music or voice that can be heard by 1000 to 10,000 people. Other Unipacs and Power Supplies take care of every power need.

Of course, the most startling audio development of the last two years would logically come from S-M laboratories, as it did two years ago. The new Clough audio transformers were deservedly the sensation of the June radio trade show. In open comparative tests, S-M 255 and 256 ($6.00 transformers) have excelled the performance of all competitive types tested, regardless of cost. The 225 and 226 transformers at $9.00 each simply leave the most skeptical marveling.

These and many other startling new S-M parts leave small wonder at S-M leadership. They prove that you can get the best radio for the least cost from S-M.

If you don't wish to build, yet want your radio to be custom-made, with all the advantages that this implies, S-M will gladly refer your inquiry to an Authorized Silver-Marshall Service Station near you. If, on the other hand, you build sets professionally, and are interested in learning whether there are valuable Service Station franchises yet open in your territory, please write us.



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....No. 7. 675ABC Power Supply and 676 Dynamic Speaker Amplifier
....(50c) Sargent-Rayment Instruction Booklet
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....Address

Miscellaneous Circuits

House Wiring Systems

(1.) Mr. W. F. Borchers, Bellefonte, Pa., asks:

Q. 1. I have recently tried wiring my house so that phones or a loud speaker could be used in any room. The experiment failed completely, however. The music was distorted and the tubes did not seem to get enough current. Can you help me in this matter?

A. 1. The simplest method for using a loud speaker to a distant set is merely to connect a length of electric-light flexible cable between the set and loud speaker. This method works fairly well if the leads are not too long. If they are of too great length, the upper musical notes will be weakened; owing to their being shunted away by the capacity formed, across the loud-speaker terminals, between the two long twisted wires.

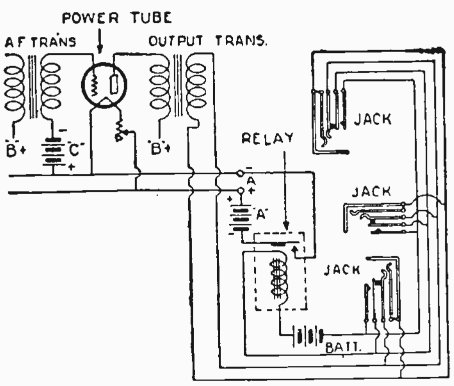


FIG. 1—A house-wiring system which is particularly well adapted to large installations is shown here.

A considerable length can be used, however, without noticeable loss if ordinary flexible cable is used. If twin bell-wire is used, the higher tones are so reduced that very disagreeable distortion is introduced, and the muffled sound is given to speech.

The reason is that the capacity of this type of wire is high. Apart from this, it is not desirable to run wires all over the house that carry a high D. C. potential (with respect to the earth); as there is risk of fire if a short circuit occurs, due to some mechanical scraping away of the insulation. This can easily be guarded against by the use of a choke-filter output circuit, or a transformer; and for various other electrical reasons, such as the question of magnetic saturation of the iron cores of loud speakers, a device of this kind should always be employed whenever a power tube is used in the output stage of the receiver.

The use of flexible cable will successfully overcome the capacity difficulty, but we are still bothered with the remote-control problem. This can easily be overcome by shunting a variable resistor of approximately 0 to 50,000 ohms across the loud speaker. Volume-control resistors similar to this, wire-wound or otherwise, can now be obtained, and should be connected permanently across the loud-speaker terminals. This will give a smooth control which is entirely satisfactory. Alternatively, we can use a jack in conjunction with a volume-control plug.

Switching the Filaments

Regarding the method of switching the set on and off, the first idea which occurs is merely to extend two wires, connected directly to the filament circuit, and to place a switch across the two at every place where there is a loud-speaker jack. There are a large number of objections to such a project; one of the principal ones being that there is a certain voltage drop along the wires which, in some cases, might reduce the actual filament voltage below the normal and thus affect the operation of the receiver.

We can get over this difficulty, however, by the use of a "constant-current" relay; this consists of an electromagnet, which, when excited, closes and holds close against a spring, a local switch, which is connected in the "A" battery circuit. The relay itself is operated by a separate battery, which is switched on by closing one of the switches already mentioned; this being installed by the side of the loud-speaker jack. The relay has to be supplied with current passing through its windings all the time; but, since relays of remarkably low current consumption are available, this doesn't greatly matter.

If the ordinary type of open jack with filament control is used, quite a neat and attractive scheme can be worked out. This method is shown in Fig. 1.

Series and Parallel Systems

It will need no great effort of the imagination to see that the insertion of the loud-speaker plug into one of the jacks will switch on the set via the relay, the effect being the same as though a separate switch situated close to the loud-speaker had been closed. Removal of the loud-speaker plug switches off the set. If a second loud speaker is inserted we merely close another switch in parallel with the existing closed filament switch. This is an excellent scheme for a block of flats or an institution, with outlets, fed from a master receiver; since the set will remain switched on until the last loud speaker or phone plug is removed. This system has one or two drawbacks, however, for the ordinary home installation. In the first place, it is impossible to use a volume control with each individual loud speaker, as already described.

The "circular" system illustrated in Fig. 1-A, operates in a somewhat different manner. To explain it, we will first ignore the filament-switching device and concentrate on the method of switching in the loud speakers. Each of the jack boxes shown contains two double-circuit jacks. Supposing we have, in the same room as the jack shown schematically, a receiver having a telephone plug attached to the secondary terminals of an output transformer or choke coil. In any of the rooms containing the other jack boxes, we can connect a loud speaker and, if desired, a pair of phones as well.

It will be realized that a transformer or choke-coil output device is imperative in this case as, otherwise, the total resistance of the

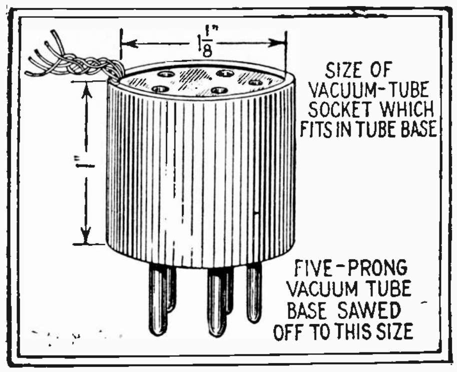


FIG. 2—Detail of five-prong plug required to connect the Booster Unit with a UY socket.

loud speakers and telephones used will be in series with the "B" battery and naturally will reduce the plate voltage to a great extent. Individual volume control can be attained with this method by using modulator plugs, or by connecting a resistance across the loud speaker or phones, as previously explained.

Doubtless the best method for the particular installation in mind will be easily chosen by the individual experimenter; but we would suggest that, for small locations in which it is desired to have separate volume control for each loud speaker the second method should be used. For large installations, in which separate control is necessary, the first method is better.

R.F. Booster Unit for A.C.

(2) Mr. R. A. Middleton, Seattle, Washington, writes:

Q. 1. "In the article I recently read on the Booster Unit a four prong plug was connected to the socket of the detector tube in the set. In the Radiola 17, the detector tube has five prongs instead of four. For this reason, this plug cannot be used. How can this Booster Unit be connected to this set without rewiring the set, or how can a plug for the five-prong detector tube be made?"

A. 1. You refer to the Grimes R.F. Booster Unit. A number of fans desire to use this unit with superheterodyne receivers, and others with alternating-current sets. Naturally, since the Booster Unit is used either with the fundamental or on the "half-wave" or second harmonic of a signal, this Booster Unit cannot be used with the intermediate-frequency amplifier of a superheterodyne. The only way in which the unit can be used with a superheterodyne receiver is to connect it in the first-detector circuit. This

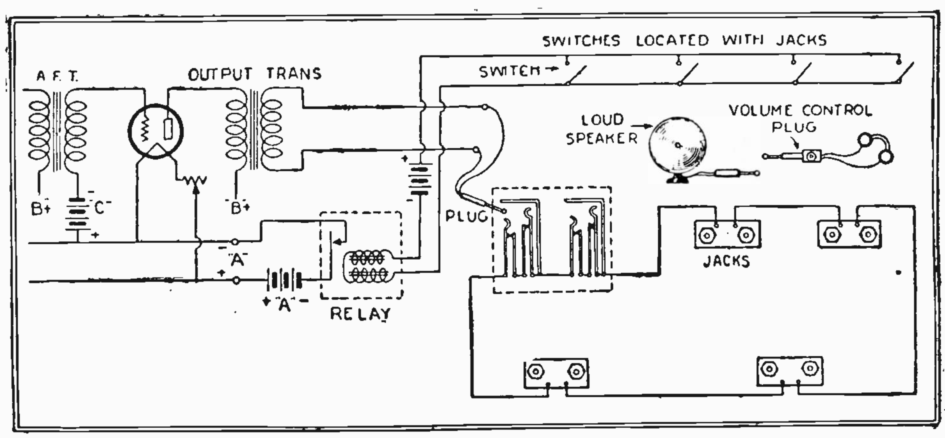


FIG. 1-A—The "circular" system of house wiring is best in small houses where only a few speakers are to be used at the same time.

method will work quite satisfactorily, especially if one or more stages of radio frequency amplification are employed before the first detector; although with a set of this type, in which a number of radio-frequency amplifier tubes are used, the gain is not very great.

When employing the Booster Unit with alternating-current sets of the tuned-radio-frequency type, it is necessary to use a heater-type (227) tube in the detector and Booster circuits. Fig. 2-A shows the necessary changes in the diagram for employing this type of tube.

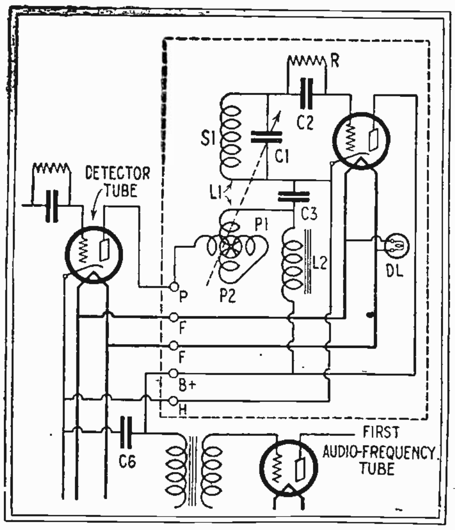


FIG. 2-A—Connections of the Grimes R.F. Booster Unit when used with a 227-type detector tube.

The method of making the required plug is shown in Fig. 2. If you have difficulty in obtaining a five-point socket which will fit into the tube base, it may be necessary to take a piece of bakelite or hard rubber and drill holes at suitable points. Prongs should be taken from an ordinary socket and fitted into the tube base to make the contact with the prongs on the tube.

It may be advisable, in some cases, to use a separate twisted lead for the A.C. filament connections; since the capacity between the filament and grid wires may cause A.C. hum. In this case, the three wires marked "P," "B+" and "H" should be twisted together. The two wires for the filaments should also be twisted together and kept some distance away from the other twisted cable.

We would not suggest the use of the R.F. Booster Unit in A.C.-operated superheterodyne receivers; since the radio-frequency amplification gained by using this unit with a set of this type will not improve the operation to any great extent, and some trouble may be encountered in keeping the A.C. hum at a minimum. In tuned-radio-frequency receivers employing the 227- or a similar heater-type tube in the detector, or heater tubes throughout, it is entirely practical to use this unit if care is taken to keep the filament wires away from the grid and plate leads.

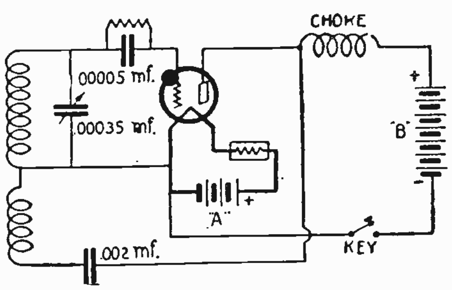


FIG. 3—The circuit of the laboratory oscillator is shown here. By coupling a small coil to the grid conductor, and then connecting an aerial and ground to this coil, the oscillator may be used as a small transmitter.

Laboratory Oscillator

(3) Mr. A. Miller, St. Louis, Mo., writes:

Q. 1. We would like to obtain information regarding the construction of a laboratory oscillator which we can build and which will be comparatively accurate.

A. 1. An oscillator consists, essentially, of a vacuum tube with an inductance and a variable condenser. It generates an oscillating current of a frequency determined by the setting of the variable condenser. For satisfactory use, which should be free from hand-capacity effect, its range should extend over the entire wave band. It ought to be easily portable, flexible and, above all, should be permanent in calibration. The circuit of an oscillator which meets these specifications will be found in these columns, Fig. 3.

The various parts may be either home-constructed or factory-built. The grid coil requires 8, 17 and 45 turns of No. 26 D.S.C. wire for the several corresponding wave bands (50-110, 90-210, and 190-550 meters); and the plate coil 8, 17 and 35 turns respectively, all wound on 2½-inch tubing. The smaller coils should be space-wound with thread between turns. All coils should be made rigid with shellac or heavy varnish.

The number of turns required for the longer wavelengths are as follows:

Wavelength Meters	Grid Coil Turns	Plate Coil Turns
8000-20000	2000	1000
3500-8500	900	700
1500-4000	400	250
500-1800	125	100

The first three pairs of these coils may be lump-wound with No. 32 S.S.C. wire. The last is wound with No. 30, as described for the short-wave coils. The choke coil can be wound with No. 32 S.S.C. in "slab" fashion with paraffine binder. Together with the by-pass condenser, it isolates the tube from the "B" battery. All of these coils are available in stock, the Silver-Marshalll 111 (types A, B, C and E) being typical.

The condenser should be a .00035-mf. variable, preferably of the straight-line-frequency type. It should be rugged in construction with heavy plates and bearings, with provision to take up the minor wear without altering the plate spacing or position. It should have vernier control and be smooth in operation, and the dial should be provided with a permanent hair-line indicator.

Other necessary minor parts are self-evident from the circuit diagram. The grid condenser should not exceed .00005-mf. in value; as it is necessary to keep the tube capacity low in relation to the circuit capacity, to insure permanency of calibration. For the same reason, the negative filament line should be clear of anything except the permanent and unchanging wire connections.

When this oscillator is used for the calibration of an unknown new receiver the experimenter first tunes in a station on a known receiver, and adjusts the oscillator dial until a strong squeal is heard. He disconnects the old set, connects the new, and turns the dials until the same squeal is heard from the oscillator. This locates the point for receiving that station on the new receiver. This process can be repeated until enough stations have been logged to enable a curve to be drawn. Many other uses will suggest themselves to the owner of this handy instrument.

Output Filters

(4) Mr. J. Jenkins, Bryn Mawr, Pa., asks:

Q. 1. Will you please explain the use of an output filter for a loud speaker; stating its advantages and theory of operation and giving diagrams of several possible methods

A. 1. The amount of current which actually actuates the loud speaker is continually varying with the voice or music frequency received by the set. This may be considered as an alternating current, superimposed upon a direct current. The direct current is flowing through the last audio tube at all times, and is dependent upon the voltage supplied and the resistance of the tube. This direct-current component, however, does no useful work at all in the circuit and, if it were possible, it would be gotten rid of. The output device does away with this unnecessary current-component in the loud speaker.

All loud speakers have motor mechanism, of some type, which consists of one or more coils which act upon an armature or reed, which then transfers the motion to the diaphragm or to the cone. A permanent magnet also is arranged in a certain relation to the coils and accentuates the movement.

These coils must have a large number of turns in order to be effective, as the alternating current is very small. That is, to get enough force to actuate the speaker properly, we must have a large number of *ampere turns*. The ampere turns are measured by multiplying the *number of turns* by the *current* (in amperes) flowing in the coil and

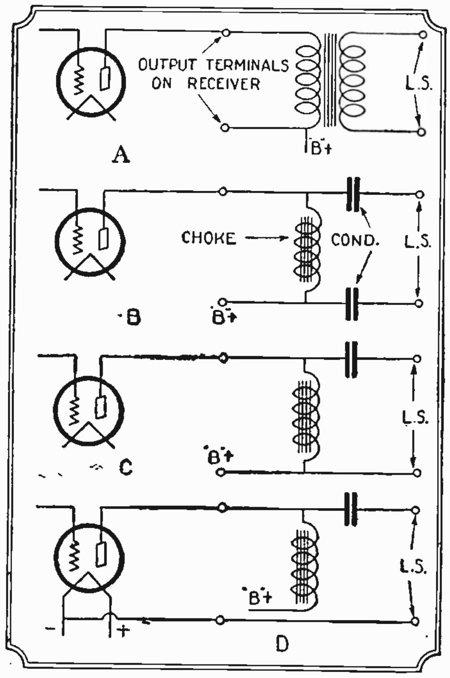


FIG. 4—The various types of output filter devices shown here are used to protect the loud speaker from being damaged by heavy currents. They are fully explained in the text.

are, in a way, a measure of the force we may obtain from the magnet. Therefore, as the current is small, we must have a very large number of turns. In order to get the number of turns required for proper operation, it is necessary to use a very small wire. If sufficiently large wire were used, the heavy current used in power tubes could be carried; but the bulk of the coil would be much greater and we would still have the unwanted direct current interfering with the operation.

Rather than redesign the speaker completely, to take care of a large D.C. component, it is much more simple to eliminate the direct current from its windings. This is what the output device does. There are several different kinds of these, available for use when the power tube is used.

Use of Transformer

In one method a low-ratio or a 1:1 transformer is used. As a transformer has an output of alternating current only, the speaker is entirely free from the D.C. current, and the voltage across the speaker is very small. The connections for this device are shown in Fig. 4-A.

As we are not limited by size of wire, etc., the primary of the transformer may be made of sufficient carrying capacity so that there will be no danger of burnout. Special transformers are made for this purpose; though sometimes fair results may be had by the use of a standard low-ratio transformer. It may be connected directly across the output of the receiver.

Choke-and-Condenser Coupling

Fig. 4-B shows another type of output device, which has a choke coil connected directly across the two output terminals of the receiver. Two condensers are used to transfer the A.C. to the speaker. This device puts no high-voltage strain on the loud speaker and may be connected directly; its condensers may be of the low-voltage type, as there is no great electrical strain on them. The burning out of one condenser, while it would give the speaker a considerable potential above ground, would not burn it out.

Fig. 4-C gives another choke-coil connection, using only one condenser and one choke. A low-voltage condenser may be used and there is little danger of burning it out; as the only voltage impressed across it is the drop in the choke. The disadvantage of this method is that the speaker lead is at high potential and a severe (though not dangerous) shock may be had by coming into contact with the leads. The D.C. component is eliminated, as before, since direct current will not flow through a condenser.

Fig. 4-D gives perhaps the most common connection for an output device. A choke is used as before, connected between the "B" supply and the plate of the tube. A by-pass condenser, between one side of the loud speaker and the other output terminal, is connected also to the negative return of the "B" battery. The loud speaker has on it no high voltage at all, and is perfectly safe to handle. It must be noted, however, that the full "B" potential is placed directly across the speaker to the negative return. This means that the condenser must be of the high-voltage type. A shorted condenser would put the full "B" through the speaker, by way of the choke, with the result that the speaker windings would probably be burnt out.

Where there is no danger in coming in contact with the loud-speaker lead, there is no reason why the method shown in Fig. 4-C should not be used. The results obtained from the various methods when properly operated seem to be practically the same; though some preference may be perhaps given to the choke-coupled methods.

The type shown in Fig. 4-B, while requiring two condensers, is perhaps the safest and easiest to install. The condensers may be of the cheaper type, and a burn-out is not likely to cause any damage other than to the condenser. The value of the coupling condensers may be from 2 to 6 microfarads; the higher values giving better results on the low notes. The choke is usually about 30 henries. These constants are not at all critical; and any sort of output device will certainly improve the quality over none at all. Some manufacturers recommend the use of output filters on voltages as low as 90, but others say only that all voltages over 135 should have a coupling device.

Makeshift Antenna

(5) Mr. Clarence Seid, Brooklyn, N. Y., asks:

Q. 1. Will you kindly describe in your columns a makeshift method to be employed when the regular aerial is down?

A. 1. As an emergency measure, when the regular aerial is "down," connect the input circuit of the receiver as shown in the accompanying diagram; it may be found satisfactory for both local and distant reception.

In effect, the aerial is replaced with the ground-condenser combination shown. The ground, G1, should be one other than the regular ground to the receiver. This combination will often be found very satisfactory in apartment houses where G is the water pipe and G1 a radiator. The condenser, C, should be as large as possible. However, the lower this capacity, the less the pickup through this means and the greater the selectivity.

Laboratory Oscillator

(6) Mr. J. Walther, Redlands, Calif., asks:

Q. 1. I would like to construct an oscillator for use in my experiments. I have heard that such an apparatus can be constructed without using "A," "B" or "C" batteries, using the line supply as a source of power. Could you give me a diagram and any other information relative to this device?

A. 1. The suggestion of an oscillator hook-up on a power line without "A," "B" or "C" batteries is one which will appeal

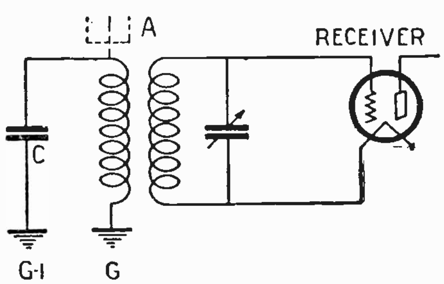


FIG. 5—This diagram illustrates the use of a separate ground connection as a temporary substitute for the aerial.

to all experimenters. The added advantage of being adaptable to either A.C. or D.C. circuits makes it universal in character. Of course, A.C. has advantages, and in this case the tube is supposed to do whatever rectifying action may be necessary. With D.C. the author of the circuit relies on the commutator ripple found on any D.C. line.

The accompanying diagram (Fig. 6) is self-explanatory, except that the connections of plate return and grid return are to opposite sides of the filament, on the theory that in this way the grid will be minus when the plate is positive. The resistor can be anything, but a simple 25-watt lamp is suggected where the line voltage is 110. The frequencies through which the oscillator will work are determined by the size of coils and condensers, as in any radio set. Plate and grid coils are of equal size. Coup-

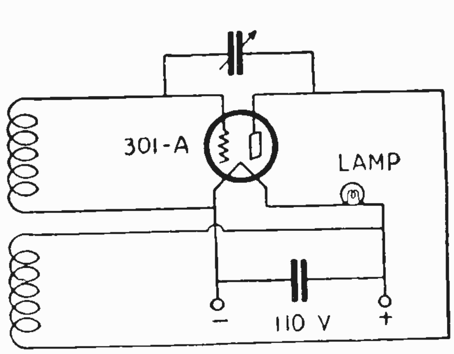


FIG. 6—An experimental oscillator utilizing the power line for its "A" and "B" supply.

ling is kept close, by winding both coils on the same tube.

Portable Receiver

(7 Mr. Thomas Robinson, Seattle, Washington, writes:

Q. 1. Kindly publish the schematic wiring diagram of a simple portable receiver using two tubes. I desire to operate this set from a loop so that it can be used when it is impossible to erect a temporary aerial.

A. 1. As a rule, portable receivers consist of several stages of radio-frequency amplification with a detector and the usual audio amplifier. However, considerable care must be taken in the design and construction of receivers of this type. A circuit which will give good results with a regular antenna will often be unstable when operated in conjunction with a loop. This is due, in part, to interaction between the loop and the radio-frequency transformers, which can be prevented only by very complete shielding. Again, where compactness is of prime importance, which is usually the case in a portable receiver, there is always a tendency to crowd the parts; thus again setting up unnecessary oscillation. The best course for the average radio fan might be to adopt a circuit without any form of radio-frequency amplification other than that obtained from the use of regeneration.

Providing that accurate control of regeneration is possible, the sensitivity of a combination as shown in Fig. 7 is surprising; even when it is operated with a loop aerial small enough to be accommodated in a case of medium size. The arrangement is a modification of the well known Hartley circuit, using a center-tap loop. Unless the control of regeneration is really smooth, results will be disappointing from the point of view of range; and to attain this end, every effort should be made to operate the detector tube to the best advantage. A potentiometer is included in order that the grid circuit may be adjusted to a point giving a compromise between best detection

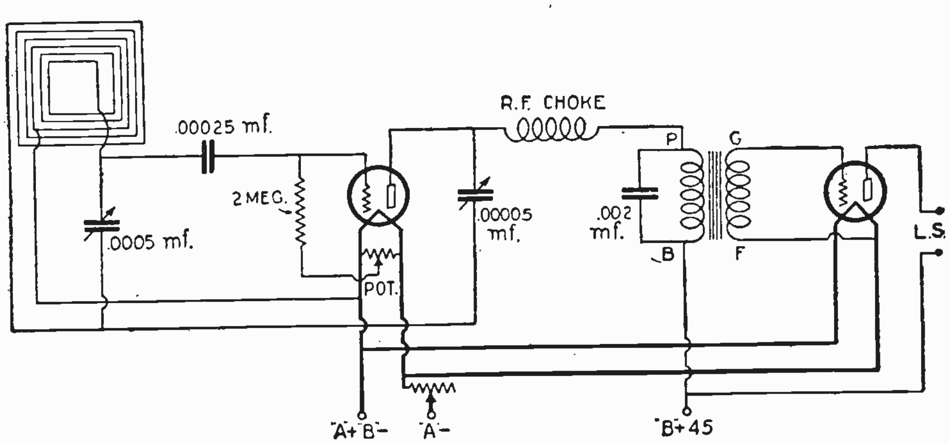


FIG. 7—The schematic diagram of a two-tube portable receiver, which may be operated from a loop antenna, is shown above and should give satisfactory reception.

and smoothest regeneration. In a set of this kind, where light weight and compactness are important, the voltage of the "B" battery may be low; 45 volts is sufficient. The range of the receiver is, of course, increased enormously by the connection of an aerial and ground, as a loop is at best only a feeble collector of energy. In order to provide for this addition, aerial and ground terminals may be attached; the former being joined to a point on the loop which is found by experiment to give best results (generally to the second or third turn on the grid side of the center tap), and the latter to the negative side of the "A" battery.

The apparatus needed for the building of this receiver is as follows: One center-tap loop; one .0005-mf. variable condenser; one .00025-mf. fixed condenser; one 2-megohm grid leak; one .00005-mf. condenser for regeneration control; one 400-ohm potentiometer; one R.F. choke coil; one audio transformer, ratio 5:1; one fixed condenser, .002-mf.; one rheostat; two sockets; tubes, batteries, wire, etc.

The Varion A.C. Receiver

(8) Mr. E. F. Palm, Flint, Mich., writes:

Q. 1. I have seen somewhere the description of a Varion A.C. receiver, which is a 6-tube affair and obtains all power from the light socket (A.C. source). Can you furnish me with any information and circuit diagram employed, battery eliminator system, etc.?

A. 1. The circuit diagram, for the Varion A.C. receiver is shown in Fig. 8-A; that for the eliminator device in Fig. 8-B.

The following will be helpful to the constructor:

"A" battery elimination in the Varion is accomplished by means of a special circuit in the eliminator and receiver. The problem of "A" elimination depends entirely upon the quantity of current to be passed through the filter system. Referring to the diagram of the receiver, it will be seen that five 199 tubes are employed before the final or output tube. These five tubes require approximately sixty milliamperes of current each, at three volts, to operate the filaments. If these five tubes were placed in a circuit with their filaments in parallel, a total of three hundred milliamperes current would be required and this would be more than an efficient filter could easily handle. However, if we were to place these tubes in series, it would then be necessary to have only sixty milliamperes of current available, but the voltage across the filament series terminals would have jumped to fifteen.

Obviously, since we have up to two hundred and fifty or more volts at our disposal with the Varion, and there are eighty-five milliamperes of current, it is only necessary to find some way to apply some of this excess

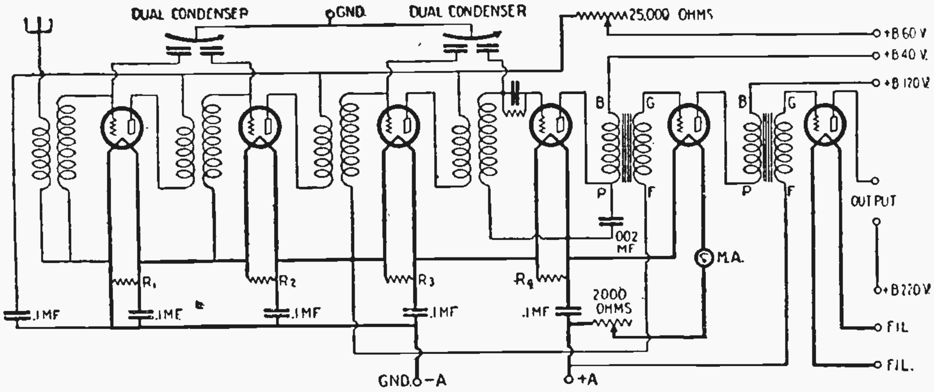


FIG. 8-A—Hook-up of the Varion, which is designed for use with an "A, B & C" battery eliminator, such as that shown in Fig. 8-B. The filaments of all tubes are wired in series to keep down their current consumption. Ballast resistances are placed across each tube. Only 199-type tubes may be employed in the first five stages of the receiver.

current and voltage to the tube filaments. Glancing at the eliminator diagram, we find a resistance has been placed in shunt across the total output of the unit. Current will flow through this resistance, varying in quantity with the resistance across the circuit. Now, if we break the "B—" line and insert our filament series connection, we shall have, assuming that the value of the shunt resistance is correct, the right amount of current flowing through each tube; and in doing this we have lost but fifteen volts from the maximum of our plate voltage supply. This, in effect, is what is done in the Varion.

There are a number of other points to take into consideration, however, before actually building a receiver to operate in that manner. In the first place, the plate current of the tubes, including that of the power tube in the Varion circuit, will be added to the filament supply; and this must be compensated for by raising the value of the shunt resistance, so that the total of the two currents does not exceed sixty milliamperes. We also have the factor of line-voltage fluctuation. This is easily taken care of by making all values in the eliminator proper for a minimum line-voltage, and then absorbing the excess current by means of an additional shunt resistance. The manner in which this is done is shown very clearly in the various receiver diagrams.

The "C" bias voltage on the power tube is supplied by the voltage drop across the 2,250-ohm resistance. We still have, though, the problem of bias voltages for the balance of the tubes in the receiver. As we have already placed the tube filaments in series, we may readily utilize the fact that there is a three-volt drop across the filament of each tube in the circuit. By properly positioning the various tubes we have the detector operating at a positive bias of one and one-half volts, the three radio-frequency tubes at a negative bias of three volts, and the first audio tube at a negative bias of nine volts. These values, in respect to the particular plate voltage under which each of these various tubes operates, are exactly those called for by the tube manufacturers.

Correcting the Filament Current

There is one point about the receiver circuit which many of you have probably noticed. That is the presence of resistances placed across all of the tubes in the series connection except the first tube. These resistances are placed at these points to compensate for the addition of the plate current to the filament supply by each tube in the connection. If this extra filament current were not taken care of in some manner, the last tube in the line would be getting approximately ten milliamperes more current than the first tube.

Reference to the circuit diagram of the eliminator, as shown herewith, will disclose that it is very similar to the standard Raytheon circuit. There are several refinements, however, which have not been heretofore included in eliminators; for example, experienced constructors will appreciate the fact that successful design and operation of the receiver is largely dependent upon the quality and design of the apparatus used throughout. In selecting parts for the Varion receiver, apparatus of the highest grade was used and in several cases where present apparatus was not satisfactory, special instruments have been designed and manufactured especially for the Varion.

The plate voltages supplied are sixty-seven for the radio frequency tubes, forty-five for the detector, and one hundred and thirty-five to one hundred and eighty for the power amplifier. Independent of the type of power tube used the 2250-ohm resistance in series with the center tap of the filament winding will give it a correct negative bias. The "C" bias voltage is obtained by the drop across this resistance. The heavier the current drawn through this resistance, the greater the voltage drop will be and, correspondingly to the heavier current drawn by the UX-171, the grid bias will increase correspondingly over its value when a 112 is used.

The parts necessary for the construction of the receiver and eliminator are as follows:

Parts For Receiver

2 Double condensers (.0003-mf. each unit);
1 Panel (radion or bakelite), 17 x 3-16x28 inches;
1 Sub-panel (radion or bakelite) 7x3-16x26 in;
6 Sockets;
2 Illuminated controls;
1 Variable resistance, 2,000-ohm;
1 Variable resistance, 25,000-ohm;
1 Milliammeter, 2 inch, 0-100 milliamperes;
3 Brackets;

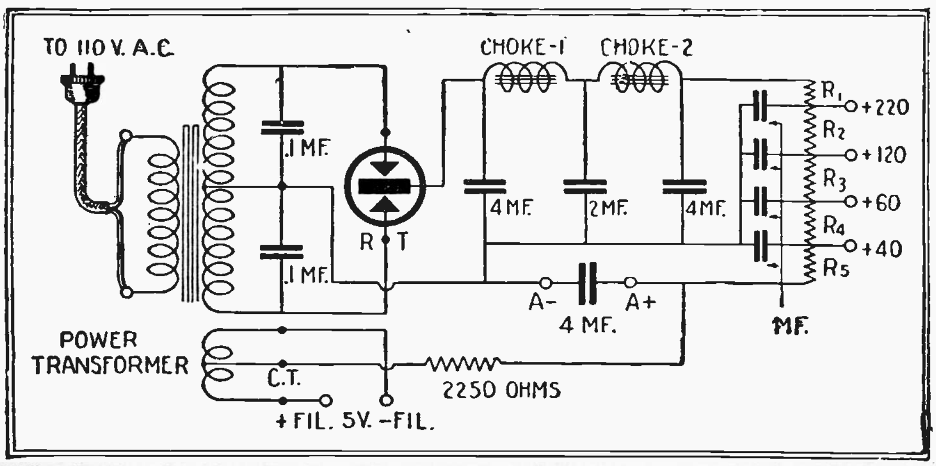


FIG. 8-B—The schematic wiring diagram of an efficient "A, B & C" battery eliminator. This power unit may be used in conjunction with any type of receiver constructed along similar lines to those of the Varion A.C. set. A rectifying tube with an output of 80 milliamperes should be used.

3 Aluminum shields;
4 T.R.F. coils;
3 Binding posts;
1 Condenser, .001-mf.;
1 Condenser, .00025-mf.;
5 Condensers, 0.1-mf.;
1 R.F. choke;
1 First-stage transformer;
1 Second-stage transformer;
4 Filament resistors;
1 Grid leak, 3-megohms;
1 Six-conductor cable;
1 Two-conductor cable;
25 feet No. 18 flexible wire, etc.

Parts For Eliminator

1 Metal box 10x12x24 inches;
1 UX socket;
1 Condenser block;
1 Transformer;
8 Binding posts;
2 Transformer brackets;
1 Cord and plug;
2 Socket bushings, 1/8 inch;
1 Strip insulating paper;
1 Resistor, 2250-ohm;
1 Rectifying tube;
1 Condenser, 2.0-mf.;
1 Resistance (Ward-Leonard ABC);
2 Choke coils 30-henry;
1 Binding-post strip, drilled;
8 feet No. 18 flexible wire, etc.
Nuts, bolts, lugs, etc.

Eliminating Interference

(9) Mr. D. Walker, Norwood, N. J., asks:

Q. 1. I am bothered by constant interference from one particular local station which transmits with 1,500 watts of power. The transmitting station is in the immediate vicinity. Is there any selector or wave-trap circuit that you can give me, which will eliminate this interference? I am positive that the trouble is not in the receiving set, as neighboring friends with radio sets are experiencing the same difficulty.

A. 1. A filter, or wave trap, which will eliminate the trouble you mention is shown in Fig. 9. Its construction is fairly simple, there being only two parts, although the adjustment of this filter is somewhat complicated. However, once adjusted, it needs no further handling or dial twisting.

The parts necessary for this wave filter are as follows:

1 variable condenser, .001-mf. low-loss type;
1 variable condenser, .0005-mf. low-loss type;
1 variable resistance, 0-25,000 ohms;
2 bakelite tubes, 3 inches in diameter, 4½ inches long;
½ pound No. 22 D.S.C. wire.

L1 consists of 55 turns wound on one of the tubes. L3 is 45 turns wound on the remaining tube. L2 is wound on top of L3, but is separated from it by a sheet of empire cloth, or waxed paper, and has ten turns. C1 is the .001-mf. variable condenser. The theory of this wave trap is as follows:

The incoming signal flows through coils L1 and L2. The circuit comprising L1 and C1 is tuned to the frequency of the interfering station, and the condenser is then set at that position. The circuit including C2 and L3 is what is commonly termed an absorption circuit. The condenser of this circuit is rotated until the signal of the interfering station is heard at a minimum strength. The circuit, when in resonance with the interfering station, will absorb almost all of the energy received from that station. The energy is received from coil L2, which is closely coupled to L3, and is also closely coupled to L1. In this way, signals of other stations will be allowed to pass through, but that of the interfering station is dissipated in the absorption circuit. The resistance across L1 and C1 serves as a static-leak, and is variable to obtain the best adjustment possible.

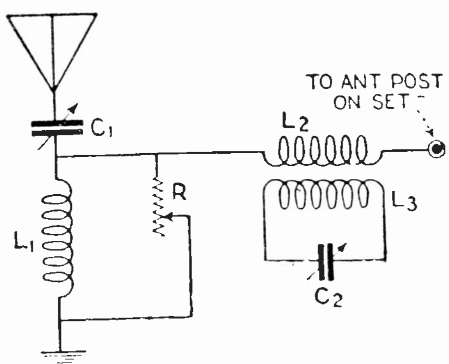


FIG. 9—A very efficient wave trap which can be constructed at a very low cost. It will be found of great benefit by those located in the vicinity of a broadcast transmitter.

Loop-Antenna Transmitter

(10) Mr. K. Washburne, Newark, N. J., asks:

Q. 1. I intend going camping this summer and would like to construct a portable transmitter using a loop antenna. Will you please give me the necessary data, and diagram?

A. 1. For those who intend going to camp this summer, or contemplate week-end trips, this particular transmitter should be adaptable; since it has the necessary characteristics, such as portability, efficiency, ability to operate on a loop, etc. The advantage of the loop antenna in transmitting is that directional signals may be sent by simply pointing the loop in the desired direction.

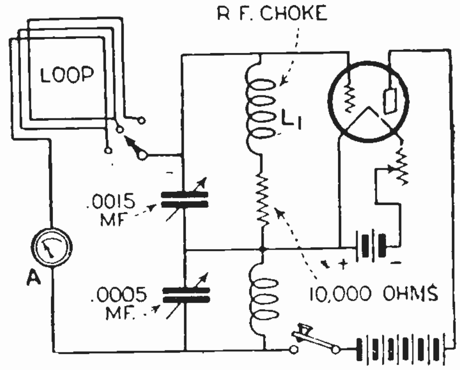


FIG. 10—A loop is used in this portable transmitter to give a directional effect to the signals.

An ordinary 5-watt tube should be used in this circuit. Plate voltage may be supplied by either "B" batteries, or a generator which may be coupled to the engine of the automobile, or a motor-generator whose motor runs on a single storage battery. Loop should consist of 3 turns of No. 10 wire wound on a wooden frame, about 3 feet square. Both variable condensers shown in the circuit should be of the transmitting type and able to withstand a fairly high voltage.

The radio-frequency choke coil L1 consists of 200 turns, wound on a 2-inch tube with No. 28 D.C.C. wire. L2, the other, has 150 turns wound on a 2-inch tube with No. 28 D.C.C. wire. The wavelength of the transmitting may be varied by changing the position of the switch lever on the various loop taps. When maximum deflection is obtained in the "radiation ammeter," the transmitter is operating at its maximum efficiency for that particular wavelength.

A regular transmitting license is necessary for this outfit, as for any other radio transmitter.

The Multiple Receiver

(11) Mr. L. Davis, San Francisco, Calif., asks:

Q. 1. Please publish circuit diagram, and constructional data on the five-tube Multiplex receiver.

A. 1. As it is a five-tube radio-frequency circuit, operating from a loop, the tuning of the Multiplex is very sharp. The inherent selectivity of the receiver is aided materially first, by the directional effect of the loop, and, secondly, by the variable primary coupling of the double-rotor coupler. Whereas, in a great many sets, one has only the variable condensers to rely on for separation, in

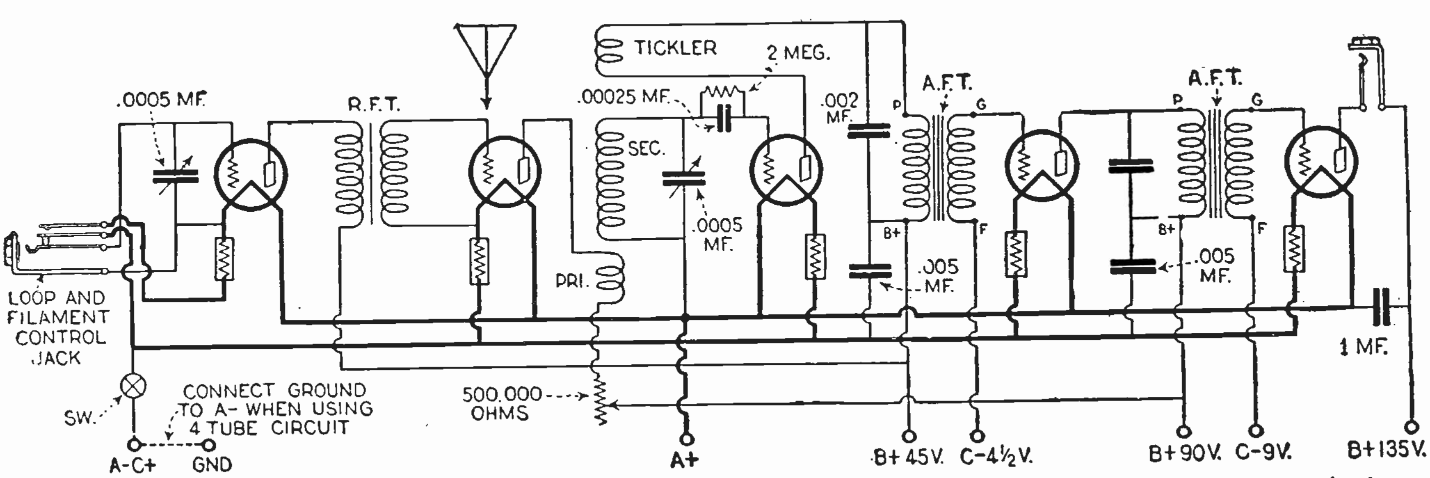


FIG. 11—Circuit diagram of the Multiflex 5-tube receiver. It operates from either a loop or outside aerial with excellent results. The regenerative detector facilitates the reception of extreme DX.

the Multiflex he can loose- or close-couple the primary coil and bring in or eliminate a signal almost entirely by changing the direction of the loop. With these three elements varying the selectivity of the receiver, we certainly should achieve a degree of sharp tuning adaptable to practically all conditions of location.

Suppose one wishes to employ the receiver as a five-tube antenna-operated outfit. In a great many locations the directional effect of the loop will not be required and we shall undoubtedly gain signal strength by using the outside aerial. Here an antenna coupler or adapter comes in handy, converting the five-tube loop set to a five-tube aerial-operated receiver. Certain loops now on the market are equipped with such an adapter, making it unnecessary to disconnect the loop when the antenna is employed.

However, the flexibility of the Multiflex does not stop here. When the plug from the loop is disconnected from the input jack, the first tube in the circuit is automatically extinguished. The set then becomes a single-tuning-control four-tube outfit for antenna operation. Using but one tuning condenser, the selectivity of the four-tube set in the average location is still splendid. The variable-primary-coupling feature is still available, as in the five-tube circuit. It has been found that, in city locations removed a mile or two from the nearest powerful broadcaster, the four-tube combination does very well in separating all the local stations.

This volume and quality are secured with a simple combination of four 201-A tubes and a 112 in the output stage. The maximum "B" voltage necessary is 135 volts.

A glance at the schematic circuit diagram indicates the comparative simplicity of the receiver. Few five-tube circuits today are much easier to handle. A simple tuned-loop circuit, fixed R.F. amplification, a regenerative detector and two stages of well-designed A.F. amplification, well by-passed; that is all there is to it. The cost of the necessary parts is moderate, and the job of assembly and wiring is far from a complicated or involved one.

An automatic filament-control jack takes care of the optional-tuned loop stage, lighting the first tube when the loop is plugged in and extinguishing it when the loop is disconnected. When the loop is not used the antenna connection is made to the binding post marked "Input," which in turn connects to the grid of the R.F. tube. The ground connection is made to the "A—C+" post. With the four-tube circuit only the secondary of the fixed R.F.-transformer is employed, the primary being thrown into the circuit when the loop is plugged into the circuit through the jack on the left of the panel.

The filament control of the tubes is automatic. The receiver can be readily adapted to the use of 199-type tubes by simply changing the amperites in the filament legs of the circuit.

The following is the list of parts necessary for the construction of this receiver:

2 A.F. transformers;
2 variable condensers, .0005-mf.;
1 double-rotor coupler (an ordinary three-circuit tuner will do);
1 untuned R.F.-transformer;
4 amperites, type 1-A;
1 amperite, type 112;
5 sockets;
1 single-circuit jack;
1 single-circuit filament-control jack;
1 variable resistance, 500,000-ohm;
2 by-pass condensers, 1-mf.;
1 fixed condenser, .005-mf.;
1 grid leak, 2-megohm;
1 filament switch;
1 grid condenser, .00025-mf., with leak mounting;
2 vernier dials;
8 binging posts, marked "Input"; "A—C+"; "A+B—"; "45V+"; "C—4½"; "90V+"; "C—9"; "135V+";
1 panel, 7x21;
1 wooden baseboard, 7x20x7 inches;
1 binding-post strip.

Battery Charger

(12) Mr. J. Reed, Springfield, Mass., asks:

Q. 1. Please give complete constructional details and how to make a Tungar type of battery charger.

A. 1. Fig. 12 is a schematic diagram which shows the electric apparatus and connections necessary to assemble a two-ampere battery charger, which will operate on the usual 110-volt A.C., 25 to 60 cycles. The diagram shows a transformer with three windings, which we will designate as P, S1 and S2. P is the primary winding and is connected to the 110-volt A.C. light socket. S1 is the filament secondary and supplies the power for heating the Tungar bulb filament. This winding is provided with a center tap B which is used as the positive lead for the charger. Winding S2 is the charging winding and supplies the necessary potential to operate the rectifier tube proper. Leads are taken out from points B and C and run, respectively, to the positive and negative terminals of the storage battery.

To construct the transformer a core is necessary. The simplest way to obtain it is to go to your local electric-light company

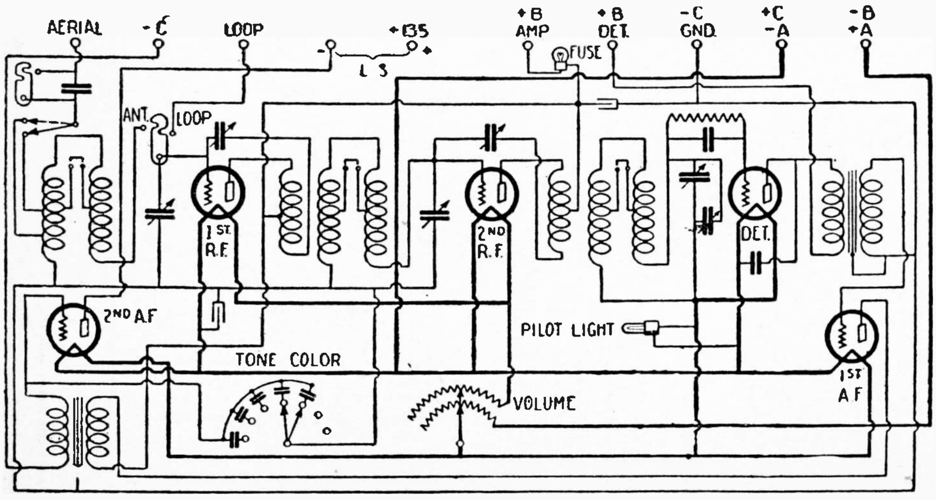


FIG. 13—The efficiency of the Grebe Synchrophase receiver is due to careful design and construction. The use of binocular coils and straight-line-frequency condensers aids considerably in overcoming present-day interference. The employment of a "tone-color" device enhances the quality in the reproduction of broadcast programs.

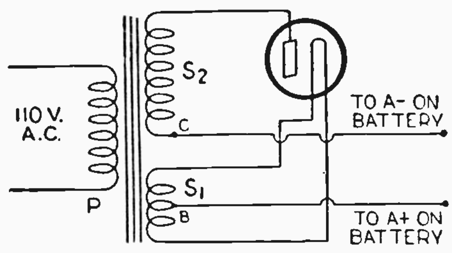


FIG. 12—Wiring diagram of a Tungar type battery charger, showing charging (S2) and filament (S1) windings of transformer.

and ask for a junked pole transformer of about 1-kva. capacity. These transformers can usually be obtained for a small sum. Both primary and secondary windings of the transformer should be removed.

Now for the winding of the coils. A simple way to calculate the correct number of primary turns is to divide the cross-sectional area of the core in inches into 588. For instance, if the core should measure 2x2 inches, the required number of primary turns is 147, of No. 20 D.C.C. wire, wound on one segment of the core.

The charging winding S2 should have one-quarter as many turns as the primary or in this particular case, 37 turns of No. 15 D.C.C. wire, wound on a different segment of the core. The turns of the filament winding S1 are one-fiftieth the number of the primary turns; in this particular instance 3 turns of No. 12 D.C.C. wire. A tap is taken off from the second turn and is used as the midpoint of this winding. Of course, all these different numbers of turns depend on the size of the core, as stated above.

After assembling and wiring the charger as per circuit diagram, an inspection should be made to determine the initial performance. If possible, the charging rate should be measured, if only by connecting a Ford-dash ammeter or similar device in one of the charging leads. When a 6-volt storage battery is being charged, the rate should be 2 amperes; on a 12-volt battery the rate will be 1 ampere. If the charger delivers less current than the above amounts, and still gives some appreciable current, turns should be added to the winding S2 until the proper rate is obtained.

In case the charger fails entirely to operate, first look for loose wires or broken connections. Then try reversing the battery leads or clips and observe if charging ensues. Occasionally it will require the addition of several turns of wire to the winding S2 in order to obtain satisfactory starting of the Tungar arc; but this should be necessary only when the transformer has been assembled or wound carelessly.

When the charger has been adjusted so that it does operate at the proper rate, it should be left charging for at least two hours under continued inspection before it is pronounced satisfactory.

In normal operation the transformer should get fairly hot after having run several hours. The temperature will be such that it is just a little too hot to touch. If, however, it should heat excessively, look for short-circuited turns, low-quality steel, or careless assembly of the core. Any of these three points will in itself be sufficient to warrant rebuilding the transformer.

Grebe Synchrophase Receiver

(13) Mr. D. Jackson, Elizabethtown, Pa., writes:

Q. 1. I recently attempted with the aid of several "radio experts" to repair my Synchrophase receiver, which, through violent mishandling when moving, became inoperative. The receiver at the present time does not look quite like the original, due to numerous experiments. However, I seriously contemplate rebuilding it in its original shape, providing you are able to supply me with the necessary information. Most important of all; I need a schematic wiring diagram of the Synchrophase receiver and any other additional information you can supply me which may be of help to me.

A. 1. The information you desire relative to the Synchrophase receiver may be obtained from the manufacturers of this set, who publish an instruction manual in which are contained hints for adjusting, and correcting troubles, etc.; or else from the distributor of this product in your territory. We are publishing a few points of interest relative to the Synchrophase Model MU-1.

Your receiver will undoubtedly require balancing after it is repaired and the necessary parts replaced. The following is the process for balancing the receiver described in a bulletin issued by A. H. Grebe & Co., which we feel sure will be of considerable help when adjusting the receiver.

"Balancing of the receiver must be done while the instrument is in operation. A practical and efficient balance can best be obtained by employing some form of modulated radio-frequency oscillator. This oscillator should have a range of 200 to 550 meters and should be modulated in such a way as to produce a pure tone. The oscillator serves three major purposes:

"1. The balancing of receivers can be perfected when no broadcast stations are available for testing.

"2. The radio-frequency carrier from the oscillator, beating with the carrier set up by the receiver when oscillating, will cause a whistle or beat note which is a sure indication of the unbalanced condition on that wavelength to which the receiver is tuned.

"3. The modulated note forms a final test of perfection of the balance adjustment, since a receiver may be balanced so as to prevent a beat note or heterodyne whistle, but a modulated note may be distorted or 'fuzzy,' requiring a closer adjustment to clear up the modulated tone.

"For these adjustments, the oscillator must be far enough from the receiver to produce only a weak signal, permitting the volume control to be turned up full.

"Where no oscillator is available, a very satisfactory balance can be obtained by employing the signals from a broadcasting station. The method of procedure in this instance is similar to that outlined.

"Since various accessories are often accountable for unbalanced receivers, it is essential that all accessories such as aerial, ground, loud speaker, 'A,' 'B' and 'C' batteries be in perfect condition and properly connected. Perfect vacuum tubes, of the particular type recommended, should be in their proper sockets. The Synchrophase should always be balanced while in its cabinet. The most stable balanced condition will result if the instrument is balanced with at least 135 volts applied to the intermediate-amplifier terminal, where 90 volts is ordinarily connected. The 'C' battery voltage should be left as recommended. On 1926 and 1927 model receivers the wave-changing switch should be in 'high range' position. Loosen dial thumb nuts so that all dials may be operated independently. Set 'tone color' on No. 6 setting. Turn volume control to No. 6 setting. Volume control of 1925 model should be on setting No. 6. Filament rheostat should be turned on full.

"Dials should be set as follows:—No. 1 or left-hand dial in 100 degrees. No. 2 (center or master dial) and No. 3 (right-hand dial) on 40 degrees.

"Before proceeding it would be advisable to note the position of the slots of the adjusting screw heads before making the first readjustment; so that, in any event, the original adjustment may be duplicated.

"Start oscillator and set on wavelength to which the receiver is adjusted so note will be heard in the loud speaker.

"With a wooden-handled, hard-rubber or bakelite screwdriver or wrench as described, loosen balancing condenser No. 2, meanwhile rotating No. 2 dial rapidly between thirty and fifty degrees. A click will be heard as the set goes into oscillating condition. Next tighten No. 2 balancing condenser screw until click just disappears, then tighten up about one-quarter turn beyond.

"Set all dials at 40, rotate No. 1 dial rapidly between 30 and 50 degrees, following same procedure on No. 1 balancing condenser screw as described for No. 2 balancer. If the click cannot be balanced out readily, a slight further adjustment of No. 2 should clear it up.

"Leaving receiver still set for high range, turn all dials to 20 degrees, reset oscillator on wavelength to which the receiver is now adjusted. No oscillation should be experienced; if such a condition exists turn in slightly more on No. 2 balancer. Continued oscillation would be a likely indication that balancers No. 1 and No. 2 were turned slightly too far in past the click. The first balancing operations already described should be repeated.

"If no oscillation is apparent with dials at 20 degrees, set switch for 'low range' and turn dials to 65 degrees. Reset oscillator as previously described. If slight oscillation occurs, effect readjustments of No. 1 and No. 2 balancers. If there is tendency to oscillate on the high range, screw in No. 1 balancer slightly further. If set tends to oscillate on the low wavelength, screw in No. 2 balancer slightly further. This procedure should be repeated if not successful with the first attempt.

"After these two balancing condensers are adjusted to their final positions, the third dial readings may be made identical with No. 2, should a marked variation be experienced.

"Tune your oscillator until it is heard between 10 and 20 on the dials. Note the dial readings of condensers 2 and 3. If the third dial reads higher than the second tighten the balancing condenser No. 3 until the readings coincide with those of the second. This adjustment will have little effect on dial settings at high wavelengths."

Superheterodyne Connections

(14) Mr. H. E. Edwards, Trenton, N. J., asks:

Q. 1. If possible, I would like to change my 8-tube loop-type superheterodyne for use with an outside aerial. Will you give me the necessary instructions for the coils and condensers which will be required?

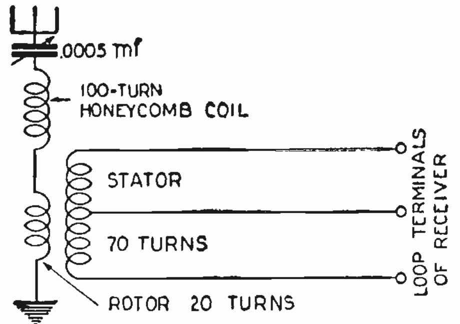


FIG. 14—The method used to couple a loop-type superheterodyne to an outdoor aerial is shown here. The honeycomb coil is used for loading and the antenna tuning is accomplished with the .0005-mf. condensers.

A. 1. The equipment necessary for this purpose consists of a variable condenser of .0005-mf. capacity and a loading coil, of 100 turns of No. 24 D.C.C. wire on a 2½-inch tube, or a 100-turn honeycomb coil. It will also be necessary to construct a coupling coil to be used in place of the loop antenna. The rotor (primary) of the coupler may be wound on a 1¾-inch tube and should have not more than 20 turns of No. 24 or No. 26 D.C.C. wire. The secondary may be wound on a 2½-inch tube with 70 turns of No. 24 or No. 26 D.C.C. wire, a tap being taken out at the 35th turn. The coupling between the rotor and stator should be very loose, to prevent the tuning from being broad. When the rotor has been adjusted, the antenna tuning is accomplished entirely with the antenna series condenser, which will have a low capacity setting for the short wave, and will be set at practically full capacity at the higher waves. See Fig. 17.

Increasing Range of Three-Circuit Tuner

(15) Mr. S. Snyder, Hackensack, N. J., asks:

Q. 1. I have a 3-circuit receiver of the Ambassador type employing a detector and two stages of A.F. amplification. I wish to increase the range of this receiver to include the wavelengths from 200 down to 150. Would you please inform me of the changes necessary to enable me to receive these wavelengths?

A. 1. From the accompanying diagram, it will be seen that only a few minor changes would be necessary to adapt a receiver of this type to the lower wavelengths.

A.S.P.D.T. switch, S, is connected as indicated. A tap taken on the secondary of the

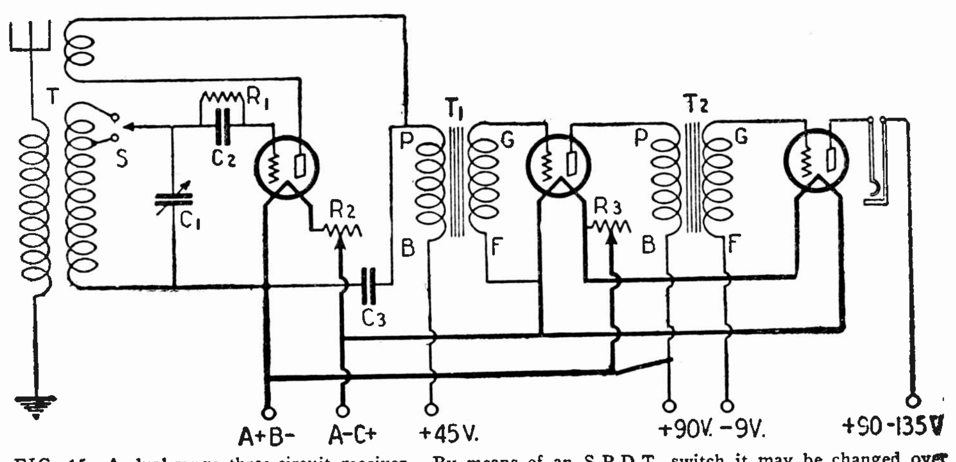


FIG. 15—A dual-range three-circuit receiver. By means of an S.P.D.T. switch it may be changed over instantly to the 150-200 meter band. This will be interesting to many experimenters.

3-circuit tuner, at a point 15 turns from the grid end, is connected to one tap of the switch. The end of the secondary which usually goes to the grid condenser is connected to the other tap of the switch. The lead from the grid condenser and tuning condensers is brought to the movable arm of the switch. It is now a very simple matter to tune to either the high wavelengths or the lower ones by simply using the correct switch tap. It may be necessary to reduce the detector voltage when tuning to the shorter wavelength, since the tickler coil may be too large and excessive oscillation may occur.

For those desirous of constructing this receiver the following is the list of parts:

1 three-circuit tuner, T;
1 variable condenser, .0005-mf., C1;
1 grid condenser, .00025-mf., C2;
1 grid leak, 2-megohm, R1;
1 fixed condenser, .002-mf., C3;
1 switch, S;
1 rheostat, 20 ohm, R2;
1 rheostat, 15 ohm, R3;
2 audio frequency transformers, **ratio 3:1,** T1, T2;
1 single circuit jack, J.
Structural material, sockets, etc.

Uses of Filter Condenser

(16) Mr. E. J. Schofield, Chicago, Illinois, writes:

Q. 1. Very often I have noticed the use of large filter condensers in receiving sets for various purposes, and I would like to know just why and how these are used.

A. 1. It is very important to determine the proper sizes of large-capacity fixed condensers in a receiver; since, if these are not of the correct capacity, the operation will be affected to a remarkable degree. One of the first uses of fixed condensers of high capacity, of the order of 0.5 to 1 mf., is for by-passes in radio-frequency circuits. In the average tuned-radio-frequency circuit, a fixed condenser of at least 0.5 mf. should be connected across the "B" battery. Where no high-resistance stabilizer is used in the radio-frequency stage, the fixed condenser should be connected between the "B" positive and "B" negative terminals of the receiver.

The increase in populariy of resistance-coupled audio-frequency amplifiers has brought another use for large-capacity fixed condensers, of values ranging from 0.1 to 1 mf. In resistance-coupled amplifiers such condensers are used as coupling and stopping condensers between the plate and grid resistors, as shown in Fig. 16A. In its functioning as a coupling condenser, it serves to couple together the plate and grid circuits; so that the voltage variations in the plate circuit are reproduced in the grid circuit of the succeeding tube to act on the grid of the tube. The condenser acts also as a stopping condenser to prevent the grid of the tube from being made strongly positive; as it would be if the positive "B" battery terminal were connected directly to the grid of the tube. This action applies also in choke-coil-coupled amplifiers.

With the increased plate voltage required by the new power tubes, the problem of keeping the plate current out of the speaker windings to prevent burning them out, and obviate distortion due to the saturation of the loud speaker core, is brought up. A very effective circuit for overcoming this difficulty is shown in Fig. 16-B. In this case the direct current flows through the choke coil, whose windings are designed to stand up under heavy current. When this circuit is used, it is very important to use a fixed condenser which is made to withstand any high voltage which may be applied to it; as a breakdown of this condenser will result in a short circuit of the "B" battery.

By-Passing Improves Performance

When potentiometer control is used in the plate circuit of the detector tube, the by-pass condensers in the detector and other circuits should be connected, not across the "B" power supply, but between the positive "B" terminals and the positive "A" battery lead, as shown in Fig. 16-C. When potentiometer control is used for stabilizing radio-frequency amplifiers, a fixed condenser should be connected between the movable arm of the potentiometer and the negative "A" battery lead, as shown in Fig. 16-D. In this way, the radio-frequency current in the grid circuit is by-passed across the high resistance of the potentiometer. A little-understood function of the by-pass condensers, when connected across the "B" battery lead, is their effect in minimizing the troubles due to the use of long battery leads when the batteries are located at some distance from the receiver.

The use of long leads tends to produce instability of operation, due to the high resistance placed in the radio circuits by the long leads, and also the tendency of these leads to act as miniature antennas. The use of the by-pass condensers eliminates the high-frequency resistance, and also limits to a certain extent the pick-up action of the leads. This sharpens the tuning and increases the selectivity of the receiver. The condensers should be connected at the receiver and not at the battery.

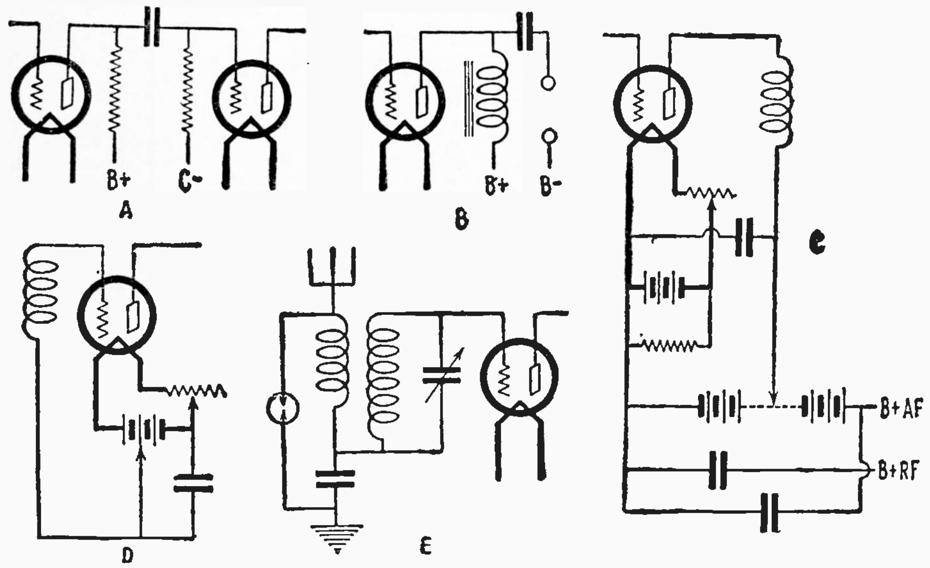


FIG. 16—Some of the uses of large-capacity condensers are here. A, shows the condenser used for coupling amplifier tubes; B, how the loud speaker is protected by using a large condenser. In C, and D, are shown radio frequency by-pass methods and, in E, a method of isolating receivers from the ground, to prevent a D.C. short circuit.

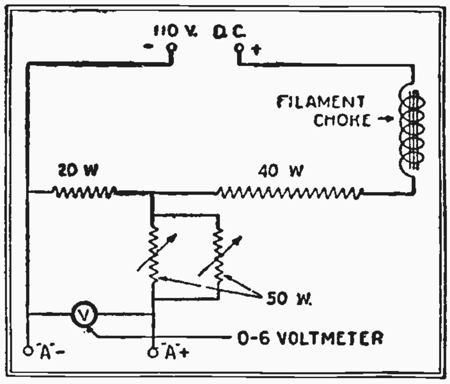


FIG. 17—The hook-up for the D.C. "A" eliminator is shown in the above drawing.

Another use of condensers of the by-pass type which is rapidly gaining favor is in series with the antenna circuit. The use of a by-pass-type condenser of about 1 mf., connected as shown in Fig. 16-E, in the ground lead of the antenna circuit, will serve to prevent any possible short circuit of the lighting line, when a "B" power unit is used. Because of the large capacity of this condenser, it will have no effect on the tuning.

If you want to use such a condenser in the ground circuit, do not connect it externally (that is, between the ground post of your receiver and the ground), unless you have your lightning arrester connected directly between the aerial and ground. A glance at the diagram will show the proper connections of the condenser, the ground, secondary circuit, and the lightning arrester.

The use of condensers of large capacities in the ways outlined above, will result in more realistic reproduction and a better appreciation of the quality of music which it is possible to obtain with a properly-designed receiver.

D.C. Filament Supply

(17) T. D. Sanstag, Fairland, Okla., asks:

Q. 1. I live in a district where the house lighting supply is direct current and would be glad if you could give me the necessary information showing how I may utilize this to operate the filaments of my radio tubes.

A. 1. Those having direct house lighting supply will find it quite an easy task to construct and put into operation a D.C. "A" eliminator. On this page you will find a diagram designed for the hook-up of such a device. The parts used are as follows:

1 filament choke coil
1 40 ohm 2 ampere resistor
1 20 ohm 1 ampere resistor
2 50 ohm ¼ ampere rheostats.

The choke and resistors should be connected in series across the D.C. supply line going from the positive to one end of the choke, and from the other end of the choke to one end of the 40 ohm resistor, from the other end of this resistor to one end of the 20 ohm resistor, and from the other end of this unit to the negative side of the D.C. supply line. The negative lead for the "A" battery supply is taken directly from the negative terminal of the D.C. supply line. The positive "A" battery lead is taken from the connection point between the 40 and 20 ohm resistors and is connected through the 50 ohm rheostats (the latter connected in parallel), to the positive binding posts on the receiver. A 0-6 voltmeter should be connected across the filament terminals of the receiver tubes, and the two 50 ohm rheostats varied until a potential of 5.0 volts is maintained across them. These two rheostats are connected in parallel to increase their current carrying capacity, and their effective resistance can be varied between the limits of 0 and 25. ohms, which will allow for plenty of voltage regulation, under varying load conditions.

Hum In Radio Set

(18) W. S. Clawson, Red Hook, New York, writes:

Q. 1. I have a radio set which utilizes impedance coupled audio amplification. When using this set with a "B" eliminator I get a loud humming noise. The eliminator works fine with my other set. What is the matter?

A. 1. Operate the impedance coupled set on dry "B" batteries as an experiment, instead of with the eliminator. If this overcomes the trouble it is reasonably sure that the by-pass condensers between the several tube plates and the grounded side of the "A" battery are of insufficient capacity or incorrectly placed, resulting in the effect known as "motor-boating". The addition of suitable choke coils in each plate lead near the eliminator terminals may also be desirable.

Henry-Lyford Receiver

(19) Mr. T. J. Dolan, Connersville, Indiana, asks as follows:

Q. 1. I would like to obtain the schematic wiring diagram of the Henry-Lyford receiver, and whatever constructional information you can furnish as regards the various coil units employed in its construction. Please show the adaptation of a power tube in the last audio stage with its proper B and C voltages.

A. 1. The schematic wiring diagram of the Henry-Lyford receiver is shown in Fig. 19. The set comprises one neutralized tuned-R.F. stage, one untuned stage, and a tuned detector stage. Two stages of transformer-coupled A.F. amplification are used, the last stage employing a power tube, and the first stage a variable resistance for controlling the volume. The following are the items necessary for the construction of this receiver:

2 Variable condensers, .00035-mf.;
1 Fixed condenser, .001-mf.;
1 Fixed condenser, .002-mf.;
2 A.F. transformers, low ratio;
1 Midget balancing condenser, 55-mmf. maximum;
3 Automatic filament controls, ½-amp. each;
1 Filament-control jack, single-circuit;
1 Single jack, closed-circuit;
1 Radio frequency transformer, untuned type, (see below);
1 Variable resistance, 500,000-ohm;
5 Sockets (UX spring-cushion type preferred);
1 Panel, 7 x 20 inches;
1 Baseboard, 7 x 20 inches;
5 By-pass condensers, 1-mf. each;
10 Binding posts;
1 Filament switch.

Construction of the Coils

L1 is somewhat similar to an ordinary three-circuit tuner, with the exception that the rotor is only semi-variable. Winding R is simply adjusted by hand until maximum efficiency and selectivity is obtained, and also when in the position that permits neutralizing oscillations by means of the small midget variable condenser (BC). The secondary winding, S, is 3 inches in diameter and consists of 60 turns of No. 22 D.C.C. wire, space wound. The wire is imbedded in a celluloid form, which is accomplished by means of acetone, a solvent for celluloid. The primary winding, P, is wound on a 2¾ x ½-inch celluloid form (also imbedded), and consists of 15 turns of No. 24 or 26 D.C.C. wire. R consists of 18 turns of No. 22 D.C.C. wire, on a 2⅛-inch celluloid form. The construction and assembly of this entire unit is shown in Fig. 19-A.

Inductance L2 is practically an ordinary T.R.F. transformer, of the low-loss type. The secondary winding, S, consists of 65 turns of No. 22 D.C.C. wire, space-wound on a 3-inch celluloid form. The primary winding, P, is wound on a 2¾-inch celluloid form, and consists of 15 turns of No. 24 or 26 D.C.C. wire, and is also space-wound. This complete construction and assembly is somewhat similar to that of L1 except that the third or rotor winding is omitted. Note that these two coils have plug-in mountings, so that coils of other dimensions for various wavebands may be substituted. The untuned-radio-frequency transformer, RFT, should preferably be of the manufactured type, since it is somewhat difficult for the amateur to construct this type of instrument.

Adjustment and Operation

In the adjustment of the receiver, to obtain proper results, all that is necessary is to obtain a combination adjustment of the position of coil R in its relation to winding S and the balancing condenser, which is simply set at various positions until both .00035-mf. variable condensers can be rotated to any desired frequency, without obtaining the usual regeneration or oscillations heard with regenerative receivers.

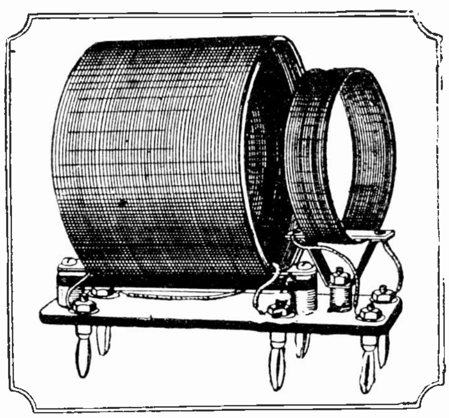


FIG. 19-A—The appearance of the coil L1, which is usel in the Henry-Lyford receiver. L2 is very similar in construction, except that the third or semi-variable winding at right is omitted. Plug-in mountings are used so that coils of various inductances may be employed.

The three automatic-filament-controls are amply able to regulate the filament temperatures of the various tubes, which feature reduces the number of controls. The 1-mf. condensers are placed in various portions of the receiver, to by-pass any stray R.F. current that may exist in the battery and audio amplifier circuits. A filament-control jack is used in the last or final output stage; so that when using only one stage of audio-frequency amplification, the filament of the fifth tube is automatically disconnected, thus preventing any unnecessary waste of filament current.

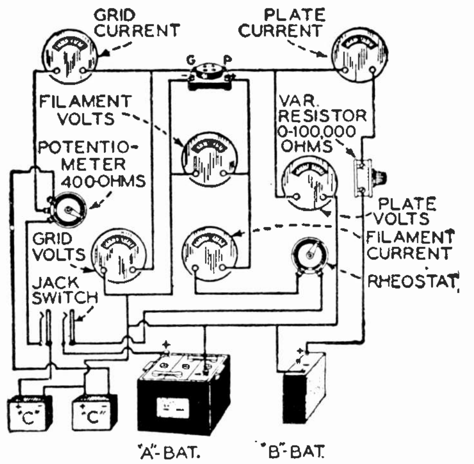


FIG. 20—The hook-up of the vacuum tube tester is shown in the above illustration.

For this receiver there are two other sets of plug-in coils which have smaller dimensions, so that with one a wavelength range of from 25 to 135 meters is covered, and with the other 75 to 225-meter reception may be obtained. The coils for which constructional data has been given above cover the entire broadcast range.

If an intermediate volume is desired between the outputs of the first and second stages, the resistance R2 is increased until the desired volume is obtained. The dial readings for two variable tuning condensers correspond very closely; and the readings may be jotted down with the assurance that should the station be desired again, it will be obtained at their respective positions.

Tube Tester

(20) The International Radio & Repair Organization, Chicago, Ill., writes:

Q. 1. Will you kindly furnish us with a diagram showing the hook-up of a tube tester with meters for obtaining all of the important characteristics of the vacuum tube under test?

A. 1. On this page you will find illustrated a diagram showing a tube tester with meters for giving all readings. From the readings obtained it is possible to calculate the tube's plate resistance, amplification factor, and mutual conductance. The grid voltmeter should be of the zero center type, having as great a range as the maximum "C" battery voltage to be used and should be of the highest possible resistance. The other meters should also read as high as the highest voltage used. The potentiometer may have a resistance of about 400 ohms, and is placed across the "C" battery so that a negative or positive bias can be obtained. The switch shown should be of the double pole single throw type, so that both the "A" battery circuit and the "C" battery circuit are

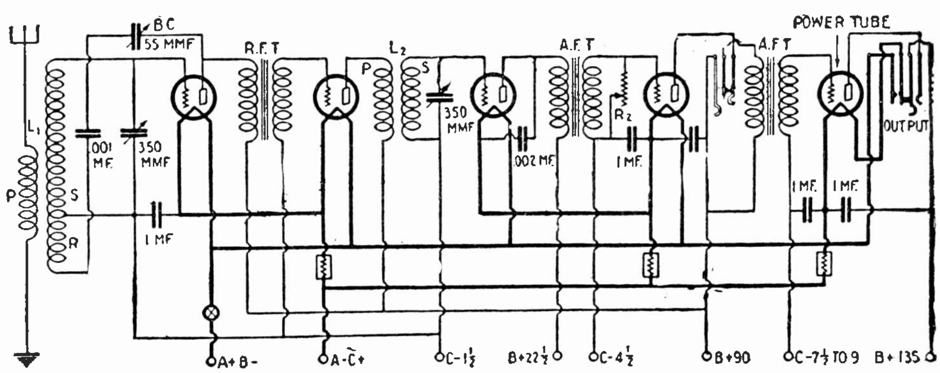


FIG. 19—The circuit diagram employed in the wiring of the Henry-Lyford receiver. A stage of neutralized T.R.F. is used in conjunction with an untuned stage, detector, and two stages of A.F. amplification. A power tube is recommended in the last audio stage.

opened, otherwise the "C" batteries will discharge through the potentiometer.

The resistor in the plate circuit should be of the variable type, giving a resistance up to 100,000 ohms, so that the plate voltage may be changed without changing the "B" battery connections. The rheostat should have a resistance suited to the tubes to be tested. Additional switches may be placed in the tester so that any of the voltmeters may be open circuited by opening their switch or any of the ammeters short circuited by closing their switch. This instrument will also make tests of filament emission, grid current, positive grid voltages, and the effect of filament voltages on filament currents.

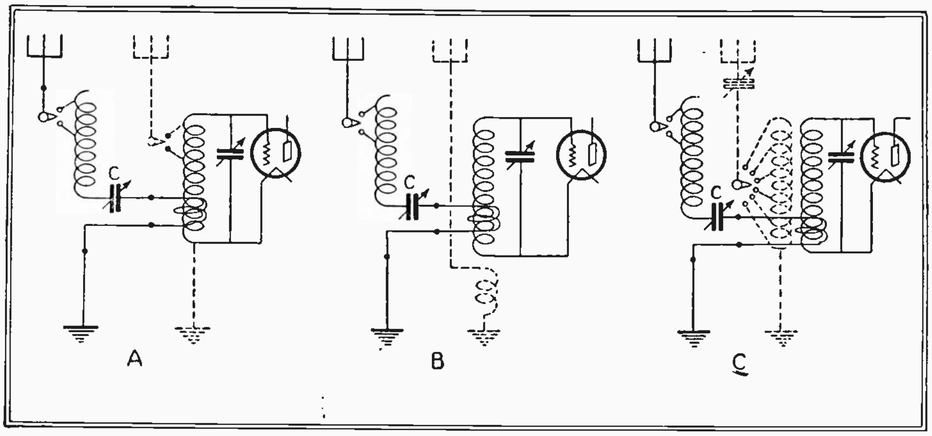


FIG. 22—Methods of connecting the unit to the three most common types of antenna couplers. The first is used in sets with conductively-coupled inputs, the second for semi-aperiodic antennas, and the third for ordinary tuned antenna couplers.

Radiola Amplifier

(21) W. L. Prescott, Paragould, Arkansas, asks:

Q. 1. I have recently taken apart my Radiola III-A receiver and would like to know how to hook-up the audio transformers, so that I may make a separate amplifier for another receiver.

A. 1. You will find illustrated on this page a circuit diagram of an amplifier using the transformers mentioned above. An ordinary audio transformer, a push-pull input transformer and a push-pull output impedance are used in the Radiola amplifier. The output from the radio receiver is connected to the primary of the transformer used in the first audio stage. Self-adjusting filament ballasts are placed in the "A" negative lead, their size depending upon the type of tubes used in the amplifier.

The center tap of the push-pull input transformer is connected to the "C—" power. A small fixed condenser having a capacity of .0001 to .00015 mf. is connected across one-half of the secondary of this transformer and prevents any tendency of the amplifier to "sing." The center tap of the push-pull output impedance is connected to the "B+" power. Power tubes of the 171 or 120 type should be used in the push-pull stage for best results. A 201A- or 112-type tube is used in the first audio. The "A—," "B—," and "C+" are connected together.

Increasing Selectivity

(22) Mr. H. Johnson, Long Island City, N. Y., writes:

Q. 1. I have a Browning-Drake receiver which is giving me very good results, although the tuning is not as sharp as I would like to have it. I am very much interested in receiving distant signals and because of this I do not want to reduce the size of my aerial to sharpen the tuning. Is there any other method by which I can make my set tune sharper without reducing the signal strength and sensitivity?

A. 1. A long unsheltered aerial will bring in signals from far greater distances than a small one can ever hope to pick up; stations heard faintly on a small aerial will come in with a remarkable increase in volume when the set is coupled to a longer, higher aerial. This is simply because the antenna, being more extended and covering a greater area, is collecting considerably more energy; thereby resulting in a more effective radio-frequency delivery to the detector. A number of methods of increasing set selectivity are suggested by our contemporary, *Radio Broadcast,* as explained below.

There are in use today several types of receivers which employ a tuned-antenna circuit. By this is meant that the primary coil is capable of being tuned to the exact frequency of the incoming signal, by means of either a variable condenser of the proper capacity, a system of taps or a combination of both. There are also many receivers which employ the untuned or semi-aperiodic type of primary, as in some forms of neutrodyne and tuned-radio-frequency receivers. Each system has certain advantages.

The tuned primary provides greater signal strength, since the antenna coil may be tuned exactly to the frequency of the desired signal and. in turn, the secondary may be brought into resonance with the received signal. The untuned primary produces greater selectivity with some sacrifice in volume; because the primary coil, having a low inductance value and not being variable, cannot be tuned to the frequency of the incoming signal, but depends for its operation upon "shocking" the grid coil at the frequency to which this coil is tuned. The greater the number of turns, the broader the tuning will be, with an increase in volume; likewise, as the number of turns is reduced, selectivity will be more pronounced with a decrease in signal strength.

In a particular case, when the antenna coupling coil was cut down from ten turns to one, and this one turn then loaded with a specially-designed loading coil (thereby making it a combination of the two coupling methods referred to above) the selectivity was as great as if one turn alone was used, while the volume was practically the same as with the ten turns. The aerial used for these tests was about 175 feet long.

Construction of Antenna Coil

From this it will be found that it is possible to use the long, high aerial system, with its resulting high efficiency for intercepting signal energy, yet without sacrificing that degree of selectivity which is generally obtained only by the use of a small antenna—provided that the correct apparatus is used.

The first thing to do is to build a variable loading unit. It consists essentially of a tapped spiderweb coil and a variable condenser. Great care must be observed when constructing this unit, since a considerable resistance would effectually block the passage of weak signals, making the change a disadvantage rather than an asset to the receiver.

The variable air condenser employed should preferably be of the straight-line-frequency type, and the requirements of the circuit are such that this condenser should have a maximum capacity of .001 mf. The inductor is of the well-known spiderweb type, since such a coil offers a very low resistance to high-frequency currents and is very easy to construct. It consists of 50 turns of No. 22 D.C.C. wire, wound through every other slot of the form and tapped at the 15th turn from the beginning. No shellac, varnish or other material is used on this coil. After the coil has been completed, it may be mounted on a baseboard, directly behind the condenser, by means of a bakelite mounting strip or other means.

It is important that this coil shall be placed at right angles to the electrostatic field of the condenser, and also that it shall be out of inductive relation to the first coil of the receiver itself. If any coupling should exist between the loading unit and the coils of the receiver, the purpose of the one-turn coupling coil would be defeated; for no energy should be transferred except at this point. In mounting, the switch points on the panel, keep them as far apart as the width of the switch blade permits.

The next point is to erect as large an

PUSH-PULL AMPLIFIER

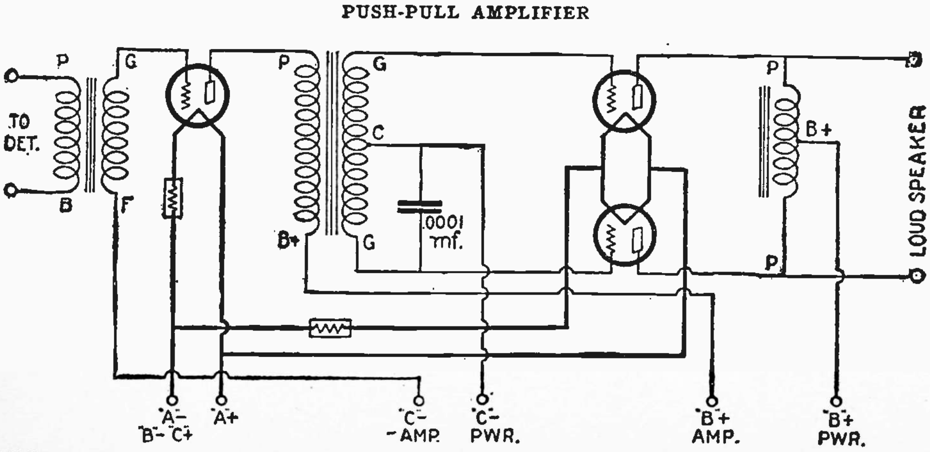


FIG. 21—The circuit diagram for a push-pull amplifier using Radiola III-A audio transformers. A small unbalancing condenser having a capacity of about .0001 mf. is connected across one-half of the secondary of the push-pull input transformer.

aerial as circumstances permit, bearing in mind that, the higher and freer the aerial is kept, the greater will be the signal strength.

Changing Receiver Connections

Assuming that your receiver employs the same direct antenna coupling as the commercial Browning-Drake receiver, it will be necessary to remove the two interior lead wires which connect to the antenna and ground posts. In their place is attached a piece of copper wire, no smaller than No. 14 and long enough to reach from the aerial terminal *once around the grid coil*, and then to the ground post. In order that this wire may not cut into the finer wire of the grid coil, it should be covered with a good grade of spaghetti.

The method of connecting this wire is shown in Fig. 22A; this constitutes the coupling coil through which the received energy is transferred from the loading unit to the receiver. The output terminals of the loading unit are then connected between the lead-in and the aerial post on the receiver.

If your set employs a semi-aperiodic coupler, as in many modern receivers, the changes to be made are very similar. The small coil which is connected between the antenna and ground posts is removed, and in its place is put the single turn of heavy wire. (Fig. 22B.)

In a set which the antenna circuit is tuned (such as a variocoupler set, where the outside winding is connected between the antenna and ground and the rotor used as the main tuning inductance) the primary will have to be unwound and removed. It is not, of course, necessary to dismantle the coupler, but it would not be wise to leave the unused primary coil in such close relation to the grid coil. The single turn of heavy copper wire is wrapped around the secondary and connected to the antenna and ground posts as before. (Fig. 22C.)

The operation of the unit is very simple. For wavelengths below 350 meters, the switch lever is set on the first point; so that 35 turns of the loading inductance are included in the antenna circuit. The dials of the receiver are then adjusted to the setting at which a station is known to come in, after which the antenna condenser C is varied until signals are heard. The first dial of the receiver will not read exactly as before, because of the changed inductance of the circuit.

A Filter Circuit

(23) George Murphy, Knoxville, Ten., asks:

Q. 1. Will you please illustrate in your department a filter system which may be adapted to any type of "B" eliminator to quiet the noises coming through from the line?

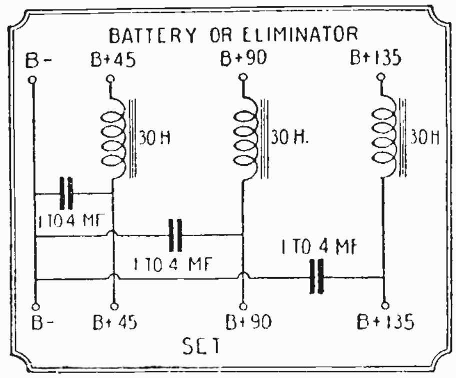


FIG. 23—The circuit above shows the connections for a filter system which may be connected to the output of any "B" eliminator. This filter will iron out noises and fluctuations in voltage which might otherwise cause considerable trouble.

A. 1. You will find on this page a diagram of a typical filter system which has been found highly efficient. This filter system is made up of 30-henry chokes and 1- to 4-mf. condensers, three of each. It is absolutely necesary that the input and output sides be not confused, as a reversal of the filter will make it inoperative. This filter is adaptable to use with "B" batteries, to cut down any noises due to the age of the batteries, or with A.C. or D.C. "B" eliminators. Note that *this is not an eliminator*, but is simply a filter system to be applied to the output of any type of eliminator.

The electrodes of the rectifier are made of lead and aluminum plates as indicated in the article. They may be 1 inch wide by 3 inches long with an additional length allowed for projection above the surface of the liquid. The latter may consist of a saturated solution of ammonium phosphate or borax in water. The surface should be covered with a 1/8-inch thick film of mineral or paraffin oil to prevent evaporation. The electrodes should be thoroughly sandpapered before being placed in the solution.

The 2-mf. condenser may be purchased from any radio or telephone supply house or possibly from your local telephone company.

Counterphase Power Six Receiver

(24) M. E. Thomas, Milwaukee, Wis., asks as follows:

Q. 1. Please furnish me with a description of the Counterphase Power Six-Tube Receiver, including those details which are necessary to obtain satisfactory reception with the receiver.

A. 1. The schematic wiring diagram for the Counterphase Power Six Receiver is shown in Fig. 24. It incorporates three stages of tuned-radio-frequency amplification, a special neutralizing system for overcoming oscillations in each R.F. stage a detector and a two-stage transformer-coupled audio-frequency amplifier, in whose final stage a power tube is employed.

No constructional data for the special toroidal coils can be furnished as it is exceedingly difficult to construct a coil of this type without adequate facilities. Two tandem condensers with compensating verniers attached to each unit are employed for tuning. The following is the list of parts necessary for the construction of this receiver:

4 Torostyle transformers, 1 type TA, 3 type TC;
3 Non-inductive resistances, 1500-ohm;
2 Twin condensers, type LD-17;
1 Variable resistance, 500,000-ohm;
1 Fixed condenser, .001-mf.;
3 R.F. chokes;
3 Neutralizing condensers;
1 Grid condenser, .00025-mf.;
3 Fixed condensers, .006-mf.;
2 A.F. transformers;
2 Vernier dials;
2 By-pass condensers, 1.0-mf.;
1 Grid leak, 2-megohm;
6 Binding posts (or battery cable);
1 Double-circuit jack;
1 Single-circuit jack;
1 Filament switch;
1 Rheostat, 3-ohm;
2 "C" batteries, 4½-volt;
6 Cushioned sockets;
1 Panel 7x24x3/16 inches;
1 Baseboard, 9¾ x 23½ x ½ inches.

Adjustment

After the receiver is completed, the following process of adjustment should be used. Adjust all neutralizing condensers so that the movable plate is halfway down. Tune in a station of moderate power on a low wavelength (200 to 300 meters) to exact resonance on both dials, using the small trimmer condensers to obtain fine adjustment. Adjust the 500,000-ohm volume control to give the greatest volume without oscillation or squealing in the loud speaker; which means to a point where no whistling will be heard when the dials are rotated back and forth across the signal. Place a small piece of paper over the "F+" contact spring of the third R.F. tube socket, so that the tube filament does not light.

The signal will, no doubt, still be heard; and the neutralizing condenser should now

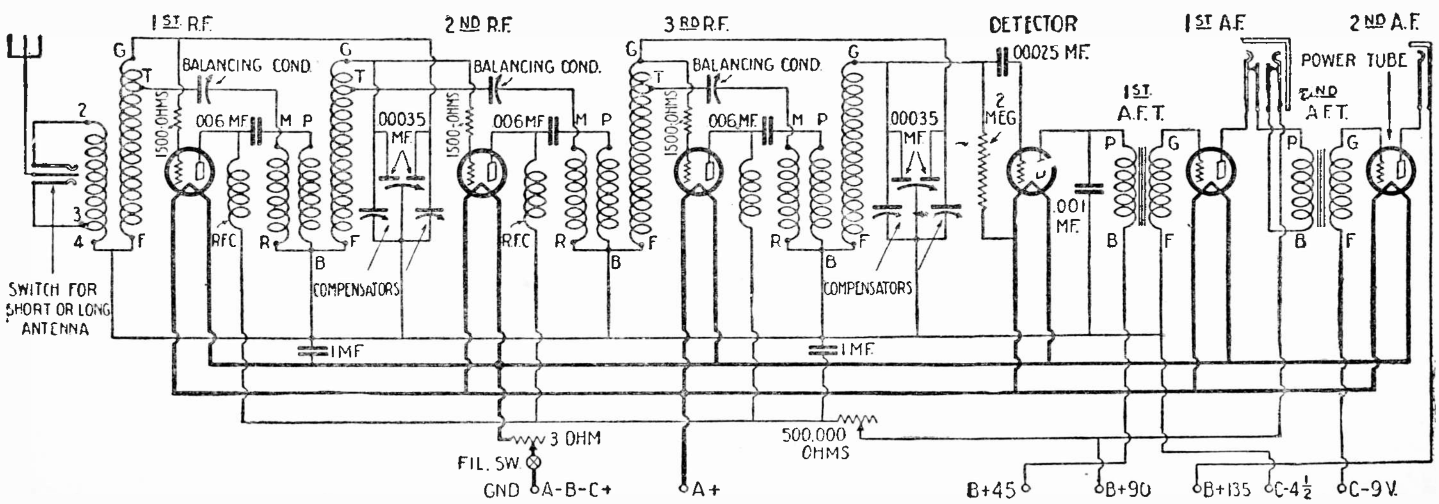


FIG. 24—The efficiency of the counterphase six-tube receiver is considered by most radio experts to be unsurpassed. The above diagram incorporates several new features, which serve to enhance the sensitivity and quality. A power tube is employed in the last stage, the 112 type being used. The 171 type can be used if the power tube plate voltage is increasd to 180 volts, and 40½ volts "C" battery is used.

be adjusted back and forth with a small screw-driver, until the signal becomes weaker, or disappears altogether. Now retune the right-hand dial for the loudest signal, and again adjust the neutralizing condenser for minimum signal. If it can be tuned out entirely the correct adjustment of the condenser has been obtained.

Now remove the piece of paper from the filament spring and repeat the operation with the second R.F. tube. Retune both tuning dials before making the final adjustment of the neutralizing condenser, and make sure that the signals remain weak, or entirely disappear, over a band of one or more turns of the neutralizing condenser, before finishing the adjustment.

Replace the filament connection, and repeat the performance with the first R.F. tube; being very careful in adjusting the neutralizing condenser, as the band of silence in this stage is very small, and may be passed over. As soon as the position of reduced volume is heard, replace the tube, and note whether the amplifier can be made to oscillate when the 500,000-ohm resistance is entirely cut out of the circuit, with the tuning controls set around 350 meters. If the receiver has been carefully wired, it may be possible to secure slight oscillation at this wavelength; but this is desirable for greatest sensitivity. If no oscillations occur, turn the volume control on full, and rotate the neutralizing condenser of the third R.F. tube by half turns until oscillations occur at 350 meters, and the position of greatest sensitivity is thus obtained.

Madison-Moore Superhet

(25) Mr. J. S. Cody, Waterbury, Conn., asks as follows:

Q. 1. Have you any information or diagram available on the Madison-Moore Superheterodyne receiver? Have heard this super discussed many times at radio fan gatherings, and some of the remarks made me conclude that it must be highly efficient. If you can furnish me with the information, please include the values of the parts employed, and any other information which might be of interest and help to me.

A. 1. The schematic wiring diagram with the values of the parts indicated over their respective symbols is shown in Fig. 25.

Some of the remarkable features of the Madison-Moore Superheterodyne are that there is no body capacity or other inductive effects or pick-up; due to the fact that all of the accurately-tuned air-core-transformers employed are shielded. All of the metal shields are grounded to the "A—" terminal.

The oscillator is specially designed and connected in an entirely novel manner, the pick-up coil being placed on the plate circuit of the first detector, as the diagram shows. This helps to eliminate noise and other effects of placing the pick-up coil in the grid circuit; and moreover it eliminates the usual superheterodyne annoyance of tuning in a station at two or more points on the dials of the condensers.

Some Special Features

No potentiometer is employed in this superheterodyne circuit, and no "C" battery is used on the I.F. amplification tubes, as in previous circuits where the potentiometer has been eliminated. A potentiometer may be inserted in the circuit for controlling the grid bias on the intermediate-frequency tubes if desired. One source of noise (namely, the grid leak and grid condenser in the first detector circuit) is eliminated by the use of a 4½-volt "C" battery, connected in series with the loop and grid.

High-resistance rheostats are used on the tubes in order to give accurate and smooth control over a considerable range; the tubes having to burn at only a dim brilliancy, another source of noise is eliminated. It is best to use shock-proof sockets for all tubes, or else to mount the sockets on a piece of bakelite, suspended on rubber bands. The metal shields on all the I.F. air-core transformers are grounded to the "A—" terminal; except in the case of the No. 5 unit, which has a wire running from "A—" to the lug on the shield. A radio-frequency choke coil is placed in series with the primary of the first audio transformer. The iron cores or shells of the transformers are grounded to the "A—", as well as the rotor plates of the two principal tuning condensers. It is best to place one of the new protective fuses in series with the "B—" battery line.

Option of Tubes

If fairly strong signal or voice is desired on the loud speaker, a UX112 tube can be used in the second audio stage, with a 9-volt "C" battery, as indicated in the diagram. The 4½-volt "C" battery is sufficient for both A.F. tubes if UX201-A tubes are employed throughout. UX199 3-volt tubes can be used in this superheterodyne, its manufacturers supplying specially-designed tuned-air-core transformers for these tubes. The small tubes can be used with the transformers supplied for use on the UX201-A, but results obtained are not satisfactory as with transformers of the proper impedance for the type of tube selected.

The volume control, comprising a graphite compression unit giving a range of from 25,000 to 250,000 ohms, is connected across the secondary of the first A.F. transformer, as shown. The voltmeter and milliammeter may be dispensed with if the constructor does not care to purchase them. Only the best grade of rheostat and by-pass condensers should be purchased, as these are two probable sources of noise, especially in superheterodynes. The rheostat used to control the oscillator tube should be of very highest quality; as variations in the resistance, due to a faulty rheostat, will cause changes in the frequency. In such a case the signal will fade and the set will not be satisfactory. Cheap by-pass condensers are other bad offenders, if they begin to leak. The operator may never suspect that these are the source of the noise, which resembles a steady steaming sound.

The tuned-air-core transformers, of the shielded type utilized in this set, may be placed about 3 inches apart in a row at the rear of the base, with six of the tube sockets spaced in between them. When using these shielded transformers, there is no danger of picking up noises from house-lighting circuits, etc.; and, unlike other superheterodynes of the unshielded type, it is also impossible for this set to pick up a station unless the loop is actually connected in. Such reception shows that the various intermediate transformers are picking up radio waves; and it can readily be seen that a set which does this is not likely to tune sharply, and also that there is liable to be trouble from picking up more than one station at a time, as well as interference from nearby lighting and power circuits.

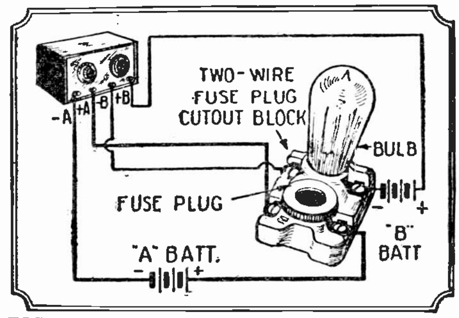


FIG. 26—One of the simplest methods of protecting the tubes of a radio set from being burned out is to place a 40-watt bulb in series with the negative B-battery lead, with a small fuse in the A-battery circuit.

Protecting Tubes

(26) Fred Heenan, White Plains, N. Y., asks:

Q. 1. Can you recommend any simple method of protecting the vacuum tubes of a set from actually burning out?

A. 1. This very simple method would no doubt be of interest to you. As you will see from the illustrations on this page, a device is shown which comprises a double-fuse block which is arranged with a bulb in one side and a small fuse in the other, the values of both the bulb and the fuse depending entirely upon the current requirements of the set and the safety margin which is desired. This may be easily figured out by estimating, in the case of the "A" battery, the current draft for the tubes used. The bulb used in the "B" battery circuit is simply there to limit the current flow and to prevent burning out the tubes in case the batteries are incorrectly connected.

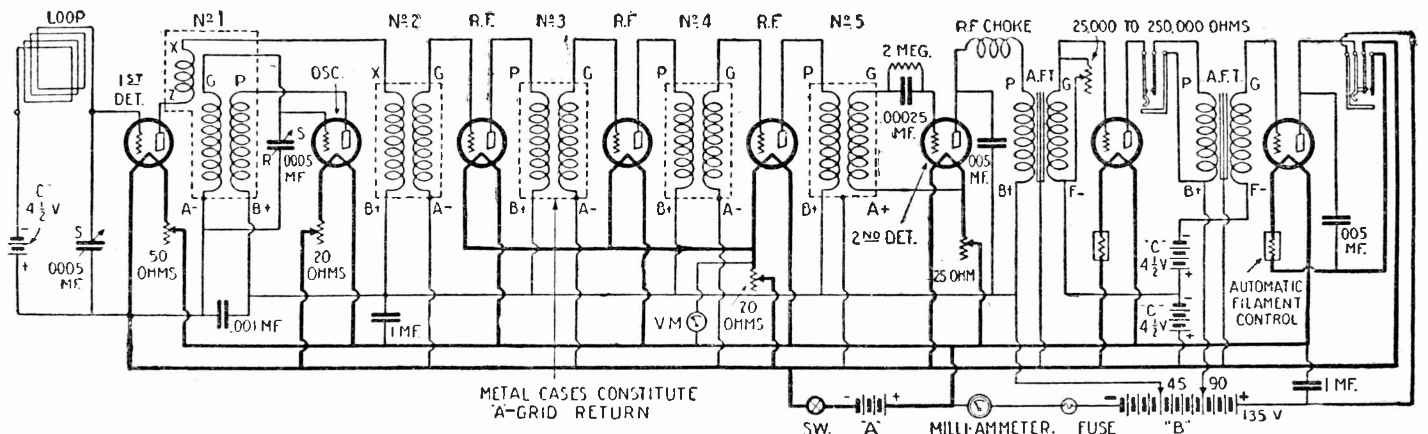


FIG. 25—The Madison-Moore Superheterodyne circuit, one of the recent super heterodynes. Special intermediate-frequency transformers are designed for the 199 and 201-A type of tubes, which makes possible perfect matching between tubes and transformers.

D.C. Receiver

(27) William F. Kephart, Clearfield, Pa., writes:

Q. 1. Will you publish a diagram of the *Science and Invention* 3-tube A.C. D.C. set with an added stage of radio frequency and with tubes lighted direct from the D.C. 115-volt lighting circuit. I wish to use a power tube of the 171-type in the last stage. I desire to have the circuit non-regenerative.

A. 1. On this page you will find illustrated a diagram showing a 4-tube receiver meeting with the above requirements. The detector coil should be placed in a shield and the shield walls should not be any nearer to the coil than a distance equal to the coil's diameter. If no shield is used, the radio frequency and detector coils should be placed at right angles and as far from each other as possible. Type 226 tubes are used in the radio frequency, detector and the first audio stages. A type-171 power tube is employed in the last audio stage.

R1 are filament ballasts of the A.C. type rated at 1.05 amperes, R2 is a filament ballast of the half ampere type, R3 is rated at 83 ohms capable of handling 100 watts, R4 has a resistance of 16 ohms and is rated at 20 watts, R5 is rated at 9 ohms and 5 watts. The two tuning condensers have a capacity of .0005 mf. and the neutralizing condenser, a capacity from .000002 to .00002 mf. From the filament end of the secondary of the detector coil to the neutralizing tap the same number of turns should be used as are employed on the primary coil.

A variable resistance of 500,000 ohms placed across the secondary of the second audio frequency transformer serves as a volume control. The set can easily be made regenerative by employing a tickler coil. A switch should be installed in series with the A- and B-leads. With the circuit as shown here, it is possible to light all tubes from the direct current line, and to obtain the necessary "C" bias.

Measuring Capacity

(28) H. Ferriera, Superior, Wisc., asks:

Q. 1. Can you tell me how it is possible to measure the capacities of condensers by using a neon lamp and also publish a diagram of the hook-up, if possible.

A. 1. On this page you will find illustrated a diagram of the condenser tester using a neon lamp. This is a simple form of tester and can be used for approximate measurements of capacity. It involves the use of the properties of the neon lamp. If a condenser is shunted by such a lamp, in which the discharge does not commence until a certain voltage is reached and is extinguished when

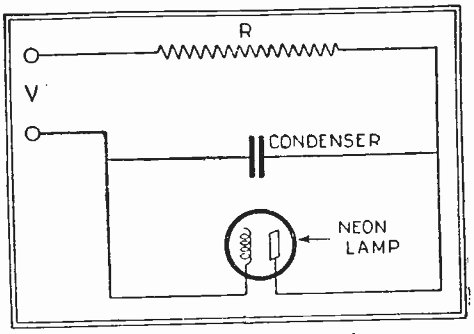


FIG. 28—The above diagram shows how a neon lamp may be employed for measuring the capacity of condensers.

this voltage falls below a certain value, the light of the lamp will become intermittent. The voltage is applied at V and should be in the nature of 200 volts or more, and if R is rated at 1 megohm or more, the lamp will flash intermittently at a rate determined by the voltage V, the capacity of the condenser, and the resistance R. By counting the rates of flashing obtained, with two condensers, their capacities can be compared. Thus, if the value of one is known, the capacity of the other can be calculated approximately. The rate of flashing is very nearly inversely proportional to the capacity.

Oscillations

(29) M. D. Ullman, Augusta, Maine, asks:

Q. 1. What are the general things which have an effect upon oscillation in a radio receiver?

A. 1. The tendency to oscillate increases as the frequency increases or as the wavelength decreases, other things remaining the same. This is also true of regeneration. A receiver may deliver very weak signals from high wavelength stations, which are of low frequency. The same receiver may be very satisfactory at medium frequencies and wavelengths and may be also impossible to control or to prevent from howling at low wavelengths and high frequencies

We may have oscillation with radio frequency amplifier tubes, with detector tubes or with audio frequency amplifier tubes. In a receiver which includes all three kinds of tubes the greatest tendency to oscilate is found in the second radio frequency tube or in the third radio frequency tube if a third one is used. The next greatest tendency toward oscillation is found in the detector tube. The tubes in the audio amplifier have the least tendency to oscillate.

As a general rule the tendency toward oscillation is increased by low resistance, that is, by good design in the grid circuits. It is also increased by using large tuning coils with small condensers, although this is good practice. The tendency to oscillate is generally increased by close coupling in radio frequency transformers because the close coupling allows a greater transfer of power and increased signal voltage in the grid circuit. Loose coupling of the antenna circuit increases oscillation tendency because the loose coupling removes some of the load from the grid circuit of the first coupled tube, or reduces the loss of energy from the coupled circuit into the antenna. Tube filaments lighted at normal brilliancy further increase the likelihood of oscillation. The tendency to oscillate is increased by increase of plate voltage. The higher the voltage the more easily will the circuit oscillate. Oscillation is increased by connecting two or more radio frequency or audio frequency stages to the same B-battery or power unit. Of course, this is the common practice. The reason for this increased oscillation is that the resistance of the common power supply forms a resistance coupling between the stages and there is a feed-back of energy through this resistance coupling. The converse of all of the above causes of increased oscillation will naturally reduce oscillation.

Reducing R.F. Coupling

(30) Mr. J. R. Baker, Ft. Worth, Texas, writes:

Q. 1. I have noticed that in tuned-radio-frequency receivers, three general positions of the coils are used. In the first the coils are all in the same positions, but are placed some distance apart. In the second, the coils are placed at right angles; and in the third they are at a critical angle of about 57 degrees. Can you explain why these three methods are employed, and the advantages of each?

A. 1. It is well known that their magnetic fields will couple together two coils of the solenoid type, unless they are a considerable distance apart. When two such coils have their axis directly in line, the degree of coupling depends upon their separation; the closer the coils, the greater the coupling effect, and *vice versa*. If the separation between the two coils remains at a fixed value, turning them so that their lines of center or *axis* are at an angle to each other reduces the coupling. When the axis of the coils are exactly 90 degrees apart, or at right angles, this coupling is minimum for the particular distance they are separated. This is one effective method of reducing the feed-back between coils.

There is another method of reducing magnetic feed-back of this kind. If two coils are placed parallel to each other, the magnetic field of one will pass through the other. Wherever magnetic lines of force cut one side of the turns of wire on a coil, and do not cut through with equal strength the opposite sides of the same turns, they set up a voltage difference across the turns. However, if all of the lines of force which cut through one side of a coil also cut through the other side, then equal and opposite voltages are induced into the two sides of the same turns of wire. These voltages balance out each other, so no undesirable transfer of energy is made.

Still keeping the center lines of the coils parallel, but changing the angle they make to a straight line drawn through both of them, causes more and more of the magnetic lines of force sent out by one coil to cut through both sides of the turns of the other. This angle or degree of inclination may be increased until a point is reached at which all of the lines of force cutting through one side of the coil will also cut evenly through the other side. In this particular position, there will be minimum magnetic coupling between the coils. The exact

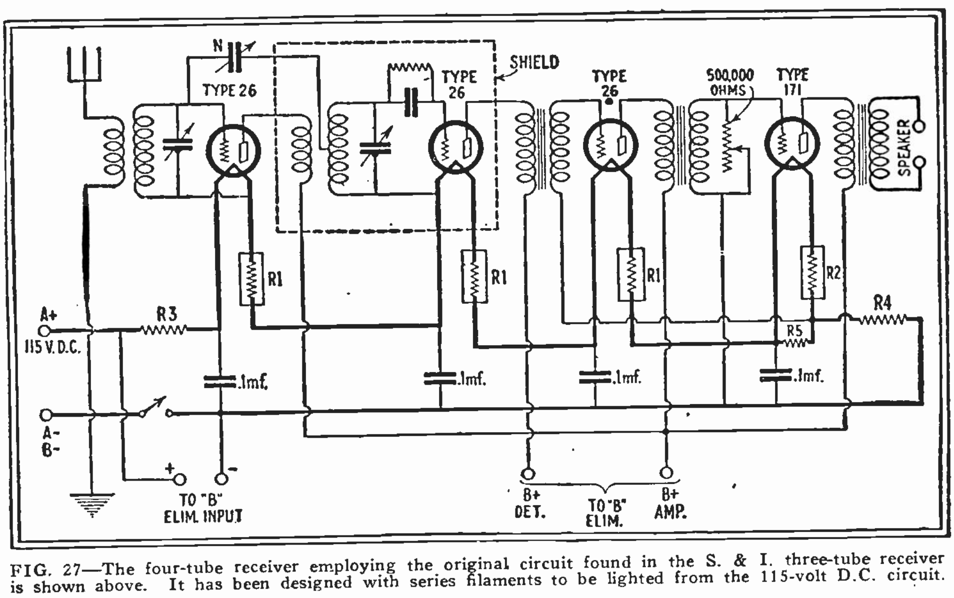


FIG. 27—The four-tube receiver employing the original circuit found in the S. & I. three-tube receiver is shown above. It has been designed with series filaments to be lighted from the 115-volt D.C. circuit.

angle for this minimum coupling position varies with the coil diameter and coil length. It has often been stated that the proper angle is 54 degrees and 57 minutes, because in many factory-made neutrodyne receivers this particular angle is used. To determine the proper angle for any receiver the quickest and most practical method is to try various coil inclinations while the set is in actual operation.

When two coils are placed parallel to each other and only a short distance apart (four to six inches), the efficiency of the coils and their associated circuits must be reduced to such an extent that the feed-back will not cause oscillation.

Wired Wireless

(31) J. B. O'Sullivan, Philadelphia, Pa., asks:

Q. 1. Will you kindly publish a diagram showing how the radio transmitter is coupled to the line in a wired wireless system.

A. 1. On this page you will find illustrated a diagram which shows the method used in the above mentioned system of radio transmission. By utilizing high frequency currents, it is possible to superimpose these currents on to lines or circuits which are normally carrying other currents, such as, telegraphic, telephonic, or power circuits. This can be carried out without interfering with the normal use of the lines or circuits. An ordinary radio transmitter is coupled to the circuit which is to be used as the medium for the tranmission of the signals.

The action of the power lines is to act as a guide for the radio frequency energy between the transmitting and receiving stations, instead of allowing this energy to be radiated in all directions. The transmitter is usually coupled to the line through a coupling condenser, or the coupling may be provided through the capacity of a wire stretched near the power line, but suitably insulated from it. The coupling condenser method provides greater security, as it is not affected by atmospheric conditions which might cause damage to the coupling wire.

The low potential terminals of the two coupling condensers are preferably connected to a three electrode spark gap, the middle point of which is grounded so that in case of a breakdown or accidental flash over, no excessive voltage will be applied to the radio apparatus. When this method is used with low voltage lines, no special apparatus is required for the condensers. When using high tension networks, however, the condensers must be larger, since they must be capable of withstanding the line voltage with a good factor of safety. Carrier current operation has the advantage over ordinary wire communication inasmuch as it is less liable to interruptions during storms. Furthermore, when there is a break in the line, there is usually sufficient capacity across this gap to convey enough energy to be picked up by the receiver.

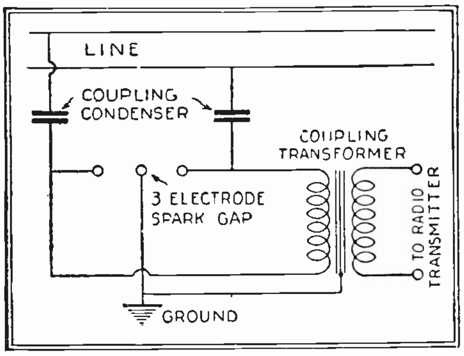


FIG. 31—Above is the hook-up of a wired wireless system, showing how the transmitter is coupled to the line.

Reducing Machine Interference

(32) J. G. Bendigo, Salem, Mass., writes:

Q. 1. I have an electrical lighting plant in my neighborhood. Is there anything I can do to reduce interference from this source?

A. 1. See the circuit printed in these columns. This shows the circuit of an interference eliminator. The apparatus required will be one coil consisting of 100 turns of No. 26 D.C.C. wire wound on a three-inch cardboard former. This is the radio frequency choke. Next one fixed condenser of about 0.0002-mfd. capacity is required, but the exact capacity must be found by experiment. The choke and condenser are joined together as shown. The other terminal of the condenser is connected to the aerial terminal of the set. The aerial must be connected to the junction of the choke and condenser. The remaining end of the choke is connected to the ground terminal of the set, and the ground wire should be left connected to the terminal.

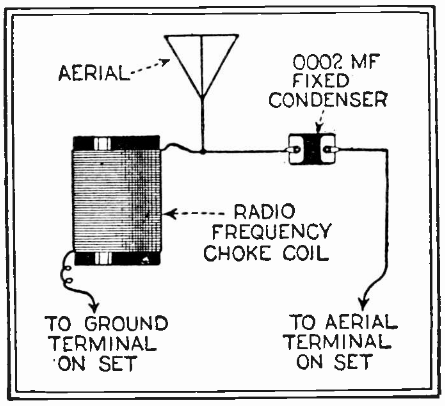


FIG. 32—Interference eliminator hook-up.

Interference Elimination

(33) Mr. A. L. Brown, New York, N. Y., writes:

Q 1. Can you give me any information regarding the elimination of interference in the congested districts of the metropolitan area?

A. 1. In Fig. 33 is shown a series of diagrams illustrating the best approved methods of eliminating undesired signals. The first diagram shows an "Acceptor" circuit, where the auxiliary coil and condenser are tuned to the wanted signal, thus tending to raise it above the interference level. The second coil and condenser in parallel "reject" the undesired signal by trapping it and preventing it from energizing the antenna circuit of the set. The third circuit by-passes the undesired signal to the ground, while the primary circuit of the set may tap off any desired frequency. The fourth, "Absorption" circuit, utilizes the principle of the fourth circuit in the Cockaday set, in vogue a year or so ago. The fifth is a "Relay" circuit, where the antenna is tuned and an intermediate trap is used between the receiver and antenna circuit. The sixth circuit illustrates one of the most efficient methods of tuning a set equipped with an aperiodic primary. The seventh circuit is that employed by the designers of a commercial filter called the "Filterola." The makers claim that the signal is amplified with the usual elimination of undesired frequencies. For the broadcast wavelengths the coil and condenser used in these trap circuits may conform in each case to the following specifications: The coil, 55 turns of No. 26 double silk covered wire on a 3-inch form; the condenser, .00035 or .0005 mfd. low-loss variable. The better the constructoin of the coil and condenser, the better the results to be expected.

Vreeland Receiver

(34) Mr. Blaine G. Sweet, Rome, N. Y., writes:

Q. 1. May I ask you if you have any constructional data available for the construction of a broadcast receiver using the Vreeland band selector with band amplifier in a 6-tube set using three stages of tuned radio frequency amplification?

A. 2. We regret that there is no information available on receivers employing the Vreeland Band system. The patent situation is not yet clear in this matter and naturally no data will be available until Dr. Vreeland has completely settled this matter.

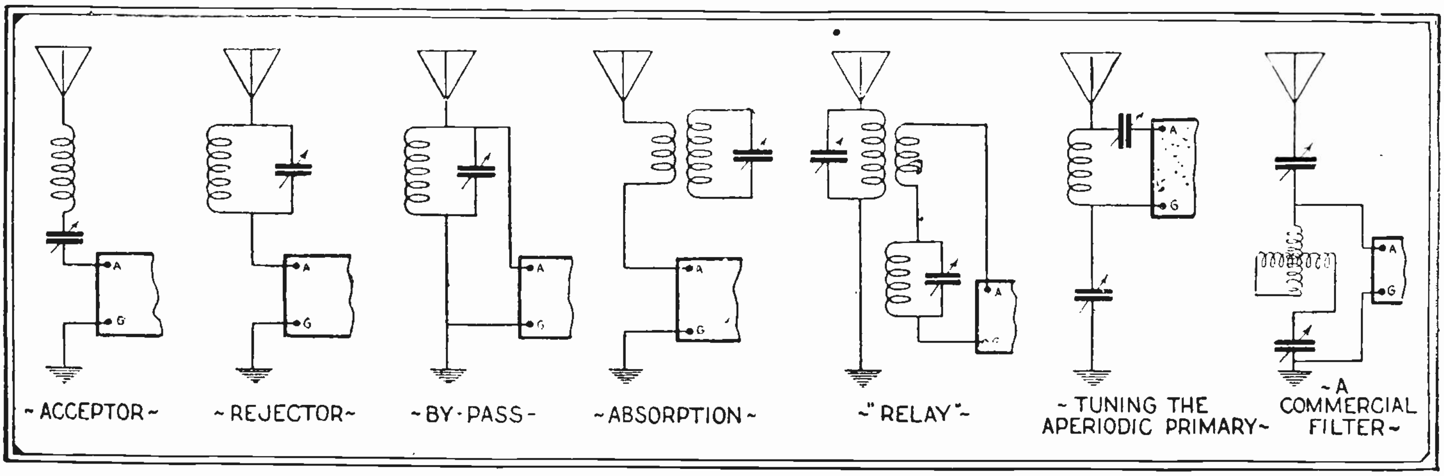


FIG. 33—The seven circuits illustrated in the diagram above cover the basic principles used in interference eliminators or wavetraps. It will be found that each type is best suited to a condition, and a judicious selection is possible only after a reasonable amount of experimentation. In most cases the absorption filter will be found sufficiently practical for use in all but the most congested localities.

Body Capacity

(35) A. Johnson, Minneapolis, Minn., writes:

Q. 1. I am employing a regenerative tuner of the so-called three-circuit type and find that I have trouble holding the signals when I place my hand on the variable condenser dial. Furthermore, when I tune in a station and remove my hand from the dial the station usually disappears. How can I eliminate this trouble?

A. 1. Undoubtedly reversing the connections to your secondary tuning condenser will eliminate most, if not all, of your trouble. In other words, the rotary plates of the condenser should be connected to the ground. By doing this, the parts of the variable condenser that are near at hand will be placed at ground-potential so that the capacity effect of the hand will be reduced to zero. If, for some reason, this connection does not overcome the effect which you have noticed, try shielding the panel. Do not allow the metallic parts of the condenser to touch the metal shield, which should consist of a sheet of tinfoil fastened to the panel with some adhesive, such as shellac. This shield should be connected to the ground.

Sharp Tuning with Crystal Detector

(36) Lester Delaney, New York City, writes:

Q. 1. I have a crystal detector set using a fixed coupler for the tuning arrangement. The antenna circuit is untuned, while the secondary is tuned by means of a variable condenser. Can you tell me how to increase the selectivity of this set?

A. 1. Crystal detector types of receiving sets are inherently broad in tuning, although in some cases it is possible to produce a semblance of sharpness. In your particular instance, we would advise you to increase the coupling between the primary and secondary coils. This will, of course, result in slightly decreased volume, but you will notice an over-all increase in selectivity. This is of particular value in congested districts and will undoubtedly solve your interference problems.

Underground Antennas

(37) Col. L. L. Rice, Mayland, Tenn., asks:

Q. 1. I have been doing some extensive experimenting with various types of underground aerials to determine whether static can be positively eliminated by underground means without excessive sacrifice of signal strength. I am in a position to make a very thorough test; but, before I attempt any further work, I would like to know whether the following methods would be of any advantage?

First, four coils of rubber-covered wire, each about 60 feet in length, are to be wound about a cylinder of wood some four inches in diameter; the four separate wires at the top of each cylinder being soldered to the lead-in wire. This lead-in wire is to be shielded from a point one foot under ground to receiving set by a lead tube in order to be relatively impervious to atmospherics. The four cylinders are to be buried from three to five feet under porous soil and about two feet apart. As I am not a mathematical expert, I am not certain as to the capacitative effect of these four buried coils. Please do not hesitate to check me up if I am running into a scientific absurdity.

Second, a rubber-covered wire is to be dropped into a well about seventy-five feet deep, the lower end of wire being sealed to be impervious to water; said wire continuing to a point about four feet from surface, where it will be led sidewise under ground to a point beneath my receiving set

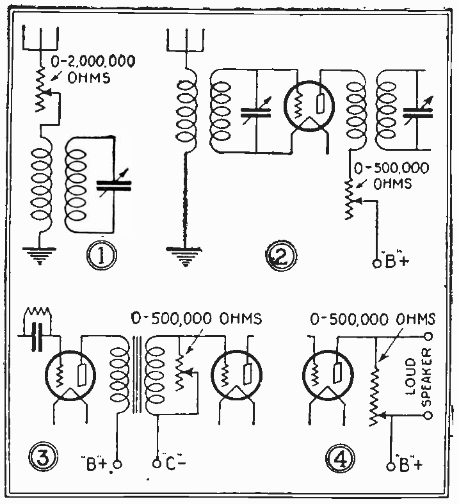


FIG. 40—The illustration above shows four methods of controlling the volume in radio receiving sets. The simplest volume control is a variable high resistor placed in series with the antenna lead.

—on the first floor—and before it leaves the ground to be lead-sheathed, to be relatively free from picking up *atmospheric static*. That the receiver itself may have no pick-up static effect, I propose to shield it by placing it on a metal sheet and then to cover it by a box-like metal container. Is there anything else you can suggest that may help me prove whether static is eliminable. If so, I will be greatly obliged.

A. 1. We are indebted to Dr. J. H. Rogers for the following reply to the above inquiry:

"I do not see that the four coils you suggest would be as efficient as one of a larger size.

"By the use of underground and underwater antennas, static is reduced, and this is the most effective means yet found. I believe it only a question of time before someone, possibly yourself, will devise some form of earth antenna that will further reduce or eliminate atmospheric disturbances.

"Best results with any form of these collectors are only attained when burried deep, at least to 'depth of water earth.'

"As to your proposed tests in a fifty-foot well, I would suggest that as it is well known that intensity of signals remains almost constant even when antennas are located far beneath the surface of the earth, and conversely, 'atmospheric static' decreases rapidly; if you could devise some form of antenna which would take advantage of these characteristics, static would be greatly reduced. Shielding the receiver as you suggest, and certain portions of the leads, might solve the problem."

Four-Tube Set

(38) E. C. Clark, Jacksonville, Fla., writes:

Q. 1. I have built a four-tube receiver and find two sources of trouble with it. In the first place, the regeneration control does not seem to have much effect on the operation of the set and the second trouble is that a whistle is heard when the loud speaker is plugged into the second stage of audio frequency amplification. Can you help me remedy these defects?

A. 1. In the first place we would advise you to look to your regeneration control condenser. Is it of the correct size and as you vary it from zero toward maximum, do you obtain an increase in signal strength up to a certain point where a click is heard and the music becomes very distorted? If this happens, your regeneration control is operating properly and you will undoubtedly find that your trouble lies in the audio frequency amplifier. By the way, if the regeneration control works over the entire wave band as described, a choke coil in the plate circuit of the detector is not necessary.

The writer had a trouble somewhat similar to the second one which you mention, namely a whistling that at times was very annoying and prevented "DX" reception. It was found that shunting the secondary of the second audio frequency amplifying transformer with a fixed condenser entirely eliminated this whistle and cleared up reception remarkably. We far prefer this system to the usual resistance control of noise. The condenser that the writer uses is of a capacity of .0005 mf. However, the various sizes should be tried until the best results are obtained. This condenser in any case should not be larger than .001 mf.

In case the condenser does not clear up your trouble make sure that you are not obtaining an audio frequency feed-back in your receiver. Possibly the audio transformers are close together or their cores are parallel and if such is the case this will of course take place. In such an event separate the transformers or turn them at right-angles to each other. Occasionally grounding the cores or the metal cases or both of the transformers will be of considerable assistance.

One further thought is that the grid leak that you are using may not be of the correct value.

Use of By-pass Condensers

(39) Mr. W. C. Stephens, Trenton, N. J., writes:

Q. 1. Will you please give me your views on using a 1-mf. by-pass condenser across the "B" battery on a radio receiving set?

A. 1. A by-pass condenser should always be used across the "B" battery. This should be mounted within the cabinet and serves to reduce the effective length of the battery leads for set to the battery. It is most important in a set using one or more stages of radio frequency amplification or where the battery leads are exceptionally long as is the case when the batteries are in the basement and the receiver is located on the first or second floor.

Q. 2. Which is the best way to connect the "A" battery and "B" batteries together, the —"A" to the —"B" or the +"A" to the —"B"?

A. 2. The system which is considered best in most receiving sets is one in which the positive "A" and negative "B" are connected together. When these two terminals are connected together the effective "B" battery voltage is increased by the amount of voltage of the "A" batterey.

Volume Control

(40) H. W. Hillwell, New York City, asks:

Q. 1. Which method do you consider the best for controlling the volume in a radio set?

A. 1. The simplest volume control is a variable high resistor in the antenna lead, which serves to cut down the signal energy and is of real value, especially when intercepting powerful local signals. This is shown in Fig. 1. In some cases the resistor is shunted across the antenna and ground posts on the set. The resistors used for this purpose range from 0 to several million ohms in the case of the resistor placed in the antenna lead, which appears the better of the two arrangements.

If we do not control the energy at the very entrance to the radio set, the next best point is to control it as soon as possible in the radio-frequency stages. Here the best practice is to place a variable resistor in the "B" battery lead supplying current to the radio frequency tubes, as shown in Fig. 2. This resistor should be of the 0 to 500,000-ohm type. With a volume control in the plate circuit of the radio-frequency tubes, it is possible to use coils which will normally oscillate with 90 volts on the tubes, together with whatever stabilizing method is employed. Then, with variable plate voltage the receiver can be worked at its highest efficiency right at the verge of oscillation, and if desired it may be brought down to very low volume without considerable distortion. In this way, we combine both a sensitivity and volume control in one.

If the set is of the regenerative type, the regeneration is the most logical thing to control. In this case, a 0 to 500,000-ohm resistor shunted across the terminals of the tickler of feedback coil serves to control the volume. This is the most popular method of controlling regeneration and, at the same time, volume, especially in critical short-wave receivers.

The next point at which volume may be controlled successfully is at the secondary of the first transformer shown in Fig. 3. A resistor is placed across the secondary and serves both as a volume control and for matching the characteristics of the transformers used in the amplifier. In this way, a more uniform amplification curve may be obtained.

In case of resistance coupling and impedance coupling, a potentiometer arrangement is more desirable, as a rule, but it is a good practice to shunt a variable resistor across the input of such an amplifier to by-pass more or less the energy delivered by the detector. The next and last place for controlling the volume of a receiver is to shunt a resistor capable of handling the plate current, across the loud-speaker terminals. This method will be seen in Fig. 4.

From all standpoints, the use of a variable resistor in series with the antenna lead is probably the most satisfactory means for controlling the volume. Furthermore, this method controls the sensitivity as well as the volume and is of considerable value in this respect, since it is possible to prevent detector tube from being overloaded by local high-power stations. Obviously, it is equally true that one or more variable resistors employed in the "B" power leads of the tuned-radio-frequency amplifiers will allow the volume and sensitivity to be altered in much the same way as a variable resistor in the antenna lead, but it is hardly as convenient a method as the latter, unless the variable resistors are employed for stabilization as well as volume control.

Four-Tube Set

(41) Horace Potter, East Orange, N. J., writes:

Q. 1. My radio set gives plenty of volume but the reproduced tones are not clear. Can you help in locating the trouble?

A. 1. Probably the addition of a 3- to 4½-volt "C" battery to your radio set would aid in clearing up your trouble. Also there is a possibility that one or another of your tubes is poor and does not function properly. Changing tubes around in the set might help you out as might also the addition of a good variable grid leak, properly adjusted.

Tandem Tuning

(42) R. L. Gordon, Los Angeles, Calif., asks:

Q. 1. Is it possible to tune two stages of radio frequency with one condenser of .001 mf. capacity? I notice that in the tandem condensers now on the market the sets of rotating plates are usually connected together, and in some, the stationary plates also.

A. 1. In the standard tandem condenser the rotary plates are usually connected together but the sets of stationary plates are insulated from each other. If the stator sets were all connected together, the grids of the tubes in the R.F. circuits would all automatically be placed at the same potential and no amplification would result.

Aerial With Loop Set

(43) Mr. R. N. Langley, Lakeland, Fla., writes:

Q. 1. I have been using a portable receiver which operates from a built-in loop aerial, and I believe I could get better results with an outside aerial. I do not wish to make any changes in the receiver, however, and since the loop aerial is built in I would not like to remove it. Is there any way in which an aerial can be used with my set?

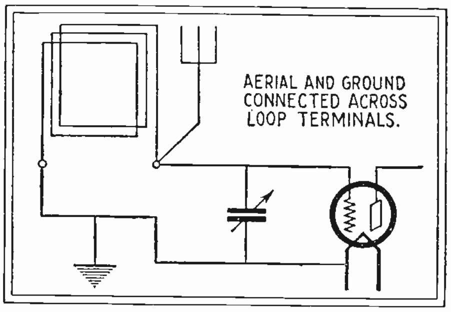


FIG. 43-A—The loop shown above corresponds to the ordinary tuned aerial-coupler coil. The characteristics of the antenna combine those of loop and aerial.

A. 1. There are several methods which could be used for connecting an aerial and ground to a portable set operated from a loop aerial. Some receivers are so constructed that either a loop or outside aerial can be used; the loop being cut out while the aerial system is being used. However, there is another way to use an outside aerial with a loop receiver. The loop can be used as the secondary or tuning inductance and the aerial and ground connected to the two ends of it. This method is shown in Fig. 43-A.

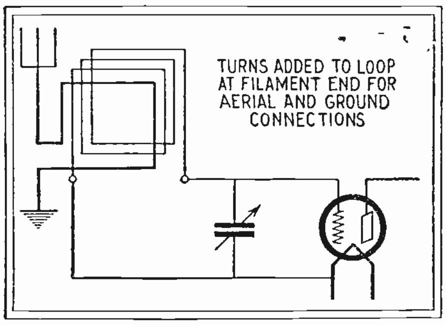


FIG 43-B—The loop used in this fashion becomes the secondary of an aerial-coupling R.F. transformer. The coupling may be made variable.

As you will notice, the aerial and ground connections are simply made to the two ends of the loop aerial. When making these connections, *the end of the loop which is connected to the filament circuit of the receiver* should be connected to the ground and the grid end to the aerial. This method will increase the signal strength, but will also reduce to some extent the selectivity of the receiver. The selectivity can be increased by making a tap on the loop aerial, two or three turns from the ground end, and connecting the aerial to this tap.

Another method is to wind two or three additional turns of wire on the loop frame, placing them near that end of the loop which connects to the filament circuit of the receiver. One end of this new coil connects to the aerial and the other end to the ground.

It is possible also to arrange a small loop inside of the regular loop used in the set, in such a manner that it can be rotated within the larger one. This allows a variable coupling, so that the correct device of selectivity can be obtained. An increase of signal strength can be obtained also by simply connecting the filament end of the loop in your set to ground. No aerial is used with this connection.

All of the methods described above will increase the sensitivity and volume of a loop set *at the expense of the selectivity.*

By careful manipulation, however, a system can be found which supplies sufficient selectivity with an increase in signal strength.

Eliminating Oscillator Fault

(44) Mr. L. Miller, Brooklyn, N. Y., asks as follows:

Q. 1. I have a superheterodyne receiver which I feel sure would be very efficient and satisfactory, if it were not for the double-place-reading effect obtained on the oscillator dial. This, of course, I understand is common with superheterodyne receivers. Nevertheless, I wonder if there is some conventional means of installing a wave trap, or some other absorbing system, by which the second reading could be eliminated. This would allow me to obtain other stations, as the present dial reading on the oscillator condensor for various stations leaves me no room to obtain distant reception.

A. 1. A means for eliminating the double reading on the oscillator dial obtained on all superheterodyne receivers has been completely described in the Saturday Radio Section of the *New York Sun.* We are reprinting below the description of this device, and feel sure that the information will be of much value to superheterodyne set users who experience the same difficulty as Mr. Miller.

"The floating-beat-note hook-up, an automatic frequency-changing system, is put forward as a cure for the one fault of that king of all receiving sets, the superhterodyne. It does away with the double-beat note, that inherent and annoying habit of the super in bringing in a station at two different points on the oscillator dial.

"Like Venus, the superhterodyne was born into this world all but perfect. Either by accident or a *tour de force* on the part of its inventor, Major E. H. Armstrong, it emerged from his laboratory in Paris in 1918 in so mature a form that it has been susceptible to little improvement since. Unlike other receiving circuits of note in this rapidly changing period of radio art, it continues to increase in vogue. Of the true super, it can be said it will do anything any other set will do, and throw away the antenna to boot. That is, it will do anything on a small loop that any other set can do on a good antenna. And, in addition, it possesses an inherent degree of selectivity never attained by any other combination of tuned circuits.

"But—there is the fly in the ointment—the double-beat note. A station will come in equally well at two points on the oscillator dial. And the upper beat note of one station will very frequently collide with the lower beat note of another station, or vice versa, and very seriously upset, by this interference factor within the receiver, the much-prized selectivity. So serious may this double-beat-note trouble become that different wavelength transformers are recommended for different locations.

"Prof. Walker Van B. Roberts of Princeton, originator of the popular Roberts set, said in one of his writings how nice it would be if all broadcasting stations in the country were on the same wavelength and at the same time couldn't interfere with each other! In such a radio paradise one could design a receiver for a single frequency without any compromises and it would always work at its best. Having said so much, Prof. Roberts went on to say that this is just what the superheterodyne does—it reduces the signals of all stations to a single frequency and then passes them on to a detector and amplifier built to handle only that frequency. It is the 'frequency changer' of the super that accomplishes this miracle; the rest of the super is merely a fine receiver, with two, three or four stages of fixed radio frequency, a detector and one or two stages of audio. Taken from this point of view, the super is not such a complicated animal.

Function of "Super"

"How the frequency changer works is shown schematically in Fig. 44-B. First let us say the receiver is designed to function at 6,000 meters, or 50 kilocycles. Properly designed, it will respond to this wavelength and no other, within easily-controllable limits. That is where the selectivity of the super comes in.

"The frequency changer, which is to change all wavelengths within its tuning range into one (that of 6,000 meters or 50 kilocycles), consists of a so-called 'first detector' and a 'heterodyne,' or oscillator. The first detector receives the tuned signal from the loop, like any other single-circuit tuner, being tuned by C1. The 'heterodyne' is merely a second tube in an oscillating condition, like an ordinary regenerator that has spilled over. This tube is tuned by C2, and to the signal itself, but to 50 kilocycles above or below the signal. Let us say that C1 is tuned to 600 kilocycles (500 meters), then C2 would be tuned to 550 or 650 kilocycles. These signals are mixed together on the grid of the first detector tube through the coupler X, the oscillations cancelling each other out until there are only 50-kilocycle frequencies left; the output of this tube thus becomes 50 kilocycles. Thus we have taken a signal of 500 meters and, by a simple process of subtraction, we have changed it into a signal of 6,000 meters to pass on to our one-wavelength receiver.

"These are the only tuning controls there are on a super: one for wavelength and one for the heterodyne. The first dial is very broad, like any other single-circuit tuner; the second is as sharp as a razor, unlike any other tuner known. The heterodyne dial has, as we have stated, the single weakness of a double-beat note; that is, it can be tuned either above or below the frequency of the signal, so long as the difference between the two frequencies remains 50 kilocycles,—or whatever wavelength the receiver is designed for.

The New System

"The floating-beat-note system is suggested as a means of doing away, not only with the heterodyne dial itself, but also with the troublesome double-beat note. It accomplishes this at a sacrifice of the inherent selectivity of the standard superheterodyne. It is therefore necessary to add selectivity to the tuned signal itself, which may be done by using a stage of tuned radio frequency before the 'first detector.'

"A schematic diagram of the floating-beat-note device is shown in Fig. 44-A. Tube A is a radio-frequency stage, B is the 'first detector,' and C is a fixed oscillator (heterodyne), oscillating at the exact frequency for which the receiver is designed. Thus, in the above instance, tube C would be tuned to oscillate permanently at 50 kilocycles.

"Tubes A and C are connected in parallel across the tuned loop. The operation is as follows: the incoming signal, say of 600 kilocycles, is tuned by C1; this signal divides between tubes A and C equally. The half signal passing through tube A is amplified at radio frequency and rendered highly selective by C2, and passed on to the grid of tube B. The half signal passing through tube C is mixed with the fixed oscillations of this tube, 50 kilocycles in this instance. The output of this tube thus becomes automatically 600 minus 50, or 550 kilocycles, the same heterodyne value which would be achieved in a conventional super by manual tuning. The output, 550 kilocycles, is mixed up with the 600 kilocycles signal on the grid of tube B, through the coupler X, in the same manner as in Fig. 44-B.

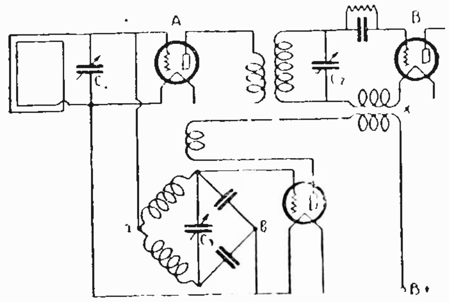


FIG. 44-A—The wiring diagram of the "floating-beat" device which eliminates second dial reading effect when tuning the oscillator dial of a super-heterodyne.

Many Forms Possible

"Since this is accomplished by the use of a fixed oscillator, instead of the tuned oscillator, several interesting schemes for this fixed oscillator immediately suggest themselves to the experimenter. The fixed oscillations may be generated by: a separate local oscillator tube, as in super, or an oscillating crystal. The latter method (*i.e.*, the quartz crystal) suggests the most interesting possibilities, though it also injects technical difficulties to tax any but the advanced amateur.

"The simplest method for experimental purposes is the one shown in the diagram, the 'autodyne' or feed-back method, in which the same tube is used for the fixed oscillator and the mixer. This is accomplished by means of the capacity-impedance-bridge method of coupling, a superheterodyne system brought out a year or two ago by Capt. Pressley of the Signal Corps, U. S. A.

"The tube C is connected as a long-wave oscillator. The inductance of the bridge consists of two 250-turn honeycomb coils, with tap at (a). The capacity of the bridge is obtained from midget condensers to balance the two arms, and the feed-back may be a honeycomb coil of 250 turns or less. The parallel circuit feeding into the tube is connected at (a) and (b). C3 is semi-variable and need not be touched after it is once adjusted. This fixed oscillator may be attached to any tuning circuit as a frequency charger."

Multiple Radio Installation

(45) Mr. D. Wilkerson, Norwood, N. J., asks:

Q. 1. I wish to make a multiple radio installation in an apartment building. Can you furnish me with any data or diagram of the method of procedure?

A. 1. The system employed for making a radio installation where a number of outlets or loud speakers are to be used, as in hospitals, hotels or apartments, has often puzzled a good many constructors and radio-set builders. We have received numerous letters which show interest in this subject. We here present a diagram of a simple installation which, when completed, is a neat and interesting affair.

It is essential that a power amplifier be employed where three or more outlets are concerned. The power amplifier should incorporate a volume control, which must be turned more and more towards the maximum setting, as the number of loud speakers to be used is increased. The jacks and plugs may be mounted in switchboard fashion, the plugs on the horizontal board, the jacks on a vertical one. The plugs should be numbered corresponding to the apartment or ward number in which the loud speaker is placed; thus, if radio reception is desired in apartment 13, plug 13 is placed within the jack. The constructor may also incorporate a volume control in each separate output; so that if apartment 13 complains that the volume is too great, the operator may easily reduce the volume for that particular line, without in any way decreasing the signal strength to any other outlet. The volume control should be connected to the leads marked "X," and consists of an ordinary variable resistance, 0 to 25,000 ohms.

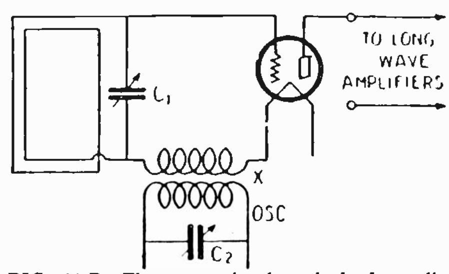


FIG. 44-B—The conventional method of coupling an oscillator to the first detector in the super-heterodyne receiver.

The scheme as illustrated can of course be improved upon; for instance, three or four lines of jacks can be employed, each line running to a different receiver, each obtaining different stations, should one apartment desire to listen to some other program. Also, a common connection might be used for the installation of the loud speaker, instead of two separate wires for each outlet, which is a somewhat tedious and laborious installation.

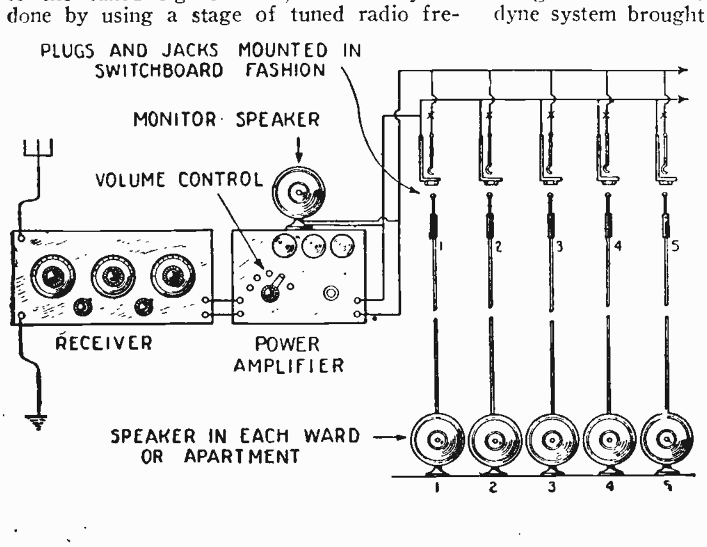


FIG. 45—This system can be used where a number of outlets or loud speakers are to be used as in hospitals, hotels or apartments.

Audio Frequency Oscillator

(46) R. Plauser, Brady, Texas, writes:

Q. 1. Please publish a circuit diagram of an audio frequency oscillator using some method of stabilization, preferably a piezo electric crystal.

A. 1. The U. S. Bureau of Standards has done some valuable work along these lines and has constructed an audio frequency oscillator which uses a piezo electric quartz disk for control. On this page you will find a diagram showing the hook-up of the oscillator in question. A straight frequency line condenser is used for changing the frequency within the audible range and its scale is calibrated in audio frequencies. Final adjustments of frequency can be obtained by means of a hand control attached to the quartz disk.

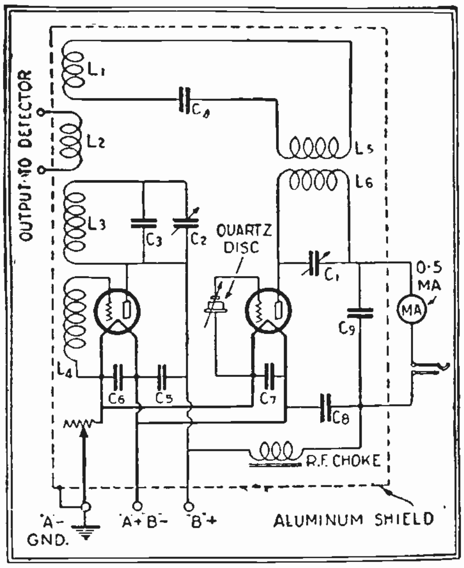


FIG. 46—An audio-frequency oscillator with quartz crystal control is shown above. A straight frequency line condenser is used for changing the frequency within the audible range.

In the diagram, coils L1 and L2 are the oscillator coupler. L3 and L4, the intermediate frequency coils, and L5 is a pick-up coil placed in proximity to L6. C2 has a capacity of .0007 mf. and C1 a capacity of .00035 mf., C5, C6, C7 and C9 are by-pass condensers, while C8 is a filter condenser. The apparatus is placed within a metal shield, preferably of aluminum. The outgoing audio current is produced by the interfering of two high frequency currents. The frequency is fixed by the dimensions of the quartz disk and its position in the holder. The particular oscillator shown here was designed to have a range from about 50 to 4,000 cycles. A thermostatic control is used for accurate work and a power amplifier can be used when a large amount of energy is required.

Oscillation

(47) Richard Langley, Hooker, Oklahoma, asks:

Q. 1. In a three-circuit tuner; what are the most obvious causes of too much oscillation? In other words, what causes a receiver to oscillate continually, it not being possible to stop the oscillations and use the receiver for broadcast reception?

A. 1. One of the most common causes of this effect, particularly in home-made receivers, is the employment of too many turns on the tickler coil. The remedy is obvious; remove sufficient turns to cause the receiver to operate correctly as a regenerative set but not to squeal. This should be done with the receiver tuned to the highest wavelength, which it is desired to receive. Ten turns on the tickler is often found sufficient for a coupler covering the broadcast wavelength.

Another cause of self-oscillation over the entire range is long grid leads and plate leads that are run parallel to each other. Remedy: separate the leads or run them at angles to each other. Also have grid and plate leads as short as possible.

Sometimes the addition of a by-pass condenser across the output of the detector circuit will aid considerably in controlling a continuously oscillating receiver. Also try adjusting the grid leak, the detector tube rheostat and varying the plate voltage applied to the detector tube. Changing tubes may be of further assistance.

A. C. Receiver Diagram

(48) Mr. G. C. Edwards, Tarrytown, New York, writes:

Q. 1. "I have one of the All-American 6-tube A.C. receivers. The receiver is working perfectly satisfactory, but I would like to know just what type of circuit is employed in this set. Can you publish the diagram for me? This should be of interest to a number of radio fans who own these sets."

A. 1. We are showing the requested diagram as Fig. 48. As you will notice, a system similar to the Rice method of balancing is employed. In this system, the voltages fed back through the internal capacity of the tube, from the plate to the grid, enter the secondary winding and pass down through part of the secondary coil to the filament. The voltages fed through the balancing condenser enter the winding at the opposite end and pass up through the winding to the filament. The voltages in these two circuits are made equal by adjusting the balancing condenser. Since the two halves of the secondary winding are *in opposition*, the two voltages balance each other and any tendency to oscillation is suppressed.

A number of by-pass condensers are employed to pass the radio-frequency currents and to obtain the zero-potential points in the filament circuits of the A.C. tubes. The aerial is coupled to the first tube through a variable condenser, which controls the selectivity of the receiver to some extent.

Selectivity

(49) Mr. W. M. Butler, Cedar Rapids, Iowa, writes:

Q. 1. In reading articles on the subject of selectivity in radio sets, I have noticed that various authors have different ideas on the subject and very often they are conflicting. For instance, I noticed some time ago, a reference to the use of large condensers and small inductance coils to give the greatest selectivity. Recently, I noticed a statement which said that a large inductance coil and small capacity gave the greatest selectivity. Which is correct?

A. 1. There are several points which must be considered when discussing the subject of selectivity. Considering an oscillatory circuit, in which we assume that the resistance remains comparatively constant over its complete tuning band, it would probably be better to use a large inductance and small tuning condenser; since this type of circuit gives a higher radio-frequency voltage than one employing a small tuning coil and large condenser. This fact can be proved both mathematically and by laboratory tests with various type of coils.

However, in most oscillatory circuits, the resistance does not remain constant, but varies considerable at different points of the band. *The resistance of the coil is usually much higher than the resistance of the condenser,* and the resistance of the condenser remains almost constant except at the low end of the capacity scale. From this standpoint, it would be better to employ an oscillatory circuit with a small coil and large tuning condenser; since a circuit is much sharper when the resistance is low than when it is high.

In general practice, however, there is a nominal value in which both the resistance and voltage are considered. In this way, by balancing the values of resistance and voltage in the circuit, a value will be found in which neither the voltage nor resistance is at the best point, but the complete oscillatory circuit supplies best results. Of course, this involves a different condenser value for each type of coil considered; and for this reason, no particular condenser can be recommended to give the best selectivity.

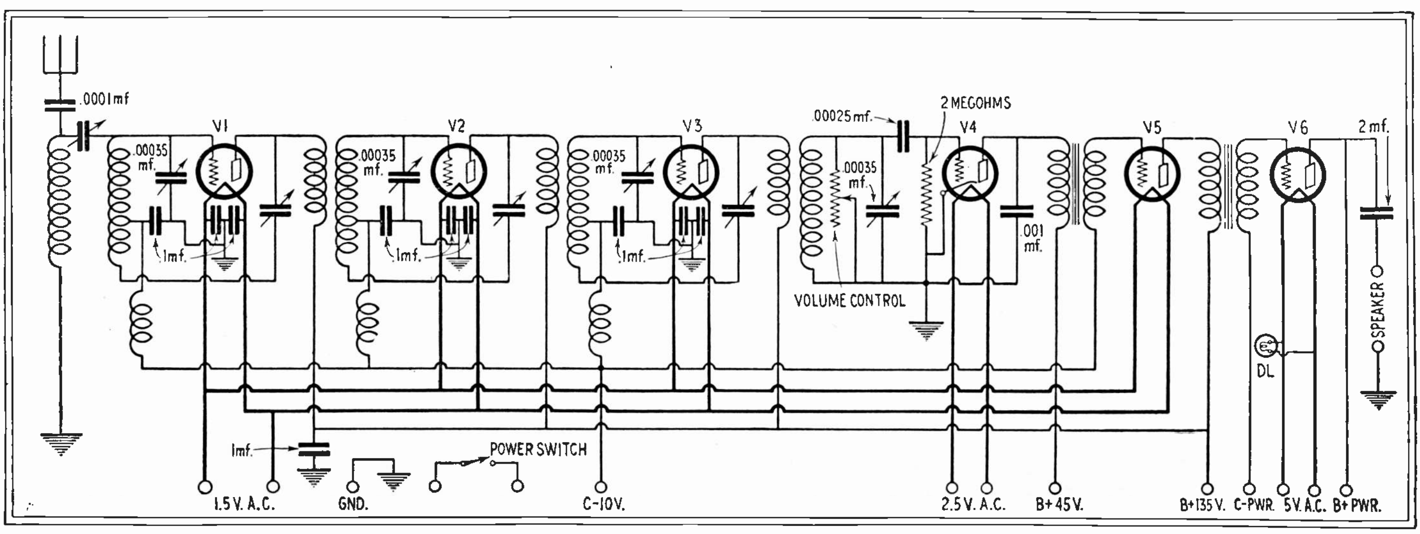


FIG. 48—The schematic diagram of the All-American 6-tube electric receiver, showing its special balancing method.

Popular Circuits

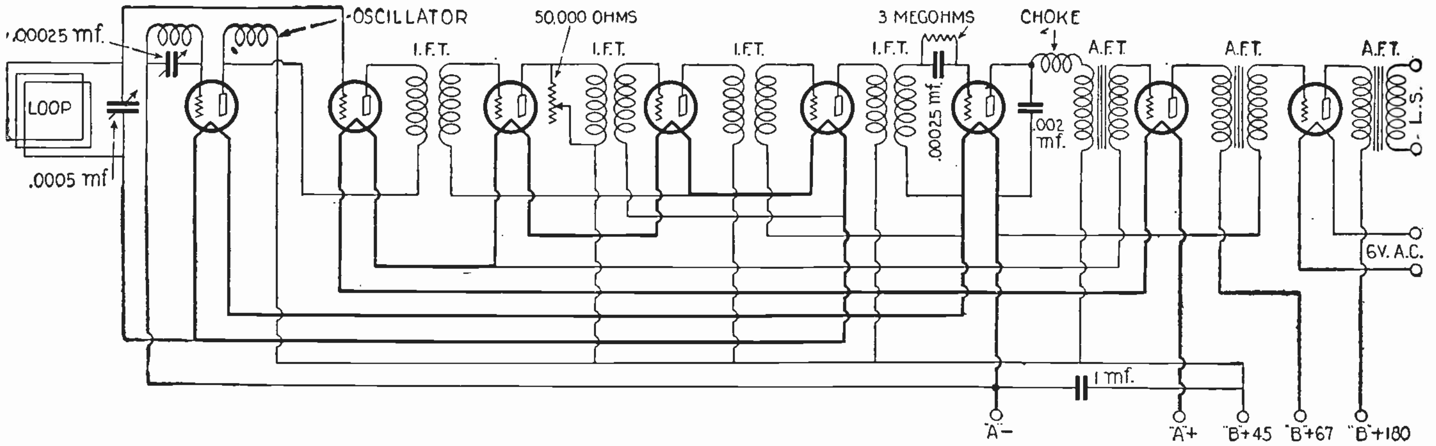


FIG. 50—This circuit shows how the Madison-Moore Superheterodyne may be adapted for use with an "A-B-C" socket-power unit. For this purpose the filaments are connected in series and a tube of the 350-milliampere type is used to supply both the plate and filament currents. The 500,000-ohm variable resistor in the second intermediate-frequency stage is used to control the volume of the set. The filament of the power tube is operated directly from the A.C. lighting source.

Madison-Moore Power Supply

(50) Mr. R. W. Wilson, Philadelphia, Pa., asks:

Q. 1. Please furnish a circuit diagram for the Madison-Moore superheterodyne with series filament connections, so that I may use the set in connection with an "A-B-C" power-supply device.

A. 1. The circuit that you requested will be found on this page. All the apparatus used is standard, and may be obtained for the ordinary Madison-Moore circuit. In order to obtain proper volume control, it will be necessary to shunt the primary of the second intermediate transformer as shown, with a 50,000-ohm variable resistor. The use of the filaments in series, so that they may be supplied from a power unit, necessitates tthe use of one of the new 350- or 400-milliampere rectifier tubes.

The Synchrophase Seven

(51) Mr. C. Williams, Salt Lake City, Utah, writes:

Q. 1. I would like to obtain copy of the schematic diagram of the Synchrophase Seven receiver. If possible, I would like to have you publish this diagram.

A. 1. You will find the diagram in Fig. 51. The designers of this circuit desired a receiver in which the fan need not fear altering the neutralization if tubes were changed in the set. The frequency-response curve of the average tuned-radio-frequency amplifier shows maximum response on some short wavelength with falling characteristics as the wavelength is increased. To overcome this difficulty, the variable condenser and two resistors were placed in the grid circuit of each radio-frequency amplifier tube.

The action of these units is twofold; first, they eliminate the effect of the tube's grid-filament capacity upon the tuned circuit, particularly on the low settings of the tuning condenser, in such a manner that the tubes could be changed without affecting the original resonance setting. Secondly, they control the voltage being fed into the grid-filament circuit of the amplifying tube, so that the radio-frequency input is practically uniform over the complete tuning scale. With this arrangement, and the inherent lack of regeneration in this system, a high degree of stability of amplification is afforded.

The four stages provide ample selectivity and sensitivity and are designed to possess sideband characteristics with minimized suppression for 1,000 cycles. The detector functions by the grid-leak method, affording maximum sensitivity and selectivity. The same compensating system utilized in the radio-frequency stages is resorted to in the detector input circuit, thus permitting the use of any detector tube without unbalancing the tuning system. A non-regenerative detector is used, because the four stages of tuned-radio-frequency amplification give sufficient sensitivity and selectivity.

The capacities used in the "tone color," to regulate the characteristics of reproduced voice and music, vary from .00008 mf. down.

Model C-7 Superheterodyne

(52) Mr. J. Hathaway, Weirsdale, Florida, asks as follows:

Q. 1. I would like to construct the C-7 type superheterodyne receiver which I am informed, has a high degree of efficiency and is very sensitive to weak signals. Any particulars regarding the construction of this receiver, also a list of parts, which I could use in the construction of this set, wherever it is impossible to make the instruments, will be greatly appreciated.

A. 1. The Model C-7 receiver was at one time manufactured by the Norden-Hauck Co., 1617 Chestnut St., Philadelphia, Pa. All information on this receiver published in these columns was kindly furnished by this company. The schematic wiring diagram will be found in Fig. 52.

List of Parts

One cabinet, 40x8x8 inches;
One panel, 40x8x¼ inches;
Eight binding posts;
One heterodyne condenser, .0005-mf.;
One wavelength condenser, .00025-mf.;
Three midget condensers, .000045-mf.;

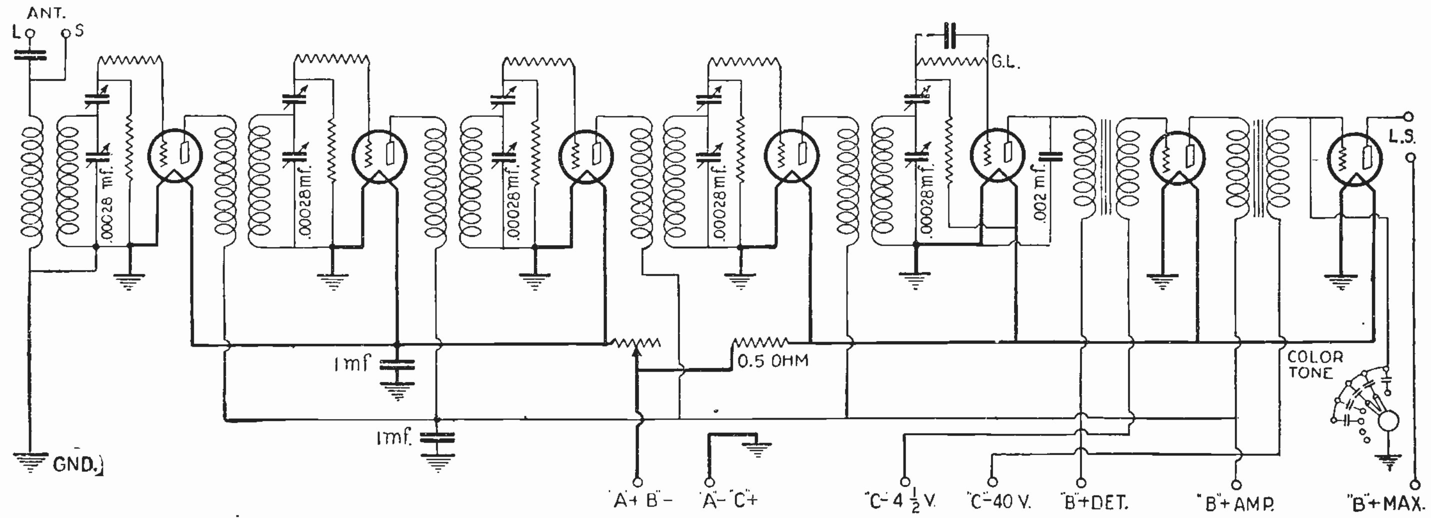


FIG. 51—The schematic diagram of the Grebe Synchrophase Seven is shown above. It will be noticed that a variable condenser and two resistors have been placed in the grid circuit of each of the radio-frequency amplifier tubes, in order to stabilize the set, regardless of changes in tubes employed.

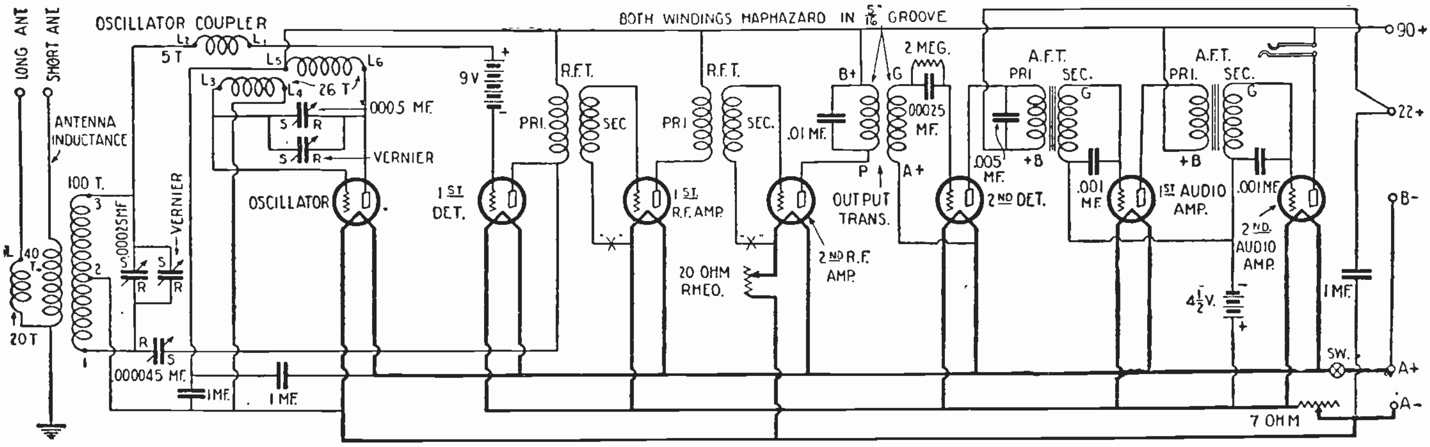


FIG. 52—The model "C-7" superheterodyne receiver; constructional details of the various parts will be found in the text. Intermediate frequency transformers, whose characteristic peaks are around 10,000 meters (R. C. A. 1716 will be satisfactory), may be employed.

One oscillator coupler, as per specifications below;
One output transformer, as per specifications;
Two radio-frequency transformers, Type "C" only E.I.S. special (or 1716's);
Two audio-frequency transformers;
Three "C" batteries, 4½ volts;
Three by-pass condensers, one .005.-mf., and two .001-mf.;
One open jack;
One grid leak, 2-megohm; and grid condenser, .00025-mf., with mounting;
Three by-pass condensers, 1.0-mf.;
Seven sockets;
60 ft. each No. 12 bus wire soft drawn tinned copper and No. 12 spaghetti, with necessary screws and nuts;
One filament switch;
Two 4-inch dials, and knobs;
One antenna inductance (see below);
Two mastter rheostates, one 7-ohm and one 20-ohm;
One fixed condenser, .01-mf.;
One voltmeter, 0-7, 0-140 scale, and one ammeter, 0-3 amps. (optional as extra equipment).

Coil Specifications

Oscillator Coupler: form is a 3½-inch tube, ⅛ inch thick, 2⅝ inch long. Start ¼ inch in from edge and wind 26 turns of No. 20 D.C.C. wire, two-layer bank winding (L5, L6); start ¼ inch over and wind 26 turns of No. 20 D.C.C. wire, two-layer bank wound in the opposite direction (L3, L4); start ¼ inch over and wind 5 turns of No. 20 D.C.C. wire, two-layer bank winding in the same direction as the first coil. Connect as shown in the schematic wiring diagram. (L1, L2).

Output Transformer: form is 2 inches inside, 4 inches outside diameter, with a winding space 5/16 inch wide; the primary is 100 turns of No. 28 D.C.C. wire wound at random; the secondary 300 turns of No. 28 D.C.C. wire, wound in the opposite direction.

Antenna Inductance: primary form, 1¾-inch tube, 1/16 inch thick, 2⅝ inches long. Wind 20 turns of No. 32 D.C.C. wire, in 2-inch winding space, and equally spaced from ends of tube (L). On top of the first coil, and separated from it by a piece of paper, wind 40 turns of No. 32 D.C.C. wire in same direction; Secondary form—2-inch diameter x1/16-inch wall x2⅝-inch long formica tube. Wind 100 turns of 10-strand No. 38 (Litzendraht) with a tap at 50 turns. Wind in opposite direction from the two primary coils and spaced evenly from ends of the tube.

Oscillations and the sensitivity of the receiver may be controlled by the insertion of a 400-ohm potentiometer (in the proper manner) at points marked "X" in the intermediate-frequency stages. One may be used for both stages.

Neutrodyne With Regeneration

(53) Mr. James Sherlock, Detroit, Mich., writes:

Q. 1. I wish to build a neutrodyne receiving set with regeneration. I have never seen the hook-up for such a set but see no reason why it should not be possible to use such a combination. Can you send me the details about such a set and let me know if it would be satisfactory?

A. 1. Yes, a receiving set of this type may be constructed. In building such a set the specifications are exactly the same as those for a non-regenerative neutrodyne except that a variometer is connected in the detector plate lead. This regeneration does not disturb the bridge arrangement or radio frequency amplifiers and usually improves the results obtained with sets of this type. Simply follow the wiring diagram for any good neutrodyne and add the variometer.

Freshman Masterpiece

(54) Mr. J. Lyons, Roxbury, Mass., asks:

Q. 1. Can you furnish me with a wiring diagram of the new Freshman Masterpiece receiver, and the circuit diagram of the firm's power amplifier, which operates directly from the 110-volt alternating current line?

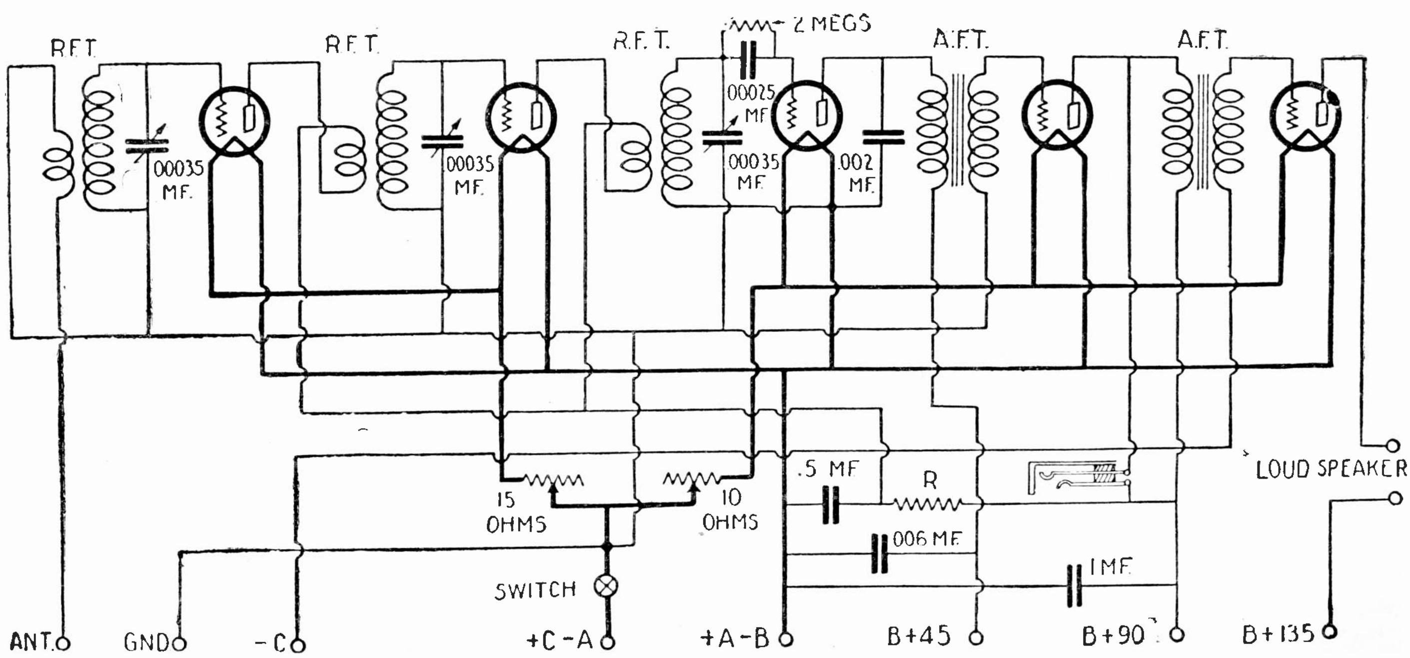


FIG. 54—The wiring diagram of the Freshman receiver, comprising two stages of tuned-radio-frequency amplification, detector and two stages of transformer-coupled audio-frequency amplification. The receiver is well shielded, and the cable scheme of wiring is employed.

A. 1. The two circuits requested are illustrated in Figs. 54 and 54-B.

A UX-210 power tube is employed in the power amplifier and a UX-216B for the rectification, the latter tube being of the half-wave rectifier type. Constructors may easily assemble an amplifier of this type with apparatus obtainable in any radio store.

The receiver consists of two stages of radio-frequency amplification, detector stage, and two stages of transformer-coupled audio-frequency amplification. This combination produces sufficient loud-speaker volume for ordinary operation. Those desiring extreme volume can easily obtain this additional factor by simply connecting the power amplifier to the receiver.

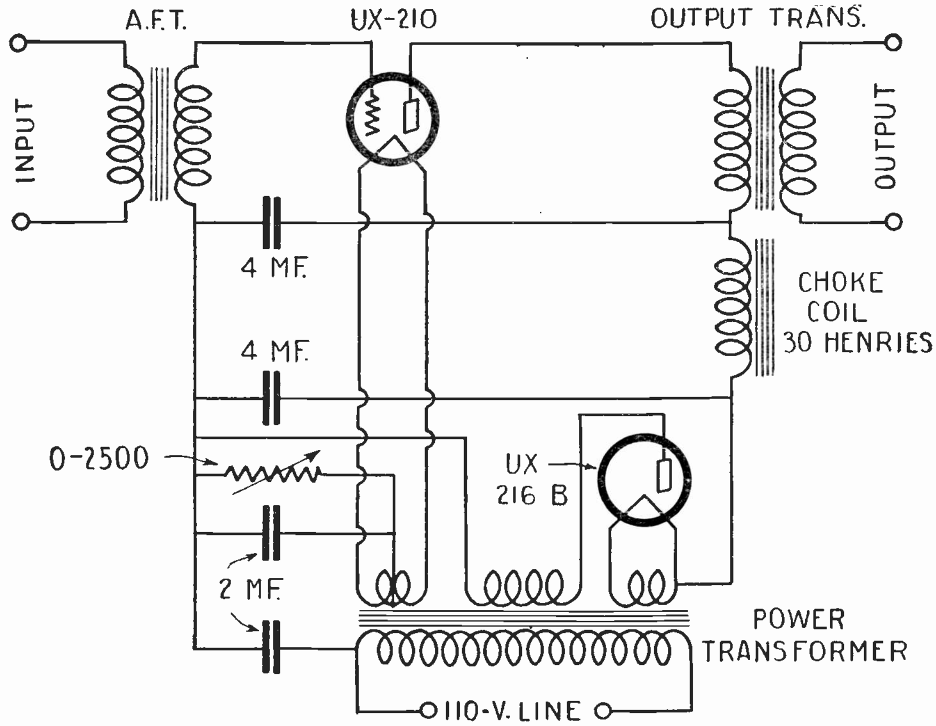


FIG. 53-B—A "B" eliminator and power audio-stage unit, the circuit of which is exactly similar to that employed by the Freshman Amplifier. It is possible to tap off from this device and obtain "B" current for the receiver

Samson Dual T.C. Receiver

(55) Mr. Martin, Jersey City, N. J., asks:

Q. 1. Can you furnish me with the complete schematic wiring diagrams of the Samson Dual T.C. receiver and all other details such as coil construction, list of parts, etc.? This will be of help to me when constructing this set, and for this information I will be greatly indebted.

A. 1. The Samson Dual T.C. circuit has been previously described in *Radio News*; but since then a later factory model has become available. The following are the specifications and description of that particular model. Incidentally, this model when tested performed unusually well, giving much more volume than is usually obtained from five-tube receivers. The quality also was excellent and extremely pleasing to the ear. This is undoubtedly due to the special type of audio amplifier incorporated in the receiver, which uses the new Donle system of audio amplification.

The receiver consists of one stage neutralized-R.F., a regenerative detector with variable coupling on the input R.F. transformer (one unit composing three coils) one stage transformer-coupled and two of dual-impedance A.F.)

The following are the list of parts employed in the construction of the set:

- 2 Variable condensers, .0005-mf. (C and C1);
- 1 Neutralizing condenser, adjustable (C2);
- 1 Fixed grid condenser, .0005-mf. (C3);
- 1 Fixed condenser, .0001-mf. (C4);
- 1 Fixed condenser, .0001-mf. (C5);
- 1 Aerial coupler (L);
- 1 Double-rotor coupler (L1);
- 2 Radio-frequency chokes, 85-M.H. (L2, L3);
- 2 Dual impedances (T1, T2);
- 1 Audio-Frequency Transformer, low-ratio (T3);
- 3 Automatic filament controls, 5-v. ½-amp. (R, R1, R2);
- 1 Grid leak, 9-meg. (R3);
- 1 Volume control, 500,000-ohm max. (R4);
- 5 Sockets, UX type;
- 1 Battery switch (SW);
- 2 Tip jacks (L.S.);
- 2 Vernier dials;
- 11 Binding posts;
- 1 Panel, 7x21x3/16-inch;
- 1 Baseboard, 9x20x¼-inch;
- 2 Brackets.

The receiver is, from an electrical viewpoint, very carefully designed. For example, in the tuned-R.F. stage neutralization is provided for and made easy by the correct placement of the R.F. choke coil, L2, in the grid-return lead of this stage. In the detector stage there is incorporated regeneration controlled by means of a rotor or "tickler" coil. Any stray R.F. currents are kept out of the audio amplifier by means of another R.F. choke coil, L3.

The volume of the receiver is controlled by a variable resistance, R4. This particular method of volume control is much more effective and efficient than employing filament rheostats and reducing volume by reducing the filament temperature of the tube; since the tonal quality is not in any way altered by the first method.

Coil Specifications

Aerial coil, L: tube 2½ inches in diameter, 3¼ inches long; primary 18 turns of No. 26 D.C.C.; secondary 54 turns of the same-sized wire.

Double-rotor coupler, L1: tube 2½ inches in diameter, 3½ inches long; primary (lower rotor, P), 40 turns of No. 28 D.C.C.; secondary, S, 54 turns of No. 26 D.C.C.; tickler (upper rotor, T) 16 turns of No. 28 D.C.C. The primary of this unit is wound on a rotor coil, as well as the tickler, in order that coupling between primary and secondary windings may be varied at will; which permits a variation in the selectivity-and-sensitivity factor.

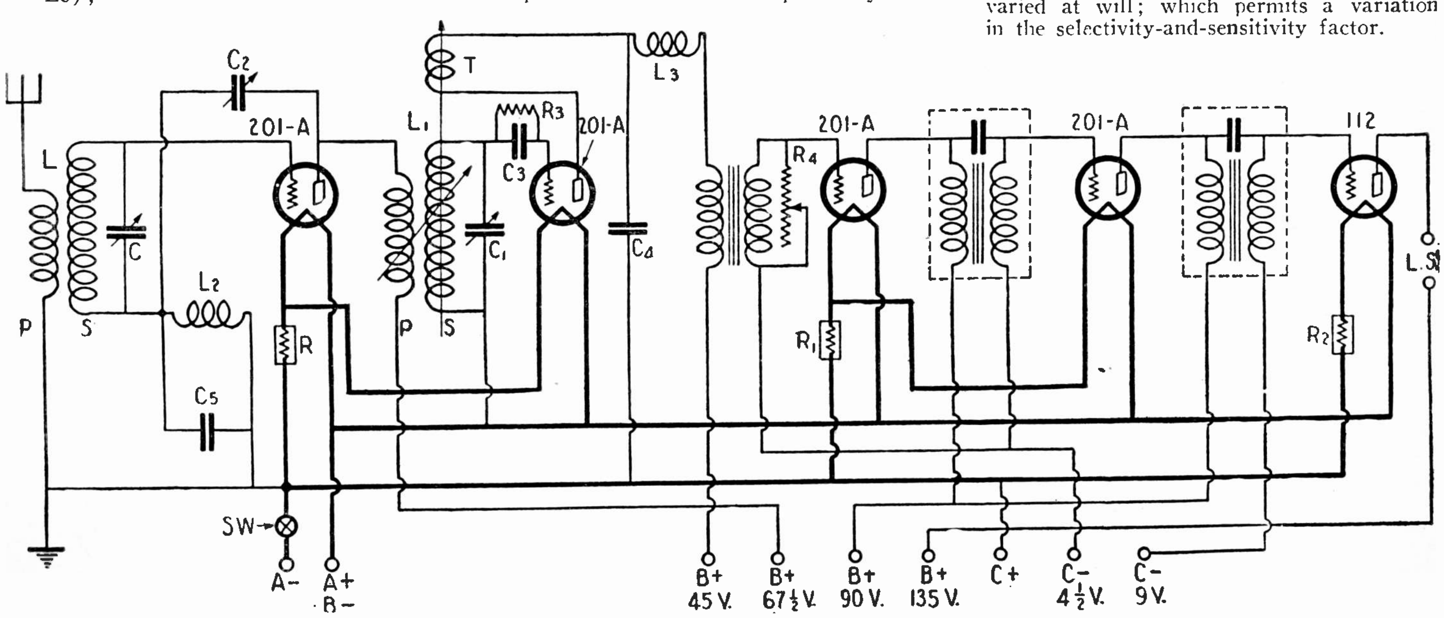


FIG. 55—The circuit employed followed in the wiring of the Samson Dual T.C. receiver consists of a stage of neutralized R.F. amplification, a regenerative detector, one stage of transformer coupled audio frequency amplification and two stages of audio.

In constructing these I.F. units, the transformer condenser is not varied to tune the transformer, in connection with an oscillator and wave meter as is often done; but the number of turns on the secondary is changed until the circuit is balanced to within a fraction of 1 per cent accuracy.

Note that the grid return of the second detector goes to the "filament plus" on the tube socket. Be sure to test all rheostats, and all condensers, including the fixed unit, to see that they are not short-circuited or open-circuited before you install them. It is important to keep the "A" battery always well charged in operating superheterodynes, and a storage "B" battery is desirable.

A Quality Superheterodyne

(56) Mr. Geo. Taber, Cornwall, N. Y., asks:

Q. 1. I am desirous of constructing a superheterodyne combining the latest type of R. F. amplification with an audio amplifier designed for quality reproduction. Could you supply me with complete information and schematic wiring diagram of such a receiver, employing preferably 9 tubes, with push-pull amplification in the last stage?

A. 1. As we all know, a superheterodyne is considered the most sensitive set yet developed, and, if good results are to be obtained, it must be so designed that it is not encumbered with internal parasitic noises. Then again, a set of this type must possess unusual selectivity to overcome the terrific congestion on the present-day broadcast waveband. Another drawback, due to the exceptional sensitivity of a good superheterodyne, is that the input energy of the audio amplifier is excessive when receiving local stations. Nearly all audio amplifiers, and even the second detectors in these sets, are incapable of holding such a great amount of energy without serious distortion. These are but the few of the problems which have come up in relation to superheterodyne receivers.

The superheterodyne we are about to describe was designed by Mr. A. E. Poté and originally described by him in the *New York Herald Tribune*. In this receiver an entirely new form of I.F. amplification is employed. Reference to the schematic diagram will show that the I.F. amplifier is of the choke coil-impedance-coupled type, very similar to an ordinary impedance-coupled audio amplifier. R.F. chokes having a value of 500 millihenries are used in the plate circuits of the three I.F. tubes V2, V3 and V4 and the first detector tube V1. Standard-type resistors R1, R2 and R3 are used in the grid circuits.

This particular I.F. amplifier is not peaked at any one frequency; in other words, it is perfectly impartial to all frequencies and will amplify one equally as well as another To put it in another way, this type of amplifier has no selectivity whatsoever. It would seem that we are losing efficiency and selectivity here; however, here is where the band-pass filter or filter transformer comes into play. This filter, indicated as L5 in the diagram, is tuned to 45 kc. and allows a 10,000-cycle band of frequencies to pass. This includes just the normal audio frequency band which we desire to get through and no more. The filter is connected in the usual manner in the input circuit of the second detector tube V5.

Referring to the schematic wiring diagram (Fig. 56), the antenna circuit is tuned to a signal and the oscillator circuit adjusted to produce a beat-frequency of 45 kc. This frequency is passed through the first detector tube V1 and amplified in the I.F. amplifier; but this will amplify any other intermediate frequency just about as well as 45 kc. As mentioned above, there is no selectivity whatsoever present in these stages. The band-pass filter now separates the 45 kc. from all the rest of the frequencies and lets it pass through, with 10,000 cycles on each side of it, to take care of speech and music. In this manner all of the selectivity is gained by the use of the band-pass filter, without any of the usual troubles experienced when employing tuned or untuned transformers which are hard to stabilize.

No potentiometer or other form of oscillation control is used for stabilizing the I.F. amplifier; nothing of this sort is necessary, since the tubes are operated at maximum efficiency at all times and work with a negative bias on the grids. As stated before, the band-pass filter is tuned to a frequency of 45 kc. This was found to be about the best point of operation, but it is obvious that, since the choke-coupled amplifier itself is not tuned to any definite intermediate frequency and amplifies one band as well as the next, the band-pass filter can be tuned to some other frequency if it is found desirable. This can easily be done by altering the values of the fixed condensers C9 and C10, which in this particular case are .001-mf.

The A.F. circuit is rather unique. This superheterodyne is so sensitive that it was found necessary to employ plate rectification in the second detector tube V5 in order to eliminate distortion due to overloading. Consequently the grid leak and condenser were dispensed with and the grid return of this tube run to a "C" battery having a negative value of 4½ volts. Incidentally, the same "C" battery is used to bias the grids of the I.F. tubes. The audio amplifier consists of one stage of transformer coupling and a push-pull stage using two power tubes of the 171 type. The reason for this arrangement is the fact that, when not more than one stage of transformer amplification is used, distortion is practically eliminated without decreasing the volume perceptibly.

Semi-power tubes of the 112 type could be used in the push-pull stage of this receiver, but they are not large enough electrically to handle the load. The 171 tubes, however, are perfectly satisfactory; the two of them used in this manner are equal to a power tube of the 210 type and will require only 180 volts of "B" battery. It will be noted from the diagram that a push-pull impedance T2 is used at the output, rather than another push-pull transformer. This is by far the best method; this is the first time it has been employed in an audio amplifier. It takes the place of the usual type of output impedance or output filter and, in one sense, it is a cheaper arrangement, as no blocking condenser is required.

All the tube filaments are controlled by a single power rheostat R5, as there is no necessity for critical filament adjustments. The volume is controlled by a 500,000-ohm variable resistor R4 connected across the grid resistor of the first I.F. tube V2. Since the choke-coil I.F. amplifier is capable of amplifying high frequencies, a R.F. choke L2 having a value of 85 millihenries is connected in the plate circuit of the first tube to keep the R.F. currents out of the amplifier circuits.

A choke of 85 millihenries is also connected in the oscillator "B" battery lead, to keep the oscillator currents out of the common battery circuit. Two more chokes L4 of 500 millihenries are used in the common plate and grid leads of the intermediate amplifier to keep any of the I.F. currents from leaking into the battery circuit; also two A.F. chokes, L7 and L8, to keep the A.F. currents where they belong.

The following is the list of parts necessary for the construction of this receiver:

1 antenna coupler, L;
1 double-wound oscillator coupler;
3 I.F. impedances, L3;
2 chokes, 500-millihenry, L4;
2 chokes, 85 millihenry, L2;
1 band-pass filter, 45 kc., L5;
1 R.F. choke, 250-millihenry, L6;
1 A.F. choke, 30-henry, L7;
1 A.F. choke, 3.5-henry, L8;
2 variable condensers, .0005-mf., C, C1;
1 neutralizing condenser, 45-mmf., C2;
2 by-pass condensers, .001-mf., C3, C12;
4 fixed condensers, .002-mf., C6, C7, C8, C11;
2 fixed condensers, .001-mf., C9, C10;

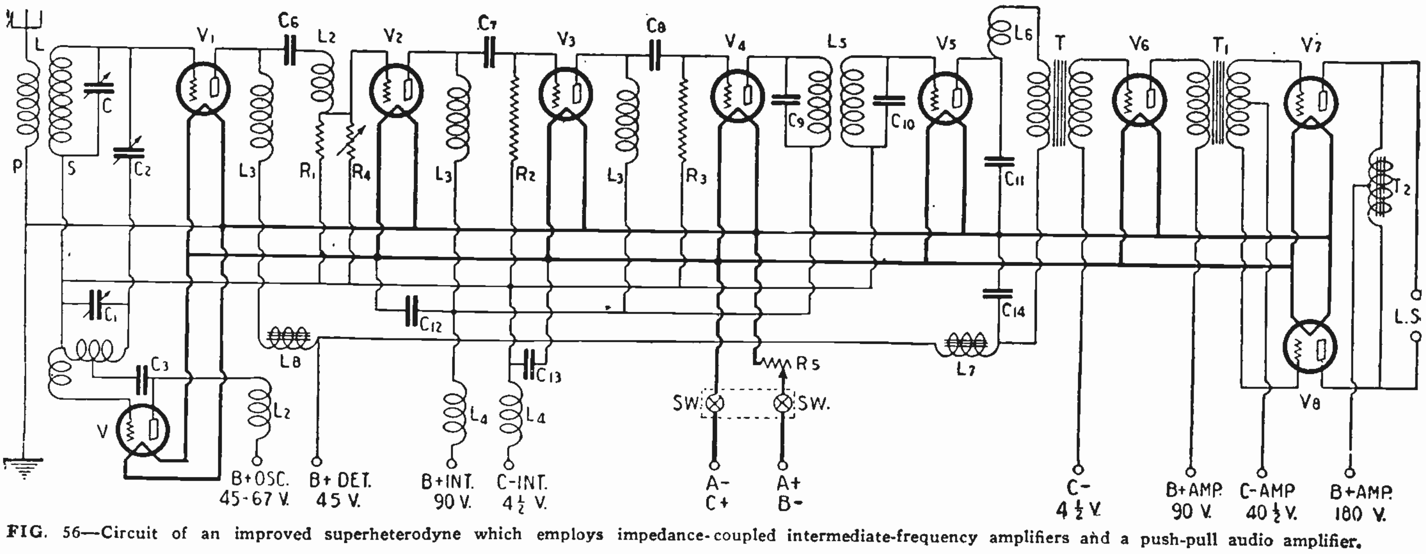


FIG. 56—Circuit of an improved superheterodyne which employs impedance-coupled intermediate-frequency amplifiers and a push-pull audio amplifier.

2 fixed condensers, .001-mf., C9, C10;
1 by-pass condenser, 1-mf., C13;
1 by-pass condenser, 4-mf., C14;
1 by-pass condenser, 2-mf., C15;
3 resistors with mountings, .05-megohm, R1, R2, R3;
1 volume control, 500,000-ohm, R4;
1 power rheostat, 2-ohm, R5;
1 audio transformer, T;
1 push-pull transformer, T1;
1 push-pull impedance, T2;
1 voltmeter, 0-8 volts;
1 switch, D.P.S.T.;
7 vacuum tubes, type 201-A, V, V1, V2, V3, V4, V5, V6;
2 vacuum tubes type 171, V7, V8;
9 sockets, UX;
1 seven-wire battery cable and plug;
2 tip jacks for loud-speaker connection;
2 binding posts (antenna and ground);
2 vernier dials;
1 bakelite panel, 8x24;
1 sub-base panel, 11x23;
2 mounting brackets;
1 roll of flexible hook-up wire.

Synchrophase Seven Receiver

(57) Mr. S. Jacobson, Brooklyn, N. Y., asks:

Q. 1. Kindly print in your columns the description of the latest type of Synchrophase receiver. This is a seven-tube set and employs coils of the binocular type.

A. 1. We are indebted to A. H. Grebe Co. for the following description of this receiver.

Principally by the combination of ingeniously-devised tube-isolating circuits and fieldless, space-wound, binocular coils, the following improvements have been achieved: greater and more uniform signal response and selectivity on both the high and low wavelengths within the broadcast band; nullification of all tendency toward oscillation; removal of detuning effects due to differences in vacuum-tube characteristics of any one type; liberal tuning leeway on dial below and above broadcasting range; elemination of critical tuning effects on low wavelengths; accurate matching of tuned stages on all broadcast wavelengths.

The fieldless properties of the binocular coils overcome feedback between the tuned stages and prevent signals from entering the detector except through the first radio-frequency stage. The space-winding of this wire produces a marked increase in selectivity on the shorter wavelengths, where selectivity is particularly desirable.

Close scrutiny of this circuit reveals that we have four stages of tuned R.F. amplification, a detector and two stages of A.F. amplification; the last audio stage being designed for use with a 171-type power tube. In all we have five tuned stages, requiring five available condensers, with a maximum capacity of .000275-mf. each.

These five individual variable condensers, horizontally mounted and rigidly secured in place, are driven in unison by a three-point tuning-drive device, which is connected with the single dial and vernier on the front of the marquetry panel. The rigidity of the tuning condenser assembly insures the permanency of the accurate factory adjustment.

The letters L and L1 indicate the binocular coils in the schematic diagram. (Fig. 57.) L1 is the primary coil, which is the same in each stage throughout the receiver, and consists of thirty-five turns of No. 36 wire. The secondary coils are divided into two halves, each having 122 turns of 10x38 Litz wires.

In the grid circuits of the tuned stages, R, R1 and C1 comprise the newest Grebe feature, the tube-isolating circuits, through which more uniform signal response and better reception on the low wavelengths are obtained, as well as nullification of excess oscillation.

Briefly, the tube-isolating circuit consists of an adjustable condenser having a maximum capacity of 100-mmf., a resistor R, with a value between 3 and 8 megohms, and a second resistor, R1, value 425 ohms.

Note carefully that all of the "A—" terminals are connected to the aluminum "deck," this acting as a ground and master-connector. Where such connections are made, they are indicated by the conventional "ground" symbol. Thus the "A—" terminal goes directly to the shield (deck) and to a small by-pass condenser.

The detector stage is slightly different (*i.e.*, the tube-isolating circuit) in that we have here one less resistor; and the remaining one is connected between the grid and the "A+." The adjustable capacity remains at the same maximum as in previous stages, and in the same place in the circuit.

The receiver is adaptable to use with either a short or long aerial, having facilities in the antenna circuit, in the form of a direct connection and a series-condenser connection, for use with either type respectively.

The method employed by the designers of the Synchrophase Seven, of operating five variable condensers through one dial and a tangent vernier, which is unusual, utilizes a three-point driving device which controls through its main shaft the five variable condensers simultaneously. Perfect control and synchronization is had throughout the entire wavelength range by the final factory adjustment of the various tube-isolating capacities.

These capacities, it will be noted by referring to the accompanying diagram, are adjustable, final adjustment being made before the set leaves the testing room.

Operating on six 201A-type and one 171-type (power) tubes, the Synchrophase Seven is suited for operation with any standard type of A and B power unit. When this receiver was tested with a standard socket-power unit, supplying both "B" and "C" voltages, no hum or "motorboating" was noticeable in the reception on the loud speaker.

Voltages varying from 22 to 180 are required for the plate supply; 90 volts for the four R.F. and the first audio stages, 22 volts for the detector, and 180 volts for the 171-type tube.

A negative bias of 4 volts is fed to the grid of the first A.F. tube, and 40 to the grid of the power amplifier.

Because of the greatly-improved quality output, due to the use of specially designed A.F. transformers, this receiver is particularly adaptable to use with the modern cone type of loud speaker. These transformers employ heavy cores with a great many turns of well-insulated wire. A chart, drawn to indicate the frequencies which these transformers reproduce with fidelity, shows almost a straight line; which indicates that they reproduce faithfully practically the entire range of audible frequencies.

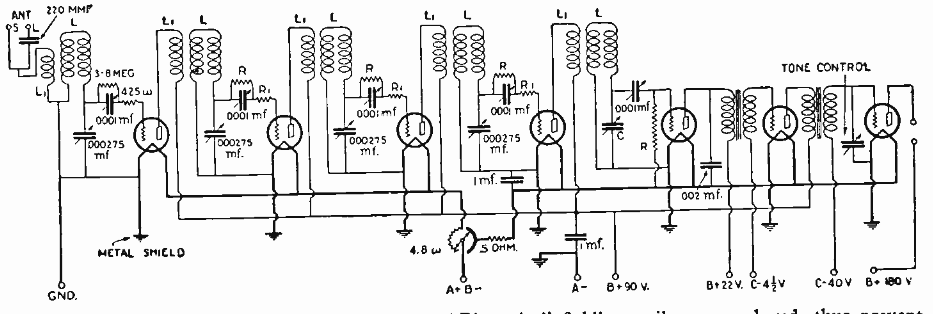


FIG. 57—A seven-tube receiver of recent design. "Binocular" fieldless coils are employed, thus preventing any feed-back and oscillation due to interaction between coils.

Improved Ambassador Set

(58) Mr. D. Nelson, Paterson, N. J., asks:

Q. 1. Kindly furnish me with a schematic diagram and constructional data on the revised Ambassador 4-tube set. This set employs one stage of radio frequency, detector, and two stages of audio frequency with an output filter.

A. 1. We give here the schematic diagram of this popular circuit, which is simple and economical of construction, besides possessing a great deal of selectivity and good receiving range. This receiver was recently described in the *New York Telegram* by Jack Grand. This compact set can be easily assembled on a 7x21-inch panel, and features a double-primary antenna coil, a double-primary 3-circuit tuner, and a new method of neutralization. By means of a single-pole double-throw switch, the primaries of the antenna coil can be changed to vary the degree of selectivity.

The 3-circuit tuner also employs the double primary in a similar manner by locating the exact electrical center of the primary to be used in neutralizing. Both the antenna and the 3-circuit-tuner secondaries may be tuned by .0005-mf. condensers of standard make. There is no need of a neutralizing condenser in this circuit, as the center tap on the primary inductance makes the latter act as two arms of a Wheatstone Bridge, while the two other arms are the grid-plate capacity and the grid filament capacity. The .01-mf. fixed condenser is used to keep the "B" battery voltage off the grid of the tube. This method is preferable to a variable neutralizing condenser, as it eliminates an additional control, simplifying the operation of the set.

This receiver employs only four tubes, but the results obtained compare very favorably with any number of six-tube sets now on the market. It is built for power, the circuit consisting of a stage of balanced tuned radio frequency, a regenerative detector and two stages of transformer-coupled audio amplification, with an output filter between the last tube and the loud speaker. This system allows the use of a power tube which employs high plate voltage without danger of burning out the loud speaker. The antenna coil and the 3-circuit tuner can be constructed by the average set builder, although they are easily obtained from any reliable dealer.

For the benefit of the home constructor the following data will be of some assistance:

Specifications

The primary of the radio-frequency coil has 6 turns for each of the two primaries, and the secondary has 52 turns of No. 26 D.S.C. wire on a 2⅜-inch form. The 3-circuit tuner has the same constants as the antenna coil, but in addition has a 14-turn tickler of No. 30 D.C.C. on a 1½-inch form. The space between the primaries and secondaries is 5/16-inch. In the construction of this coil it is suggested that six binding posts be used; two for each primary and two for the secondaries. The same is recommended for the three-circuit tuner, with two additional binding posts for the tickler, making a total of eight.

It will be found that, by having each primary on a separate binding post, one can do quite a bit of individual experimenting for his own particular location. It is also suggested that various-colored wires be used on these coils; such as white for one primary and blue for the other.

The audio transformers should be chosen with care, since hêre lies the secret of tone quality. Transformers recommended are those which would match best with parts used. The filter system between the last tube and loud speaker consists of a 30-henry choke and a 2-mf. condenser, although there are other combinations that can be used.

The choice of tubes is of the greatest importance in any set. For the radio-frequency stage any one of the special tubes made by a reliable manufacturer is recommended, such as Ceco type K, or tubes of the 201A type. A 201A or a Ceco type H will be satisfactory, the latter tube operating best with a plate voltage of 67 to 90. The first audio tube is not very critical; a 201A or Ceco type A tube may be used. In the power stage, the choice of the proper tube requires a great deal of consideration. In the event that 135 volts is used, a tube of the 112 type, or Ceco type F, can be used with a 9-volt negative grid bias. If a 171-type tube is employed, 27 volts of "C" bias is required. At 180 volts, these tubes require 40½ volts of "C" battery.

Automatic filament controls are used for all tubes, with the exception of the radio-frequency tube, which employs a combination rheostat and filament switch. This also adds to the simplicity by putting two units under one control. The rheostat for the radio-frequency tube acts as a volume control in conjunction with the tickler. In this way, the volume may be varied before the detector, resulting in a minuimum of distortion; as only the signal intensity is varied.

Parts Required

The following is the list of parts used in the construction of this set:

Two vernier dials; one pointer knob; one 7x21 panel; one 5¼x20 sub-panel; one pair sub-panel brackets.

Two .0005-mf. variable condensers; one double-primary tuning coil; one double-primary antenna coil; one single-circuit jack; one combination switch and rheostat; four UX sockets; two audio transformers; one output filter; eleven binding posts.

Two ¼-amp. and one ½-amp. filament ballasts; one 2-mf., one .01-mf., one .001-mf. and one .00025-mf., fixed condensers; one 2-meg. leaks, and one aerial switch.

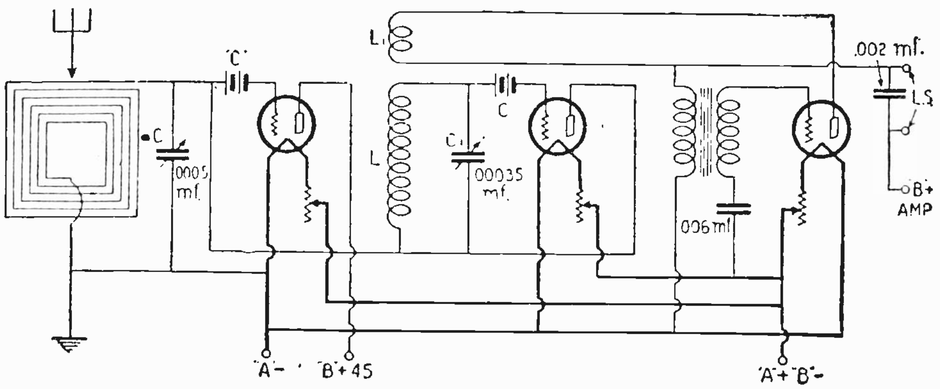


FIG. 59—The schematic diagram of the Retrosonic three-tube receiver, with which a loop in combination with an aerial is employed.

Construction

The following information will be of assistance when wiring the receiver:

First, study the schematic diagram and have a mental picture of the layout impressed upon your mind. It is not advised that metal brackets be employed in this particular circuit. For socket holes it is recommended that a good circle cutter be used and, after holes are cut for the size of socket, bring the socket up from under side of sub-panel and fasten securely. The screws used in fastening the sockets to the sub-panel are used also as connecting terminals.

After a wire has been traced from one point to another and the connection made, that line should be crossed off the diagram. This is a good method for checking wiring, as the wire that is not crossed off is not connected. After the set is completely wired, it is ready to be tuned. The following method may be followed:

Adjustment

Set the tickler at a slight angle and tune your condenser dials until you hear a slight squeal (if no squeal is heard, reverse the tickler connections). This is a signal that you have a station. Swing the dials slowly until you bring the station in as loud as possible. You can then manipulate the tickler to increase or decrease the volume. If all instructions are followed carefully, and if you have a good antenna and ground connection, a good loud speaker and batteries, excellent results should be obtained from this set.

The arrangement of parts and wiring should be carefully considered. Poor placement may result in feed-backs and oscillations which are hard to locate and eliminate. All apparatus should be inspected for possible loose contacts, open or short circuits.

This receiver should appeal to all who want one that is easily tuned and delivers sufficient volume combined with excellent tone quality. There is no danger of any oscillations being radiated, since the neutralization of the first radio-frequency tube prevents any feed-back from the oscillating detector into the first stage and thence to the antenna. We are thereby enabled to take advantage of the extra sensitivity afforded by a regenerative detector, which in itself is equivalent to an extra stage of radio-frequency amplification.

The Retrosonic Receiver

(59) Mr. M. Perran, Niagara Falls, New York, writes:

Q. 1. I have noticed in magazines references to the Retrosonic receiver, which I understand is popular in European countries. I have seen several diagrams of this receiver, but unfortunately the constants of the different parts were not given. Can you supply me with a schematic diagram of this set giving the values of the different components?

A. 1. In these columns will be found the

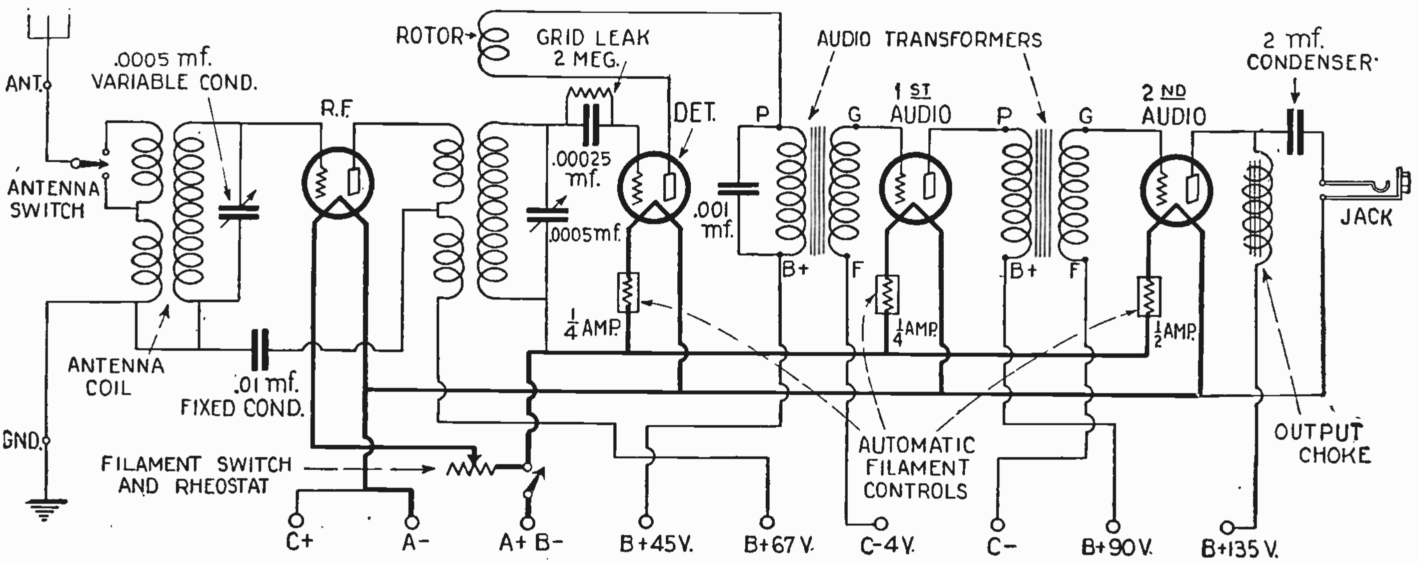


FIG. 58—Above is the circuit diagram of the Ambassador four-tube set, a very efficient and sensitive receiver, employing one stage of tuned radio-frequency with a regenerative detector, and two stages of transformer-coupled audio-frequency. An output filter is used to protect the loud speaker.

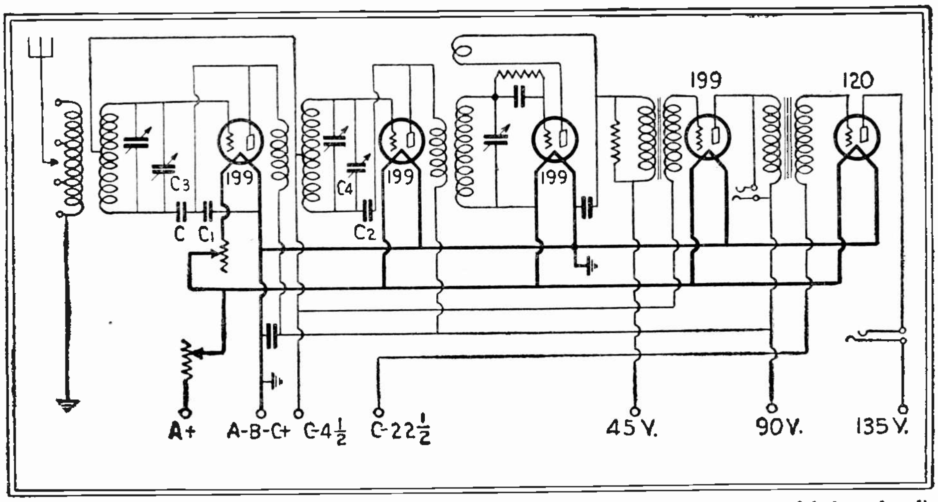


FIG. 61—Circuit diagram of the popular "Radiola 20" five-tube receiver. Two stages of balanced radio frequency, with a regenerative detector, provide unusual sensitivity.

diagram of this receiver. The following are the parts used in its construction: One standard loop aerial; one .0005-mf. variable condenser; one .00035-mf. variable condenser; two cardboard tubes, each 3½ inches in diameter and 3 inches long; four ounces No. 24 D.S.C. wire, for coil L; two ounces of No. 28 D.S.C. wire, for coil L1; two "C" batteries (tapped); one audio transformer, 5:1 ratio; one .006-mf. condenser; one .002-mf. condenser; three sockets; three rheostats; one panel, 7x20 inches; binding posts, bus bar, etc.

The windings of coils L and L1 are absolutely elementary. L consists of 64 turns of No. 24 wire and L1 consists of 89 turns of No. 28 wire. Both coils are wound in single-layer style, and separated by approximately 4 inches; although the exact distance must be found by experiment. Two 4½-volt "C" batteries, tapped at 1½ and 3 volts, will be quite satisfactory. The best position of the aerial connection on the loop must be found by means of a clip. With the clip temporarily connected to the terminal of the loop which goes to the first "C" battery, tune in some local station by means of the two variable condensers. Adjust all three rheostats for best volume, that is, for the time being. Disregarding the degree of selectivity, try changing the position of coil L1 with respect to L, remembering that for each such adjustment condenser C1 should be readjusted. Now turn your attention to the aerial, trying different taps on the loop until the greatest volume is had. For local stations, changing the clip on the loop will not apparently make any difference, but for distant stations it should be adjusted carefully.

When tuning for distant stations always remember to point the edge of the loop in the direction from which the transmission is expected. By this means you will get fair volume; but the maximum signal strength will be had only when the correct position of the aerial has been determined. This tapping of the loop is the key to the set's ultimate efficiency and, so, too much care cannot be expended upon it. As each station comes in note the particular portion of the loop which gave the best results. However, before the set can be considered finished, the coupling between the two coils should be adjusted on a distant program and a trial should be made of reversing the connection to the primary of the audio transformer.

Laboratory Superheterodyne

(60) Mr. C. G. Moseley, Borger, Texas, asks:

Q. 1. Kindly publish the schematic wiring diagram of the Improved Laboratory Superheterodyne using the time-signal amplifier, with the new heated-cathode type of raw-A.C. vacuum tube.

A. 1. You will find the diagram you request at Fig. 60. The intermediate-frequency amplifier is tuned to 112 kilocycles, which is equivalent to 2675 meters. This makes the intermediate-frequency amplifier suitable also for receiving time signals from station NAA, Arlington, Virginia. The components of the set are the same as those specified for D.C. operation, except for the filament supply. The filament connections to the time amplifier are left open and the A.C. filament wiring is put in separately. The tuning coils used in this receiver are of the plug-in type which adapt the set for receiving short, intermediate (broadcast) and long wavelengths. All of the radio-frequency stages are shielded and two attractive drum controls are used for tuning.

Radiola '20' Receiver

(61) Mr. R. Palusso, Glenhead, N. Y., asks:

Q. 1. Will you please publish in your columns the circuit diagram, and any other information on the Radiola 20 five-tube receiver?

A. 1. The diagram which you request will be found on this page.

The Radiola model 20 employs tuned-radio-frequency amplification with regeneration in the detector tube. The tuned-radio-frequency stages are two in number and of the neutralized type, employing the Rice method of neutralization. The neutralizing condensers are designated in Fig. 61 as C, C1 and C2.

The tuned circuits are capacitatively tuned with S.L.F. condensers mechanically coupled so that they are controlled from one drum. Vernier adjustments in the form of two vernier condensers are also included; these condensers are designated as C3 and C4. The complete receiver system consists of two stages of neutralized tuned-radio-frequency amplification, a regenerative detector and two stages of transformer-coupled audio-frequency amplification. The regeneration is obtained by means of a tickler coil connected in the detector-tube plate circuit and coupled to the grid coil of that tube.

The aerial input coil (the primary) is tapped in order to provide for various aerial lengths and conditions. The R.F. amplifying tubes are so wired that a bias of "—4½" volts is applied to the grids of these tubes. The tubes utilized are 199 in the R.F., detector and the first audio stages; and a 120 in the output stage. The filament control is obtained by means of a rheostat controlling the second R.F., detector and both A.F. tubes. The volume control is a separate rheostat for the filament control of the first R.F. tube.

The sequence of the tubes, looking down upon the receiver with the panel facing the individual, is as follows: First R.F., second R.F., second A.F., first A.F., and detector. A jack is provided so that either or both stages of A.F. amplification can be employed. Pin jacks are provided, to make possible the connection of a voltmeter for the determination of the filament potential.

A Six-Tube Receiver

(62) Mr. A. Klein, St. Louis, Mo., writes:

Q. 1. "I am writing for a class of thirty-eight pupils at our school. We have bought quite a number of 17-plate straight-line condensers and also basket-weave coils of the Freshman type. Each of us wishes to build a radio receiver, one for each room in our school. We have decided on a five- or six-tube set, using three coils and condensers of the type I mentioned above. We wish to

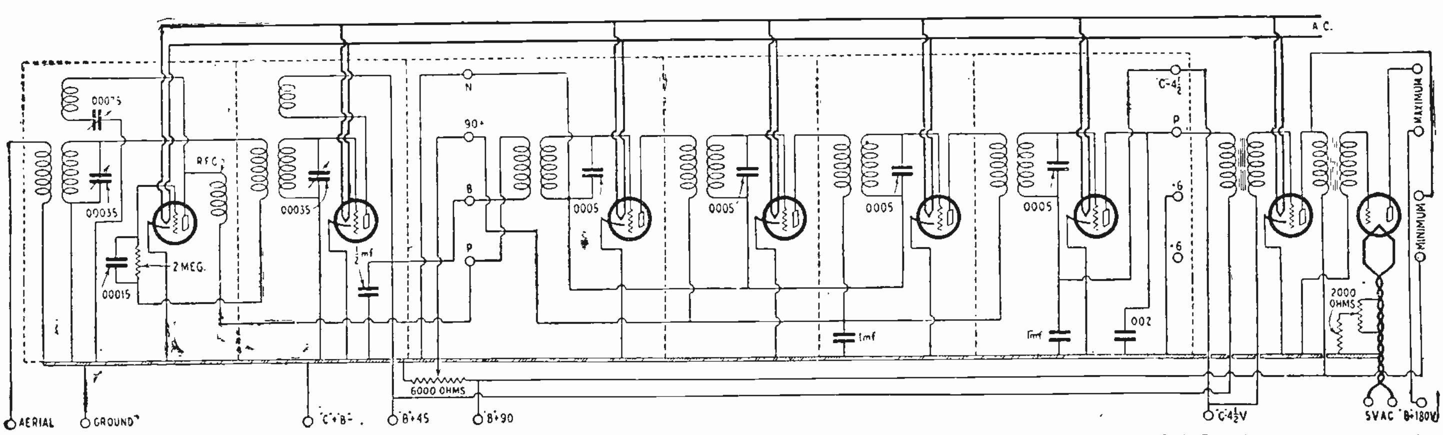


FIG. 60—The laboratory superheterodyne, using the time-signal amplifier, is shown adapted for operation with the heater type of A.C. tubes. The power tube is of the 171 type and operated from the five-volt secondary of the heater transformer. The grid bias for the last tube is obtained automatically.

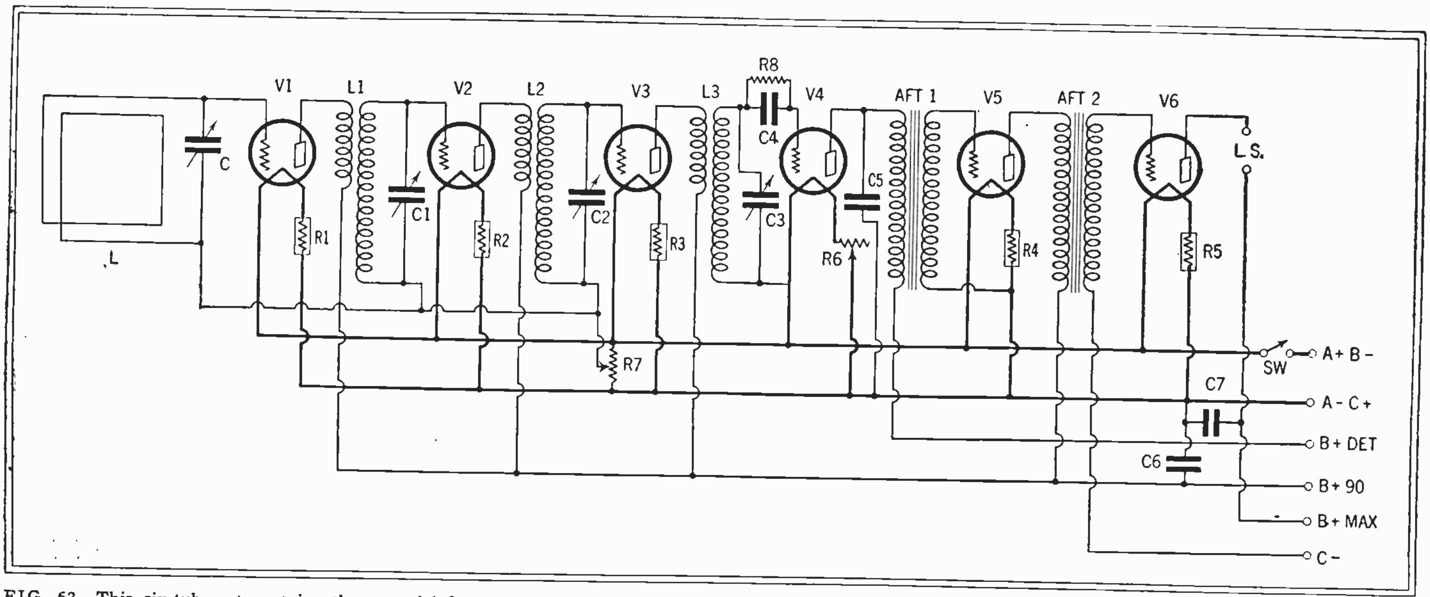


FIG. 62—This six-tube set contains the essential features of the most popular commercial sets, it is easy to build and to operate; it is sufficiently sensitive and highly selective, without shielding, when not too close to a transmitter; and with a suitable power tube, will give ample volume for a large room. It is therefore recommended for construction and use in schools. It does not require an outside aerial.

use two or three stages of radio frequency, and two stages of audio-frequency amplification. We would be very thankful to you if you would publish a diagram of such a circuit or send us one. If possible, we would like to use a loop aerial."

A. 1. You will find here the schematic and pictorial diagrams of a six-tube receiver employing the apparatus that you have on hand. As you will notice, a loop aerial is used with four tuning condensers and three radio-frequency inductance coils. Two stages of transformer-coupled audio-frequency amplification are used in order to give satisfactory loud-speaker volume.

Parts Required

The apparatus employed in the set is as follows:

L. loop aerial (designed for a .00035-mf. condenser);

L1, 2, 3, radio-frequency choke coils;

C, C1, 2, 3, .00035-mf. variable condensers;

C4, .00025-mf. fixed condenser, with grid-leak mounting;

C5, .002-mf. fixed condenser;

C6, 7, 1-mf. by-pass condensers;

R1, 2, 3, 4, 5, filament ballasts, ¼-ampere type;

R6, 20 ohm rheostat;

R7, 400-ohm potentiometer;

R8, 2-megohm grid leak;

AFT1, 2, audio-frequency transformers;

SW filament switch;

V1 to V5, 201A-type tubes;

V6, 201A-type tube (or 112A- or 171A-type; see below);

Six sockets, panel, baseboard (see below), eight or ten binding posts and strips, wire, etc.

Assembly

The apparatus should be laid out on a sub-panel slightly shorter than the panel, and should be placed in the respective positions shown in the pictorial diagram. A panel about 7x24 inches should be employed, and a baseboard about 23x8 inches. When the parts have all been mounted on the panel and baseboard, the set should be wired. This should be done following either the pictorial or the schematic diagram, checking off each lead as connected, and all the wires should be run as directly as possible, especially the grid and plate leads. The connections should be soldered carefully, either to soldering lugs or directly to the wire terminals.

If a power tube is employed in the set, the "B+Max" and "C—" terminals should be connected to the correct "B" and "C" voltages on the batteries or plate supply, the voltages depending on the type of tube employed. If a power tube is not used in the last stage, the "B+Max" lead shown should be connected to "B+90", and the "C—" terminal should be connected to the negative terminal of a 4½-volt "C" battery.

When the set has been completed and the connections carefully checked, it may be tested for short circuits by connecting the "A" battery, one terminal to the "B—" and the other to the "B+" terminals in turn, with the tubes in the set. If the tubes light when contact is made in this manner, the wiring must be corrected. If it proves safe, connect the batteries in the proper manner, and proceed to operation.

It should be found that the four condensers give almost exactly the same reading when tuning in a station—that is, if the loop used is of the correct design for the

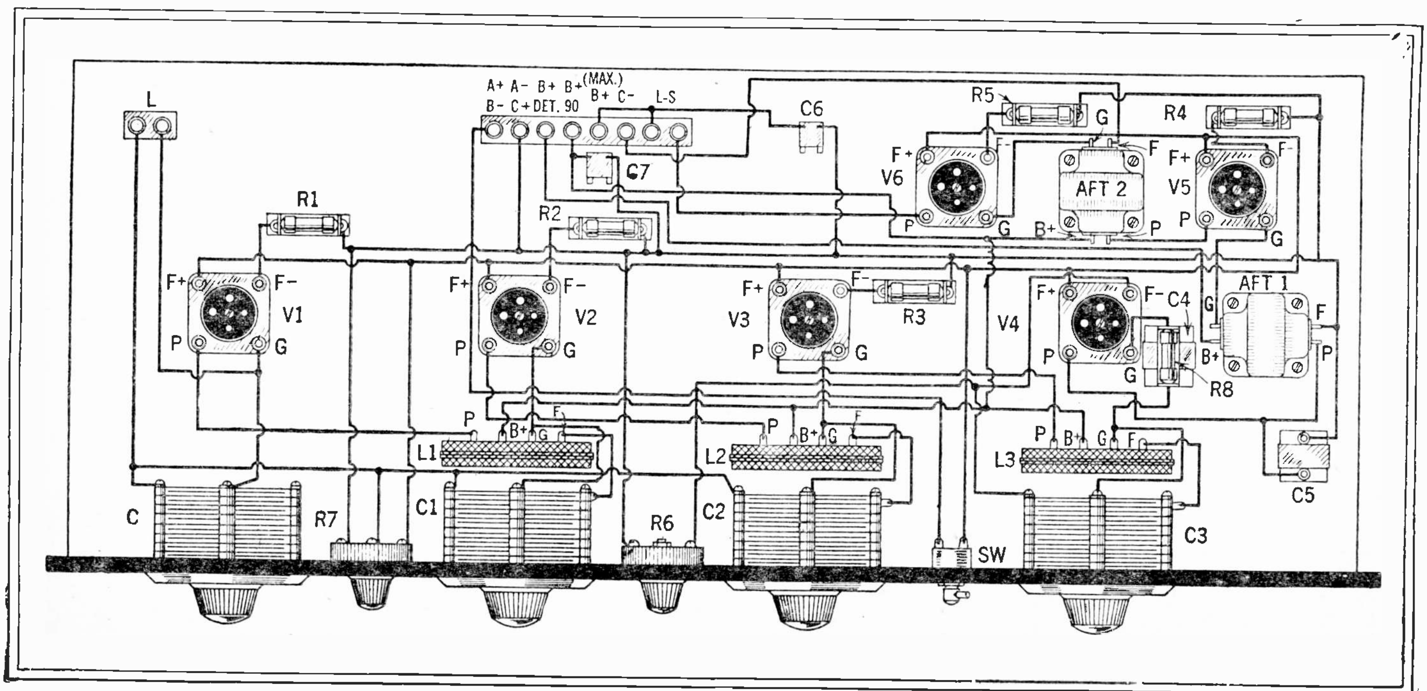


FIG. 62-A—Layout for the six-tube set. It should be easy to assemble.

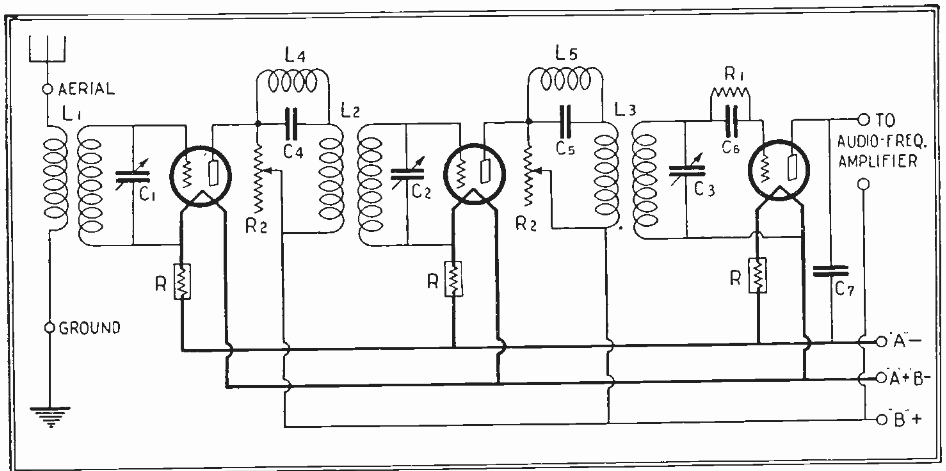


FIG. 64—This is an unusual radio-frequency circuit which gives comparatively even amplification over the entire broadcast band; the small coils, L4 and L5, are used for increasing the amplification on the longer waves.

condenser used with it. If it is so desired, the other three condensers may be ganged together for simplicity of control. This, of course, would necessitate changing the layout to correspond with the mechanical coupling arrangement used, but the tuning will be much simpler, and very satisfactory results may be obtained. It is not advisable to attempt to operate the loop-tuning condenser C from the same dial, however.

The potentiometer R7 should be turned until no whistles can be heard when the dials are rotated; the rheostat R6 should be turned up until normal brilliancy is obtained on the detector tube.

Browning-Drake Receiver With Screen-Grid Tube

(63) Mr. G. A. Deering, Providence, R. I., writes:

Q. 1. "I am enclosing a diagram of my two-tube Browning-Drake tuning unit, in which I would like to use a screen-grid tube. I believe that the use of one of these tubes in the radio-frequency stage will increase the amplification and improve the results that I am obtaining. Can you give me the necessary details for making this change?"

A. 1. We are publishing the diagram of the original receiver and the new diagram showing a 222-type tube used in the radio-frequency amplifier circuit. (Figs. 63-A and B.) As you will notice in Fig. 63-B, the original primary of the detector coupling coil has been left out of the circuit. It will be desirable to shield both the radio-frequency stage and the detector, in order to obtain the best results from the screen-grid tube. The radio-frequency stage is capacity-coupled to the detector by a ½-mf. condenser between the radio-frequency tube plate and the coil of the detector coupler. A radio-frequency choke coil is also placed in the "B+" lead to keep the radio-frequency current in the correct channel. It may also be necessary to connect a 15-mmf. condenser across the tuning condenser.

The filament current of the screen-grid tube is controlled by a 10- to 15-ohm fixed resistor and a 30-ohm rheostat. Both of the tubes are connected to the "A" battery through a filament ballast resistor of ¼-ampere capacity.

Adjusting the Receiver

When these changes have been made, the set may be tuned in the usual manner. The screen-grid tube requires no neutralization, so the original neutralizing condenser may be dispensed with.

The use of the screen-grid tube should increase the radio-frequency amplification to a great extent; we believe that very good results will be obtained when using it in place of the 201A. The voltage on the screen-grid is rather critical and must be very carefully adjusted, and the shields must be made very carefully in order to have the tube operating correctly. The parts should be laid out approximately in the same positions that they occupy in the original set, but with the addition of the extra by-pass condensers, etc. The control-grid lead should be kept as short as possible and preferably should be placed in a length of copper or brass tubing. The tubing should be grounded to the shield.

A New T.R.F. Receiver

(64) Mr. J. R. Wilson, Portland, Oregon, writes:

Q. 1. "I have recently read about a system which is used for increasing the efficiency on the higher wavelengths, of tuned-radio-frequency receivers employing the phasatrol balancing method. These compensating units work very well, except that a lack of sensitivity is noticed on the upper end of the condenser scales. The system that I refer to uses a small coil across the condenser in the unit. Can you supply any data on this subject?"

A. 1. A system which was recently suggested for this purpose by several radio engineers, shown in Fig. 64. In this unit small R.F. coils, L4 and L5, are shunted across the phase-shifting condenser. This coil serves to increase the feed-back at the wavelengths to which it is tuned and naturally increases the radio-frequency amplification on this wave. In this particular case, the coils are wound with about 40 turns of No. 30 D.C.C. wire on a ¾-inch tube. These coils, in conjunction with the .002-mf. condensers C4 and C5, are tuned to a wavelength near the upper end of the band; since this is the point at which the loss of efficiency occurs. Because the coils are tuned more or less sharply, the operation of the set on the lower wavelengths is not affected.

The apparatus used in the set shown in Fig. 64. is as follows:

Three T.R.F. coils L1, L2, L3;
Three .00035-mf. variable condensers, C1, C2, C3;
Two .002-mf. fixed condensers, C4, C5;
One .00025-mf. fixed condenser, C6;
One .001-mf. fixed condenser, C7;
Three automatic filament ballasts, R;
One grid leak, R1;
Two 10,000-ohm resistors, R2;
Three tube sockets;
Seven binding posts;
Panel, baseboard, wire, etc.

The tuned-radio-frequency coils can be made by winding 82 turns of No. 22 D.C.C. wire on 2½-inch tubing for the secondary; and 14 turns for the primary, with about ¼-inch spacing between the coils. Any type of audio-frequency amplifier can be used with this set and should be connected in the normal manner to the output of the detector.

The small coils, L4 and L5, and the fixed condensers should be mounted directly on the terminals of the variable resistors. These resistors can be mounted inside the set, since it is not necessary to readjust them when the set has been balanced correctly. When laying out the apparatus on the base-

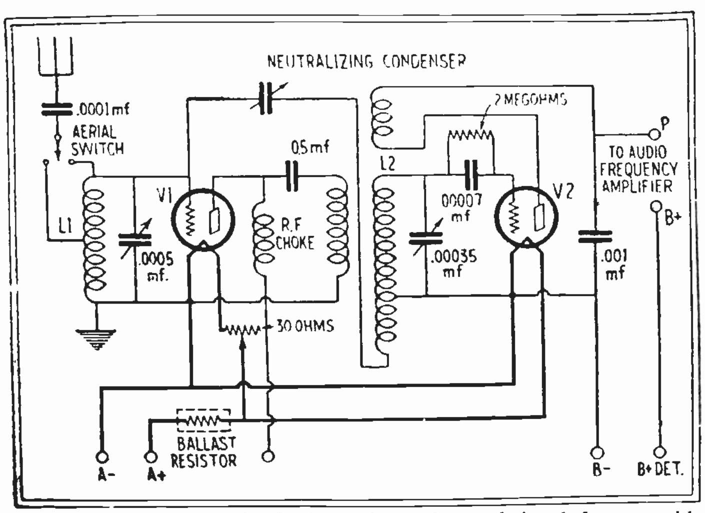


FIG. 63-A—The Browning-Drake tuning unit, as designed for use with ordinary tubes. To use a screen-grid tube in the R.F. stage, it is rebuilt as shown at the right.

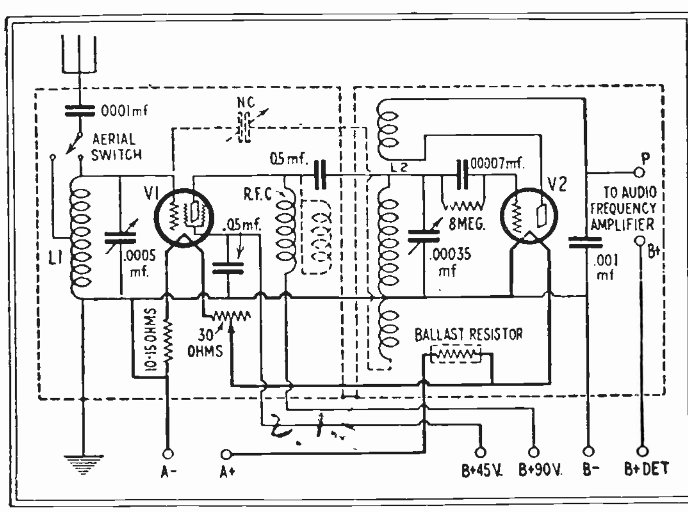


FIG. 63-B—The screen-grid Browning-Drake must be shielded as indicated by the dotted lines above. The neutralizing condenser is eliminated, and the primary of the R.F. coupler unused.

board, the coils L1, L2 and L3 should be placed as far apart as possible, and at right angles. If desired, the tuning condensers can be ganged together to simplify the tuning; but it will be advisable to place small compensating condensers across each section of the gang condenser, to correct any differences in inductance or capacity of the coils or condensers.

The Ultimax Circuit

(65) Dudley Caverson, Rochester, N. Y., inquires:

Q. 1. Will you please publish the circuit diagram of the Ultimax receiver, designed by Louis G. Pacent?

A. 1. You will find the circuit diagram of the well-known Ultimax receiver on this page, together with a drawing illustrating the winding data for the auto transformers used in the radio frequency stages. The other constants are specified in the circuit diagram, where the values of the phase-changing condensers and radio-frequency chokes are indicated. This circuit has been found to be very efficient on the broadcast wavelengths, and is peculiarly characterized by its wonderful tonal qualities. The set is very simple to assemble and adjust and has proven to be quite a hit.

Strobodyne Data

(66) Mr. A. J. Drummer, Baltimore, Md., writes:

Q. 1. "Please answer the following questions: At which frequency are peaked the long-wave transformers which are employed in the Strobodyne receiver? Would it be of advantage to use two stages of radio-frequency amplification before the Strobodyne receiver instead of one? Would it be advisable to employ a push-pull detector, like that in the enclosed diagram, in the second detector circuit? Should the 201A-type tube be employed; and should the grid return be to "A—" or "A+"?

A. 1. The intermediate-frequency transformers employed in the Strobodyne receiver are tuned to a frequency of 120 kilocycles when the secondary coil is shunted by a fixed condenser of .00025-mf. capacity. The exact frequency, of course, depends upon the accuracy of the condensers across the secondary; and these condensers must be matched very carefully, so that each of the intermediate-frequency transformers will be tuned to the same frequency.

We would not advise you to try to use two stages of the radio-frequency amplification before the Strobodyne receiver, since this would involve the use of too many tuning controls and, if the tuning condensers were

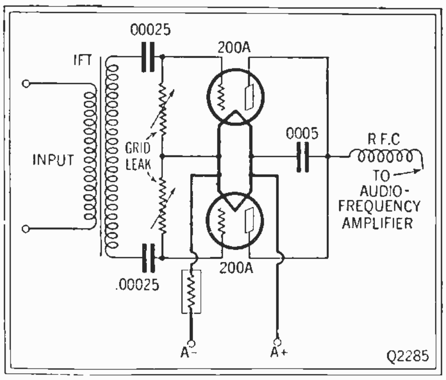


FIG. 66—Circuit of a push-pull second detector, suited to the Strobodyne and other receivers with 120-kc. I.F. amplification.

ganged together, difficulty would be encountered in keeping the circuits exactly in resonance. The use of this extra stage would increase the size of the receiver considerably, too; since it would be necessary to shield both radio-frequency stages in order to obtain good results.

If you desire, you can employ a push-pull second detector in your set by the method that you suggest. (For the benefit of other readers, we are printing the diagram to which Mr. Drummer refers, since this should be of interest to many other fans). If the 200A tube is used, it will be necessary to connect the grid return to the "A—". If 201A tubes are employed, the grid return should be connected to the positive "A" battery terminal. In order to obtain good results with this detector system, it will be necessary to have tubes which are matched closely, and also to adjust carefully the grid leaks; since the resistance on each side of the connection running to the filament must be exactly the same, in order to keep the grid bias on each tube at the same value.

"DX" Crystal Set

(67) Marcus McCoy, Dallas, Texas, writes:

Q. 1. Can you tell me how to hook up a crystal set capable of receiving over long distances?

A. 1. There is really no such thing as a "DX" crystal set because of the fact that the same set will give results differing very much when used in various localities. Location as well as length and height of aerial has a very great deal to do with the "DX" qualities of any receiver whether it employ a crystal detector or a multitude of tubes. We would suggest that you use any standard type of crystal detector circuit, preferably loosely coupled to the antenna.

"Superhet" Troubles

(68) B. H. Blaker, Westfield, N. J., writes:

Q. 1. I hooked up a superheterodyne using Victoreen transformers, following the circuit shown in the current number of *Radio Review*. It does not work satisfactorily. Can you tell me where the trouble might lie?

A. 1. We believe that what has happened is that you have followed the Madison-Moore hook-up a little too faithfully in wiring your Victoreen transformers. The Victoreen transformers can be used, but where you got into trouble was when you hooked up the oscillator coupler.

You will note in looking over the article in *Radio Review*, that in the Victoreen circuit the oscillator variable condenser is really connected across both windings, *i.e.*, the total inductance of both windings is used in shunt with .0005 condenser. In the Madison-Moore hook-up the .0005 oscillator variable condenser is connected across only one of the oscillator coupler windings, and in consequence you onl yreach to about 300 meters.

The thing to do is to follow the Victoreen hook-up in connecting up the oscillator coupler with particular respect to the oscillator variable condenser, but take care to connect the pick-up coil in the plate circuit of the first detector, as the Madison-Moore circuit indicates.

Choice of Frequency

(69) D. Stanton, Somerville, Mass., writes:

Q. 1. Will you kindly tell me what is considered the best intermediate frequency to be used with a superheterodyne receiver?

A. 1. The best frequency or intermediate frequency at which a superheterodyne is to operate, must be above the audible range. The low limit of intermediate frequency should be at least 20 kilocycles, and in actual practice 30 kilocycles has been found to be the lowest practical frequency. The great amplification of superheterodyne receivers is largely due to the fact that this amplification is carried out at low frequencies.

The lower the frequency, the greater will be the stability and consequently the amplification, the power and the sensitivity of the receiver. Taken from this standpoint, it is desirable to work at the lowest possible intermediate frequency. On the other hand, the lower the intermediate frequency, the closer it comes to audible frequencies and the greater will be the amplification of all kinds of low frequency noises, such as power line interference, static, and the like.

The low frequency amplifiers are also

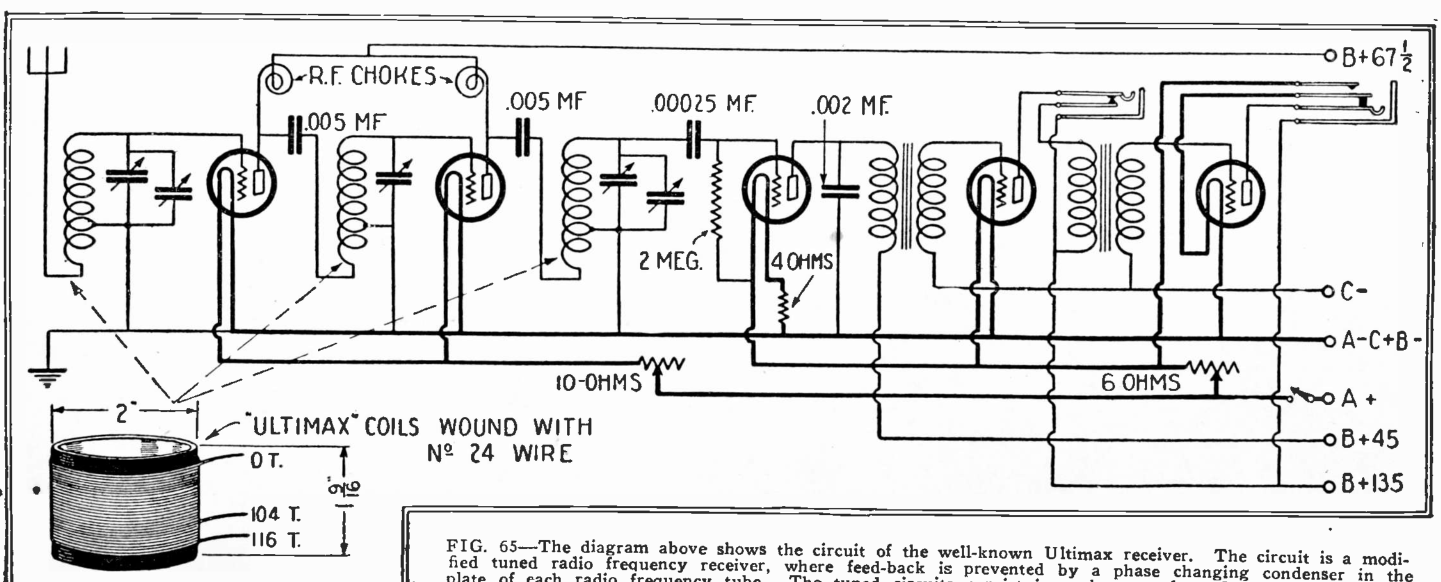


FIG. 65—The diagram above shows the circuit of the well-known Ultimax receiver. The circuit is a modified tuned radio frequency receiver, where feed-back is prevented by a phase changing condenser in the plate of each radio frequency tube. The tuned circuits consist in each case of an Ultimax coil shunted by a .0005-microfarad variable condenser.

less selective than the high frequency types. By using at least three intermediate stages and a good filter, or using all air core transformers, it is possible to obtain sensitivity, regardless of the frequency employed. The lower the intermediate frequency, the closer together will be the signal frequency and the best frequency, or heterodyne. This may allow interference from powerful local stations, and it always brings in stations on the oscillator dial at two points which are quite close together.

The "Thermiodyne" Receiver

(70) Mr. A. N. King, Trenton, N. J., writes:

Q. 1. "I would like to obtain the diagram of the 'Thermiodyne TF6' receiver. I have one of these receivers which is not working correctly, and I would like to check the wiring if possible."

A. 1. We are printing the diagram of this receiver in Fig. 70. Unfortunately, *none of the constructional details or values of the parts employed in this set are available*, as its manufacturers are out of the business; but we trust that the diagram may be of assistance to you in the matter of locating the trouble in your set.

Antenna "Super" Operation

(71) J. C. Stevens, Elgin, Illinois, writes:

Q. 1. I wish to use an antenna in connection with my Radiola Super, which is of a model about 2½ years old. Have tried several antenna connections, but they are not selective. How may this be done?

A. 1. While you could build an antenna tuner with antenna circuit separate from the secondary, and tuned by means of a variable condenser and loading coil, a stage of tuned R.F. amplification would be a better means of prividing selectivity, added sensitivity, and freedom from radiation of energy into the antenna, to the great joy of your neighbors. In Fig. 71 is shown a suggested circuit for an antenna tuner, R.F. amplifier, and coupling transformer, requiring only one control, and no critical adjustments.

The output transformer, which in this case is a Silver Marshall Type 110-A, is designed so that the secondary is tuned with a .00035 mfd. variable condenser, to cover the broadcast band. As the condenser shunted across the loop in your set is about .0008 mfd., it would probably tune the 110-A coil through a range of 250 to 800 meters and you would be unable to tune in the lower wavelength stations. Hence only one whole section of the stator winding should be used, with 6 additonal turns from the other stator winding, the remaining turns

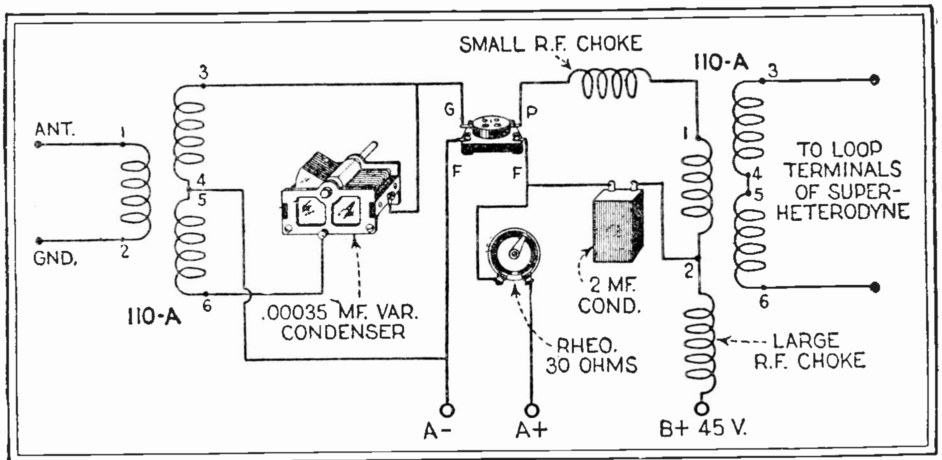


FIG. 71—The method of coupling the antenna and ground to a Radiola superheterodyne receiver is clearly shown above. This system will give excellent resuts and selective tuning.

being removed. It is best to unsolder the wire leading to terminal 3 of the transformer, and remove turns from the coil until only 6 are left, soldering the end of the 6 turn coil to terminal 3 Connect the terminals 3 and 6 of the coil to the binding posts in the set which are marked for "external loop" connection, and the loop condenser will thus be shunted across the coil. The filament and plate voltages for the R.F. tube may be obtained from the same set of A and B batteries supplying the main set.

Self-Neutralization

(72) H. L. Burmeister, Holyrood, Kan., writes:

Q. 1. I have made up a tuned radio frequency receiver in which various adjustments of the neutralizing condenser do not effect reception. Why is this so?

A. 1. There are few receivers that will self-neutralize; your receiver seems to be one of the few.

Q. 2. How can a tuned radio frequency set of this nature be made to oscillate?

A. 2. Slightly changing the angles of your neutroformers should enable you to make the set oscillate, if you wish it to, or to only regenerate.

Q. 3. Where should the grid returns of the radio frequency and detector tubes be connected.

A. 3. Be sure your radio frequency tubes do not have the grid return leads connecting to the A+; this return should be to A— on all tubes but the detector tube, when it should be at A+.

Tuned R.F. Receiver

(73) George Rayner, Newark, N. J., wants to know:

Q. 1. Do you consider a variometer to be superior to an inductance coil and variable condenser for use in a tuned radio frequency receiver, where one or the other of the instruments are to be used as the tuned radio frequency transformer?

A 1. No, we do not. A tuned radio frequency receiver employing single layer inductance coils and variable condensers for tuning them will usually be found far superior in many ways to a similar type of receiver using variometers for the variable tuning units. The variometer set will be found to be much broader in tuning than the other type.

Improving a T.R.F. Set

(74) K. Milton, Barnegat, N. J., asks:

Q. 1. I have a five-tube T.R.F. Set and desire to improve its sensitivity and selectivity. Can I add another tube, and how, in order to do the above?

A. 1. Instead of adding another tube we would suggest that you either reduce the primaries of the radio frequency coils, or add regeneration to the detector. This can be done by winding a three-inch coil with 20 turns of No. 22 D.C.C. wire and placing it at the grid end of the detector coil. This coil, should of course, be wound in the same direction as the detector coil. A variable resistance, say from 0 to 50,000 ohms can be used, shunted across this coil to control regeneration.

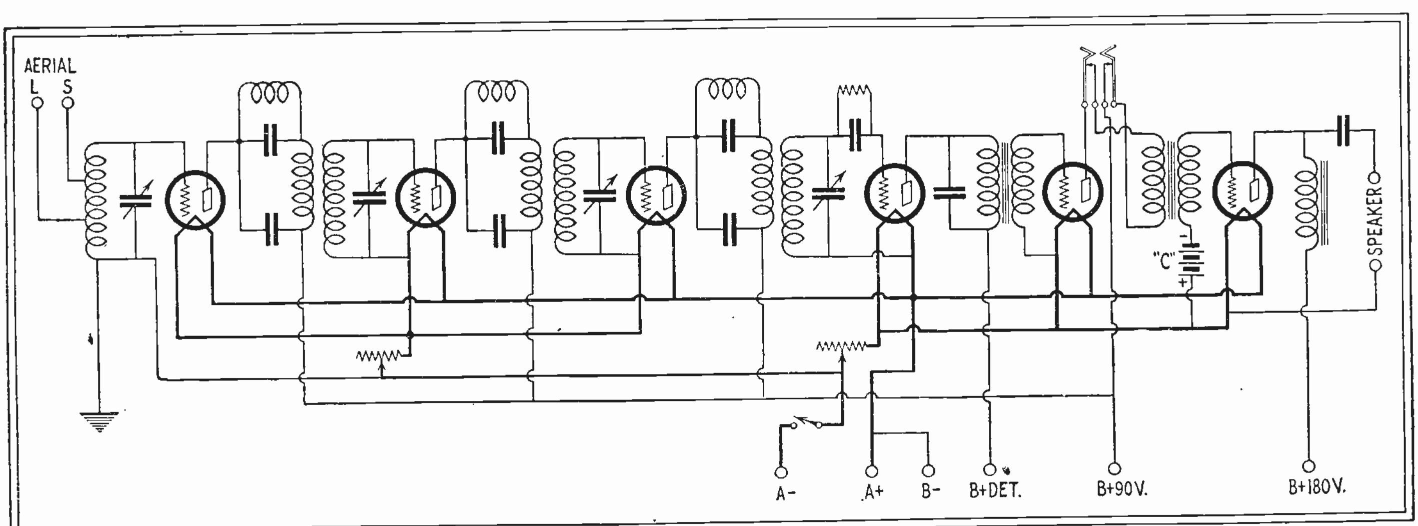


FIG. 70—The schematic diagram of the "Thermiodyne" receiver, of which many were manufactured and sold. Unfortunately, no data are available as to the coils, or the value of the other parts used in this set.

Battery Charger

(75) Ross L. Douglas, Bellflower, Calif., asks:

Q. 1. Why are taps arranged on the primary coil of the transformer used in connection with a tungar receiving bulb?

A. 1. In the battery charging transformer that you mention, the taps on the primary are to compensate for line voltage changes. The transformer is designed to operate on ordinary 110 volt 60 cycle line, but since the voltage is silghtly different in different locations, taps are taken off the coil.

Q. 2. Do both "A" and "B" batteries give off the same type of current?

A. 2. There is no difference between the type of current given by "B" batteries and that given by "A" batteries.

Q. 3. How can I place an ammeter in my battery charger circuit so as to show the rate of charge?

A. 3. You can connect an ammeter in the circuit of this battery charger in series with one or the other lead to the battery.

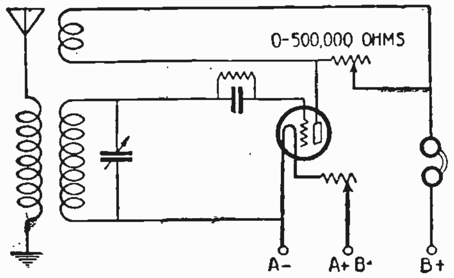


FIG. 76—One of the simplest methods of controlling regeneration.

Controlling Regeneration

(76) A. Sohn, Bronxville, New York, asks:

Q. 1. Can you give me a method for controlling regeneration whereby the tickler coil can remain more or less stationary?

A. 1. You will find illustrated on this page a simple and efficient method for the controlling of regeneration by means of a high resistance in the tickler leads. Although the circuit shown here is a standard three-circuit receiver this method may be used in any circuit which employs regeneration. The resistance should have a range of about 0 to 500,000 ohms.

Trouble in the Victoreen

(77) R. C. Andover, Ironwood, Michigan, writes:

Q. 1. I have a Victoreen radio and would like to know if I can place the coils straight, instead of on an angle as it would make a better job. I am bothered with a lot of interference and I think by shielding I will reduce some of it.

A. 1. If you shield your Victoreen and have shielding between the stages, so that the coils you refer to are in separate compartments the angular placement can probably be done away with. Before bothering to put in the shielding, remove the loop (or antenna and ground) from the set and see whether the noise decreases or is entirely eliminated. If all the noise stops when the pick-up systems are removed, shielding will do you no good, as your pick-up of noises would be entirely through the antennas.

Peridyne Troubles

(78) Mr. H. M. Stetson, E. Weymouth, Mass., writes:

Q. 1. I have recently constructed a Peridyne receiving set and find that the set does not oscillate below approximately 300 meters or above 450 meters. The tuning is broad, it being practically impossible to tune out a nearby broadcast station. What can I do to eliminate this trouble?

A. 1. The tuned circuits in this set must be exactly in resonance or the shields will not compensate for differences of more than 5 percent in the inductace capacity. When operating correctly, the shields and filament resistors will have a very marked effect on the operation. In fact a quarter of a turn on the knob on the adjustable shield will throw the set into and out of oscillation.

When adjusting the set the first thing to do is to get the set to oscilalte freely on all wavelengths and then use the method described in the original article on this set for balancing it. If you persevere with the adjustments of this set you will be quite surprised with the results which you can obtain. However, it is necessary to follow the instructions given in the original article exactly in order to obtain satisfaction.

Operating Super-Het

(79) Arthur Manson, Kalamazoo, Mich., writes:

Q. 1. I would like your advice as to the best method of operation for my eight-tube super-heterodyne.

A. 1. A superheterodyne is a very flexible type of receiving set and one which if properly operated will afford great satisfaction. It requires a certain technique of operation which is peculiar to itself alone. but it is not at all difficult to master the principles and to put them into effect. There are usually three active controls on the superheterodyne: The antenna or loop condenser, the oscillator condenser, and the potentiometer.

The best method to proceed for tuning-in local stations is to adjust the potentiometer to a point considerably below the oscillation point and to run over the wavelength range with both condensers until foreign signals are picked up, when the process may be concluded by tuning the condensers more carefully to the point of maximum audibility. This process will hold for local reception under ordinary conditions, and if the tubes are kept from oscillating, there will be no interference with the reception of neighboring listeners.

When the set is adjusted in this fashion, carrier waves will not be heard, hence there will be no squeals floating around uninvited. For "DX" work, it is quite necessary to bring the set to the point of maximum sensitivity, which is attained when the tubes are adjusted to a point just below oscillation. The best way to tune in a "DX" station is to advance the potentiometer until the carrier-wave whistle may be heard on rotating the oscillator and loop dials.

While the potentiometer is still adjusted so as to cause the tubes to oscillate, the set may be sharply tuned to a point between the two peaks of the carrier-wave whistle, and then the potentiometer should be retarded to stop the oscillation. The next step is to retune the set by means of verniers or other fine adjustments, to bring the signal in as loud as possible, with the potentiometer retarded to eliminate distortion.

Interference on Radiola

(80) Mr. Arthur Sprouse, Castonia, No. Carolina, writes:

Q. 1. I have a Radiola No 28 and a No. 104 power speaker. When the Kelvinator nearby is in operation it causes so much noise in the receiving set that we have to shut off the radio. How can I stop this noise?

A. 1. The interference from the Kelvinator can be reduced by connecting two 1-mf. condensers in series and then connecting them across the input line to the motor. The center tap which links these two condensers together should be grounded.

If this does not reduce the interference sufficiently, two radio frequency choke coils should be constructed and placed in the line between the condensers and the supply lines. These chokes should be wound on bakelite or wooden forms one inch in diameter and should contain about 150 turns of No. 18 or 20 D.C.C. wire.

Of course, this arrangement will not overcome interference picked up by the antenna, but if the interference is being power supply unit, this system will be quite satisfactory.

Superheterodyne Trouble

(81) Mr. L. Thomas Siglin, Providence, R. I., writes:

Q. 1. I have a "World Record 10" superheterodyne in which a dead spot occurs from approximately 400 to 450 meters. Above and below this spot it functions perfectly on a strong signal but on a weak or distant signal it must be worked right up to the point of oscillation, and poor reception is the result. What is the cause of this and what can be done to remedy it?

A. 1. The trouble in your superheterodyne is probably due to the oscillator not working correctly on this particular part of the band. We would suggest that you try increasing the plate voltage on the oscillator and also check over the apparatus in the circuit in order to locate the difficulty. You might also try varying the plate voltage on the intermediate frequency tubes and make sure that they are not oscillating. You might also try a different aerial and check over the rest of the wiring in your set. The use of a good oscillator tube may overcome the difficulty.

Receiver Lacks Volume

(82) Mr. Edgar Stroschein of Oshkosh, Wis., writes:

Q. 1. I have a receiving set that does not give much volume, although everything tests O. K. The amplifier consists of 1st and 2nd stage resistance coupled and the last stage transformer coupled. When using it on a power supply unit the motor-boating is terrible. What would you suggest?

A. 1. Probably the use of audio frequency chokes in the "B" plus leads and by-pass condensers between each of the positive "B" battery terminals and the negative "B" terminal will overcome the difficulty that you are encountering.

The audio frequency choke coils should have an inductance of about 20 or 30 henries and the by-pass condensers should have a capacity of 1 or 2 mf.. We would also suggest that you place a radio frequency choke coil in the plate lead of the detector tube and carefully adjust the "C" bias on each of the amplifier tubes in order to overcome the trouble.

The "Junk Box" Set

(83) Mr. B. Stone of Point Richmond, Calif., writes:

Q. 1. I have constructed the "Junk Box" short wave receiving set described in a recent issue of *Radio News* and I am able to receive most of the local broadcast stations when using the short wave coil that is only supposed to cover the wave band from 45 to 64 meters. Why is this?

A. 1 The broadcast stations which you are picking up are being received on the harmonic of the original carrier wave and this is a very common occurrence on the short wave lengths. Nothing can be done at your end to eliminate the trouble. It is a fault which must be corrected at the transmitting station.

Q. 2. I have two 32-mmf. variable condensers. These condensers do not seem to make any difference in the strength of a station, in fact you can get one station all over the dials. Please advise.

A. 2. The tuning condensers are evidently incorrectly connected or some of the apparatus is defective, since they do not tune the set correctly. Some of the trouble may be due to the use of too long an aerial or to an aerial which is not carefully insulated. These points effect the operation of short wave receivers much more than they do the ordinary broadcast receiving set.

Neutralizing Methods

(84) Mr. David B. Smith of Pottstown, Pa., writes:

Q. 1. I have a five-tube neutrodyne receiving set which whistles and howls quite a bit. I believe that it isn't neutralized. Can you tell me how I can neutralize it?

A. 1. In order to neutralize your set we would suggest that you tune in a station at about the middle of the dial and then remove the last radio frequency tube from the set. A piece of paper should be wrapped around the filament prongs and then the tube should be replaced in the socket. In this way the capacity of the tube elements remain in the circuit although the tube is not lighted. The neutralizing condenser on this tube should then be adjusted until the signals from the station fades out or is at a minimum value. The paper should then be removed and the tube replaced in the socket and the same operation should be repeated for each radio frequency tube in the set, taking them in order and starting from the one nearest the detector.

"Super-Het"—T. R. F.

(85) David Sinclair, San Jose, Calif., asks:

Q. 1. Why is a super-heterodyne receiver employing only two stages of intermediate or radio frequency amplification considered to be superior to a two stage tuned radio frequency amplifier?

A. 1. The main reason for this can be readily seen when it is thoroughly understood that radio frequency amplification takes place at its greatest efficiency at a certain wavelength, and when the transformers carrying the current are so designed as to operate at their greatest efficiency at the particular wavelength or frequency to be amplified. In the super-heterodyne receiver, all incoming signals are acted upon by an oscillator and as a result, they are all changed, regardless of their original wavelength, to one certain fixed wavelength and are then amplified by the intermediate stages.

By proceeding in this manner, the two requisites of efficient radio frequency amplification are obtained. First, the signals are amplified at a wavelength where the greatest building up of signal strength is possible and second, since all signals are heterodyned to a specific frequency, the intermediate amplifying transformers can be so tuned as to pass this frequency with the greatest efficiency and the least loss.

In the tuned R.F. receiver, it is obvious that the transformers, being variable, will work at a greater efficiency at certain wavelengths than at others and in consequence it would be necessary to change the electrical constants of the respective circuits for each wavelength in order to regain the loss, which is quite impractical. From these statements, it can be readily seen that the super-heterodyne is justly considered superior to a tuned radio frequency amplifier, providing, of course, that the super-heterodyne is properly designed, built and operated.

Multi-Tube Neutrodynes

(86) John C. Hays, Indianapolis, Ind., asks:

Q. 1. Why is it that a neutrodyne with five stages of radio-frequency amplification has not been put on the market? Would such a set be a success?

A. 1. We consider your inquiry very interesting. Sets having more than four stages of radio-frequency amplification are available, but there are no neutrodynes among the lot. Some of the points are:

1. Two stages require three dials; five stages, at that rate, would necessitate six dials! Take too much time to tune. One-dial controls are easy, in the laboratory. When it comes to commercial production, we have "an equine of a differing hue." A two-dial arrangement might prove practical, after a great deal of experimentation, but there would be plenty of work before the set was ready for the public. It takes a mighty good one-dial set, where the one dial operates two controls, to equal a 2-dial set where each dial has but one control.

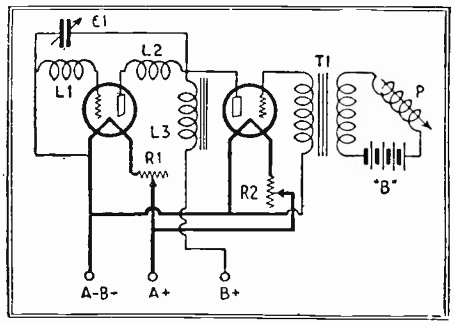


FIG. 87—The use of a modulated oscillator for testing receivers will save a lot of time when there are no strong stations "on the air." P is the phonograph pick-up.

2. Some current supply units will work well with five tubes but poorly with eight. The eighth tube also means added expense (the tube price) and battery consumption (if batteries are used) would be more.

3. Tube noises would be more pronounced. Detector tube would often be overloaded, resulting in distortion. Audio amplifier would have to be a wonder to be really efficient, if the set were to include two stages of audio, for both tubes and transformers would have a terrific load when locals were operating.

4. If set is made on low-loss lines, one would have to put a "ring door-bell" sign out, and hope the signals could read, for the selectivity would be so high that it would take considerable time to tune in wanted signals originating at a distance of more than, say, 150 miles. Anyone who has tuned a neutrodyne can appreciate this.

5. Every stage requires neutralization. This is more or less easy to do at home, given all the time, knowledge and patience necessary for success. But to do this rapidly and certainly in production is an entirely different matter. Then again, a set balanced in the factory test-rooms would not necessarily be balanced (neutralized) when entirely different tubes and batteries are used by the broadcast listener.

6. There is the amount to be added to the purchase price of the set, due to several additional production costs. Considering everything, there would probably be a safe for a set having five stages of radio-frequency amplification, neutralized, if the above stated objections were overcome.

A Set Tester

(87) Mr. T. B. Riley, Springfield, Mass., writes:

Q. 1. I am a set constructor and dealer. In testing receivers, I often find it difficult to obtain a satisfactory signal from a broadcast station in order to test their operation. I believe that it would be a very simple matter to build an oscilator to be used with a portable phonograph for doing this test work. Can you supply me with the diagram or any other information on the subject?

A. 1. You will find the diagram of a modulated oscillator of this type in Fig. 87. As you will notice, it consists of an ordinary oscillator circuit L1-L2-C1 with a modulator tube coupled to the plate circuit. The transformer T1 should be a modulation transformer or a low-ratio audio-frequency transformer. The battery "B" depends in its value upon the type of pick-up employed, and the best value will have to be found by experiment. The choke coil L3 should be of the ordinary audio-frequency variety and, if desired, the secondary of an audio-frequency transformer can be used for this purpose.

The oscillator coils, L1 and L2, are wound on a 3-inch tube. Coil L1 contains 32 turns of No. 22 D.C.C. wire and coil L2 contains 34 turns of the same wire; both of these coils are wound in the same direction with a space of about ¼-inch between them. The condenser C1 tuning the two coils should have a value of .00035-mf. It will be necessary to use a well-constructed condenser for this purpose, since the "B" battery will be short-circuited if the condenser plates touch.

The two tubes employed in this test circuit may be of either the 201A or the 199 type. If desired, the complete unit can be built in a small portable-phonograph cabinet with dry-cell tubes, so that the batteries and all apparatus can be placed in a small space. If 201A-type tubes are used, the filament resistors R1 and R2 should have a value of about 10 ohms each. If 199-type tubes are employed, these resistors should have a value of 30 ohms each.

Operation

When the complete unit has been finished, it should be tested to make sure that it will operate over the complete broadcast waveband. If the oscillator is not operating correctly, the plate coil L2 should be reversed. The plate voltage should be varied until the correct value is found; but usually one between 60 and 90 volts will be satisfactory. If the transmission is distorted when picked up with a receiving set, the value of the battery "B" should be varied, and the plate voltage on the modulator should also be varied. This can be accomplished by placing a variable resistor in series with the plate lead of the modulator tube; one of about 10,000 ohms will be suitable.

A unit of this type will be satisfactory for neutralizing receivers, testing sets, etc., when convenient broadcast stations are not available for this purpose. The unit should be placed about 10 or 15 feet away from the receiver with the coils facing it. When testing a receiver, the oscillator should first be tuned to a low wavelength and then picked up in the receiver. The operation should then be repeated for the middle and the upper end of the band. If the oscillator cannot be picked up on any part of the wavelength band covered by the receiver, or if whistles are encountered when tuning the set to the wavelength of the oscillator, the set is not operating correctly and the usual methods should be employed for adjusting it. Of course, there are a number of tests for which this oscillator can be used and they will suggest themselves quite readily to the experimenter.

A Shielded Wavetrap

(88) Mr. F. E. Potter, Hamilton, Ohio, writes:

Q. 1. I have recently read about a shielded wavetrap, which will satisfactorily increase the selectivity of a radio set under adverse conditions. If possible, I would like to obtain constructional details for building a unit of this type; since I am having some difficulty with interference from nearby broadcast stations.

A. 1. Wavetraps were originally designed to increase the selectivity of inefficient tuners and, although some of them accomplish this to a greater or less extent, they are usually unsatisfactory. *If the coils in a receiving set pick up stations when the aerial and ground are not connected, it is impossible for a wavetrap of any type to operate.* This is due to the fact that the wavetrap increases the selectivity only in the aerial circuit and, naturally, has no effect on the selectivity of the other tuned circuits in a receiver. Unshielded wavetraps are usually unsatisfactory, for the reason that the coils in the set will pick up the signals from the coils in the wavetrap.

The function of a wavetrap is to eliminate undesired stations and pass desired signals. To do this properly and without a

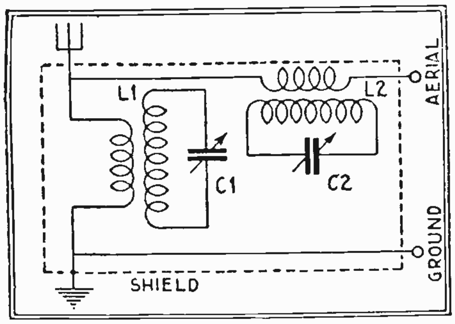


FIG. 88—Shielding prevents interaction between the coils in the set and the wavetrap, thus increasing effectiveness.

loss in signal strength, it is necessary to use good apparatus and employ a system which is tuned to the particular station to be received. The diagram of a wavetrap of this type, which is entirely enclosed in a metal shield, will be found in Fig. 88.

There are incorporated in this trap two filters of different types. The *shunt* circuit L1 operates as a drain for all frequencies other than those to which the circuit is tuned; in other words, this filter has an infinite impedance to the tuned frequency and almost no impedance to other frequencies. In operation, this part of the circuit is tuned to the frequency of each signal to be received, and serves to pass all other signals to the ground.

The *series* part L2 of the wavetrap is used to eliminate any particularly undesired station which is causing interference; this circuit possesses infinite impedance to the frequency to which it is tuned, and practically zero impedance to all other frequencies.

By the use of these two circuits, the deficiencies of each are overcome. Without the shielding, the reaction of the entire wavetrap upon the receiver will defeat the purpose of the unit; since a signal will pass from its tuned circuits to the set. The shield may be any of the commercial box shields employed in modern radio receivers, or may be made by taking sheet copper or aluminum and bending it to the correct shape.

The coils employed in this unit are of the spiderweb type and each consists of 65 turns of No. 26 D.C.C. wire for the secondaries and 5 turns for the primaries. They are wound on circular forms two inches in diameter with 9 pegs around the circumference. Straight-line-frequency condensers, having a capacity of .00035-mf., should be used with such coils.

It is possible to separate stations a few kilocycles apart with this wavetrap, if it is well shielded and the coils in the set do not pick up signals from the interfering station when the aerial and ground are disconnected. It must be remembered, however, that no wavetrap will function if a coil pick-up is noticeable in the receiver.

Strobodyne Condensers

(89) Mr. Robert H. Stock, Tuscaloosa, Ala., writes:

Q. 1. Please give me the value of the 5 matched condensers to use with the intermediate transformers for the Strobodyne receiver described in the August, 1927, issue of *Radio News.*

A. 1. The fixed condensers placed across the secondaries of the intermediate frequency transformers employed in the Strobodyne have a value of .00025-mf. These condensers must be matched so that the various circuits in the intermediate frequency amplifier will be balanced correctly.

Q. 2. Where can they be purchased and at what frequency are these transformers supposed to tune?

A. 2. These transformers are tuned to a frequency of 120 kilocycles when a condenser of .00025-mf. is placed across the secondary. It is very important that all transformers be tuned to the same frequency, since if one transformer is not correctly tuned, very poor results will be obtained.

Garod Neutrodyne Changes

(90) Mr. A. J. Spinney of Fairhaven, Mass., writes:

Q. 1. Will you kindly tell me what changes in parts, etc., are necessary to improve the quality and performance of my Garod 5-tube neutrodyne set? This set uses a 200-type detector tube and 201-A tubes. Have tried a 290-A detector and a 112-A tube in the audio amplifier but had to cut down the voltage on the first audio amplifier to 90 volts. I also tried 112-A tube in the radio-frequency amplifier but the set oscillates.

A. 1. We would not suggest that you try changing the radio-frequency amplifier since this would necessitate completely re-balancing the set in order to obtain satisfactory results. Probably the use of 201-A tubes in the radio-frequency amplifier, a 200-A tube in the detector with a 112-A and a 171-A in the audio amplifier together with the correct plate and grid voltages will give better results than you are now obtaining. The correct grid and plate voltage for the 171-type tube are 180 volts on the plate and 40 volts on the grid. For the 112 tube, 100 to 135 volts should be used on the plate and 9 volts on the grid. It may be advisable to try changing the "C" bias on the radio-frequency tubes in order to operate them at a more efficient point.

Oscillation Control

(91) Mr. J. White, Savannah, Georgia, writes:

Q. 1. I would like to obtain some information about the various systems used commonly in modern receivers for controlling oscillation in radio-frequency amplifiers. I would appreciate any information on the subject, as I am contemplating building a receiver and do not know which system will be the simplest and most efficient. Several of the systems that I refer to are plate-voltage control, grid suppressors, potentiometer control, phase-shifting devices and tuned absorbing systems.

A. 1. The whistles that are encountered, when an unbalanced T.R.F. receiver is tuned, almost invariably indicate instability and poor operation. As a general rule, all T.R.F. receivers not employing a balancing method of stabilizing should have some variable means of controlling the oscillation. This is necessary, since the tendency to oscillate increases as the dials are tuned to the lower-wave stations and, if a receiver is designed to operate efficiently on the long wavelengths, it will almost invariably oscillate on the low wavelengths. By using some variable control, the receiver can be kept just under the oscillation point, which of course supplies the greatest efficiency.

A variable resistor in the plate-supply lead to the R.F. amplifier tubes is a simple and effective method of controlling the oscillation. This acts also as a volume control; since on the powerful local signals, the resistance can be increased and the sensitivity of the receiver reduced. (See Fig. 91-A). A by-pass condenser is usually connected across this plate resistor; so that the radio-

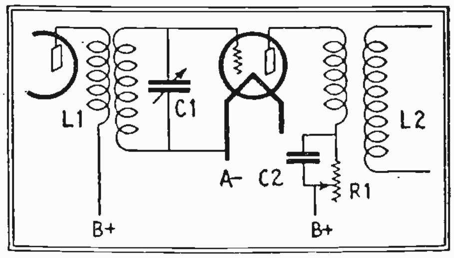


FIG. 91-A—Controlling the plate current in a radio-frequency tube will also control the oscillations.

frequency resistance will not be increased. A resistor of about 200,000 ohms and a condenser of about .006-mf. will be satisfactory. A very similar effect can be obtained by employing a rheostat in the filament circuit of the R.F. tubes and increasing or decreasing the filament current to control the oscillation. However, this system causes a certain amount of distortion, since the undistorted output of the amplifier is reduced considerably when the filament current is cut down below the rated point.

Resistors connected in the leads to the grids of the radio-frequency tubes supply another simple and effective means of stabilizing an amplifier. These resistors should not have sufficient value to entirely stop the oscillations; since this will reduce the efficiency of the amplifier. A better method is to use a resistor of between 200 and 400 ohms, connected as shown at R1 in Fig. 91-B. A variable adjustment should be provided to bring the receiver below the oscillation point, so that it can be kept at the maximum efficiency. In operation, this resistor limits the energy feed-back from the plate to the grid circuits of these tubes, sufficiently to suppress the oscillation. The resistor used for this purpose *should never be connected between the coil and condenser;* since this will decrease the selectivity of the set to a great extent, and will also reduce the amplification.

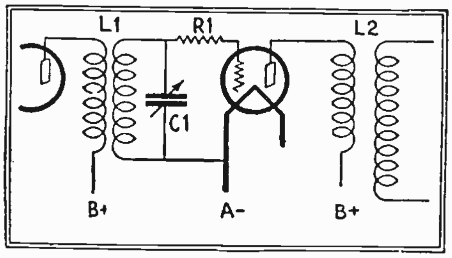


FIG. 91-B—The "grid suppressor" provides an easy way of stabilizing a receiver.

Phase-Shifting Systems

Another very good stabilizing system is one which shifts the voltage phase in the plate circuit of the R.F. tubes, so that the plate voltage will be out of phase with the grid voltage, thus preventing a feed-back. In this method, a variable condenser is connected in the plate circuit of the radio-frequency tube, and the plate current is supplied through a choke coil or resistor instead of through the primary of the succeeding coupling coil. The primary is then connected to the negative filament terminal instead of the "B+" terminal; since no direct plate current flows through this coil. The condenser used for this purpose should have a maximum value of about .001-mf. (See Fig. 91-C.)

Another variation of this system is to use a fixed condenser and a variable resistor. In this case, the condenser C2, in Fig. 91-D. should have a value of about .002-mf., and a resistor of about 100,000 ohms should be used as R1.

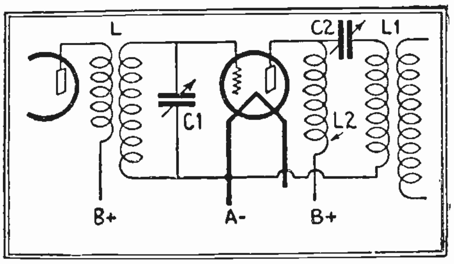


FIG. 91—One method of "phase-shifting" in a radio-frequency amplifier, to prevent interaction between stages, is shown here.

Methods of controlling oscillation which employ resistors, such as the potentiometer, to increase the resistance of the tuned circuit or place a positive bias on the R.F. tubes, are not very efficient; since a positive bias allows a current to flow in the grid circuit, which acts as a leak, thus cutting down the signal strength. The grid returns of the R.F. tubes shoul dalways be connected to the negative filament line between the filament resistor and the filament, so that the voltage drop across the latter will be impressed on the grid of this tube.

Another very common and simple means of controlling oscillation is to couple to the secondary of the radio-frequency transformer an *absorbing circuit*, which consists of a coil and condenser connected together as shown in Fig. 91-E. at L3-C1. Since the absorbing action of a circuit of this type is greater on the higher frequencies, the

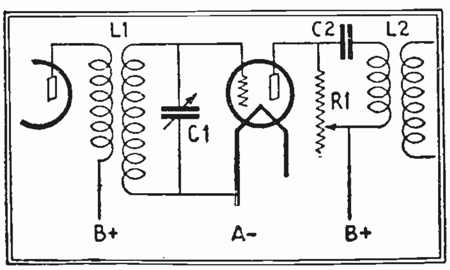


FIG. 91-D—A variation of the "phase-shifting" system of stabilization varies the resistor, instead of the condenser.

stabilization tends to be constant over the complete band covered by the coils.

A coil for this purpose can be wound on a tube slightly smaller than that of the secondary of the R.F. coupling coil, and should contain about 30 turns of No. 28 wire. The condenser should have a value of about .00025-mf. This absorbing coil should be so arranged that the distance between the secondary coil and absorbing coil can be varied to obtain the greatest sensitivity over the complete wavelength range. If the coil is coupled too closely to the R.F. transformer, the amplification will be reduced and, naturally, the sensitivity will also be reduced. A little experiment, however, will soon determine the correct value and position of the absorbing coil, so that each R.F. stage is just slightly below the oscillation point.

Combinations of the methods described above can be made which will result in high efficiency. As an example, you can use grid resistors which will allow each R.F. stage to oscillate slightly, and then use either filament resistors or plate resistors for bringing each of these circuits just below the oscillation point. A single plate resistor may be satisfactory, and allow a continuous variable adjustment over the oscillation at any point on the dials; it will act also as a very convenient volume control for the receiver.

Superheterodyne Oscillator

(92) Mr. R. Koch, Montreal, Quebec, asks:

Q. 1. What is the law governing the number of turns, size of wire and closeness of coupling of the grid and plate coils of an oscillator in a super-heterodyne? Is there any relation between the sharpness of tuning of the oscillator dial and the intermediate amplifier?

A. 1. The sharpness of tuning on the oscillator dial is, practically, controlled entirely by the characteristics of the intermediate amplifier. If your oscillator settings are broad, it is due, not to any inherent broadness of the oscillator itself, but to the selectivity of the intermediate amplifier. If your intermediate transformers have a very flat "amplification characteristic" and the filter circuit tunes broadly, then the oscillator settings will likewise be

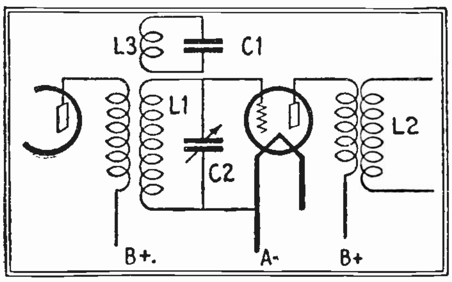


FIG. 91-E—An absorbing circuit, shown at L3-C1, will allow even amplification over the complete band, as explained in the text.

broad, and the set will not be selective. If, on the other hand, your intermediate transformers have a fairly definite "peak" at a certain frequency, and the filter is well designed, with a sharp maximum at the same frequency as the transformers, then the oscillator-dial settings will probably be very sharp.

The usual oscillator circuit consists of a grid coil tuned with a variable condenser, the number of turns on the grid coil being designed to work over the broadcast band with the particular type of condenser used. The plate coil is not tuned, and has sufficient inductance so that the tube will oscillate at all frequencies within the broadcast range. An oscillator coil of this type may be made by winding 90 turns of No. 24 enameled wire on a 2-inch tube, for use with a .00035-mf. variable condenser, and 45 turns of No. 30 silk-covered wire, wound double-jumble fashion at the filament end of the grid coil, for the plate inductance. The coupling coil is wound on a 1-inch tube placed inside the oscillator, and consists of 25 turns of No. 36 silk-covered wire. This coil is usually placed in series with the secondary coil of the first detector and serves to couple the oscillator with the detector.

Underground Antennae

(93) B. F. Mills, Waco, Texas, writes:

Q. 1. How can I construct an underground or underwater antenna to the best advantage? Does an antenna of this nature compare favorably with the usual type of receiving antenna?

A. 1. Ground antennae usually consist of a single wire lying on the surface or a short distance under the surface of the ground. They operate more efficiently when the soil is wet rather than dry and with an insulated rather than with a bare wire. They may also be used under the surface of fresh or salt water. In salt water they should be submerged only a short distance below the surface.

The best results are usually obtained with wires well insulated with moisture-proof material. The amount of power received by ground antennae is considerably less than that received by the usual elevated antennae. The ground antennae, however, have a number of compensating advantages as they are directional receiving devices, the strongest signals being received when the wire extends along the lin of propagation of the waves. Also they do not develop the usual troubles during local thunderstorms which make elevated antennae dangerous to the operator. The ground antennae as sometimes employed, have a somewhat greater ratio of signal strength to strays than the usual elevated antenna.

The length of wire which should be used as a ground antenna depends upon the wavelength of the signals to be received. Thus for a long wavelength longer wires should be used than for short wavelengths. The length of the ground or underwater antenna which should be used for the reception of a particular wavelength depends upon the diameter of the conductor itself and also upon the nature of the dielectric material adjacent to the conductor. If it is desired that a wire buried in the ground should remain in effective operation more than a few months it is usually necessary to use wire insulated with at least ¼ inch of good live rubber.

In earth of the average range of moisture content a ground antenna 75 feet long may be expected to give satisfactory reception from 150 to 500 meters. Under average conditions it will be advisable to use stranded or solid conductors, about No. 14 B & S, with good rubber insulation, buried in a shallow trench 6 to 12 inches below the surface of the ground. Under some conditions it may be advisable to bury a wire as deep as 24 inches. It should be noted that a ground antenna can not be expected to give good results unless several stages of amplification are used. At a small receiving station with the usual equipment it will usually be found more satisfactory to use the ordinary elevated antenna.

"A" Battery Charger

(94) William F. Brockenbrough, Richmond, Va., asks:

Q. 1. How can I construct an "A" battery charger, using a type 200 or 201A tube?

A. 1. It is impossible to construct an apparatus of this sort for charging "A" batteries, because a rectifier employing a 201A tube delivers only a very slight amount of current and would be entirely unsuitable for the purpose you mention. The type 200, being a soft tube, is unsuitable even in a rectifier supplying plate current. For an "A" battery charger we recommend using a rectifier tube of the Kenotron type.

Short-Wave Transmitter

(95) Mr. R. S. Bower, Galveston, Texas, writes:

Q. 1. I would like to obtain the diagram and instructions for building a transmitter for the 40-meter band, using a 210 tube and crystal control. This transmitter is to be used for amateur transmission and should be as efficient as possible. A 400-volt rectifier-and-filter system will be employed for supplying the plate voltage to the 210 tube, and the filament will be supplied with alternating current.

A. 1. You will find the diagram of a transmitter of this type in Fig. 95. As you will notice, the transmitter consists of two tubes, one a 112 type for an oscillator, and the other a 210 for the amplifier. The first tube is controlled by a quartz crystal tuned to 160 meters, or 1,874 kilocycles. In operation, the *second harmonic* of the oscillator (3,748 kc.) is picked up in the grid circuit of the amplifier; and this frequency is again doubled in the plate circuit of the amplifier, producing a frequency of 7,496 kc. or 40 meters. With an arrangement of this type, it is possible to transmit on either 20, 40 or 80 meters without any difficulty. For 20-meter transmission, the plate circuit of the amplifier tube is tuned to the 20-meter band. For 80-meter transmission, it is tuned to the 80-meter band. In this case, however, the 160-meter circuit is eliminated and the amplifier input circuit is tuned to 160 meters.

The coil L1 in the plate circuit of the oscillator is constructed so that the crystal operates correctly without placing a tuning condenser across this coil. No data can be given for the exact dimensions of this coil, since it depends upon the individual crystal. With a crystal tuned to 160 meters, it will consist of about 40 turns of No. 20 D.C.C. wire on a tube 2¾ inches in diameter. The best way to adjust this coil is to place a few extra turns on it, and then gradually remove turns until the correct value is obtained. If a ½-ampere ammeter is placed in the lead to this coil, a gradual increase in current will be noticed as the correct coil value is reached. Wire should be removed from this coil until the resonance point is passed. This will be indicated by a sudden drop in current. The inductance should then be increased slightly, so that the correct resonance point is obtained.

The next point in operating the transmitter is to tune the 80-meter circuit, consisting of L2 and C2, to resonance. Finally, the 40-meter circuit should be tuned to resonance and the transmitter is ready for operation. The best way to tune the last two circuits to resonance is to use a wavemeter; since in this way the actual wavelength is obtained that is desired for operation. A milliammeter in the amplifier plate lead and a radio-frequency ammeter will indicate the resonance point for each circuit. When operating correctly, the amplifier tube will be drawing about 60 milliamperes and the oscillattor about 25 milliamperes. A good way to check the circuit is to remove the crystal from the circuit and notice whether the output of the amplifier drops off to zero. If the transmitter is adjusted correctly, the amplifier plate current will drop to almost zero when the crystal is removed from the circuit.

As you will notice, a key-filter system is used to prevent key clicks and thumps when operating the key. These noises are particularly noticeable with a system of this type, and unusual care should be exercised.

Apparatus Specifications

Coils L2 and L3 should both be wound with No. 14 wire on a 3-inch tube, with 8 turns of wire to every inch of tubing. A satisfactory way to do this is to place the tubing in a lathe and thread it, 8 turns to the inch. Coil L2 contains 28 turns and coil L3 contains 20 turns. The tuning condensers used with these coils (C2 and C4) have a maximum value of .00025-mf. The radio-frequency choke coils, L4 and L5, should be wound with about 100 turns of No. 30 D.C.C. wire on a 1-inch bakelite tube. These coils may be wound jumble fashion or layer wound, as desired.

The center-tapped resistors placed across the two filament circuits should have a value of about 200 ohms, with a tap at the center. Condensers C6, shunted across these resistors, should have a value of .001-mf. The resistor R1 is a grid leak with a value depending upon the plate voltage used on the oscillator tube. The resistors R3 and R4 are ordinary rheostats of about 10 ohms each. They should have sufficient current-carrying capacity so that they will not be overheated. Resistor R5 has a value of about 12,000 ohms, and is used for reducing the plate voltage applied to the oscillator tube. The by-pass condensers, C1 and C7, should have a value of .01-mf., and be capable of standing the plate voltage supplied to the tubes.

The condenser C8 in the key filter has a value of 1 mf., and the choke coil employed in this filter system should have an inductance of about 3 henries. If desired, a 150,000-ohm resistor may be shunted across the key in order to increase the filtering action. The condenser C3 should have a value of .001-mf. You will notice that no "C" bias is supplied to the oscillator tube; this is due to the low plate voltage which is employed, so that the crystal will not be injured. A "C" bias is employed on the amplifier tube and should have a rather high value. A bias of between 50 and 125 volts will give the best results. This comparatively high "C" bias is used so that there will be obtained a rather distorted output, which will tend to increase the value of the harmonics and naturally will increase the output of the transmitter.

Several meters should be connected in the circuit in order to obtain the correct results. An alternating-current voltmeter should be used to measure the filament voltage supplied to the tubes, and a plate voltmeter with a scale deflection of 1,000 volts should be used for measuring the plate voltage. An 0-to-200 milliammeter should be used for measuring the plate current and also to adjust the various circuits to resonance as described above. The input filament voltage should be 8 volts and the plate voltage should be about 500.

The quartz crystals used in this transmitter are manufactured commercially and are ground quite accurately, so that the exact frequency can be obtained.

Phonograph Pick-Up

(96) Mr. G. A. Sheppard, Mt. Village, Alaska, writes:

Q. 1. Is the new electrical attachment for the phonograph usable on a Radiola superheterodyne No. 28?

A. 1. Yes an electrical phonograph pick-up device may be used with the Radiola 28. It is simply necessary to connect it in the circuit of the second detector by means of a plug-in adapter.

Q. 2. What make would you recommend and what does it sell for?

A. 2. Almost any good make can be employed. The instructions for using the various kinds of units always accompany them and we would suggest that you read over these instructions very carefully before using one.

Extending the Speaker

(97) O. Rochelle, Riverside, Ill., asks:

Q. 1. I have a radio set and my friend who lives one and a quarter miles away would like to use the same receiver. Would it be possible to run a line from my radio set along the telephone posts to his home?

A. 1. It would be possible to erect a line between the two places. Only one line would be necessary, the earth being the second connection at both ends. Wire used should be of a heavy gauge rubber covered and should be suspended by means of insulators wherever held in position. An output transformer having a ratio of one to one should be used at your friend's home and a two-stage amplifier will be necessary with your radio receiver. The amplifier is to bring the drop in the signal strength along the line back to normal. This combination will be entirely possible and good results will be obtained if a power amplifier or power pack is employed.

Coil Data

(98) Mr. A. Wedelich, St. Louis, Mo., writes:

Q. 1. Please furnish me with a chart showing the simple calculation of coil windings. I have several books on radio, but most of them give rather intricate formulas that involve algebra and higher mathematics and are too deep for me.

The coils I wish to construct are for the broadcast band; the primary, secondary and tickler for radio-frequency transformers, antenna coupling coils, etc."

A. 1. You will find below a chart of inductance coils suitable for use over the wavelength band between 200 and 550 meters with condensers of .00025-, .00035-, .0005- or .001-mf. This chart shows the size of the sceondary coil for use in the coupler. The size of the primary and the distance between the primary and secondary are matters which depend upon the particular circuit in question and the size of the coil used.

As an example, a radio-frequency coupling coil, to be used with a neutralized circuit when a 3-inch tube is employed, can contain 15 or more turns of wire. In a circuit

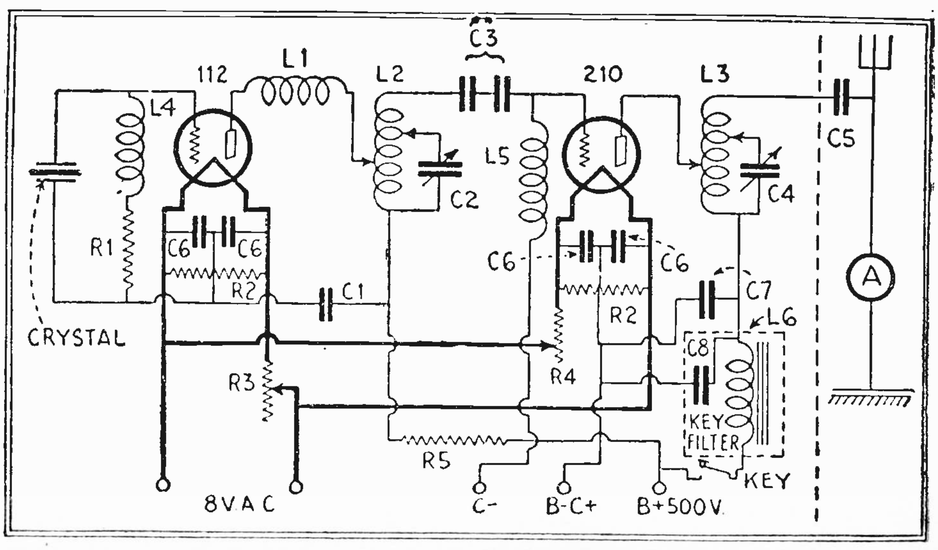


FIG. 95—The piezoelectric crystal regulating the frequency of a transmitter will serve to govern its operation on any of the harmonics of the crystal's fundamental frequency; as, for instance, with a 160-meter crystal, the transmitter may be operated on 80 or 40 meters.

which is not neutralized, this value will have to be reduced to 12 or 10 turns. In actual practice it is a simple matter to find the value which will supply the desired characteristics.

The turns on a tickler coil for use in a regenerative circuit can be figured at about two-thirds the number of turns of wire on the secondary coil. This proportion, however, does not hold true in all cases, especially when vacuum tubes such as the 199-type are used. In this case, the size of the tickler coil will have to be increased, since this tube does not oscillate as freely as the 201A-type.

The distance between the secondary and tickler coils also affects the size of the coil; and the use of resistors or condensers for controlling the regeneration also changes this value. The actual size of the tickler coil can easily be determined when the set is in operation. If the regeneration is too strong and cannot be controlled, the tickler coil should be reduced in size; while, if sufficient regeneration is not obtained, the size of the coil should be increased.

Wire D.C.C.	Diam. of coil inches	Maximum capacity (MF.) of tuning condenser .00025	.00035	.0005	.001
	2	165	125	92	53
	2½	122	92	68	40
No. 20	3	90	69	54	35
	3½	76	59	46	28
	4	66	53	40	25
	2	140	105	81	50
	2½	108	82	62	38
No. 22	3	84	66	50	32
	3½	74	56	42	27
	4	60	48	37	24
	2	132	100	77	45
	2½	97	75	59	35
No. 24	3	78	62	46	29
	3½	65	53	40	26
	4	53	42	35	23

Wire D.C.C.	Diam. of coil inches	Maximum capacity (MF.) of tuning condenser .00025	.00035	.0005	.001
	2	120	93	69	44
	2½	89	70	52	34
No. 26	3	72	56	45	28
	3½	61	48	37	25
	4	51	41	33	22

Browning-Drake Coils

(99) Mr. Elwood Smith, Schenectady, N. Y., asks:

Q. 1. I am going to build the new Browning-Drake set using the 222-type screen-grid amplifier. I wish to wind my own coils and would like to have the specifications of the coils used in the 222-type Browning-Drake tuning unit. I am especially interested in the high impedance primary of the R.F. coil and the turns ratio used in it.

A. 1. The antenna coil for use with the Browning-Drake receiver employing the 222-type tube, consists of 60 turns of No. 26 enameled wire, space wound on a 2-inch form. This coil is designed to be tuned with a .0005-mf., variable condenser. The detector coil is also wound on a 2-inch form with No. 26 wire and has a primary of 12 turns, a secondary of 108 turns and a tickler of 35 turns. The secondary coil is tuned with a .00035-mf. condenser.

Trickle Charger

(100) Mr. J. K. Stone, Christopher, Ill., asks as follows:

Q. 1. I would like to construct a trickle charger, one which can be used with a storage battery even while the set is in in operation. Can you furnish me with any constructional information and other data which will enable me to construct this device?

A. 1. The parts necessary for the construction of the trickler charger are a step-down transformer (toy-train type, or bell-ringing transformer, with approximate output of 10 volts) and a chemical rectifier cell, consisting of a fruit jar, one aluminum rod element and one lead element, approximately ½-inch in diameter and supported by a rubber cap (see illustration). The solution employed is a saturated solution of ammonium phosphate and distilled water.

Q. 2. Can I employ the same device for charging my storage "B" battery, which is composed of two 46-volt blocks (23 cells in

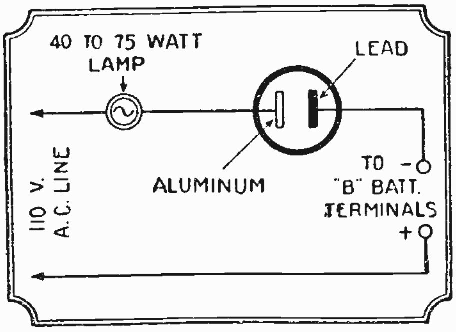


FIG. 100-B—Wiring diagram of the chemical rectifier as used to charge storage "B" batteries.

each block, two volts to each cell, lead-plate type battery). If not, please furnish me with details of construction of a storage "B" battery charger that will operate economically and satisfactorily.

A. 2. It is impossible to employ the trickle charger is arranged in Fig.100-A for charging a storage "B" battery; the voltage output is insufficient.

However, the changes in wiring, and necessary additions to convert it into a "B" battery charger, are really very few and simple. A 75-watt lamp in place of the step-down transformer and a few changes in the connections are all that are required. The wiring diagram for this device is shown in Fig. 100-B.

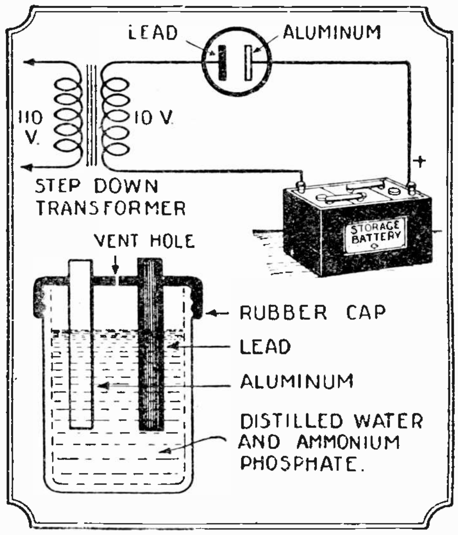


FIG. 100-A—Wiring diagram of a trickle charger system, and the construction of the chemical rectifier employed in this type of charger.

New A.C. Tubes

(101) Mr. L. Jackman, Little Falls, Minn., asks:

Q. 1. Please publish information on the new UX-226 and UY-227 tubes; also on the rectifier tubes, UX-280 and UX-281.

A. 1. UX-226 is a 1½-volt A.C. filament type, drawing a current of 1.05 amperes and intended for radio-frequency and audio-frequency amplification in circuits especially designed for its use. The filament is energized from an A.C. lighting source through a suitable step-down transformer. The operating characteristics of the UX-226, other than the method of energizing the filament, are generally similar to those of the standard 201A. UX-226 is not recommended as a detector.

UY-227 is an A.C. heater type, in which the electron-emitting element (cathode) is made active through an independent internal-heating element requiring 1.75 amperes at 2½ volts, A.C. It is primarily intended as a detector tube in receiving sets where the radio-frequency and audio-frequency stages employ the UX-226 tube; although it may be employed for radio-frequency and audio-frequency amplification as well. It employs a special five-prong base.

These new tubes will be welcomed by experimenters, and it is likely that newly designed sets will employ UX-226 in all R.F. sockets and in the first A.F. stage, UY-227 in the detector stage and a power tube in the last audio stage—*i.e.,* UX-112, UX-171 or UX-210. The requisite low-voltage supply for the filament may be obtained from an independent step-down transformer or from additional low-voltage windings on the usual "B" or plate-supply transformer.

New Rectifying Tubes

UX-280 is a full-wave rectifier designed for rectifying apparatus and circuits requiring a greater D.C. output than that afforded by the standard half-wave rectifier. It will deliver up to 300 volts at 125 milliamperes. The increased output of this tube will, however, be secured only in circuits especially designed for it.

UX-281 is a half-wave rectifier similar to the present 216-B tube, although of increased physical dimensions. It will furnish an output of up to 500 volts at a current of 110 milliamperes.

Both of the new rectifiers are of the hot-cathode type, equipped with a new ribbon, oxide-coated filament which insures great ruggedness.

Loop Antenna

(102) Richard Hays, Altoona, Canada, asks:

Q. 1. How many feet of and what kind of wire should be used in winding a loop for broadcast reception.

A. 1. Use about 100 feet of wire. No. 18 bell wire or some similar type will be found quite satisfactory. A good many constructors prefer stranded wire, such as lamp cord. Wind this on a 3½- or 4-foot frame, either of the box type, otherwise known as the solenoid, or in a spiral form, on a set of four or more radial arms.

Charging Storage "B" Batteries

(103) Geo. C. Abernethy, Tofield, Alta., Canada, writes:

Q. 1. Please give me information on how to use a Ford generator in conjunction with a step-up transformer, equipped with a vibrator similar to a spark coil for charging a 100-volt storage "B" battery.

A. 1. We would most certainly advise against your attempting to proceed as you have outlined. Charging storage "B" batteries from such a source would be a very expensive proposition and would require quite a complicated layout of apparatus. The best thing for you to do would be to obtain a small high-voltage generator, capable of delivering up to ¼ of an ampere. If this is obtained in such a size as to deliver approximately 120 volts, it could be used for charging storage "B" batteries.

Q. 2. Can the step-up transformer and

vibrator, in conjunction with a filter, be used in place of a "B" battery?

A. 2. A device of this sort would not be practical to replace a "B" battery. If the correct filter is used in conjunction with the generator mentioned in the answer to your first question, the arrangement may be successfully used for supplying the "B" potential to your radio set.

Antenna For Gomez Super

(104) Mr. G. Robinson, Newark, N. J., writes:

Q. 1. I have constructed the Gomez Super-Reflex receiver and have had excellent results with it. If it is possible, I would like to adapt this set for use with an outside aerial. Will you publish the necessary data for doing this?

A. 1. A coupler for adapting the Gomez reflex receiver for use with an aerial can be made as follows: On a 3-inch tube wind 90 turns of No. 26 D.S.C. wire tapped at the 60th turn. This coil should be spaced like the coil L2 in the original receiver. The beginning of this coil should connect to the No. 1 terminal on the receiver; the 60-turn tap at No. 2, and the far end of the coil to No. 3. A rotor coil, which will connect to the antenna and ground, is wound on a 2¾-inch bakelite tube with 15 turns of No. 24 D.S.C. wire. This coil is arranged so that it can be rotated at the No. 1 end of the secondary coil. Of course, the Gomez receiver has been made as compact as possible and it will be necessary either to use a larger panel to accommodate the new coil, or to connect it outside of the cabinet. By rotating the primary coil in the antenna coupler, a point will be found at which the selectivity and volume are best. When this point has been found, the primary coil need not be turned again, all the tuning being accomplished with the tuning condenser.

Coil Data

(105) O. Werg, Hawthorne, N. J., writes:

Q. 1. Will you kindly give me the data for coils which will cover the wavelength band for broadcast reception? These coils will be wound with No. 24 or No. 26 D.C.C. wire on a 2-inch form, and will be tuned by a .0005 or .00035 mfd. variable condenser.

A. 1. A 2-inch coil wound with No. 24 D.C.C. wire and tuned by a .00035 mfd. variable condenser will require 101 turns of wire and if tuned by a .0005 mfd. variable condenser will require 76 turns. The same size coil, wound with No. 26 D.C.C. wire, when tuned with a .00035 mfd. variable condenser will require 93 turns, and if a .0005 mfd. variable condenser is used, 70 turns of wire will be necessary. No. 24 D.C.C. wire winds 33 turns per inch and No. 26 wire winds 38 turns per inch.

Simple Wavemeter

(106) K. O. Hearst, Havana, Cuba, writes:

Q. 1. I understand that a simple and efficient wavemeter can be constructed using only a tuning coil, variable condenser, buzzer, switch and battery. If this is so, will you please tell me how to connect up these components?

A. 1. A diagram of the connections for a simple buzzer wavemeter using the parts you mention is shown on this page. The buzzer, switch and battery are connected in series with the tuning coil and the variable condenser is connected in parallel with the coil. The condenser should have a capacity of .0005 microfarad and should be of the same type as is used in the receiving set. The size of the tuning coil will depend on the wavelength range which the meter is to cover and about 50 turns of No. 22 magnet wire wound on a form having a diameter of 3½ inches will be suitable for wavelengths from 175 to 550 meters.

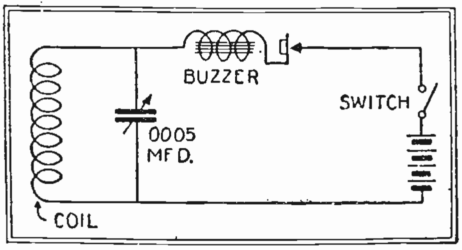


FIG. 106—The circuit diagram of a simple buzzer wave meter is shown above. The variable condenser should have a capacity of .0005 mfd. and should be of the same type as used in the receiving set.

Choke Coil Construction

(107) J. B. Gamer, New York, N. Y., asks:

Q. 1. Will you give me the data necessary for the construction of a choke coil which is to be used with condensers, in order to eliminate interference in the radio set which arises from electric motors?

A. 1. A good type of choke coil to be used in connection with condensers for eliminating interference in power lines from electric motors consists of 100 turns of No. 18 double cotton covered wire, wound in a single layer on a fiber tube of about 3-in. diameter.

A Question of Flux

(108) L. Lunkin, Enid, Okla., asks:

Q. 1. I propose adding a choke filter output circuit to my present receiver. I have a transformer, the primary of which is burnt out. Will the secondary be suitable for use as a choke?

A. 1. The iron core of a transformer is designed to accommodate only a limited magnetic flux, since most audio frequency transformers are intended to be used after medium impedance tubes, where the plate current is small. If the transformer is used as an output choke, it is probable that the core will saturate and cause distortion, due to the comparatively heavy plate current. This is more especially the case, if the secondary winding is used, owing to the large number of turns, and, therefore, the greater magnetic flux produced for a given current.

Keeping Out R.F. Currents

(109) R. Holt, Green Bay, Wisc., writes:

Q. 1. I notice that in several recent issues of radio magazines resistances of about ¼ megohm are connected directly to the grid circuit of the first audio frequency amplifier. I should be glad to know if this arrangement may be applied when an audio frequency transformer couples the detector output to the amplifier.

A. 1. The stabilizing resistance may be used in a transformer coupled set, and it will certainly do no harm. It is doubtful, however, whether its inclusion is worth while, and in many cases the difficulties of separating the radio frequency and audio frequency components are less pronounced with transformer coupling than when a resistance is used.

Locating Power Leaks

(110) J. A. Moorefield, Charlottsville, Va., writes:

Q. 1. I have had considerable trouble while operating my radio receiving set from interference probably caused by leaks in power lines. How can leaks of this nature be located?

A. 1. The only practical method of locating interference of the nature you mention is to use a loop connected to a two- or three-tube receiver. This should preferably be of the oscillating type so as to be more sensitive to interference of the nature you mention. The outfit could then be carried around the locality where trouble is experienced and by swinging the loop, the general direction of the leak could be determined. Use the triangulation method.

Matching Condensers

(111) D. McGurk, Montreal, Canada, writes:

Q. 1. I desire to match and test some small fixed condensers for use in radio receiving sets; how can this be done?

A. 1. It would be very expensive indeed to install apparatus for matching and testing of various condensers. Unless you have many condensers to test and match, it is not advisable to make this installation. Rather we would advise that you get in touch with some experienced laboratory where this can be done for you at a nominal charge. We will send name and address of such a laboratory upon receipt of stamped addressed envelope

Loud Speaker

(112) Fred Bailey, Pasadena, Calif., asks:

Q. 1. Is it advisable to purchase one of those types of loud speakers in which an ordinary phone unit is to be clamped to the small end of the horn.

A. 1. An ordinary type of headphone or receiver is not designed to carry sufficient current to operate satisfactorily as a loud speaker. This, of course, is not true in all cases, and if you employ some type of receiver in connection with the horn you mention that has been designed to withstand the heavy current found in the plate circuit of the last tube of an amplifier, you may expect quite good results.

Multiple Phone Connections

(113) J. R. Cormany, Lonoir City, Tenn., writes:

Q. 1. I have a standard type of one-tube set but cannot use more than two pairs of phones in series on the set at the same time. Can you suggest any remedy for this?

A. 1. When you put more than two pair of phones in the plate circuit of your detector tube, the resistance becomes so great that your set fails to function properly. The best thing for you to do would be to obtain one of the devices on the market today which are designed to have placed therein a single reproducing unit or telephone. Four or more rubber tubes radiate from the cover of the unit and terminate in pairs of earpieces similar to a stethoscope. Also try connecting phones in parallel instead of in series.

Capacity Ground

(114) V. A. Bower, Shelburne, Canada writes:

Q. 1. I have been able to receive signals on my set by substituting for the regular ground a wire dipped in a glass of water. I desire to know whether I have discovered a new type of ground.

A. 1. It is entirely possible to receive radio signals and to transmit them without using a direct ground connection. It is only necessary to have a capacity effect between the receiving or transmitting set and the ground. This is undoubtedly the situation that was found in the experiment you outline, but the glass of water had nothing to do with it.

Short-Wave Data

Amateur Licenses

(115) James F. Marcy, Milwaukee, Wis., asks:

Q. 1. Will you please publish the requirements which must be met to obtain an amateur transmitting license?

A. 1. We quote from the Radio Communication Laws of the United States bulletin, furnished to us by the Department of Commerce:

"Amateurs before applying for licenses should read and understand the essential parts of the International Radio Telegraphic Convention in force and sections 3, 4, 5 and 7 of the Act of August 13, 1912. The Department recognizes that radio communication offers wholesome form of instructive recreation for amateurs. At the same time its use for this purpose must observe strictly the rights of others to the uninterrupted use of apparatus for important public and commercial purposes. The Department will not knowingly issue a license to an amateur who does not recognize and will not obey this principle.

"Amateur First Grade.—The applicant must have a sufficient knowledge of the adjustment and operation of the apparatus which he wishes to operate and of the regulations of the International Convention and Acts of Congress insofar as they relate to interference with other radio communication and embody certain duties on all grades of operators. The applicant must be able to transmit and receive in Continental Morse at a speed to enable him to recognize distress calls or the official 'keep-out signals.' A speed of at least ten words per minute (five letters to the word) must be attained.

"Amateur Second Grade.—The requirements for the second grade will be the same as for the first grade. The second grade license will be issued only where an applicant cannot be personally examined or until he can be examined. An examining officer or radio inspector is authorized at his discretion to waive an actual examination of an applicant for an amateur license, if the amateur for adequate reasons cannot present himself for examination, but in writing can satisfy the examining officer or radio inspector that he is qualified to hold a license and that he will conform to his obligations."

Electrolytic Rectifier

(116) Robert K. Jones, Chicago, Ill., writes:

Q. 1. I am contemplating the construction of a complete transmitting set using rectified A.C. for supplying the plate voltage to a UX-210 tube. How many cells should be used in the electrolytic rectifier, since this is the type that I desire to use for changing the current from A.C. to pulsating D.C.?

A. 1. It is safe to figure about fifty volts per cell in an electrolytic rectifier for transmitting purposes. Presupposing that you use a transformer with the secondary tapped in the center and delivering 550 volts on either side of the center tap, use 11 jars in each of the outside secondary leads or a total of 222 jars in all. The method of connecting an electrolytic rectifier with this type of transformer was clearly shown in the Radio Constructor article appearing in the December, 1925, issue of *Science and Invention*. We would suggest that anyone interested in transmitting, refer to this article for further information.

Another Battery Transmitter

(117) C. Ferber, Santa Monica, Calif., asks:

Q. 1. Will you please recommend a radio telephone circuit using receiving tubes and dry cell B batteries?

A. 1. You will find on this page a circuit diagram of a type of transmitter which has been tested and found very satisfactory for the medium wavelengths. We do not recommend this circuit for short-wave work, and we find a modified Reinartz circuit to be best for the new short-wave experiments. You will notice that the transmitter uses two of the 210 type tubes, which are rated at about 7½ watts output. You will find these tubes of about equal efficiency to the 5-watt tubes formerly used. In the diagram, the modulation transformer, M, may be any one of the commercial makes, or it may be simply a telephone induction coil connected as shown.

The choke coil indicated at X need not necessarily have a value of exactly 6 henries, but it should not be smaller than this figure. The oscillator system, consisting of Coil L2, and Condenser C2, of the simplest design practical, and the constants of these parts depend entirely upon the wavelength range over which the set is intended to operate. The same is true of the coil L1, and the variable condenser C1, used to tune the antenna circuit. As the circuit is arranged here, a tap of the C battery is taken for the microphone circuit. You may find that an electromagnetic pick-up will work better than a carbon microphone in this case. Such a pick-up may be improvised by connecting a cone loud talker through an audio-frequency amplifier to the input side of a modulation transformer, such as that used in this diagram.

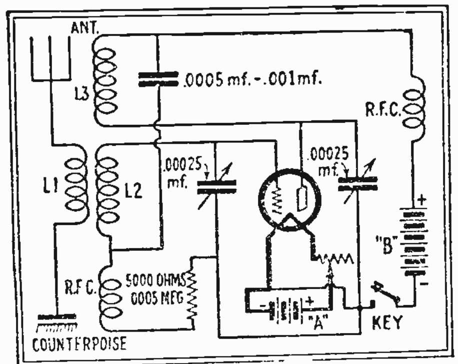


FIG. 117-A—Above is the hook-up of the forty-meter short-wave radio transmitter. The circuit is a modification of the Colpitts circuit. A single wire about 30 feet long should be used for the antenna.

Short-Wave Transmitter

(117A) W. E. Kopek, Zion City, Illinois, asks:

Q. 1. Will you please publish a diagram of 40 meter wave radio transmitting set?

A. 1. On this page you will find given a schematic diagram of a short-wave oscillating circuit, which is a modification of the Colpitts circuit. The two tuning condensers have a capacity of .00025 mf. each. The antenna coupling coil which is 3 inches in diameter consists of 1 to 6 turns, depending upon the type of antenna used. L2 and L3 consists of 7 turns each, 3 inches in diameter. These coils may be wound with No. 14 copper wire or larger. Radio frequency chokes are of the basket weave type and consist of 40 turns of No. 22 S.C.E. wire. These chokes are 1¾ inches in diameter and are wound on 8 pegs. The grid leak should have a resistance of 5,000 ohms, which is equal to .005 megohms.

For short-wave transmission, a single wire antenna about 30 ft. long should prove effective. If a counterpoise is used instead of a ground, it should be of about the same dimension as the antenna. A series antenna condenser of about .00025 mf. capacity may be connected between the counterpoise and the coupling coil. A coil, antenna or loop can be used for transmitting over short distances.

When the tube is lighted and the key is closed, the transmitter should oscillate, and the condenser settings should then be varied until resonance with the antenna circuit is obtained. A small flashlight bulb, a thermo galvanometer, or a D.C. milliammeter will show the resonant point. The thermo-galvanometer may be inserted in series with the antenna. Maximum deflection indicates resonance. A D.C. milliammeter of 0 to 50 connected in series with the "B" batteries will show resonance by deflecting sharply when the resonant point is passed.

Reflexing on Short Waves

(118) T. Stewart, New York City, N. Y., writes:

Q. 1. I have a reflex receiver which has given very good results. The set uses plug-in coils and thus I am enabled to cover a large wavelength range. Recently I purchased some short wave plug-in coils, but can obtain no success with these. Can you tell me where I have gone wrong?

A. 1. It is asking too much of any reflex receiver, no matter how well designed, to expect it to give satisfaction on short wave lengths. It must be remembered that it is necessary first, to get a tube to give complete satisfaction as a plain radio frequency amplifier on short wavelengths, before we attempt to reflex it. In other words, reflexing consists in the use of a tube, per-

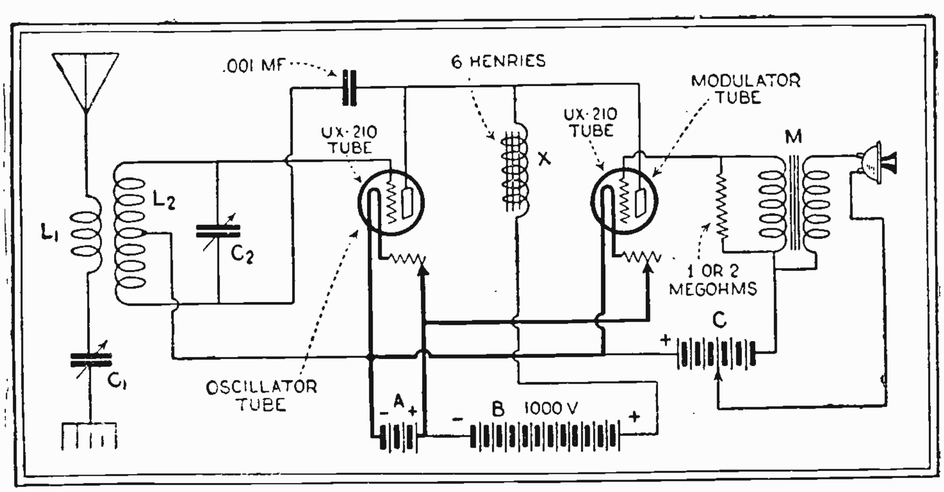


FIG. 117—Compact low power transmitters seem to interest a large number of our readers, so we are publishing another diagram suitable for this type of work above. Note that a "B" battery voltage of 1000 is used. This is the maximum of the 210 type tube, but less may be used if desired.

forming the functions of a radio frequency and audio frequency amplifier simultaneously. It is obvious, therefore, that before a tube can be said to be performing the functions of a reflex tube, it must give some account of itself as a radio frequency amplifier. First, let us make the tube perform efficiently as a radio frequency amplifier, before we proceed to reflex it. In our opinion, it would be far better to build a separate receiver for the reception of short waves.

Short-Wave Receiver Coils

(119) Mr. A. H. Lester, West Chicago, Ill., writes:

Q. 1. I am looking for a little information in regards to the coils for the RADIO NEWS *Special Short-Wave Receiver.* Can you give me the size of the wire used on these coils, and also the number of turns?

A. 1. The coils used in the receiver are as follows: the primary consists of 10 turns of No. 22 wire, 2½ inches in diameter. This coil is used for all wavelengths and is fastened permanently to the mounting, on a hinge, so that the coupling with the other coils can be varied. The secondary of the smallest coil consists of 3 turns of No. 20 enameled wire, 3 inches in diameter. The tickler, 2¾ inches in diameter, is fastened inside the secondary coil and has only 2 turns. The next coil contains 8 turns of wire on the secondary and 4 on the tickler; the same sizes of wire are used. The third and largest set uses 19 turns on the secondary and 6 on the tickler.

The coils used for the broadcast band, from 200 to 500 meters, are both wound with No. 24 D.C.C. wire. The secondary contains 95 turns 3 inches in diameter and the tickler is wound with 12 turns. The large number of turns on the secondary is necessary because of the small capacity of the tuning condenser used with this receiver. The secondary coils, of all sizes, are supported on skeleton bakelite tubes; and the tickler and the primary coils are self-supported. The secondary coils used in the three short-wave coils are space-wound, ⅛-inch separation being used.

The differences in antenna constants, as well as in apparatus used, may make it desirable to remove turns from the secondaries, the better to cover the short-wave broadcast bands. The user can quickly discover this by a few experiments.

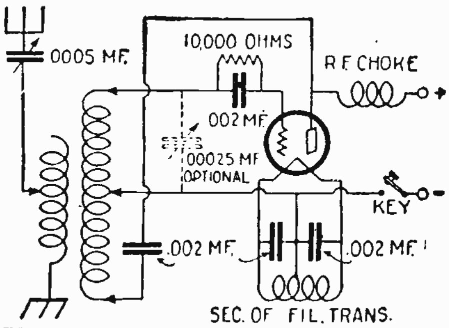


FIG. 120—Diagram of an extremely efficient short-wave transmitter employing the Hartley circuit.

A 40-Meter Transmitter

(120) Mr. K. Boyd, Schenectady, N. Y., asks:

Q. 1. Please publish the circuit diagram of a low-power short-wave transmitter employing the loose-coupled Hartley circuit, including constants of coils, condensers, etc. I intend to operate on the 40-meter band. What is the correct length of aerial and counterpoise for operation at this wavelength?

A. 1. The circuit you request is shown in Fig. 122, with the values of the various parts indicated. The Hartley circuit is reputed to be the simplest and most efficient circuit for use in amateur transmitters. This is attested by the fact that 90 per cent of all transmitting amateurs are at present employing this circuit in one form or another.

Two inductances are used, a primary or tuned circuit and a secondary or antenna coil. The emitted wave depends on the adjustment of the primary circuit, which after being turned to the required wavelength, is brought into resonance with the antenna coil by means of the antenna tuning condenser, and the proper adjustment of the coupling between the inductances. Both plate and grid condensers can be .002-mf.; but this value is not critical on the short wavelengths, and capacities as low as .0005-mf. can be used with good effect. The grid leak may be of any convenient value from 5,000 to 20,000 ohms, depending on the characteristics of the tube; a higher value usually reduces the plate current and results in a steadier output. Where low power is used, such as a 201A or a 112 tube with about 200 volts on the plate, both grid leak and condenser may be dispensed with, with no great difference in results.

The radio-frequency choke placed in the plate lead is employed to prevent the oscillatory currents from backing up into the power source, with the results of loss of efficiency and unstable operation. This choke can be easily constructed by winding on a 1½-inch form 150 turns of No. 30 D.C.C. wire. This winding should not be of the single-layer type, since the resultant increase in distributed capacity will defeat the purpose of the choke and by-pass some of the radio-frequency current. A scramble-wound coil on a spool of the correct diameter, will be satisfactory.

A storage battery should be used for filament supply; but, if larger tubes are employed and the current drain is excessive a filament transformer will prove more economical. This transformer should be provided with a center tap, to which is connected the negative high-voltage lead and the filament tuning clip. For best results, a .002-mf. by-pass condenser is connected across each half of the filament winding. Keying can be done in the negative high-voltage lead.

The primary inductance, for 40 meters, should consist of 12 turns of No. 10 copper wire wound to a diameter of 3 inches; the antenna coil of 6 turns of the same size wire having the same diameter. A variable tuning condenser may be used across the primary coil, but is not absolutely essential; since the coils have inherent, sufficient capacity for the proper oscillation of the circuit. The coupling between the primary and the secondary should be kept as close as may be consistent with a steady output; since close coupling results in a maximum transfer of energy. The aerial and counterpoise may each be about 30 feet in length, so that the transmitter is operated at or very close to the fundamental wavelength of the system. However, it has been found that results more uniformly consistent are obtained when the transmitter is operated on a harmonic of the antenna; and in most cases the *third harmonic* is used. When operating on this harmonic, the aerial and counterpoise should each be about 90 feet long, including the lead-in. Height in a short-wave antenna is not quite as important as in antennas designed for operation on the higher waves; but if it is convenient, the aerial should be made as high as possible.

Super-Regenerative Receiver

(121) Mr. G. H. Blake, Teaneck, N. J., asks as follows:

Q. 1. I would like to have constructional details for building a short-wave super-regenerative receiver. I have heard some reports that super-regeneration on short waves produces extraordinary results, and I would like to experiment to a certain degree with a circuit of this type.

A. 1. You will find the circuit of a one-tube short-wave super-regenerator on this page (Fig. 121). Some remarkable results have been obtained with super-regenerative circuits on short waves; and we believe that you will be highly pleased with the results of this receiver when you get it working properly. The parts are standard and the assembly is simple. The radio-frequency inductors are Aero plug-in-type short-wave coils, both on one mounting; they may be had in a set of three covering a band from 15 to 130 meters. The grid coil is tuned with a .00014-mf. variable condenser, while the regeneration is controlled by a .00025-mf. condenser. The antenna tuning condenser may be of the semi-variable type, such as the "Variodenser" manufactured by the X-L Laboratories.

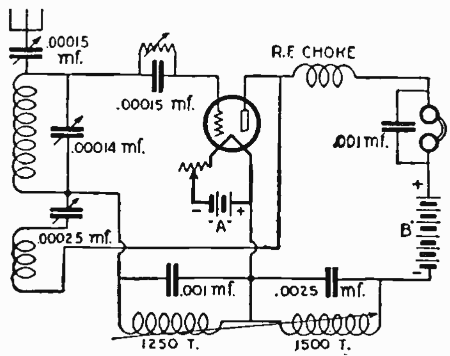


FIG. 121—The schematic diagram of a very successful short-wave super-regenerator is shown above. The .001-mf. condenser across the honeycomb coil should, preferably, be variable.

The grid coil of the low-frequency oscillator is a 1250-turn honeycomb coil shunted by a .001-mf. condenser, preferably variable, as its value is somewhat critical. This condenser also may be of the semi-variable type. The plate coil is a 1500-turn honeycomb coil shunted by a .0025-mf. condenser. The coupling between the two honeycomb coils should be easily adjustable, from very loose to very tight coupling.

Good results can be secured with a tube of either the 201A or the 199 type. The filament battery and filament rheostat, of course, are selected to suit the type of tube used. The one difficult point in the operation of this set is the adjustment of the coupling between the two honeycomb coils; these should be adjusted until the oscillating action is just at the point of stopping. This may require several trials but, once it is accomplished, the coupling may be left in its proper position and the set operated without changing it. When nothing is heard except a faint, high-pitched hum, adjust the variable grid leak until the set will go into and out of regeneration with only a slight plop. Then tune for the signals with the usual tuning controls and readjust the grid leak until the best results are secured.

The set has good selectivity, though the tuning is broad enough to "hang onto" swinging signals. The volume obtained is nearly double that ordinarily obtained on short waves with a single tube. The howls, squeals and rustling noises which too often characterize super-regenerative receivers on broadcast waves are almost eliminated. The radio-frequency choke should be one that will cover the band of frequencies over which the receiver is to be operated, and the .001-mf. condenser across the phones is almost essential.

Short-Wave Transmitter

(122) Mr. L. W. Errick, San Antonio, Texas, asks:

Q. 1. How can I construct a low-wave transmitter which will be very light, compact and can be carried by one person alone, with a pack and camping utensils? We are contemplating surveying a certain section of open country and would like to take portable radio equipment, so that the various parties can keep in communication with each other. Unfortunately, we are unable to use automobiles or pack animals; so the apparatus will have to be carried entirely by the members of the various surveying parties.

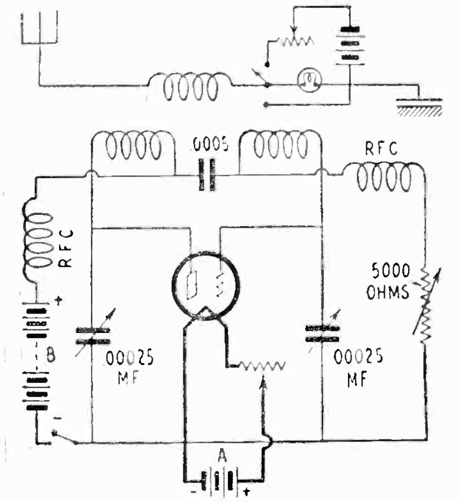


FIG. 122—This shows how the short-wave transmitter is connected. The R.F. choke coils are used to isolate the radio frequency in the grid and plate circuits and prevent losses.

A. 1. Probably the best arrangement that you could use would be one similar to the "baby transmitter" which the Burgess Laboratories have developed for experimenting with low-power, short-wave transmission. This transmitter uses a modified Colpitts circuit with a small receiving-type tube operated by small dry cells.

The principle used in operation is well known to most radio fans. Every one who operates a radio receiver, except at some isolated point, is familiar with the interference caused by other receivers which radiate. The energy from these interfering receivers, generally called "bloopers," is great enough to carry for many city blocks and cause whistling and squealing noises in the receivers of others. Ship operators have reported that, after leaving port and reaching distances from land as great as 30 miles, the "bloopers" could still be heard.

When a receiver is sending out a signal in this manner, it is functioning as a radio transmitter and deriving its power from the "A" and "B" batteries which are connected to it. The circuits and arrangements of a receiver, however, are not usually such as to make an efficient transmitter. For best receiver action, the receiving tubes are arranged to generate feeble radio currents and are very loosely coupled to the antenna system.

If the circuits associated with the small receiver tubes were made highly efficient and properly coupled to an antenna system, it would be reasonable to expect that the whistling would be heard in receivers at much greater distances, and become useful for communicating purposes. The transmitter described here is built around a 199-type tube, assembled in as compact a form as practicable, using two receiving-type (air-dielectric) variable condensers, two small inductance coils, and a small fixed condenser. This diagram is shown in Fig. 122. Radio-frequency choke coils, in series with the "B" battery feed and with the grid-leak resistor, prevent losses of the high-frequency energies in these circuits. A third small inductance coil placed between the other two couples the energy to the antenna circuit. This transmittter is suitable for continuous-wave transmission using the International Morse Code.

List of Parts

The components are as follows:

Two variable condensers, .00024-mf.;
One fixed mica condenser, .0005 or .001-mf.;
One secondary inductance coil, 7 turns;
One plate inductance coil, 7 turns;
One antenna coupling coil;
One UX-199 tube;
One grid leak, 5,000-ohm maximum;
One filament rheostat, 30 ohms;
Two radio-frequency chokes;
One telegraph key;
One bradleystat;
One flashlight bulb;
Batteries to supply "A" and "B" current.

The grid and plate inductance coils should be made of edgewise copper ribbon with a 3-inch diameter, or of No. 14 or heavier bare copper wire. Seven turns will be required on each coil, and one-half inch spacing left between turns. The antenna coupling coil is made of No. 14 or heavier copper wire and is wound two inches in diameter. The actual number of turns used depends on the antenna system used in the individual case. If a loop aerial is used, a single turn of wire will be sufficient for the antenna coupling coil. The radio-frequency choke coils contain 40 turns each of No. 22 D.C.C. wire; they are wound on a basket-weave form with 8 pins spaced around a 1¾-inch diameter form. In winding these coils the wire should be carried over one pin and under two.

Antenna Design

Several antenna systems can be used satisfactorily with this transmitter. One satisfactory method is to use a small antenna having a natural frequency approximately the same as that at which it is desired to transmit, *i.e.,* 40 meters. For this system, a single wire about 33 feet long, erected as nearly vertical as practical should prove effective. If a counterpoise is used instead of ground it should have approximately the same dimensions as the aerial. A series antenna condenser of about .00025-mf. capacity may be connected between the counterpoise and the coupling coil. Another method is to use a larger antenna and tune it to exactly three or five times the wave-length of the transmitter. This has sometimes been termed "transmitting on a harmonic," and can be used very effectively in connection with this transmitter.

Probably the best method, when using the transmitter for portable work, is a coil antenna or loop. A single-turn loop, three feet on a side, in series with a three-plate variable condenser, and a single-turn two-inch diameter coupling coil, will tune to the 40-meter band. With this aerial system, signals may be heard over three or four miles.

This transmitter may be easily adapted for phone transmission, since batteries are used throughout and naturally a very pure note is obtained. The circuit diagram in Fig. 122-A shows how a Heising modulation system can be added to the "baby transmitter" for the transmission of voice. It will be necessary to add another tube for this purpose. A microphone transformer will be required; although this may be replaced by a low-ratio audio-frequency transformer or a Ford spark coil. The microphone may be any good hand microphone. An ordinary telephone microphone will also work effectively in this circuit. The "C" battery should be of the ordinary 4½-volt type, and the audio choke coil should be 1 henry or larger. The primary of an audio-frequency transformer would be satisfactory for this purpose.

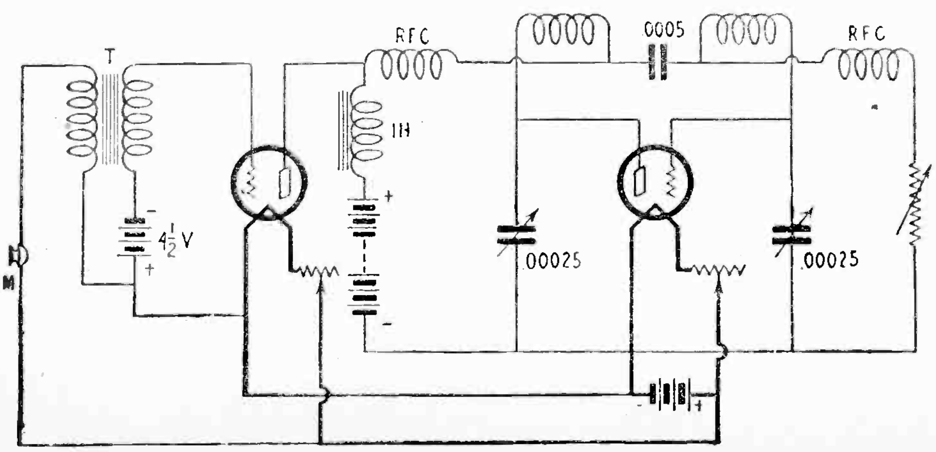
Operating Adjustments

For convenient operation, it is best to connect a switch somewhere in the lead to the "A" battery for cutting off the current to the tube filaments. Since an equal number of turns is used in each of the secondary inductance coils, the two variable condensers should be adjusted to approximately equal setting. When the tube filament is lighted and the modulator working, or the key closed, the transmitter will oscillate constantly.

The condenser settings are then varied until resonance with the antenna circuit is obtained. This resonance may be indicated by a number of methods. A thermogalvanometer, such as that ordinarily used in wave-meters, may be inserted in series with the antenna and used as an antenna ammeter; the maximum deflection denoting resonance. A D.C. milliammeter having a scale of 0 to 20 or 50, connected in series with the "B" batteries, will show resonance by rising sharply as the resonance point is passed over when tuning.

If no meters are available, a 2.5-volt flashlight bulb may be connected in the antenna circuit, as shown in the schematic diagram above. To find resonance, the switch is thrown to connect the battery to the lamp. The rheostat is adjusted until the lamp filament just begins to glow. When the

FIG. 122-A—The short-wave transmitter is shown here with a Heising modulator for phone transmission. The tubes used in this unit are both of a small (dry-cell) receiving type. The plate and filament currents are supplied from dry batteries.



transmitter is carefully tuned to resonance with the antenna circuit, the slight amount of energy radiated will noticeably brighten the lamp filament. To prevent the unstable action that may occur between coupled tuned circuits, it is best to adjust the transmitter to a point slightly one side of the point at which maximum radiation is obtained. After the adjustments are completed by means of the lamp, the single-pole double-throw switch should be thrown to the side where the lamp is disconnected from the battery and shorted out of the circuit, thus removing this resistance from the antenna circuit.

When operating any type of transmitter, it is necessary to obey the laws of the United States, which require that all radio transmitting stations should be licensed. Such station licenses are issued by the Department of Commerce, and copies of the laws may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Short-Wave Adapter

(123) Mr. R. B. Hughes, San Diego, Calif, writes:

Q. 1. "I would like to construct a short-wave unit similar to the Aero short-wave converter, and use the audio-frequency amplifier in my receiver in conjunction with the short-wave set. Will you kindly publish a diagram and constructional details for building this unit?"

A. 1. To convert the receiver, it is necessary only to disconnect the aerial and ground wires from the receiving set and attach them to the two binding posts of the short-wave converter. Remove the detector tube from the receiver and place it in the tube socket of the converter. The cable plug from the converter is inserted in the detector socket of the receiving set. No other tubes are removed, nor are the battery wires disturbed, and the loud speaker operates as usual. The tuning is done entirely by the one dial on the converter. The tuning controls on the receiving set are not used.

This converter unit is easy to build and simple to operate. No trick circuit is used and no tricky apparatus is employed.

The converter is really a short-wave set, consisting of a regenerative detector with a simple attachment-plug for connection to the

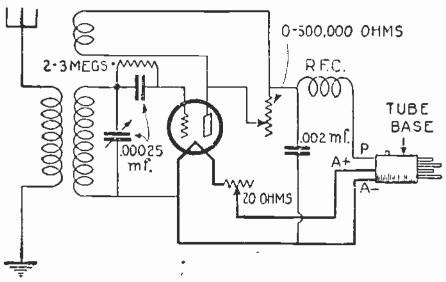


FIG. 123—The diagram of a short-wave adapter, which is designed to be plugged into the detector socket of an ordinary broadcast receiver. An old tube-base is used for the purpose of making the connections.

audio end of the present receiving set and battery current supply to light the detector tube, now transferred to the converter. This method of connecting the two units together consists of a five-conductor cable (two leads of which are not used) and an old vacuum tube, which has served its usefulness otherwise, for the plug. The glass of the latter is broken off and the base cleaned out. Three wires from the cable are soldered into the terminals of the socket, one to the "A+," one to the "A—," and the other to the plate terminal. (To identify these terminals, hold the tube right side up with the pin towards you; the rear two posts are "A+," and "A—" respectively, and the left front post is the plate terminal). The base of the tube is now filled with some compound, such as that from the top of a discarded "B" battery.

Regeneration is controlled by a 0 to 500,000-ohm resistor, connected across the tickler. A .00025-mf. variable condenser is used, with a set of three Aero coils, to tune from 15 to 200 meters. A vernier dial is necessary, as the tuning is sharp. The schematic diagram will be found in Fig. 123.

The choke coil is important and must not be omitted. When by-passed with a .002-mf. condenser it will permit the plate lead to be long enough to reach the receiving set. If a choke coil cannot be easily secured, one can be made by winding 100 turns of No. 26 D.C.C. wire at random on a wooden spool, ½-inch in diameter and with a ¼-inch core.

To operate the short-wave converter, select the plug-in-coil covering the waveband in which you want to receive and plug it into the coil jacks, connect the plug to the receiving set as previously described, and transfer the aerial and ground leads. You may listen either with headphones on the intermediate jack, if your present set is so arranged, or use the loud speaker as ordinarily connected. Turn the resistor until the receiver oscillates. Tune in a station and clear up the signal by a further adjustment of the resistor or rheostat as required.

Short-Wave Superheterodyne

(124) Mr. L. Jenkins, Peoria, Ill., inquires as follows:

Q. 1. I am contemplating constructing a short-wave receiver which will prove to be the "ultimate thing" in short-wave reception. I think a short-wave superheterodyne set would do the trick, if I could get the correct constants. Can you furnish me with the design data of the various coils necessary, schematic wiring diagram, etc.?

A. 1. A very efficient short-wave superheterodyne set has been designed by George J. L. Eltz, Jr., and published in the Proceedings of the Radio Club of America. The following is the description:

"The reception of short-wave radio signals, both telephone and telegraph, has been almost universally accomplished by means of the single-circuit regenerative receiver. This type of receiver, while it has been practically abandoned for the reception of longer wavelengths, is excellent in operation on about 3000 K.C. (wavelengths of 100 meters, or under). Indeed, so well has the single-circuit receiver operated that perhaps sufficient attention has not been given to other methods of reception. With this thought in mind, Mr. Eltz decided to investigate the possibilities of the superheterodyne method of reception and, as a result, the receiver described was evolved.

"The ordinary 'super' used for broadcast reception has two tunings: first, the loop or antenna circuit and second, the oscillator circuit. This short-wave 'super' has only one tuning arrangement, in which is combined both the tuning operations indicated above. This method of tuning was selected

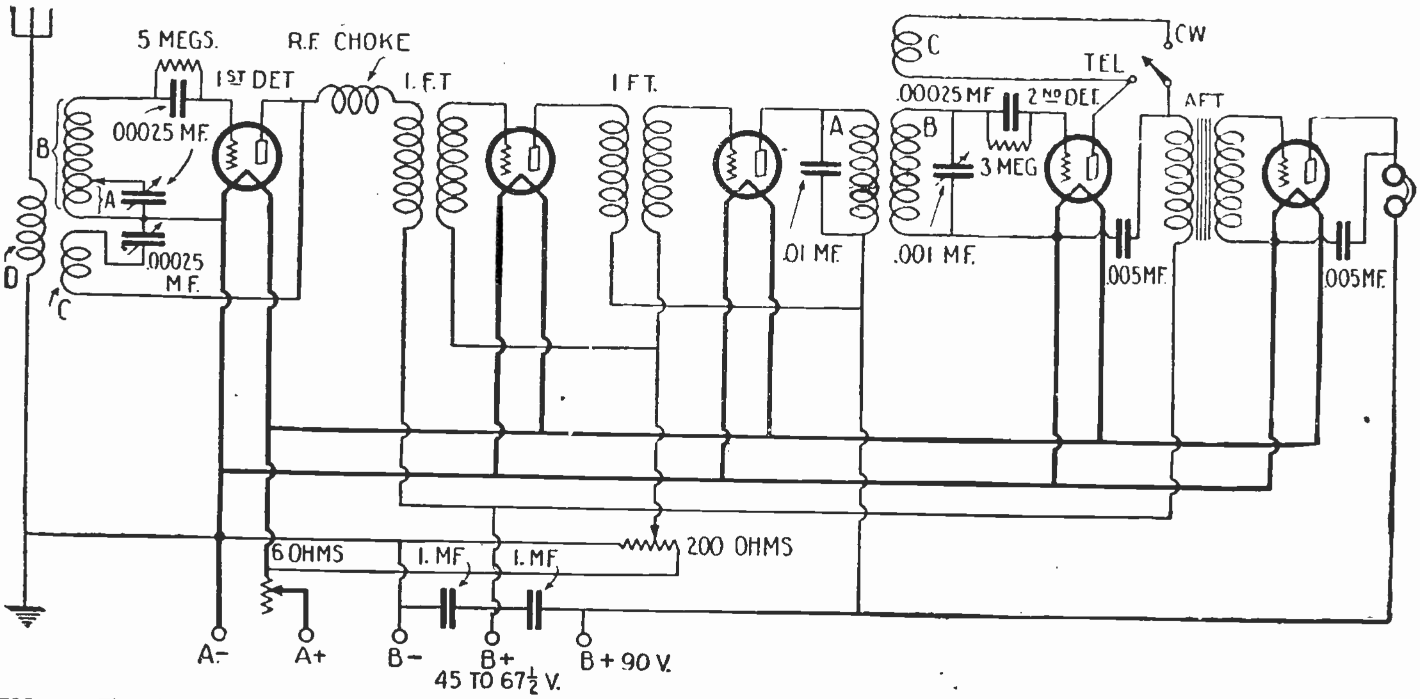


FIG. 124—The schematic wiring diagram of the short-wave superheterodyne receiver. The following features are included in the set: detector and oscillator functions are accomplished by one tube, the "autodyne" principle being employed; a regenerative second detector which permits either phone or CW reception.

because of its simplicity and because it makes possible the construction of what is practically a single-control set.

The "Autodyne" Circuit

"The intermediate frequency chosen is 22 kilocycles, which, while too low a frequency for good telephone reception, when simple tuned circuits are used, is satisfactory for C.W. or telegraph signals. The selection of this frequency necessitates detuning the set 22 kilocycles from the incoming signal; but at the frequencies corresponding to wavelengths of 100 meters or under, this detuning is of no importance in decreasing signal strength.

"The reader will recognize the description above as applying to the 'autodyne' or 'self-heterodyne' type of 'super'. The beat note of 22 kc. is created in the same manner as in the broadcast set, but at a lower frequency. For the reception of short-wave telephone signals, the amplification and detection of the 22-kc. beat note is accomplished in the usual manner. When C.W. signals are to be received, another beat note must be created, either by means of another oscillator tube or by a self-heterodyne beat note in the second detector tube. This latter method has been selected, a beat note of 1,000 cycles being chosen as the most satisfactory. This detuning of the second detector circuit, while it may appear to be inefficient because of the low intermediate frequency, is not so bad as it seems since the amplification in the intermediate circuit is very great and there is plenty of energy to spare.

Description of the Set

"The first detector and oscillator circuit may be any of the conventional short-wave receiving circuits. The one chosen is shown in the diagram Fig. 124. Two variable condensers are shown but all the tuning is done with the one in the grid circuit. The condenser in the plate circuit must be set for each band of frequencies covered; for instance, from 7096 to 6663 kc. (40 to 45 meters), or from 6663 to 5996 kc. (45 to 50 meters), etc. This setting is not critical, the only requirement being that the tube oscillate strongly but not so violently that it blocks.

"The coils, condensers, choke coil, etc., are identical with those which would be used in the construction of a regenerative set. The variable condenser in the grid circuit must be provided with some means of close adjustment, as the setting is rather critical. The plate-circuit condenser can be set with an ordinary knob or dial, without trouble.

"The choke coil consists of 100 turns wound on a wooden form 1-inch in diameter and 2 inches long. A honeycomb or similar coil of 150 or 250 turns will also serve very nicely. The intermediate transformer must be one capable of amplifying the rather low frequency of 22 kc.

"The coils used in the antenna, grid and plate circuits are made by winding bare copper wire of No. 16 gauge over a form on which are placed four narrow strips of celluloid, equally spaced. The wire is spaced with string and, when completely wound, the string is removed and the wire cemented to the strips by means of liquid celluloid. The construction of this type of coil is familiar to any one who has followed the development of the short-wave regenerative receiver.

"The number of turns required for each coil, for the respective wavebands, is as follows:

Meters	A	B	C	D
40	4	13	3	6
50	6	28	4	6
80	8	28	4	8

"The diameter of the coils is 3 inches, for whatever frequency band the coil is designed to cover. Three coils were used by the author to cover the amateur bands. The figures given for the coils are only approximately correct, as the method of wiring, mounting, etc., all effect the capacity of the coils and, in consequence, the number of turns required to cover a given frequency-range.

"Where the operator or constructor has a satisfactory regenerative receiver already in operation, there is no need to change, even though the circuit differs from the one shown. The only requirement is that the primary of the first intermediate transformer be free of a capacity shunt greater than 0.00025-mf.

The Intermediate Amplifier

"The complete circuit of the receiver is shown in Fig. 124. By reference to this circuit, it will be observed that two untuned intermediate transformers are used, and one tuned or filter transformer of special construction. The intermediate transformers used in this set were those manufactured by the General Radio Company (type number 271). These particular transformers have a flat characteristic which permits a considerable gain at 22 kc. Others of different make but of nearly similar characteristic are probably available.

"No particular description of the intermediate circuit is required. The circuit is a conventional one and the same precautions observed in the construction of any super-heterodyne should be followed. To prevent undue feed-back in the untuned circuits, space the tubes and transformers liberally and keep them in line.

The Filter Circuit

"Because of the low intermediate frequency, the filter transformer must be of a special design. By reference to the circuit diagram it will be observed that three coils are used here also. The coil in the plate circuit, of the tube preceding the detector, and the coil in the grid circuit of the detector comprise the tuning or filter circuit. The coil in the plate circuit of the detector tube is the feed-back coil by means of which the beat note of 1,000 cycles is created in the second detector tube.

"The specifications of these coils are given in Fig. 124-A; No. 32 D.S.C. wire is used throughout. In winding these coils no particular care need be used; random winding is perfectly satisfactory. Approximately the number of turns specified, however, should be wound, otherwise the frequency of the intermediate circuit will be changed. In this figure, the spacing between coils is shown, but it must be variable to determine the best setting. No hard and fast rule can be given on the point, as the arrangement of the circuit, placing of the coils, etc., will have some effect. Once adjusted, however, there is no need for further change. The coils shown make a rather small assembly. If the space occupied is no factor, honeycomb, duo-laterial, or other form-wound coils of similar nature can be used; a 600-turn honeycomb coil for A, with a 1500-turn honeycomb for B and a 400-turn honeycomb for C. The spacing may be somewhat greater than that specified for the home-made assembly.

"The variable condenser shown across the grid coil is of 0.001-mf. capacity. Because of the rather large space occupied by a 43-plate air condenser of this capacity, a variable mica condenser was chosen. The air condenser is probably better from a standpoint of efficiency. The condenser across the grid coil determines the frequency of the beat note which is heard in the telephone. Keep this frequency as low as possible since, the lower the note, the more closely will the primary and secondary circuits be in tune.

"If telephone signals are to be received, a switching arrangement should be provided to permit cutting the plate coil of the second detector in and out of the circuit. Radio telephone signals can be received when the second detector is oscillating; but reception is extremely difficult as the 'zero beat' method must be used, and the slightest change in frequency at either the receiver or transmitter causes an audio beat.

"No particular instructions are required here. Any good audio transformer is satisfactory. If radio telephone signals are to be received, as well as C.W., the transformer should be of good design. For C. W. reception only, a transformer having a high ratio between primary and secondary is best; since, although some distortion may be introduced, the amplification is higher and the distortion is of no importance.

"Two fixed condensers are shown in the audio circuit. These condensers are required as a by-pass for the 22-kc. frequency, which otherwise would feed back through the head telephones and the body to the input and cause trouble.

General Comments

"The particular receiver to which the foregoing remarks apply was one with complete shielding of the intermediate, second detector, and audio circuits. The coils comprising the first-detector circuit were not shielded but acted as loops for the reception of moderately distant stations.

"The principal advantage in the shielding came in the elimination of long-wave interference. Subsequently, it was found that by

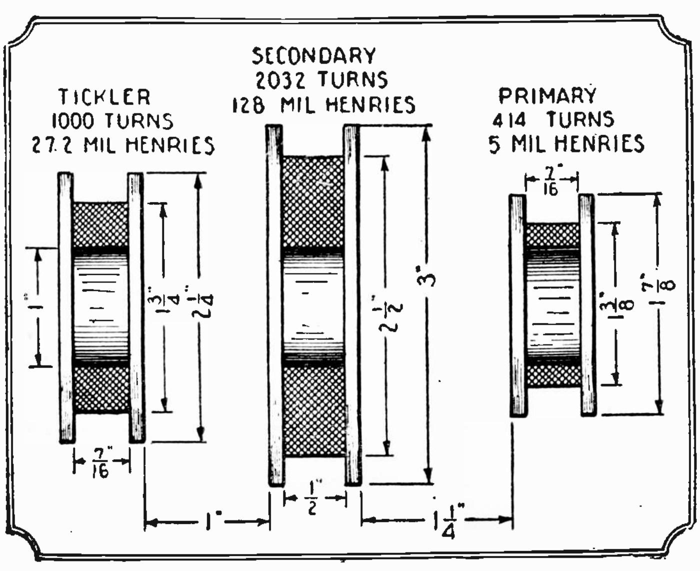


FIG. 124-A—Here are the details and specifications for the construction of the various coil windings employed in the filter transformer for the short-wave superheterodyne receiver. The distinctive feature of this filter transformer is the third or tickler, winding which is employed for obtaining regeneration in the detector stage. By means of this it is possible to obtain continuous-wave reception. This transformer has a very sharp characteristic at about 22 kc., which is the intermediate frequency used in this superheterodyne.

regulation of the amount of regeneration in the untuned intermediate transformers, practically the same result could be obtained, and at no sacrifice in sensitivity. It is recommended that the set be first made unshielded; and the shielding may then be applied if the long-wave C.W. interference is bad. In another model of this same receiver, constructed by Mr. C. R. Runyon, no shielding was used and results were entirely satisfactory.

"If a good antenna is used, the distance possibilities of the short-wave superheterodyne are limited only by the static level. For the reception of signal from a certain station or stations, where it may be possible by changing the transmitting frequency to remove the interference caused by double tuning, the superheterodyne receiver is most satisfactory.

"In operation, the plate condenser is set for strong oscillation and all the tuning is accomplished with the grid condenser. Here the action differs from that of the regenerative set, with which it is necessary to adjust the plate condenser for each frequency. Because of this single control the manipulation of the receiver is simpler and the possibility of picking up stations is increased."

Short-Wave Condenser

(125) T. S. Broch, Minneapolis, Minn. asks:

Q. 1. I am planning the construction of a receiver to cover the short-wave bands between 30 and 200 meters, but I do not seem to be able to find any really authentic information as to the proper size for the tuning condensers to be used in such a circuit. The circuit that I have selected is the shunt-feed Hartley circuit, and I am planning to use plug-in coils that I expect to make myself. I realize that if I use a very small tuning capacity I shall have to make quite a number of coils to cover this wave band; but I am willing to do this. What I want is an arrangement which will enable me to spread the stations well out over the dial instead of having them all crowded in together, as they are on most short-wave receivers that I have heard in operation.

A. 1. In the shunt-feed Hartley circuit there is only one tuning condenser; the other condenser is used to control regeneration and may be a standard 250 micro-microfarad (.00025 mfd.) receiving condenser. It is immaterial whether this latter condenser is straight-line-capacity, straight-line-wavelength or straight-line-frequency; the selection of the tuning condenser, however, is most important.

The tuning condenser should have a tuning capacity of approximately 40 micro-microfarads (.00004 mfd.). Using this condenser, seven coils in all are required to cover the waveband you mention. The wavelength range of each coil slightly overlaps the wavelength range of the next smaller and the next larger coils so that the band from 27.7 meters to 225 meters is completely covered. Even with such a low-capacity tuning condenser as this, there is some crowding at the lowest wavelengths; but if a high ratio vernier dial is used with this condenser, there is no overcrowding and the tuning becomes quite simple. The tuning condenser should have an approximately straight-line-frequency characteristic.

Tuning on the short waves will be found to be considerably sharper than on the intermediate or high wavelengths. It will also be noticed that atmospheric disturbance is greatly reduced and that volume is invariably increased. In order to eliminate antenna harmonics, it may be necessary to place a small fixed conductor in series with the aerial.

Generator for Transmitter

(126) H. C. Davidson, Montreal, Canada, asks:

Q. 1. How can a generator be connected to transmitter described in the December, 1925, issue of *Science and Invention Magazine*, said generator to take the place of the rectified A.C. current supply shown.

A. 1. It is merely necessary to connect the terminals of the generator in place of the output of the rectified and filtered A.C. circuit. Connect the positive pole of the generator to the plate through the R.F. choke and connect the negative pole to the filament circuit.

Tropical Reception

(127) E. F. Hilder, Philadelphia, Pa., writes:

Q. 1. I intend to construct a receiver for use in the West Indies, but I am undecided as to which type would prove most suitable under the prevailing conditions.

A. 1. The conditions with which you will have to contend would discount any of the multi-tube receivers designed for the reception of the medium or long-wave broadcasting stations and we think it would be advisable to concentrate on the reception of those stations transmitting on very short waves. A number of American and European stations regularly transmit their programs on wavelengths of 20 to 100 meters and these short-waves are more easily received over considerable distances than the others. In addition to this the "atmospherics" are less troublesome on 30 meters than on 300 meters, with the result that the ratio of signal strength to interference is better. Full constructional details of a short-wave receiver suitable for use under the conditions you will find in the West Indies, have appeared in *Radio News Magazine* recently.

Kick-Back Preventers

(128) L. Quentin, Baltimore, Maryland, asks:

Q. 1. What are the simplest and most efficient pieces of apparatus used as kick-back preventers and what purpose do they serve in a radio transmitting set?

A. 1. If no precautions are taken, trouble will often be encountered at transmitting stations due to radio frequency current finding its way either directly or inductively back to the source of power supply, or to other adjacent circuits. Serious difficulties may arise from this cause. Transformers and generators may be burned out, or persons may be injured by the shock.

Choke coils of suitable inductance may be inserted in the leads from the power supply to the transmitting apparatus which will prevent the flow of radio-frequency current, but permit the flow of audio-frequency current. By-pass condensers of suitable capacity may be connected across the leads from the power supply to the transmitting apparatus. These condensers will offer a path of low impedance to radio-frequency current. Instead of condensers aluminum electrolytic cells may be connected across the line.

Audibility Standard

(129) Miss Daisy Cooper, Oxford, N. C., asks:

Q. 1. Is there a definite standard for audibility and quality of signals recognized by the radio fraternity?

A. 1. Here is the table usually employed:

Signal Audibilities

R1—Faint signals, just audible.
R2—Weak signals, barely readable.
R3—Weak signals, but readable.
R4—Fair signals, easily readable.
R5—Moderately strong signals.
R6—Strong signals.
R7—Good, strong head-phone signals. Would be readable through heavy QRN and QRM.
R8—Very strong signals. Medium loud-speaker volume.
R9—Extremely strong signals, strong loud-speaker volume.

Phone Audibility and Quality

M1—Speech garbled.
M2—"Hashed" speech.
M3—Uneven modulation.
M4—Clear voice.
M5—Very clear, modulation perfect.

Q. 2. What are the difficulties in transmission of radio signals which cause varying ranges of reception, etc.?

A. 2. There are three principal sources of trouble encountered in practice which make it difficult to receive readable radio signals: (1) Interference from transmitting stations whose signals it is not desired to receive. (2) strays or static, and (3) the "fading" of the strength of the received signal.

Interference from other transmitting stations can to a large extent be eliminated by selection of frequency (wavelength), particularly by the use of transmitting apparatus which will radiate only a single wavelength or a narrow band of wavelengths. Laws have been enacted which are designed to minimize interference from other stations.

Strays are electrical disturbances giving rise to irregular interfering noises heard in the telephone receivers. They are also called "static," "atmospherics," "X's," and other names. In any particular case the possibility of getting a readable signal depends on the ratio of the strength of the signal to the strength of the static at that time. Experienced operators have stated that it is possible to copy messages when the strays were four times as strong as the signals but much difficulty is often experienced even when the strays are much weaker than this. The most common type of stray produces a grinding noise in the telephones; this type causes the most serious trouble. Another type, which produces a hissing noise, is usually associated with snow or rain. Near-by lightning produces a sharp snap.

Q. 3. Will you kindly tell me if a short-wave converter can be used with my present 5-tube receiver?

A. 3. For those who wish to explore the short-wave band from 15 to 125 meters, several ways are provided. However, most of them require the changing of connections of the present receiver over to a short-wave set. In order to eliminate this change, a short-wave converter may be built.

The converter is really a short-wave set consisting of a regenerative detector and a simple plug for connecting to the audio end of the present receiver. Regeneration is controlled by a 0 to 500,000-ohm variable resistance connected across the plate and the tickler. A .00025-mf. condenser is used with a set of three short-wave coils. A vernier dial is necessary, as tuning will be very sharp. The choke coil is important and must not be omitted. When by-passed with a .002 condenser, it will permit the plate lead to be long enough to reach the receiver. If a choke coil cannot be easily secured, one can be made by winding 100 turns of No. 26 D.C.C. wire on a wooden spool one-half inch in diameter and with a one-quarter inch core.

Socket Power Supply

Ballast Tubes in Eliminator

(130) Mr. J. Caruso, Spring Valley, N. Y., asks:

Q. 1. I have constructed a "B" socket-unit using standard parts, but I am not obtaining satisfacatory results. I have tested the voltage with a "B"-unit voltmeter and find that it reads only 90 volts on the 180-volt tap with the tubes in the set. When the tubes are removed it reads 180 volts. Is there any method of regulating the output of the eliminator in order to maintain a constant output voltage?

A. 1. A large number of fans are disappointed with the operation of some "B" socket-supply devices with their receivers. They cannot determine why; but they know that the results with them do not equal the results obtained when "B" batteries were the source of plate potential. The following may therefore be of interest:

The selection of the resistances, that is, the ohmic values of the resistances in the supply unit, is governed by the voltage desired and the flow of current through the resistance. Consequently, the lower the load upon any one tap, the higher the voltage at that tap. Conversely, the higher the load at one tap, the lower the available voltage at that tap. This condition obtains if the unit is without a voltage-balancing device, such as some of the ballast tubes available on the market at present. With these devices in use the voltages at the various taps (90 or higher) will remain constant regardless of the load applied, within certain current limits. Hence, with a socket-power device supplying 180 volts maximum and with a 90-volt tap, the use of three of the 90-volt ballast tubes (arranged as shown in Fig. 130) will give voltage control at the 90-volt tap and at the 180-volt tap.

To obtain the 180-volt control the two 90-volt ballast tubes are connected in series; and to obtain the 90-volt control the ballast tube is connected between the 90-volt tap and the "B—." In view of the characteristics of the tubes, it is necessary that the 180- and the 90-volt taps be so designed that the voltage at these taps, without these ballast tubes, is higher than 180 and 90 respectively.

If the fan is having trouble with excessive voltages at these taps, such ballast tubes can be added to the socket unit, locating the tubes outside of the cabinet or case. The connections of the ballast tubes would then be across the respective binding posts or voltage terminals.

Power Tube on A.C.

(131) H. L. Bernstein, Akron, Ohio, writes:

Q. 1. I have an eight-tube super-heterodyne receiver, using a CX-220 in the last audio stage, with a 22½-volt C battery. I want to assemble a B eliminator using the Thordarson R-171 power compact with the Raytheon BH tube to replace my B batteries. Can I not run a separate circuit from the 6-volt terminals of the eliminator to the filament terminals of the last audio stage socket and operate a CX-371 power tube in this socket?

A. 1. Yes, you may do as you suggest.

Q. 2. Would it be advisable to use an amperite in this circuit?

A. 2. No, the voltage delivered by the transformer for this purpose is five, therefore no amperite is needed.

Q. 3. With the CX-371 tube in the last stage can I use the CX-220 in the first audio stage?

A. 3. No. the CX-220 is an output tube. We would recommend using in its place a CX-229.

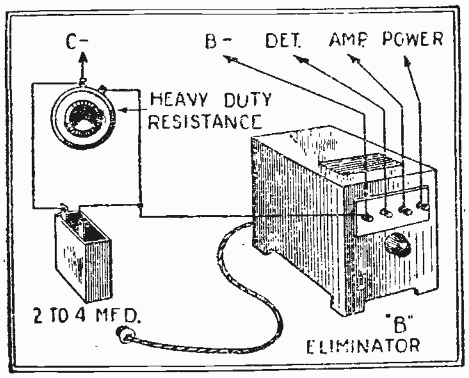


FIG. 132—The above illustration shows the changes which have to be made in the "B" eliminator in order to obtain "C" voltage. The heavy duty resistance should be rated at about 2,000 ohms.

C Voltage From B Eliminator

(132) L. Montague, El Paso, Texas, asks:

Q. 1. How can I obtain C battery voltage for my power tube from my present B battery eliminator?

A. 1. You will find illustrated on this page the necessary changes you will have to make in order to obtain the C battery voltage. The heavy duty resistance shown in the diagram should be capable of carrying at least 50 milliampere without serious overheating and should have a total resistance of about 2,000 ohms. The fixed condenser should have a capacity of at least 2 microfarads; lower values of capacity may cause some hum.

With this circuit the C voltage is, in effect, subtracted from the B voltage available on the power binding post of the eliminator. Consequently the arrangement is practical only with the more powerful types of B eliminators. After you have hooked up the apparatus as shown, set the knob so that the resistance is all in use, turn on the radio set and the B eliminator, and then slowly turn the knob until volume and tone quality are best. Do not turn the knob any farther than necessary to get proper volume and quality, because if you cut the resistance down too far the C voltage will be too low and the life of the power tube shortened materially.

"B" Eliminator Trouble

(133) A. Zach, Brooklyn, N. Y., writes:

Q. 1. I am building several A.C. operated power supply devices ("B" Eliminators) and would appreciate some general rules on trouble shooting.

A. 1. Briefly the possible sources of trouble in line supply devices are given herewith. Quite frequently it is found that a hum is audible in the output of the receiver when it is operated from a power device. This hum need not necessarily indicate poor design and may be due entirely to mechanical vibration. It can be eliminated by moving the device further from the receiver or by placing the receiver on sponge rubber or on several layers of soft cloth. Trouble in the power-supply unit may be the result of breakdown of one of the filter condensers, the break-down of one of the resistances controlling the intermediate voltage taps, a defective rectifier, or open connections. In testing the device a voltmeter is essential. It should be connected between the negative post and the various taps, and if the taps give no reading, the trouble is probably due to a defect in the resistance unit supplying that tap. This is not an uncommon cause of trouble and therefore, good resistances, capable of carrying the required current without excess heating, must be used.

Defective resistances are also capable of creating "home-made" static. If reception is accompanied by considerable noise when using the power-supply device, the antenna should be disconnected, and, if the noise persists, all of the connections should be carefully examined. Be sure that the "A" battery terminals are not corroded. If possible, substitute for the power unit good dry B batteries, and if there is no noise, it is a good indication that the line power supply device is causing the trouble. If no voltage readings can be obtained on any terminals, the rectifier tube should be examined. Make sure that the filament has not burned out, or, if the rectifier is of the electrolytic type, be sure that it contains sufficient solution. The filter condensers should be tested with phones and "B" battery to make sure that they have not broken down. The same test may also be made on the choke coils. If all the connections appear to be complete and the apparatus in good condition, it will be best to try a new rectifier tube. The fact that the tube lights does not necessarily indicate that it is functioning in a satisfactory manner.

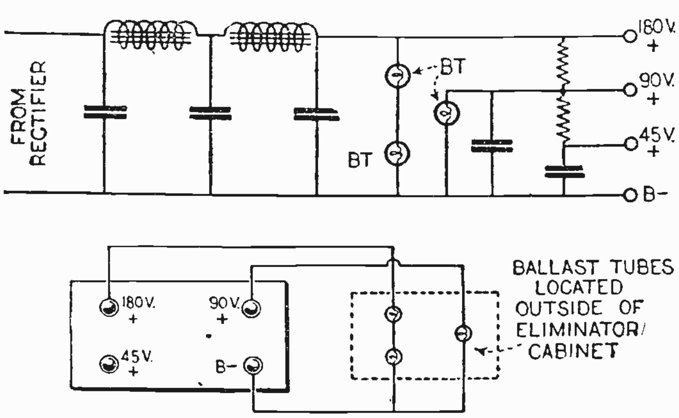


FIG. 130—The use and location of ballast tubes regulate the output of a "B" eliminator is shown here. These tubes will prevent excessive voltage at the output of the eliminator.

B-Power Supply Unit

(134) H. Moriarity, Antioch, Michigan, writes:

Q. 1. Can you give me the hook-up of a B-power supply unit, employing two Raytheon tubes and two transformers which will have an output of about 400 volts?

A. 1. You will find illustrated on this

page the correct hook-up for the B-supply unit. Two Raytheon tubes are connected in series to furnish plate voltages up to 435 volts D.C. at 20 milliamperes, when using the type B, and at 35 milliamperes, when using the type BH. Standard designs of approved transformers and choke coils are employed, the same as are found in the usual B-power unit employing a single tube. The condensers C1 and C2 have a capacity of 2 microfarads; C3, 8 microfarads; C4, C5, C6 and C7, 0.1 microfarad. However, the condensers should be designed for a working voltage of 750.

If the plate supply is to be furnished to the usual four or five tube receiver using 201 type tubes, a variable resistor should be used for R1, allowing a range of 0 to 20,000 ohms, and fixed resistors of 10,000 ohms each for R2 and R3, and 18,000 ohms for R4, with by-pass condensers C of 1 microfarad in each case, as indicated. While the C or grid bias can be obtained for the power tube by means of a suitable resistance drop, it is advisable to employ a tapped B battery. The full voltage when applied to the power tube will be approximately 425 volts.

A 25-Cycle "B" Power Unit

(135) Mr. J. B. Roubidoux, Montreal, Canada, writes:

Q. 1. I would like to obtain constructional details for building a "B" power unit for use with 25-cycle current. I have noticed quite a few articles on the construction of power units of this type in *Radio News*, but they are all designed for 60-cycle current and naturally they are not suited for 25-cycle supply. I would also like to obtain the constructional details for making the transformer and choke coils to be used in this unit; since it is not very easy to obtain this apparatus designed for 25-cycle current.

A. 1. We have received a number of letters from our Canadian readers requesting constructional details for building 25-cycle power-supply units. For this reason, we are including data for constructing both the unit and the transformer and chokes to be employed in it. The diagram of the power unit will be found in Fig. 135-A. As will be noticed, the unit has been designed to employ an 85-milliampere tube and is provided with two variable voltage output taps. This will permit the use of this unit with any type of receiver. Because of the lower frequency of this current, larger chokes and condensers are required than with 60-cycle A.C.

In Fig. 135-B will be found the constructional details for the core of the power transformer. This core should be built up of silicon steel .014-inch thick. The "L" shaped laminations should be cut to shape, with either a hack-saw or a cold chisel, and the edges should be filed down so that no sharp points will remain. A sufficient number of laminations should be cut to make a pile 1⅞ inches high for each side of the core. After each lamination has been cut and its edges smoothed it should be shellacked carefully with a thin coat of white shellac. This is for the purpose of insulating the laminations in order to keep the eddy currents and heating effects in the core at a minimum.

Winding the Coils

The primary winding is placed over one of the long sections of the core, while the secondary windings are placed on the other long section. The coils should be wound over fiber forms two inches square, so that the form will fit over the core. The primary coil consists of 600 turns of No. 26 enameled wire, and should be wound layer-fashion with thin "fish" paper (a thin, tough, insulating paper) over each layer.

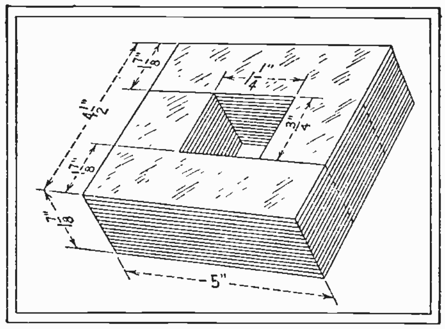


FIG. 135-B—The core of the power transformer is built up, as shown, of silicon-steel strips; each alternate layer being reversed to bind it together.

Fifty turns of wire should be placed in each layer, making a total of 12 layers. After the coil has been completed, it should be carefully taped with friction tape in order to prevent moisture from entering the winding.

The secondary consists of a center-tapped winding supplying a total of 440 volts, with 220 volts on each side of the center tap. The complete coil contains 2,400 turns of No. 30 enameled wire, with a tap at the 1,200th turn. This coil should be wound similar to the primary, with 100 turns on each layer; making a total of 24 layers. The fish paper should be used also between the layers of this coil.

When the winding is complete, several layers of fish paper should be placed over it; and over this coil is placed the filament winding for the power tube, which consists of 28 turns of No. 18 enameled wire with a tap at the 14th turn.

Each of the wires should be brought out through insulating tubing, or a section of insulated flexible wire should be soldered to each of the wires. After the two coils have been completed, the core should be assembled. The "L" shaped pieces should be butted together from opposite sides, so that they overlap as shown in the assembled core at Fig. 135-B, reversing the arrangement of the pairs in alternate layers. When this method is used, the complete core is solid without much binding, and it is a very simple matter to construct two clamps to bind the laminations tightly in place.

The Choke Coils

The two choke coils are identical in construction, each being wound with 6500 turns of No. 28 D.C.C. wire, on a core of the dimensions shown in Fig. 135-C. An air-gap of .025-inch is provided, on each side of the core, to prevent saturation and consequent lowering of the inductance. The direct-current resistance of each of these chokes is about 100 ohms, and the inductance is about 20 henries, under the conditions in which they are to be used.

The laminations of these chokes are also cut from silicon steel .014-inch thick, and each piece is shellacked in the manner described above for the transformer. These pieces are cut "U"-shaped and straight, for the outer and inner parts of the core. In this case, the various laminations are placed one directly over the other, and no staggering is used. The straight pieces can be assembled and the windings placed directly over this part of the core without the use of a fiber spool or other means of support. Several layers of insulating cloth should be wound over the core, and the winding placed directly over this core. Two fiber washers should be provided, to complete the spool for winding the coils; these should be about 3½ inches in diameter, with a hole ⅞-inch square cut in the center.

A wooden clamping arrangement should

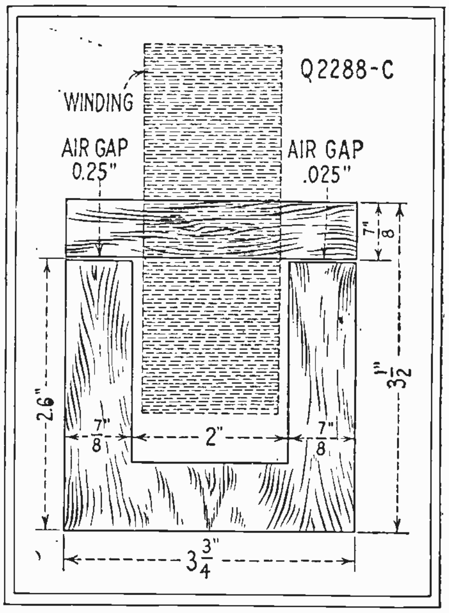


FIG. 135-C—Specifications for a 20-henry choke coil, such as are required in the 25-cycle power unit. The air gap is vitally important.

be provided for these coils, so that the air-gap can be adjusted and fixed. Straight wooden pieces with bolts may be used to hold the laminations tightly in place and, by releasing the bolts, the distance between the two sections of the core can be varied.

Assembly of the Unit

After the transformer and the two chokes have been constructed, the unit can be completed. The other apparatus needed for this unit is as follows:

One 85-milliampere gaseous-conduction rectifier tube and

One vacuum-tube socket;

Two 4-mf. filter condensers, 400-volt rating;

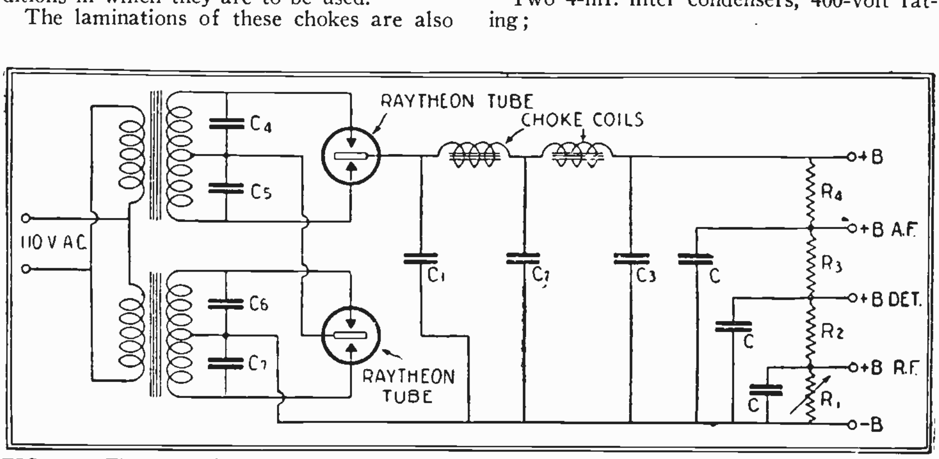


FIG. 134—The connections for a B-power supply unit, employing two Raytheon tubes and two transformers having an output of about 435 volts D.C., are shown above. Using the type B Raytheon tube 20 milliamperes of current will be delivered and with the type BH 35 milliamperes.

One 8-mf. filter condenser, 400-volt rating;
Two 1-mf. filter condensers, 200-volt rating;
Two 0-to-500,000-ohm variable resistors;
One baseboard, 10x12x½ inches;
Seven binding posts;
One insulating strip, 10x2x3/16 inches;
Wire, plugs, etc., etc.

The apparatus should be laid out with the transformer at one end, and the filter condensers and choke coils so spaced that the wiring will be as short as possible. The resistors and binding posts can be mounted on an insulating strip fastened to one end of the baseboard. If it is so desired, the complete unit can be enclosed in a metal case, with the binding posts and control panel at the front. If this is done, it will be possible to ground the metal case; this will serve to prevent any interaction between the power unit and receiver which might introduce a humming noise. The core of the transformer may also be grounded to the metal case and this will tend to increase the stability of the unit's operation.

Connection For Power Units

(136) Mr. H. Ogden, New Haven, Conn., writes:

Q. 1. I am using a five-tube receiver of the tuned-radio-frequency type. Lately I installed a trickle charger, but no sooner had I done so than two of the tubes burned out. Can you tell me the cause of this, or any precautions to take when using a trickle charger or other power unit?

A. 1. The trouble which you describe has become quite prevalent recently, because of the increasing number of receivers which are operated from socket-power units. An incorrect connection, if it does not immediately cause damage to the receiver, may not be apparent at first; but trouble may develop in a short time.

In some trickle chargers, the transformer that supplies the alternating current to the rectifier is of the *auto-transformer type*, instead of having the usual separate primary and secondary windings with insulation between them. In many places, in fact in most localities, one side of the A.C. supply line is grounded, as required by law, and then of course the receiver itself is grounded. The result of all this is that it is possible to apply the full 110 volts directly across certain portions of the receiver, resulting in their being burnt out, and the set rendered useless.

A perfect remedy for this possible source of trouble and one which is simply applied, is to connect a fixed condenser, of about one microfarad capacity, in the ground lead of the receiver, thus preventing any short-circuiting of the 110-volt supply. In addition, it may also be well to have a similar condenser in the antenna lead; for the simple reason that the minute gap in the lightning arrester may act as a path for the line current to get to the ground, and again cause some trouble. The only precaution we must take is to be sure that the condensers employed are tested to withstand at least 110 volts A.C. and not D.C., since A.C. has a greater tendency to break down condensers. Ordinary condensers, such as are used in "B" power units, will be quite satisfactory.

Power Supply

(137) Mr. Luther Steward, San Antonio, Texas, writes as follows:

Q. 1. Can you tell me of any way in which I may utilize the direct current lighting circuit of my residence to replace the "B" batteries for an amplifier using a 210 tube.

A. 1. If you have 115 volts D.C. running into your apartment or residence, there is little doubt that the line installation to your meter is a three-wire Edison circuit. In such a circuit, there are three wires run to the top of the meter box. The voltage across the two outside wires is 220 volts, while that of either of the other pairs is 110. The center wire is neutral relative to the outside leads Therefore, a voltmeter placed across the two outside leads will read from 220 to 240 volts D.C. If this voltage is impressed upon the plates of a 210-amplifier tube, it will be found quite sufficient to cause the tube to operate at highest efficiency. It will probably be necessary to install a filter system to reduce the line noises, in which case we would recommend any of the standard filter circuits. Various voltages may be drawn from this line by the use of a potentiometer of some sort, which will divide the voltage into those values required.

"B" Battery Supply

(138) Miss Eleanor Brown, Lancaster, Pa., writes:

Q. 1. What is the best method of supplying "B" battery current for my receiving set.

A. 1. The choice of the source of current supply for your set necessitates consideration of the efficiency of the several methods commonly used. First and most popular is the standard dry cell type of "B" battery. This type of current supply is the most efficient known, provided that the batteries used are of high quality. You must be sure that you are purchasing new batteries, because cells which have been standing on the dealer's shelves for any length of time are sources of much objectionable noise in the set due to chemical depreciation. Storage "B" batteries come next in order of efficiency, their only drawback lying in the fact that sulphated plates and poor intercell connections are liable to cause trouble.

If you have direct current in your home it is comparatively simple to obtain a reliable and fairly quiet source of current. All that is necessary is some sort of approved protective device to protect the set in case of shorts and a well constructed filter system. It is quite possible to draw your supply from an A.C. line, too, but a transformer and rectifier are necessary to make the current usable for radio purposes.

"B" Eliminator

(139) Frank Wiesuski, Los Angeles, Calif,. writes:

Q. 1. I built a "B" eliminator and had some trouble with it due to a reproduced hum. Can you give me some advice on an eliminator?

A. 1. We have several suggestion which may aid you in making your "B" eliminator work correctly. In the first place, your "B" eliminator unit may be positioned too close to the receiving set. It should be at least 4 or 5 feet distant therefrom. It is also true that if a perfect ground connection is not employed, a hum will be present. Be sure that your ground wire is securely clamped or soldered to a cold water pipe or to a 7- or 8-foot length of 1-inch iron pipe driven in the ground. Still another suggestion is that you connect another capacity from the positive detector post to the negative "B." Use a ¼- or ½-mfd. condenser between these two points. If there is a by-pass condenser from the negative "A" to the positive "B" binding post in the receiving set itself, take it out as it is not necessary and may be causing some trouble. Then again, if there is no connection between your filament circuit and the ground, one should be placed in the circuit, for otherwise the eliminator will not operate correctly. We are quite sure that one of these points will be the solution to your trouble

High-Voltage Power Supply

(140) Mr. Edward Mattis, Glen Cove, L. I., asks:

Q. 1. I intend to construct a power unit to deliver about 400 volts D.C., but I desire to employ two rectifier tubes of the gaseous or Raytheon type, since a single tube of this type will not furnish more than 250 volts. Kindly publish a circuit diagram and any other information which will enable me to construct this unit.

A. 1. With the trend decidedly toward higher operating voltages, especially in connection with the UX-210 or CX-310 type of super-power amplifier tube, there is often a desire for doubling the voltage of the usual Raytheon power unit. Requiring no filament current, highly economical in operation, and most rugged in everyday practice, the gaseous rectifier has proved a favorite in "B" power units, even though it has been limited to use with power tubes of the 171 type or smaller. Hence the following suggestion, which enables the radio enthusiast to employ the Raytheon type of tube for the highest operating voltage found in present day reception.

Two standard Raytheons may be connected *in series* to furnish plate voltages up to 435 volts D.C. at 20 milliamperes, when using the type B, and at 35 milliamperes, when using the type BH.

Standard transformers and choke coils are employed, the same as found in the usual "B" power unit employing a single tube.

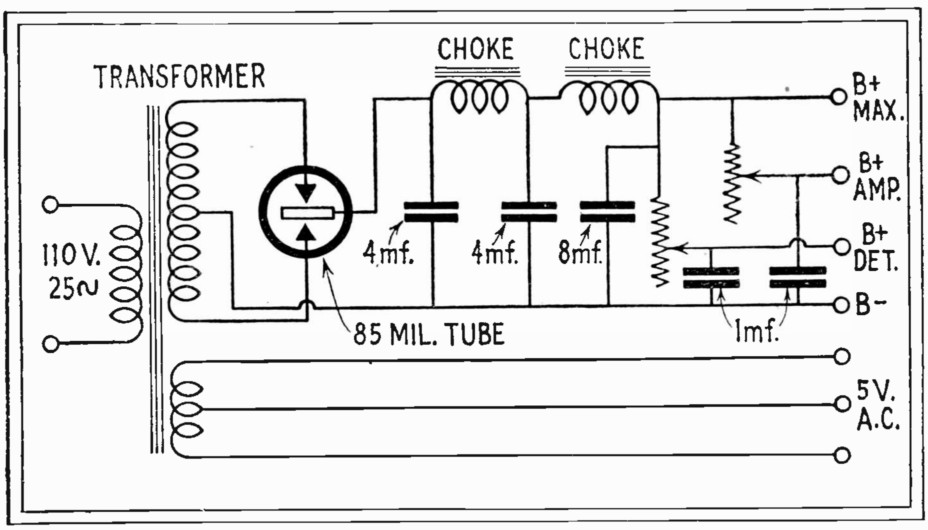


FIG. 135-A—Specifications of a 25-cycle "B" power unit, suitable for use with a 112- or 171-type power tube. Large chokes and condensers are required to smooth out rectified A.C. of such low frequency.

When different makes of transformers and choke coils are used in this arrangement, there will be variations in the output voltages and the milliampere loads for each type of tube.

High-Voltage Condensers

The condensers are of the same values as in the standard Raytheon circuit, namely, C1 and C2, 2-mf.; C3, 8-mf.; C4, C6 and C7, 0.1-mf. However, the condensers should be designed for a *working* voltage of 750. The necessity of having condensers designed and built for this working voltage is to take care of the high voltage which would be delivered if there were no load on the radio power unit; *i.e.*, when the filament of the UX-210 power tube is not lighted. In fact, care should be exercised that the filament of the power tube is always turned on while the "B" power is turned on. If the "B"-power and filament circuits are under one control, this is automatically arranged for; otherwise, peak voltages, even as high as 800 volts, may be encountered, severly straining the filter condensers, when the radio power unit is working on no load.

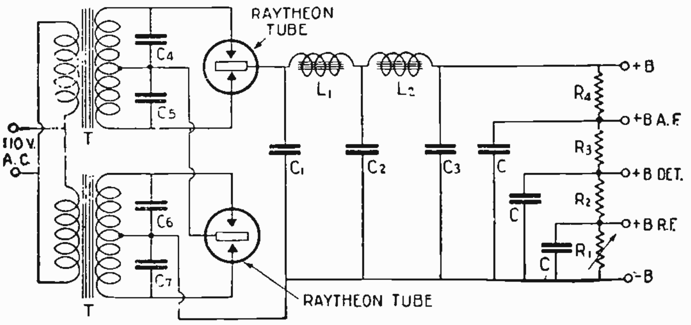


FIG. 140—Circuit diagram of a high-voltage "B" power supply unit, employing two transformers and two Raytheon tubes in series, thus giving an output of up to 425 volts. Constants for parts employed are given in the accompanying text.

The filament of the UX-210 may be operated either from a storage battery or from raw alternating current supplied by a separate transformer capable of delivering a current of at least 1.25 amperes at 7.5 volts.

"C" Voltage Supply

While the "C" or grid-bias voltage can be obtained for the power tube by means of a suitable resistance drop, it is advisable to employ a tapped "B" battery with from 28 to 35 volts in the grid circuit. This is a simpler arrangement and, since there is virtually no drain on the battery, it should last for a year or more.

Various voltage taps may be obtained by the use of suitable resistance units and by-pass condensers. Thus the full voltage is delivered to the power tube, or approximately 425 volts. If the "B" or plate supply is to be furnished to the usual four- or five-tube receiver, employing 201A-type tubes, a variable resistor should be used for R1, allowing a range of from 0 to about 20,000 ohms; and fixed resistors of 10,000 ohms each for R2 and R3, and 18,000 ohms for R4, with by-pass condensers of 1-mf. in each case, as indicated.

Remarkable volume, together with extreme depth and utmost realism, may be obtained through the use of the UX-210 tube, operating with this double Raytheon arrangement. Furthermore, there will be a complete absence of hum. There is ample voltage available for operating a high-power resistance-coupled amplifier at its maximum efficiency, with the UX-210 power tube in the final stage.

"B" Unit With Impedance Amplifier

(141) Mr. Chas. Leslie, Miami, Fla., writes:

Q. 1. I have built an impedance-coupled amplifier, but when I use it with my "B" power unit I am troubled with a humming noise and sometimes loud squeals. Three stages of impedance-coupled amplification are used and a "BH"-type rectifier tube is employed in the "B" unit. Can you help me to overcome this difficulty?

A. 1. In some cases considerable trouble has been experienced when a receiver with an impedance-coupled amplifier is operated from a "B" power unit. The usual indications are a squeal, a hum, or no response but a periodic pop. The cause of the squeal or hum may be a feed-back through the filter condenser of the "B" unit.

The remedy for the squeal or hum is a system of audio-frequency choke coils and by-pass condensers. An A.F. choke is inserted in each positive "B" lead from the unit; and a fixed condenser of 1- to 2-f. capacity is used to by-pass each choke coil. That is, between the negative "B" wire and each of the positive leads, a condenser is placed. The chokes and condensers should be placed near the receiver. If the output voltage is too high, there may result a periodic popping noise which can be remedied by using lower values of grid resistors in the receiving set. Feed-back may be caused also by the effect of long connecting wires between the receiver and source of power. The arrangement described above serves to isolate the receiver from such feed-back action.

Converting a D.C. Power Unit

(142) Mr. A. Murphy, Buchanan, Sask. (Canada), writes:

Q. 1. My present house-lighting system is 110 volts .C. I am using it in conjunction with a D.C. power unit to furnish the plate voltage for my receiver. However, I have been informed that the power company will shortly turn over to A.C., thus making my present outfit useless. Not wishing to incur unnecessary expense of purchasing a new A.C. power unit, I desire to connect my present unit into one capable of being operated from A.C. I will be greatly obliged if you could supply me with a circuit showing the necessary alterations.

A. 1. It will not be a difficult matter to convert your D.C. power unit for use on an A.C. supply. Actually this can be accomplished by the construction of an additional unit which can be attached to your present one. You will require a special rectifying tube and a transformer having a high-voltage secondary delivering about 200 volts on each side of the center tap.

The construction of this transformer is not recommended unless the reader is experienced in the making of such apparatus. It would be preferable to purchase one ready-made.

A tube of the Raytheon type is very convenient; but a rectifier such as the 213 will be satisfactory, although it requires a separate filament winding. In any event, the connections are shown in the accompanying diagram. The fuses shown in the supply leads to the primary winding are not essential, but are nevertheless advisable; as they will blow if an excessive load is imposed on the circuit, due to a short circuit in the secondary windings or a breakdown of the filter condensers. Unless a safety device of this nature is incorporated, damage may result in the primary or excessive heat be generated, which will burn the insulation of the coils. This will bring about short-circuited turns, and possible burn-out of the transformer.

"B" Eliminator

(143) E. B. Harris, Galveston, Texas, writes:

Q. 1. I have built a "B" eliminator and everything seems to work well with the exception of the transformer which has a hum.

A. 1. You do not quite make your trouble clear in your letter of recent date. It is quite possible that you have placed your "B" eliminator unit too close to your receiving set. In such a case, the magnetic fields set up by the windings of the transformer would interact with the coils in your receiving set and cause a hum.

If you have constructed your filter circuit consisting of the choke coil and condensers properly, there should be no hum in your receiver at all. Possibly you have not done this and we would advise you to check it over.

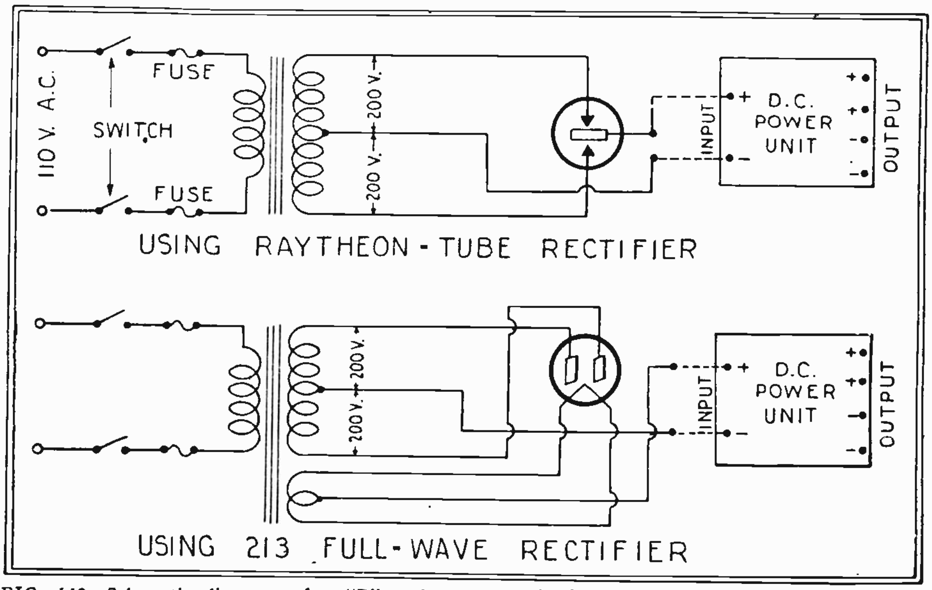


FIG. 142—Schematic diagrams of a "B" socket-power unit, for use on 110-volt A.C., and made to utilize aparatus in a D.C. unit.

Power Tube Operation

(144) Mr. J. Haletsky, New York City, writes:

Q. 1. I desire your criticism on the following device for raising the voltage of a 120-volt D.C. line so that it will satisfactorily operate a radio set on high voltage. As you know, a Wehnelt interrupter is a device working on a chemical principle which, when connected to a source of direct current, interrupts or breaks it at the rate of about 1,000 times per second. My idea is to connect this pulsating current to an ordinary "B" power step-up transformer, the necessary choke coils and condensers being used to filter out the current. I would like to know if it would work.

A. 1. This method would work if a very large condenser was connected across the primary of the transformer used. This capacity would have to be enormously high, probably over 10,000 microfarads, and the results obtained with the system would be very poor and inefficient. There are several other methods that may be used .o ooost the voltage of a D.C. line for operating radio receivers.

There has been recently placed on the market a generator and filter system which consumes 110 to 120 volts D.C. and supplies 110 volts A.C. This generator system is used with an ordinary A.C. "B" power unit for supplying the necessary high voltage. Another method is to use a D.C. "B" power unit for supplying the current to the radio-frequency and detector tubes in your receiver, and connect several "B" batteries in series with this voltage to supply the higher voltage necessary for power tubes. Another variation of this method would be to use storage "B" batteries in series with a D.C. power unit; and, when the set is not being used, employ the voltage of the "B" power unit for charging the storage "B" batteries.

If you wish to experiment with another method, you will be able to get a high voltage by connecting the shafts of two D.C. motors together and using one as a motor and the other as a generator. At normal speed, the output voltage of the motor would be approximately the same as that at which it normally operates. In other words, if a 220-volt motor is used and operated at normal speed, it will deliver 220 volts at the output. It will be necessary to use a rather large filter system, if this method is used, to suppress the commutator ripple and voltage variation due to the use of such a small generator system. It would be advisable to use voltage regulator tubes at the output to obtain really satisfactory results. It may be necessary also to connect two 1-mf. condensers in series across the input to the driving motor and ground the center tap, in order to suppress the interference caused by sparking or poor contact in the commutator.

350-Milliampere Power Unit

(145) Mr. S. C. Jones, Urbana, Ill., writes:

Q. 1. I would like to construct an "A, B and C" power unit using the 350-milliampere gaseous rectifying tube. If possible, I would like to construct the transformer and choke coils. I am enclosing a copy of the diagram of my receiver, and would like to know also what changes are necessary to adapt this receiver for use with the power unit. Five 201A-type tubes are used, with a 112-type in the last stage.

A. 1. You will find a circuit for such a power unit on this page; see Fig. 145-A. As you may see, the rectifier tube is connected to the secondary windings of the transformer in the usual manner with an 0.1 mf. buffer condenser across each secondary section, to absorb any stray radio-frequency currents present in the rectifier tube or transformer. The output of the tube is passed through a filter system consisting of a bank of condensers, totalling 16 mf., and two 10-henry chokes wound with wire of a much larger size than is ordinarily used. Under average conditions, the unit will supply about 300 milliamperes at 200 volts, at the output of the filter.

The receiving set to be used with this eliminator must have its filaments wired *in series*. You will find the diagram of your 6-tube tuned-radio-frequency set, with the filament circuit changed to suit this power unit, in Fig. 145-B. You will notice that the five 201A tubes are placed in series, while the 112 tube is operated from a separate winding on the power transformer. The five tubes in series will require 25 volts at 250 milliamperes, since each tube draws that current at five volts.

As the output of the filter system is at, roughly, 200 volts, the remaining 175 volts must be absorbed by resistors in series with the tube filaments. Added to the 500 ohms, indicated for this purpose, is the 150-ohm resistance of the "C" biasing resistor. This resistor is placed in series with the negative terminal of the filter output; so that a total of 650 ohms can be used in series with the tube filaments to limit the current to 250 milliamperes.

The "C" biasing resistor is provided so that "C" voltage drop for the power tube can be obtained. The A" current, in passing through the 150-ohm resistor, undergoes a drop in voltage; which can be used as "C" bias by connecting the grid return of the power tube to the negative side of the resistor. To regulate the various "B" voltages, a 7500-ohm wire-wound resistor unit is connected between the positive and negative terminals of the filter. By setting the slider taps at various positions, any "B" voltage up to the maximum of the filter output can be obtained for the plates of the tubes. When the "B" voltage taps are disconnected, the 7500-ohm resistor draws a steady current of about 25 milliamperes from the filter circuit. As soon as the sliders are connected, however, the plate circuits of the tubes in your receiver spit the current flow into several paths, and very little current is carried by the resistance wire itself

The Power Transformer

The construction of a power-transformer core is shown in Fig. 145-C. Silicon-steel laminations, No. 28 gauge, are used for this purpose. On account of the extremely high current capacity, it is necessary to include some regulating device in the transformer circuit, to limit the surge of current when the transformer is first connected to the line. This may be accomplished by placing a 20-ohm resistor in series with the transformer primary, thus limiting the value of the starting surge current; or by designing the transformer with a high "leakage reactance," so the secondary voltage will be reduced from 320 volts at 350 milliamperes, to below 150 volts if the load is temporarily increased, as would be caused by a sudden surge on the input side. For a home-made transformer, the resistance method, while less economical of power, is the safest to use, and the transformer has been developed with this consideration in mind.

Using a resistor of 20 ohms in the primary, and a current of about 1½ amperes, approximately 30 volts will be lost by drop in the resistance; so that the transformer must be designed for an 80-volt primary instead of 110. For the core, sufficient laminations must be used to make a pile 1¾ inches high. Using the core dimensions given, the transformer coils are wound in two identical sections, one section being mounted on each leg of the coil. The primary winding is wound first over a piece of empire cloth and consists of 113 turns of No. 16 D.C.C. wire on each coil. After a layer of empire cloth has been wound over the primary, the high-voltage section is added; it consists of 932 turns of No. 25 D.C.C. wire. Over this secondary, with suitable insulating cloth between, is wound the filament-lighting secondary, for the receiving set's power tube; this contains 8 turns of No. 22 D.C.C. wire.

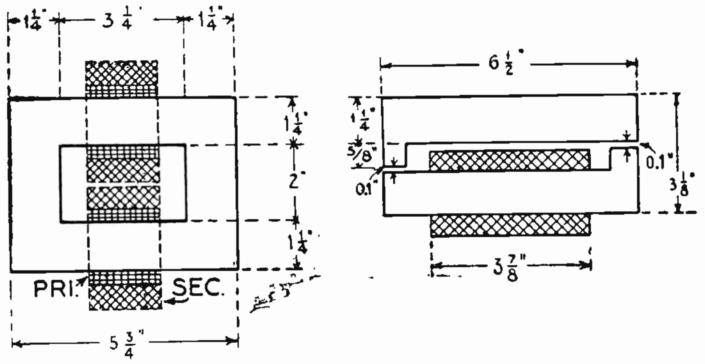


FIG. 145-C—The specifications of the cores for the transformer and choke coils are shown here. It will be noticed that two air-gaps of 0.1 inch are left in the opposite sides of the choke coil in order to reduce eddy currents, which would reduce the inductance, and consequently the efficiency of the choking action.

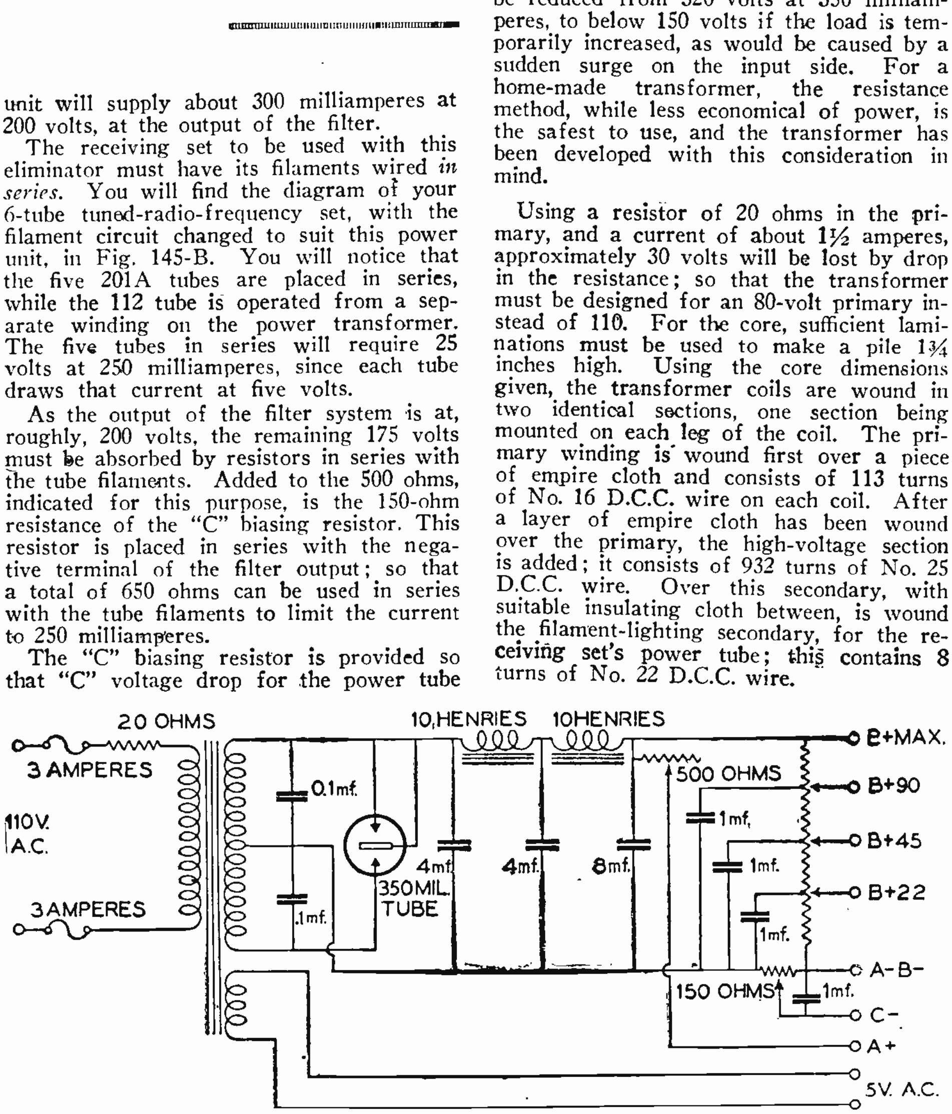


FIG. 145-A—The circuit of an "A, B and C" power unit using a 350-milliampere tube is indicated here. The 500-ohm resistor between the "B" positive and "A" positive should be able to dissipate at least 250 milliamperes.

The coils are assembled on the core so that the beginnings of the two windings can be tied together, which places the two primary coils and the two secondary coils in series. In the case of the secondaries, the junction of the two secondary coils is used as the center tap, thus assuring an accurate electrical mid-point. The assembled transformer should be securely clamped at each end, insulating the clamps from the core with fibre or heavy cardboard strips. Do not connect the transformer directly to the 110-volt line without the resistor in series; since it will become quite hot if this is done. It may be more satisfactory to purchase this transformer; as difficulty may be encountered in obtaining the silicon steel, and ordinary sheet iron is not suitable for this purpose.

The Choke Coils

They are identical in construction, each coil containing 6,000 turns of No. 26 enameled copper wire, wound on a core whose dimensions are given in Fig. 145-C. An air-gap of 0.1 inch is provided on each side of the core (at opposite ends as shown) to prevent saturation of the core and consequent lowering of the inductance. The D.C. resistance of each choke is about 160 ohms. This produces a total voltage drop of about 50 volts, with 275 milliamperes flowing through the windings.

The choke coils and transformers should preferably be enclosed in grounded iron cases to prevent magnetic inter-action. The filter condensers should be of a type capable of withstanding 300 volts D.C., and the two 0.1-mf. buffer condensers should have a 350-volt A.C. rating. The power unit should be thoroughly protected against overload by properly fusing the input leads. The normal power consumption of the unit is 1½ amperes, or roughly 150 watts. Two 3-ampere screw-type fuses should be connected in tthe primary leads. Do not use larger fuses than this size, since adequate protection will not be obtained.

If desired, the wire-wound resistors of 150 and 500 ohms can be replaced with Mazda lamps. Two 40-watt lamps in series will make a 600-ohm resistor with a current-carrying capacity of 350 milliamperes. If the current is in excess of 250 milliamperes, when the circuit of your receiver is set up, additional lamps in series can be added until the current is reduced to the right value. A 60-watt lamp has a resistance of 200 ohms, and a 100-watt lamp a little over 100 ohms. Lamps of 10- or 25-watt capacity should not be used, since they are not designed to carry current up to 250 milliamperes. The "C" biasing resistor can be made by connecting two 100-watt lamps in parallel.

"C" Socket-Power Unit

(146) Mr. L. Miller, Annandale, N. J., asks:

Q. 1. I have constructed a power unit, using a resistor and condenser to obtain the necessary "C" bias. However, I have not been obtaining very satisfactory results, and I think the trouble lies in the method of obtaining the "C" voltage. Is the resistor and condenser method of obtaining negative bias satisfactory, or should the ordinary type of "C" battery be used instead?

A. 1. A series of experiments carried out by Mr. R. P. Clarkson upon "B" power units, which also supplied the "C" bias necessary for the power tube in the audio amplifier, has brought the conclusion that in altogether too many instances trouble encountered with "B" supply devices can be attributed to the "C"-bias resistor and condenser.

"The utilization of the 'C'-bias resistor and condenser in a 'B' or 'C' unit was found to be the cause for 'motor boating' with some power-transformer-coupled audio amplifiers," Mr. Clarkson states, in an article of recent date in the *New York Sun*. "With the normal 'C' arrangement, consisting of a resistor of approximately 1,100 ohms to supply the bias for a 171-type power tube, and a by-pass condenser of 1-mf. for this resistance, there was pronounced 'motor boating' with a transformer-coupled audio amplifier, when the amplification was adjusted to maximum. But when the 'C'-bias arrangement was removed from the unit and the 'C'-bias obtained from a battery, the trouble was immediately removed. Now, with the original 'C' biasing arrangement in the circuit, it was found that the use of a higher value of by-pass capacity for the 'C'-bias resistance was necessary if the 'motor boating' was to be removed. To all intents the by-pass condenser of 1-mf. was insufficient.

"The value of the 'C'-bias by-pass capacity brings into discussion the item of cost. Judging from the experiments, a capacity of at least 4-mf. is necessary across the 'C' biasing resistor. The cost of such a capacity and the proper resistor is equal to, if not greater than that of a 'B' battery unit utilized as a 'C' block.

"Constructors of 'B' power units would do well to heed the following advice: Build your 'B' supply and omit the 'C' biasing resistor. Utilize a separate 'C' battery for the purpose. This can be carried out with perfect satisfaction whether D.C. or A.C. is supplied to the filaments. Experimental work carried out over a period of six months seems to show that the 'C'-bias arrangement in socket-power units is a cause for all sorts of noises in the receiver as heard in the speaker.

"From an angle of economy and efficiency a separate battery for 'C'-bias is more satisfactory. This is particularly true when the average 'B' supply unit is applied to the average radio receiver. Excessive hum in the output circuit of the receiver was found to be due to the 'C'-bias arrangement. The removal of the 'C'-bias resistor and the use of a separate 'C' battery in several cases reduced the hum to almost inaudibility.

"The statements in the preceding paragraphs should not be construed as signifying that all 'C' battery arrangements in use at present are deficient in operation. Many are satisfactory, as are many supply units; but it is also true that many are unsatisfactory. For the constructor the advice is to use a battery for the source of 'C' voltage."

These conclusions may be endorsed, unless the constructor is working with very high-grade material, and a plan and specifications which have been worked out satisfactorily and approved by radio engineers.

Power-Unit Regulation

(147) Mr. D. Robert, Sea Cliff, L. I., asks:

Q. 1. I am using a superheterodyne with a "B" power unit, with the 45-volt tap used to supply the detectors and intermediate stages. I do not obtain satisfactory reception and upon measuring the voltage across this tap I find it registers only 28 volts. Could you suggest some way, whereby I could maintain the voltage of this tap at 45?

A. 1. Very often the drain from the 45-volt tap on a "B" power unit is in excess of that provided for in the design of the device, with the result that the voltage is below normal. This is particularly true with superheterodyne receivers. In these instances five or six tubes are supplied from one tap, resulting in an excessive drain.

By connecting a variable resistor between the 145- and 90-volt taps. The voltage at the 45-volt tap can be raised to the desired figure. The position of this resistor is shown in Fig. 147. Its selection is governed by the current-carrying capacity of

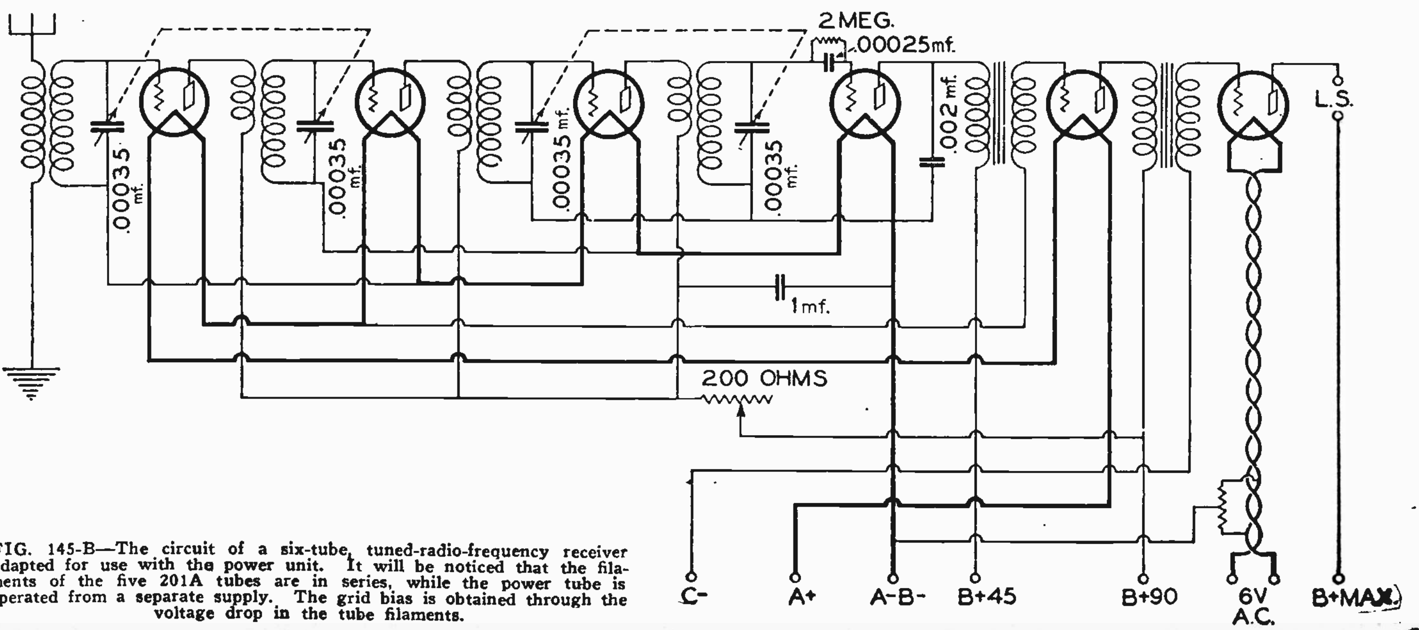


FIG. 145-B—The circuit of a six-tube, tuned-radio-frequency receiver adapted for use with the power unit. It will be noticed that the filaments of the five 201A tubes are in series, while the power tube is operated from a separate supply. The grid bias is obtained through the voltage drop in the tube filaments.

the unit. It should at all times be capable of carrying at least twice or three times the actual current flow.

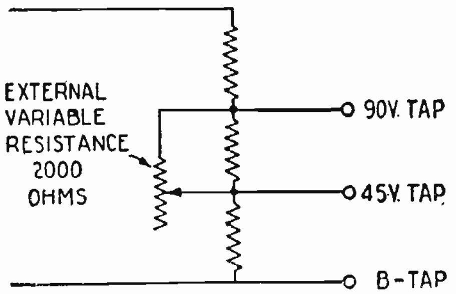


FIG. 147—Showing the use of a separate resistor to stabilize the output from a "B"-power unit.

Crosley Power-Supply Unit

(148) Mr. R. Delaney, Mt. Morris, Pa. asks:

Q. 1. I have recently purchased the Crosley A.C. supply unit for use with my model AC-7 receiver. I would like to know more about its operation; if possible, please publish a circuit diagram of this apparatus.

A. 1. Crosley A.C. supply unit was designed primarily for operation of Crosley models AC-7, and AC-7C receivers. It delivers rectified "A" current for five 199-type tubes connected in series, alternating current for the filament of a power tube, and "B" current for all tubes. Because the "A" voltage delivered by the unit is of the proper value to operate five 199-type tubes, the filaments of which are connected in series, the unit cannot be used with ordinary radio sets, which have the tube filaments wired in parallel, unless these sets are rewired.

Electrolytic Condenser

The Mershon type of filter condenser used in this power unit has many advantages, not the least important of which is that it is self-healing. That is, if a high-voltage surge punctures the insulating film, a new film is immediately built up. The principle used in its construction makes it possible to build a high-capacity condenser, which will stand high voltage, in a minimum of space. Another important feature is the smoothing action of the condenser on the pulsating direct current furnished by the rectifier, which it converts into a steady flow of direct current.

These condensers are so constructed that it is practically impossible for them to go wrong unless handled roughly. The electrolyte cannot leak out, as said before, they are self-healing. If the unit is allowed to get colder than a few degrees below zero, there is danger that the electrolyte will freeze. Freezing and breakage of the glass jar are practically the only causes which will make the condenser cease functioning. If either of these troubles is encountered, the condenser should be replaced by a new one obtained from the factory; for the electrolyte is of such character that it cannot be replaced conveniently in the field.

When the supply unit is first put into operation it usually requires from five minutes to a half-hour for the condenser to become conditioned so that it will function normally. This condenser depends for its action upon thin film of insulating material that is built upon the plates in a manner somewhat analogous to the process of electrotyping. When the units are assembled at the factory, a film is built up on the plates so that the condensers operate normally when tested. If the unit stands around for some time, however, as in shipment or in stock, the film gradually wears away and a new film must be built up.

To condition the condenser, it is merely necessary to connect the set to the unit in the usual way and operate the set until normal reception is obtained. If the unit delivers the necessary "A" current, immediately upon being placed in operation, it probably requires no conditioning. If the set stands idle for a number of weeks, conditioning, as outlined above, is sometimes necessary.

Circuit Diagram

The circuit of the supply unit is shown in the accompanying diagram. The A.C. supply line connects to the primary of a transformer through the switch (1), and fuse (2). By changing the fuse from one position to another in the clips, the transformer may be adapted for a high or low voltage A.C. supply line within limits, roughly, from 100 up to 130 volts. In the positions shown in the circuit diagram, only part of the transformer primary turns are being used. This is the proper position for use with a low-voltage supply line, and corresponds to the left-hand position of the fuse in the clips as viewed from the control-knob end of the unit.

The middle tap of the transformer secondary is the "A—B—" lead to the set. A rheostat (3) is connected in this circuit for use as a control of "A" and "B" voltage.

The two ends of the transformer secondary are connected to the terminals of the Raytheon rectifier tube (4). The central electrode of the tube connects to the "A+" and "B+" leads; the lower voltage required for the "A" supply being obtained by connecting the high resistance (5) in series with the "A+" lead. The choke coils (6) and (7) and the condensers (8) and (9) help to smooth out the current so that the hum will be eliminated. The leads (10) are from a special secondary which supplies A.C. current for lighting the filament of the power tube in the last audio stage of the set.

Eliminating Hum

A loud A.C. hum may occur if any of the connections to the Mershon condenser are making bad contacts. If the set hums persistently, examine these connections first.

A defective Raytheon tube may also cause A.C. hum. To determine if this is the seat of trouble, try another tube in the unit. In some instances, defective tubes have been known to operate satisfactorily at first, the unit later failing to deliver proper "A" current. The "A" current will fall off to as little as 20 to 35 milliamperes, despite all adjustments, and the set will operate with considerable hum. These symptoms indicate a defective tube in which the elements are too close to each other; so that arcing, and eventually short-circuiting take place within the tube. Such tubes should be replaced.

If the unit fails to deliver current, the entire circuit should be tested with a circuit tester to be sure that there are no open circuits in the transformers or short circuits in the wiring.

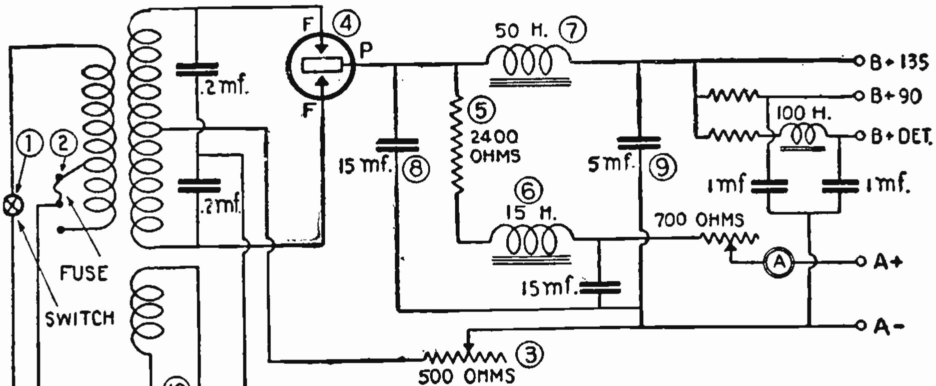


FIG. 148—Schematic diagram of the Crosley A.C. Power Unit, which operates on houselighting current and supplies both "A" and "B" current. It can be used with any receiver which utilizes 199-type tubes with the filaments wired in series.

Rectifier Solution

(149) Mr. George Smith, Philadelphia, Pa., inquires for the proper method of preparing the solution for an electrolytic rectifier of the lead-aluminum type.

A. 1. The solution used in the type of cell you mention is generally specified as a "Saturated Solution of Borax in Water." In the first place, a "saturated" solution is one in which the greatest possible amount of solid material has been dissolved. In this case it is done as follows: A quantity of water is heated to a temperature somewhat below boiling. To this water is added borax (obtainable at any grocery store) until the excess of borax begins to collect at the bottom of the container in the form of a white powder. The solution must be stirred constantly to insure the dissolving of as much borax as possible. The solution should be allowed to stand over a period of time necessary to dissolve as much borax as possible. This gives a saturated solution. After all the solid has settled, the liquid should be siphoned or decanted off and used in the rectifier cell. Due to evaporation, the liquid will have to be replaced occasionally.

Eliminating Hum in A.C. Tubes

(150) C. Shielde, Coney Island, Brooklyn, N. Y., writes:

Q. 1. I find when using the A.C. tubes that a continuous hum is produced in my receiving set. Can you suggest a simple remedy for this other than the use of center tapped resistances across filament terminals? The transformer I am using at present employs a mid-tap which is not used.

A. 1. Very often in A.C. filament circuits utilizing transformers with mid-taps better operation will be obtained if a by-pass condenser is inserted between the mid-point and the two outside leads of the low voltage end of the primary. This is shown in the accompanying drawing. The condensers should have a capacity of about 1 mfd. These condensers function as by-passing condensers for any R.F. currents which may find their way into the filament circuit. Being located as they are, the undesired currents are by-passed to the mid-tap, which is usually connected to ground or is at ground potential. In some instances, particularly in A.C. power amplifiers, condensers so located reduce the hum in the output circuit. By-passing condensers in every possible location will always be advantageous in receivers utilizing A.C. on the filaments.

Tube Data

Tubes for Resistance Coupling

(151) Mr. J. M. Sedberry, Waco, Teaxs, writes:

Q. 1. Please advise me as to the best type of vacuum tube to use in my resistance coupled amplifier. I have a two-stage amplifier constructed for use with a phonograph pick-up but do not get sufficient volume. Will it be necessary to add another tube?

A. 1. You will get much better results with this amplifier by using the 240-type of tube in the first stage with a 112- or 171-type tube in the second stage. The coupling condensers should have a value of about .01-mf. and the plate and grid resistors should both have a resistance of about 250,000 ohms. The other constants of the amplifier will remain exactly the same as in the original amplifier. An additional stage is not necessary.

Changing Tubes

(152) Mr. Thayer Stout of Lancaster, Calif,, writes:

Q. 1. I wish to ask you whether you have any plans for changing a three-tube Kennedy set into an A.C. set without the use of eliminators, etc. I am using 199-type tubes at present.

A. 1. It would be a difficult task to change your set over for the A.C. tubes since these tubes do not have the same characteristics as the 199 tubes that you are now using. It would be necessary to completely redesign your receiver so that the correct efficiency would be obtained with the new tubes or it would be necessary to employ a series filament arrangement with the 199 tubes operated from a "B" power unit supplying 85 or 125 milliamperes.

Using A.C. Tubes

(153) Mr. David R. Solomon, Birmingham, Ala., writes:

Q. 1. Can the new A.C. tubes such as the UX226 and 227 be used for resistance coupled amplifiers?

A. 1. You will encounter considerable difficulty in trying to use A.C. tubes in a resistance coupled amplifier. These tubes work perfectly in an ordinary transformer and impedance coupled circuits, but produce motor-boating and excessive hum when they are used with resistance coupling.

Q. 2. Please tell me if there is a transformer made that will stand the load of ten 227 tubes or will I have to use two transformers?

A. 2. There are several power transformers available that are capable of handling this number of tubes and we would suggest that you communicate direct with the manufacturers.

Grid Bias for Detector

(154) M. Tesak, Youngstown, Ohio, asks:

Q. 1. Will you kindly furnish me with some information concerning the grid bias method of detection which I intend to use with 199 and 201-A type tubes.

A. 1. The following biases are recommended for use with thte tubes mentioned.

Tube	45 *Volts*	90 *Volts*
Type UX199	—4 to 6	—17 to 20
Type UX201-A	—4.5	— 9 to 10

As the value of negative grid bias is increased, the output impedance of the detector tube increases. Several effects may frequently be noticed as a result of this condition. The first is a fall-off in quality of reproduction. It is therefore advisable to use the lowest value of grid potential which may be found satisfactory in actual operation for a given tube and receiver. The next condition is that as the negative grid potential is increased, the tube impedance increases so rapidly that the load of the tube on the transformer primary or coupling device decreases to a point where the audio amplifier may go off into continuous oscillation at a rather low frequency. (This is indicated by a steady hum, or howl, present when a signal is not being received.)

The remedy for this condition is a decrease in the value of detector "C" bias or the connection of a leak resistance across the secondary of the transformer; and due to the coupling effect, the primary as well. In all cases the output circuit of the detector. before it reaches the audio amplifier, should always be by-passed from plate to filament with a .002 mf. by-pass condenser to keep the radio frequency component of the detector plate circuit out of the audio amplifier.

It may frequently be necessary to ih insert a choke coil in the output plate circuit of the detector tube. This choke should have an inductance of 2½ millihenries and will further aid in the isolation of the audio frequency amplifier from the radio frequency circuits of the receiver and will promote stability. In all cases, every endeavor should be made to keep the detector wiring as short and direct as possible and to condense the circuit arrangement just as far as is practical. The leads to the by-pass condensers, etc., should be very short and direct, and every ordinary precaution taken to see that trouble may not arise in the detector circuit either individually or as the result of the cumulative effect of associated circuits.

Rejuvenating Vacuum Tubes

(155) N. O. Siegel, Nashville, Tenn., writes:

Q. 1. Will you kindly tell me what types of vacuum tubes may be benefited by rejuvenation?

A. 1. Overheating the filaments of tubes whose filament wire is of the thoriated type will cause the rapid evaporation of the surface layer of thorium. The electron emission of the tube will then be only a fraction of its proper value and very little plate current will be had. Usually fresh thorium may be brought to the surface by heating the filament, but during the heating it is necessary that the plate voltage be cut off from the tube. There is additional thorium distributed through the metal of the filament and it is often possible to form a new surface layer from this reserve supply, so that the tube will operate as well as when new. Restoration is of value after the tubes have been in normal operation for long periods of time. If the thorium content of the filament has been used up almost entirely any improvement made by the restoration process will be temporary only. If through accident high voltage has been applied to the filaments only for an instant it is quite possible that they may not have burnt out, yet the tubes remain dead so far as detecting or amplifying signals are concerned.

Under such conditions restoration is entirely practical. It must be remembered, however, that this treatment can only be used on tubes whose filaments contain thorium. It cannot be applied to tubes having plain tungsten filaments nor to tubes having oxide coated filaments. Plain tungsten filaments are found in the older tubes which use 1 ampere of filament current such as those in the 200 and 201 series. Oxide coated filaments are those which operate at very low temperatures, at a dull red or dull orange heat. These include such tubes as the 11 and 12 types, the 112 and 216-A. Thoriated filaments are found in most of the voltage and power amplifying tubes such as the 201-A, 171, 210, 199 and 120 types. Thoriated filaments are also found in the 200-A type detector tubes. Any of these above mentioned tubes having a thoriated filament may be subjected to the process of restoration, usually with good results.

A.C. Tube Connections

(156) J. C. Warner, Paulina, Iowa, writes:

Q. 1. I have a four tube radio receiver which uses six volt storage battery tubes. Will you please publish a diagram showing how these tubes may be replaced by the new A.C. vacuum tubes of the UX-226 and UY-227 types with a 210 type tube in the last stage?

A. 1. On this page you will find the circuit diagram showing the filament connections which you will have to make in order to install A.C. tubes in your receiver. The transformer will cost in the neighborhood of eight to ten dollars and provides four different voltages. The grid and plate returns are made to the mid-point of a center tapped resistance. This will eliminate

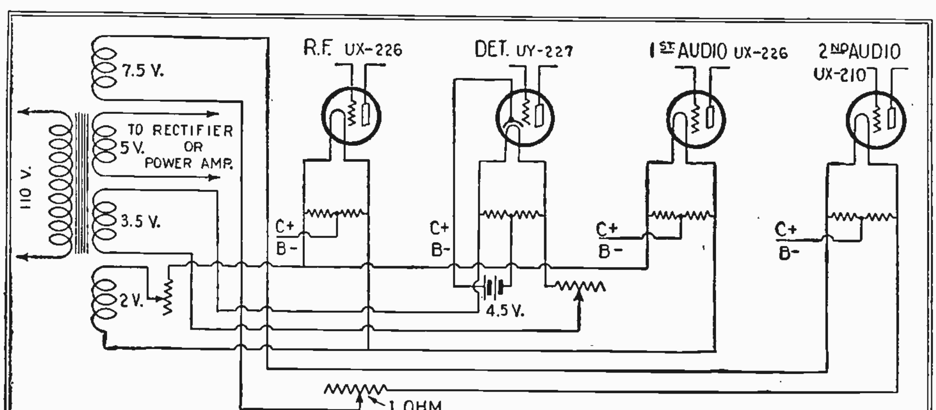


FIG. 156—The filament circuit diagram showing the necessary connections for the new A.C. tubes, is shown in the above illustration. Note that the grid and plate returns are made to the mid-point of a center tapped resistance.

any hum which may result. The detector tube is of the heater element type and is relatively quiet in operation. The 210 type tube in the last audio stage is supplied with A.C. current directly from the transformer.

It must be remembered that the amperage required by these tubes is considerably more than that for the ordinary six volt vacuum tubes. The filament circuit should be wired with No. 14 or No. 16 insulated wire. When using the five prong type of the A.C. tubes, the C+ and B— connections are made to the fifth prong. Rheostats will be required, but when once set will need no further adjustments, so that they may be placed behind the panel. The C+ and B— connections are made to the mid-tap of the center tapped resistance when the four prong A.C. tube is used.

Tube Rejuvenation

(157) J. K. McVicker, Mansfield, Ohio, wants to know:

Q. 1. Is tube rejuvenation practical?

A. 1. This process is entirely practical and is in wide use today. It is one that will give excellent results if it is rightly carried through, but which may result in failure if the apparatus used is not properly designed. Furthermore, when rejuvenating tubes by the flash process, it is necessary that the high voltage be applied to the filament of the tube only through a short and definite period of time. Then too, the aging process must be finished for a period of time sufficient for the purpose and during this time, the plate voltage must not be applied. The editor of this department has used a tube rejuvenator in his laboratory for some time and has had excellent results with both the 199 and the 201A types of tubes. It must be noted here that tube rejuvenation is practical only for those tubes having thoriated filaments.

Detector Tubes for Reflex Set

(158) Mr. A. Duckwell, Chicago, Ill., writes:

Q. 1. Is it possible to use the UX-200A tube as a detector in my reflex set, or would you suggest that I use the 201A type? If you suggest the 200A, please explain how to get the greatest efficiency from it.

A. 1. Of the vacuum tubes now available for use as detectors in reflex receiving sets, the UX-200A and similar types are the most sensitive. Compared to these the UX-201A tube is not so sensitive when used as a detector tube; although the latter is suitable for local reception and is desirable because of the good quality of sound reproduction that is obtained.

The UX-200A and similar vacuum tubes require a rather exact adjustment of filament and plate ("B" battery) voltage. Should either of these adjustments be incorrect, the tube will be insensitive. Except when there is available a "B" power unit which has a continuously-variable plate voltage at the "detector" tap, it is best to use a tapped "B" battery for the detector tube. (This battery will be referred to as the "D" battery for convenience.) Several voltages, usually varying from 16 to 22.5 volts by 1.5 volt steps, are available by the use of this device.

A UX-200A tube may be adjusted in the following manner: using the lowest "D" (plate) voltage available, adjust the filament of the detector tube by means of its rheostat until a seemingly-distinct hissing sound is heard from the telephone receivers or the loud speaker. If the hissing sound is not heard, the next higher plate voltage should be tried. When the hissing sound is heard, the rheostat should be turned back just enough to stop the hissing. In this connection, the brilliance of the filament of the detector tube is of no significance.

The next step is to tune the receiving set to a somewhat distant broadcast station, and then make a final adjustment of the filament by means of the rheostat, being careful not to pass the hissing point as that will result in poor quality. The next step is to raise the "D" (plate) voltage slightly (in the case of the dry battery this minimum change is usually 1.5 volts) and readjust the filament voltage, using the rheostat as before, with reference to the hissing point. Now listen to the broadcast station again and, allowing for fading, observe if the signal strength and quality are improved, or the reverse. In the same manner try all of the "D" voltage available and use the one giving best results. Do not try to make a fine adjustment when listening to very strong signals.

Remember that while many combinations of filament and plate voltages will permit the detector to function to some extent, only one combination will give maximum results and, as the sensitivity of the detector tube controls the sensitivity of the whole set, it is worth while to make these experimental adjustments with care.

When both the filament and the plate voltages are properly adjusted, an increase of either the filament or the "D" (plate) voltage will cause the characteristic hissing sound to be heard. When the proper "D" (plate) voltage for a detector tube has been found, no further adjustment o fthat voltage will be necessary. The detector circuit can then be controlled by adjusting the filament rheostat as the "A"-battery (filament) voltage varies. About five minutes after first adjusting the filament voltage for a UX-200 A tube, the final readjustment should be made. After this the detector tube will require no attention during the period of listening, except when the "A" voltage is low. This usually indicates that the battery should be recharged.

When a "B" power unit is used the filament voltage for a UX-200A tube should be set at about 5 volts and the "B" (plate) voltage varied until the characteristic hissing sound is heard. Then a final adjustment is to be made as described.

The best average grid condenser value is .00025-mf., and the best average grid-leak value is 1 megohm; although it is worth while to try different grid leaks up to 2.5 megohms.

When a UX-201A tube is used as detector the characteristic hissing sound described above will not be heard. The lowest filament voltage available will be sufficient and a "B" (plate) voltage of from 20 to 30 volts will give best results. With this type of tube, grid leaks varying from 2.5 to 5 megohms should be tried.

Neutralizing 6-Volt Tubes

(159) Q. B. Malvern, Fresno, Calif., writes:

Q. 1. I have a 5-tube receiver with two stages of radio frequency employing the split secondary type of neutralization. Using 1½-volt tubes, I was able to ge the set neutralized fairly well, but I have recently changed over to 6-volt tubes having similar characteristics and am experiencing trouble in neutralizing the set. Will you kindly give me a remedy for this difficulty?

A. 1. It seems logical that the 6-volt tubes do not require so much capacity to neutralize them as did the former type you were using, and the neutralizing condensers, if not of an extremely low minimum capacity, will prevent neutralization from being obtained. If you find therefore, that the more you increase the capacity of the neutralizing condensers, the more unstable the set becomes, then the trouble is undoubtedly due to the cause mentioned. To remedy this, it is necessary to increase the plate-grid capacity of the tube, in order to bring it between the maximum and minimum values of the neutralizing condensers. The adjustment of these condensers will then allow perfect neutralization.

The additional capacity between the plate and grid of the tube can be obtained either by connecting small neutralizing condensers between the plate and grid and keeping the condenser at almost minimum capacity, or else, by connecting two pieces of insulated wire about 4 inches long, to the plate and grid terminals of each tube socket and twisting the pieces together, thus forming a small condenser.

Power Output

(160) W. R. Mansbridge, So. Norwalk, Conn., asks:

Q. 1. What is meant by power output and how can the maximum output of an audio frequency vacuum tube be ascertained?

A. 1. The maximum output obtainable without the introduction of serious harmonics in the plate wave current is generally considered as the conventional power output of an audio frequency amplifying tube. The method of measuring this output is necessarily a relative or an arbitrary one, but gives a useful comparison among the various vacuum tubes employed. The procedure is given as follows:

The normal external plate resistance (non-reactive) is inserted in the plate circuit. If the value of this resistance is not specified by the manufacturers, it should be chosen as twice the normal plate resistance of the type of vacuum tube under test. The filament voltage is adjusted to its normal value; and the plate supply voltage is adjusted to give normal plate potential at the plate (that is, equal to the normal plate potential plus the voltage drop in the external resistance). A sinusoidal alternating voltage and a grid bias voltage equal to the maximum alternating voltage are impressed in the grid circuit and are adjusted together until the direct component of the plate current is 5 per cent higher than when the alternating voltage is removed. The power in the external plate resistance due to the fundamental component of plate current is then taken as the conventional power output.

Screen-Grid Characteristics

(161) Mr. J. M. Kruger, San Francisco, Calif., writes:

Q. 1. Will you publish the operating characteristics of the new screen-grid tube? This should be of interest to a number of radio fans, since this tube is becoming so popular.

A. 1. We are printing the data supplied by the Radio Corporation of America for use with the new screen-grid tube, UX 222.

It is designed primarily as a "screen-grid" tube, for use as a radio-frequency amplifier in circuits especially designed to make use of its high amplification and low feedback capacity between plate and control grid. When used for this purpose, it is not interchangeable with thte ordinary three-element tubes, and *cannot be used to replace them in standard sets.* This tube may also be used as a "space-charge grid" tube; its extra element being then operated at a positive potential to increase the mutual conductance of the tube. It is useful also for other experimental purposes where a double-grid, four-element tube is required.

Tube Must Be Shielded

The tube is provided with the standard UX base and an extra contact at the top of the glass bulb. When mounted in a vertical position, the tube should be shielded by a metal jacket fitting closely over the bulb, but having at the top an aperture, with insulated circumference, and which insures clearance (not exceeding 1/16-inch) between the metal of the jacket and the metal cap. The jacket should extend down at least to the base, and should be connected to either filament terminal of the socket.

When the tube is used in conjunction with storage-battery tubes having five-volt filaments, a tapped 15-ohm resistor should be placed in series with the negative lead of the screen-grid tube. In this way, the tube can be operated from the six-volt supply for the storage battery tubes.

When used as a screen-grid radio-frequency amplifier, the 222 tube is designed to operate under the following normal conditions:

Element	Supply Voltage
Plate	"B" +90-135
Screen-(Outer) Grid	"B" +45
*Control-(Inner) Grid	"C" —1-1.5
Filament	"A" +3.3

*This bias may be obtained from a resistor in the "A—" return.

The control-grid biasing voltage is given with respect to *the negative side of the filament*. Neither the plate nor the screen-grid voltage is critical. The same battery can be used for both, by using a tap on the battery. The control-grid bias can be obtained from a separate dry cell, or may be obtained automatically when the tube is used with a 6-volt supply. This bias is obtained by tapping thte 15-ohm series resistor at the correct point. In using this tube, it is necessary to shield the control-grid circuit, including the wiring, coils and condensers. A grounded metal case should be used for this purpose.

As a Space-Charge-Grid Tube

The 222 tube may be used in circuits requiring a tube with a high amplification factor and high mutual conductance, such as resistance-, reactance- or transformer-coupled amplifier circuits. For this connection, the inner grid is used as a space-charge grid at a potential positive with respect to the filament. The normal operating conditions are:

Element	Supply Voltage
Plate	"B" +135-180
Control-(Outer) Grid	* —0-1½
Space-Charge (Inner) Grid	"B" +22½
Filament	"A" +3.3

*The negative bias is obtained through a resistor or potentiometer.

The plate-supply voltage is not applied directly to the plate in this case, but to the plate-coupling resistor of 100,000 to 250,000 ohms.

Amplification Factors

(162) Harry D. Reirs, Merton, Neb., asks:

Q. 1. Why is it that while tubes intended for radio frequency amplification usually have a high amplification factor, audio frequency, and especially power tubes, have a much lower one?

A. 1. If the amplification factor were the only thing to be considered, doubtless all tubes would have a high one. However, there are a great many other things to be considered when designing a tube. For reasons which need not be stated here, a high amplification factor means a high impedance.

Now a high impedance means that the plate current will be comparatively small if ordinary "B" battery voltages are used, so that when a large plate current is required it is necessary for the impedance to be low and incidentally, of course, also the amplification factor. Radio frequency amplification should only be used when signals are weak, and in these circumstances a large plate current is not necessary. What is necessary, however, is a high amplification factor, as there is little or no step-up effect in radio frequency couplings.

Consequently, high impdeance tubes, with high amplification factors are generally used in radio frequency stages. For audio frequency amplification, on the other hand, a larger plate current is essential if great volume is to be obtained. Although this means that low-impedance tubes with low amplification factors must be used, the disadvantage of the latter is overcome by using step-up transformers between the audio frequency stages.

Ballast Tube

(163) R. Langweil Owensboro, Kentucky, asks:

Q. 1. Can you tell me something about the operation of the 876-type line-voltage regulator or ballast tube?

A. 1. The ballast tube is designed to regulate the input voltage across the primary of transformers used in "B" eliminators. The tube will pass 1.7 amperes at any applied voltage between 40 and 60 volts, and the load on the transformer secondary must be so adjusted as to bring the voltage on the tube to 50 volts at normal line voltage.

If the line voltage averages 115 volts, the transformer, under load, should be designed to take 1.7 amperes at 65 volts, the remaining 50 volts being dropped in the ballast tube. If the line voltage drops or rises 10 volts, the voltage across the ballast tube will change accordingly, but the transformer primary voltage will remain constant at 65 volts. The tube requires several minutes to heat up and the voltage drop increases rapidly for the first three minutes and then slowly up to about 10 minutes, by which time the tube has reached its final temperature. The voltage will remain constant thereafter, as long as the device is in operation.

Difference in CX and C-301-A Tubes

(164) J. Brecht, Sydney, Australia, asks:

Q. 1. Can you tell me the difference, if any, between the CX-301-A and C-301-A tubes?

A. 1. The CX-301-A is electrically the same as the C-301-A but is mounted on a CX standard base instead of on the old type navy base. When the new base was adopted no change whatever was made in the characteristics of the tube. Compared with the C-301-A of 1923, however, the CX-301-A has a higher efficiency, resulting in improved performance. This increase in efficiency was gained through a 20 per cent increase in mutual conductance.

Filament Connections

(165) H. Maxine, Juneau, Alaska, asks:

Q. 1. Is there any advantage in connecting the filaments of the tubes on my receiving set in series rather than in parallel?

A. 1. A strange illusion persists that the mere connecting of vacuum tube filaments in series instead of the usual connection in parallel has some effect upon the working of the tubes. There is no truth in it. The sole idea of the filament in a tube is to provide a hot metal body which will emit electrons. It makes no difference whatever in the tube action whether the metal is heated by passing a current through it, building a fire under it or hitting it with a hammer, so long as the same temperature is reached.

The difference that is made by the series connection of filaments instead of parallel connection is not a difference in tube action but a difference in the requirements of the circuit hook-up. The grid return of each tube determines the grid bias of that tube. With series connection of filaments, if all the grid returns are made to one point, say the minus lead of the supply, no two tubes will have the same grid bias. There is a drop in voltage in each filament and each tube will have a gradually decreasing negative bias. If each grid return is to its own negative filament each grid will have no bias relative to its own filament, but there will be an existing potential between any two grids. This of itself does no harm. The reason for parallel connection lies in the standard fixed voltage of the storage battery and the varying numbers of tubes in different sets all of which are made for the same battery voltage.

VT-2 as a Rectifier

(166) Harvey Seton, Sacramento, California, writes:

Q. 1. I have several VT-2 Western Electric tubes which I believe could be used in a "B" eliminator. Can you suggest an appropriate circuit in which one of these tubes could be used to supply plate voltage for a six-tube set?

A. 1. As the tube is capable of operating at a plate voltage of 350 to 450 volts, you can supply sufficient voltage, using it as a rectifier, to operate a type 310 power tube, as well as a number of tubes of lower voltage requirements. One of the power transformers designed for use with either the CX-316-B rectifier tubes, or the heavy duty Raytheon rectifier can be used, provided that the transformer has a filament winding of at least 6 volts. If no filament winding is furnished with the transformer, a small bell-ringing transformer having a 6-volt secondary can be used, with the primary connected in parallel with the plate transformer primary. The filter circuit is the same as for any of the "B" eliminator circuits now in use, and the voltage reducing resistances are connected in the customary manner, as is shown in the diagram. The grid and plate of the tube are connected together, at the socket terminals.

Glow Tube Connections

(167) H. Lambourne, Rochester, New York, writes:

Q. 1. Will you kindly tell me how I may connect a gas-filled glow tube to my present "B" eliminator?

A. 1. A tube of the type mentioned is designed as a voltage regulator for the 90-volt tap of the "B" eliminator. Besides keeping the voltage constant, it also assists in smoothing out the fluctuations in the rectified current. It acts as a shunt of negative resistance on the plate supply, taking more or less load automatically as the voltage tends to rise or fall.

When the open circuit or no-load voltage of the eliminator between the 90-volt positive terminal and negative terminal is above 100 volts and less than 130 volts, connect the 90-volt positive terminal of the eliminator to the filament plus on the socket, in the receiver.

When the open circuit voltage is between 130 and 220 volts, insert in series with the glow tube a fixed resistor of 980 to 1,000 ohms between the 90-volt positive terminal of the eliminator and the filament plus terminal of the socket.

Audio Frequency Amplifiers

A.C. Push-Pull Amplifier

(168) Mr. I. W. Johnston, New Orleans, La., writes:

Q. 1. "I would like to obtain the constructional details for building a push-pull amplifier, employing one stage of ordinary transformer-coupled amplification, and one stage of push-pull amplification. A 112A-type tube will be employed in the first stage, and 171A's in the second stage. The filaments of these tubes will be operated from a 5-volt transformer, and the 'B' supply will be obtained from a 'B' power unit."

A. 1. The diagram you request will be found as Fig. 168. The apparatus used is as follows:

- One audio-frequency transformer, T1;
- One push-pull input transformer, T2;
- One output choke or transformer (push-pull type), T3;
- One 112A-type tube;
- Two 171A-type tubes;
- Three vacuum-tube sockets;
- One 40-ohm tapped resistor;
- Eleven binding posts;
- One wooden baseboard, 6x12x¾ inches;
- One binding-post panel, 3x12x¼ inches, bakelite or hard rubber;
- Wire, screws, etc.

The apparatus should be laid out on the woden baseboard as shown in Fig. 168-A, so that the grid wires will be as short as possible. The first audio transformer, T1, should be placed on the left side; the input push-pull transformer, T2, at about the middle of the baseboard; and the output choke or transformer, T3, on the right. The tubes should be placed between the transformers. Since there are no controls on this amplifier, it will not be necessary to use a large panel. A narrow insulating strip, containing the eleven binding posts, should be fastened along the front edge of the baseboard. If a cabinet is to be placed over the amplifier, it should be made to cover the front, down to the binding-post strip.

When wiring the amplifier, care should be taken to make all contacts tight. The wires used for the A.C. filament circuit should be twisted; so that inductive effects between these wires and the others in the amplifier will be kept at a minimum. These filament wires should also be placed as far away from the other wiring as possible; since an A.C. hum will be noticed in the loud speaker if very much coupling exists between them. The 40-ohm center-tapped resistor is used to obtain an effective center tap of the filaments of the tubes; but it will not be necessary if a center-tapped heating transformer is employed. In this case, the center tap of the transformer is used as the negative "B" and the positive "C" battery terminal.

The "B" Power Unit

A number of the manufactured "B" power units are equipped with 5-volt filament windings. If a unit of this type is employed, it will not be necessary to use a separate heating transformer for the push-pull tube; for the filaments of the latter will be automatically turned off when the "B" power unit is disconnected from the line. Some transformers designed for home-assembled "B" power units are also equipped with filament windings, and, for this reason, it is advisable to examine the transformer in your "B" power unit; so that you will know whether this winding has been included or not.

If a separate filament-heating transformer is employed, it will be necessary either to use a separate power switch for turning off the filaments, or to connect the filament transformer primary to the "B" power unit leads, in such a way that the switch in the "B" power unit will also turn off the current to the "A" transformer.

The diagram shows the correct connections for use with an output choke coil. If an output transformer is used, the primary should be connected in the same manner as the choke coil and the loud-speaker connections should be made to the two secondary terminals. When using this amplifier with the set, it should be connected to the detector output or, if extreme volume is desired, it may be connected to the output of one stage of audio-frequency amplification. We would not advise anyone to try connecting the output of an ordinary two-stage amplifier to this unit, as the combination would probably be very unstable and would not operate quietly.

It may be advisable, in some cases, to connect 1-mf. fixed condensers between the "C—" terminals and the "B—" terminal, and also between each of the "B+" terminals and the 'B—" terminal.

We would not suggest that the experimenter try to use the ordinary 201A-type tube in the first stage; since this tube has a different type of filament from that of the power tubes mentioned above, and a very strong hum will be noticed if it is used.

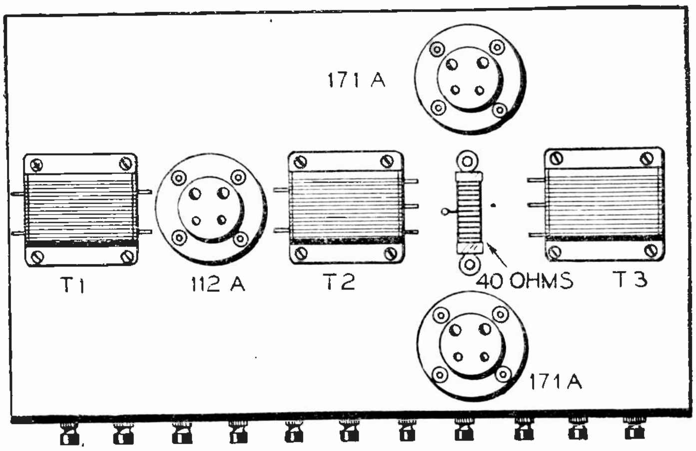


FIG. 168-A—The layout of the apparatus for the push-pull amplifier. Since there are no variable controls on this amplifier, it is not necessary to have a complete front panel; a narrow strip is used to hold the binding posts. The 40-ohm resistor is unnecessary if a center-tapped 5-volt winding is used to supply filament current from the tubes of the amplifier. The filament wires should be twisted, and kept away as far as possible from other wiring.

If the detector tube does not already have a by-pass condenser connected between the plate and "B—" battery terminal (or the plate and "A—" battery terminal) a condenser of about .002-mf. capacity should be connected across the two input terminals to the amplifier.

An amplifier of this type will give very good results, both for quality and volume. It is necessary, however, to use both the correct "B" and "C" voltages, especially in the second stage; since the quality will be affected considerably if these values are not correct.

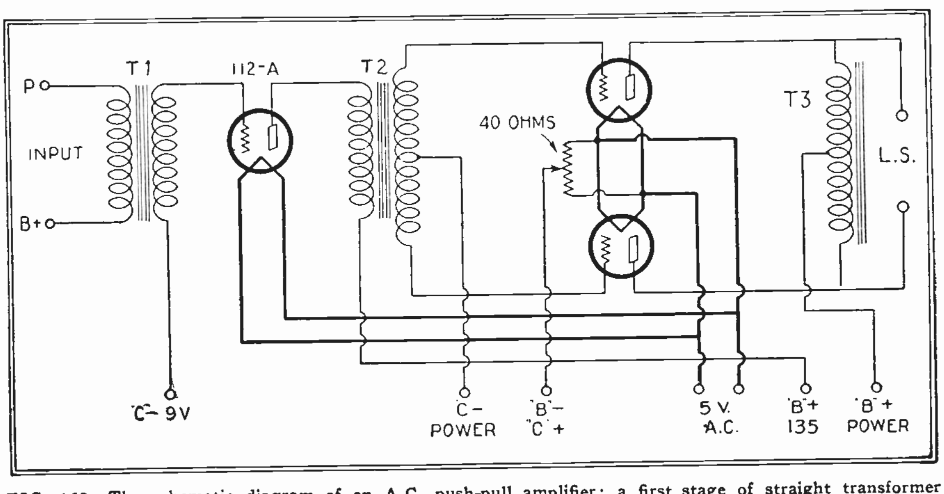


FIG. 168—The schematic diagram of an A.C. push-pull amplifier; a first stage of straight transformer coupling is used so that loud-speaker volume can be obtained. The input should be connected to the detector plate and the "B+Det" voltage tap.

Autoformer Amplification

(169) Mr. J. Brisbain, Salt Lake City, Utah, writes:

Q. 1. If possible, I would like to obtain the circuit and constructional data for building an audio-frequency amplifier of the Thordarson autoformer type. I have heard a lot about this amplifier, and recently obtained three of these autotransformers, and I would like to try them out.

A. 1. You will find the circuit diagram of this amplifier is given in Fig. 169. The auto transformer is particularly adapted for A.F. amplifiers, since a greater amplification is obtained than with either the resistance or single-choke-coil-coupled amplifiers, yet without loss of quality. The coupling condensers are not critical as to their value but, with capacities near 1 mf., they allow the unobstructed reproduction of the lowest notes. A greater volume limit can be obtained by reducing this capacity; but smaller capacities have a tendency to reduce the amplification of the bass notes. A 1-mf. condenser should be used between "B+" and "B—," and a .002-mf. condenser should be placed between the grid and the negative filament of the last tube, if any feed-back is present in the amplifier. It will also be helpful to ground the autoformer cases to prevent interaction between the stages. It is also a good plan to keep the parts well separated.

While the volume of auto-transformer A.F. amplification per stage is not as great as that of regular transformer-coupled amplification, the increased clarity, and the uniform amplification of all notes the human ear can detect, far more than compensate for this. Three stages of autoformers will usually give more amplification than the customary two stages of A.F. transformer coupling, and more volume than is required under normal conditions for home loudspeaker reception. It is usually advantageous to connect a 500,000-ohm potentiometer in place of the second grid leak, so that volume can be controlled successfully.

Remedies For Motor Boating

(170) Mr. J. Shea, Sandusky, Ohio, writes:

Q. 1. I am using a six-tube receiver, which includes a three-stage resistance-coupled amplifier. This set works very well when using dry "B" batteries; but, since I substituted a "B" power unit, I have been experiencing a great deal of "motor boating." Can you suggest any means of eliminating this nuisance?

A. 1. Various recommendations have been made to remove the disturbance which you complain of, namely "motor boating." The usual procedure usually consists of placing an audio-frequency choke in the detector "B" lead and then connecting a 4-mf. condenser from the receiver side of this choke to the negative leg ("A—") of the detector tube filament. This by-passes the detector plate current with its audio- and radio-frequency current components around the resistor of the first audio stage, thus preventing coupling with the audio stage which also passes through this resistor. The primary winding of any audio transformer makes an excellent audio-frequency choke, although standard chokes are to be preferred. If the above does not effect any improvement, the following changes in the values of plate and grid resistors will perhaps alleviate the trouble.

If the amplifier is the standard three-stage unit, it will incorporate 0.1-megohm plate resistors in the first, second and third stages, and grid resistors of 1-megohm, 0.5-megohm, and 0.25-megohm values respectively in the first, second and third stages. The changes recommended are as follows: The plate resistor for the first audio stage should be changed to a 1-megohm or a 0.5-megohm unit, and the grid resistor for this stage to a 0.25-megohm unit. The second plate resistor should be a 0.25-megohm unit and the second grid resistor an 0.1-megohm unit. For the third stage, an 0.25-megohm should be used in the plate circuit and an 0.1-megohm in the grid circuit.

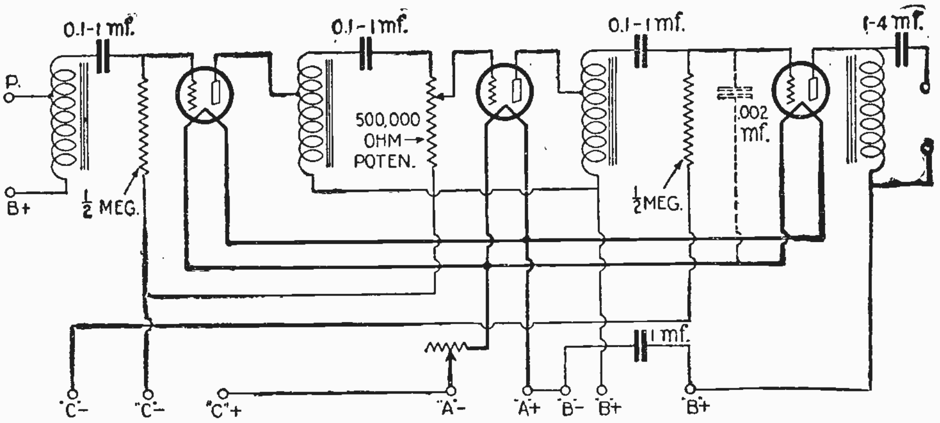


FIG. 169—The circuit of the "Autoformer" type of audio amplifier is shown above. The 500.000-ohm potentiometer in the grid circuit of the second tube is used to control the volume. The .002-mf. condenser in the last grid circuit is desirable to stabilize it.

In view of the higher plate resistances, a higher value of plate voltage should be applied to the detector stage in order to obtain the correct effective voltage. It would also be well to try different values of the coupling condensers. Values from .006 mf. to .05 mf. should be experimented with until best results are obtained.

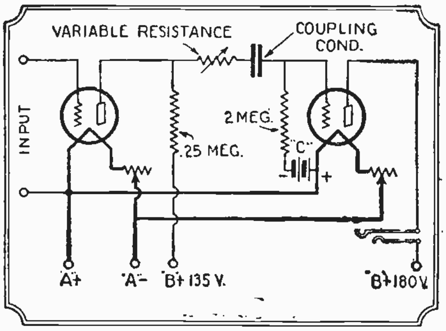


FIG. 171—A variable resistor, of 0-500,000 ohms, in series with the coupling condenser and plate, make a good volume control.

Volume Control for Amplifiers

(171) Mr. J. Norton, Linden, N. J., writes:

Q. 1. My present receiver consists of a regenerative detector with a three-stage resistance-coupled amplifier. This set delivers ample volume, but at certain times I desire to decrease the output. I have tried a modulator plug across the loud speaker, but this resulted in distortion. Can you suggest any better form of volume control?

A. 1. Now that power tubes are in universal use with "B" units furnishing both "B" and "C" supply, it is becoming more and more usual to dispense with jacks or switches for amplification stages. Generally speaking, this tends toward simplicity and freedom from stray couplings, and is therefore a step in the right direction.

When a radio-frequency amplifier is used, volume may be sufficiently reduced by simply turning down the rheostat of the R.F. stages; but when no R.F. amplifications is used the problem becomes a difficult one, and in most cases leads to distortion. Reducing regeneration control is fairly satisfactory in the hands of an expert, but is not to be recommended for sets of the family type. One drawback of reducing regeneration control is that it broadens tuning.

Perhaps the worst method is (though advised by some manufacturers) to include a variable resistance across the loud speaker. It is certainly very effective for controlling the amount of noise produced, but cannot possibly prevent distortion due to tube overloading. In fact, as far as this trouble is concerned, the method amounts merely to shutting the stable door after the horse has escaped.

A circuit which has given very satisfactory service is shown in the accompanying diagram. This volume control consists of an ordinary variable high resistor having a range from zero to approximately 500,000 ohms.

Double-Impedance Amplifier

(172) Mr. C. Gold, Brisbane, Australia, writes:

Q. 1. After much experimenting, I have come to the conclusion that the quality obtained from a receiving set depends to a great extent on the design of the audio amplifier. Therefore, I would like to construct an amplifier to substitute for my present resistance-coupled amplifier, and am thinking of using double impendances for this purpose. Can you give me any information, and a circuit diagram of an amplifier of this type?

A. 1. It is generally conceded that transformer-coupled amplification provides the simplest and most stable means of obtaining ample loud speaker volume. While the better makes of present-day transformers provide good tone quality in combination with a suitable loud speaker, to those with a critical musical ear, however, somewhat better tone quality, with less volume, may be obtained with impedance- and resistance-coupled methods. However, the last two

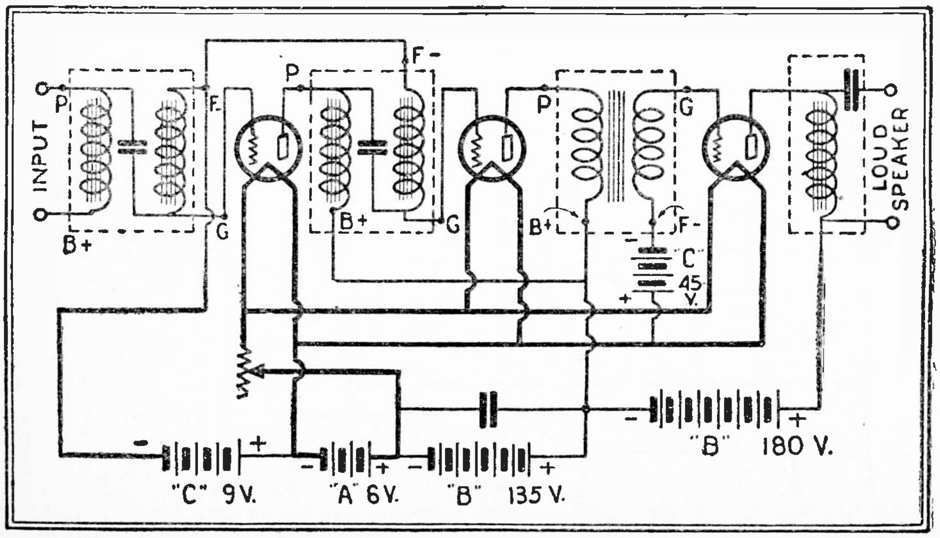


FIG. 172—An amplifier which provides a quality of reception that is unusual. The combination of a transformer and dual impedance gives faithful reproduction, throughout the entire musical range, with ample volume.

methods, because of their inherent characteristics, have often been abandoned in favor of the more stable transformer-coupling system, with its greater volume for given "B" or plate voltages, though at a slight sacrifice in realistic rendition.

Double-impendance coupling differs radically from the usual impedance-coupling in the amplifier, as well as from the well-known resistance coupling. In the usual type of impedance-coupled amplifier, "blocking" frequently occurs, particularly in the last A.F. tube. This is probably due to the fact that, in spite of precautions taken to adjust the grid bias properly, an occasional signal causes the grid to charge. Unless this charge has leaked off before the next impulse reaches the grid, "blocking" occurs. The high-resistance leak used in the usual impedance-coupled amplifier does not permit the charge to leak off rapidly enough. If the resistance is reduced to the point where blocking no longer occurs, signal strength suffers. The reactance type of leak in the double-impedance coupler, on the other hand, combines a high impedance to alternating current with a low direct-current resistance, and the tendency to block is overcome.

Problems of Coupling

The high value of the coupling resistance required in resistance-coupled amplifiers for good quality generally results in tubes being operated at a plate voltage too low for best results. (Plate voltage is the *actual voltage on the tube* and, in a resistance-coupled amplifier, *is much less than the voltage across the "B" battery* or socket-power unit.) While the drop through the resistance can be compensated by raising the plate voltage, very few users find it possible to attain the necessary high voltage for proper operation. In consequence, while distortion due to unequal amplification of different frequencies is avoided, harmonics are frequently introduced as a result of rectification due to overloaded tubes; with consequent confusing distortion in what is claimed to be a distortionless amplifier.

For those seeking the utmost realism in radio rendition, together with reliable operation on reasonable plate voltages, the amplifier shown in the accompanying diagram is suggested, although it need not be followed in precise detail. Three stages of double-impedance coupling may be employed; but increased volume, without perceptible loss of quality, results from the use of one transformer-coupled stage, as indicated. If a great volume of output is desired, a 112-type tube should be used in the second stage, and a 171-type in the last stage, with the usual 201A-type in the first stage.

With A.C. Current Supply

In using impedance-coupled amplifiers with plate supplies having an A.C. source, trouble is sometimes encountered. Several methods of overcoming this trouble are generally successful. The use of different plate voltages on the different tubes of the amplifier is frequently effective. It will sometimes be found helpful to place the transformer in the middle stage of the amplifier. In this case the primary should be reversed if necessary. Condensers placed across the plate-supply binding posts of the receiver help materially in stabilizing the amplifier. Also, to provide the utmost clarity on low, sustained notes, a large condenser, with a capacity of from 10 to 20 mf., may be shunted across the full output of the "B"-unit if found necessary.

It goes without saying that the tubes employed in this amplifier must be properly operated, with their full rated filament voltages, ample plate voltages, and proper grid-biasing or "C" batteries.

Because of the excellent frequency-characteristic of this amplifier, nothing but a very high-quality speaker, with distortion reduced to a minimum, should be employed. The high voltage output of the power tube calls for a speaker filter or output transformer. In the circuit shown, a speaker filter is employed. Practically the same results may be obtained by substituting an output transformer.

The results obtained with this combination double-impedance and transformer-coupled amplifier will prove a surprise party to the dyed-in-the-wool broadcast listener, because of the full tone and pleasing musical value of the loud-speaker rendition.

Power Tubes

(173) Morris Steiner, Rochester, N. Y., writes:

Q. 1. Will the addition of a power tube in the second stage of my three-tube receiver result in better signal strength?

A. 1. Louder signals will undoubtedly be found if a standard power tube is employed, and if care is taken to apply a higher voltage to the plate than is ordinarily used for a second stage of audio frequency amplifier. With the power tubes on the market today use at least 135 volts on the plate; 150 volts will probably be found even better. Also increase the "C" battery to at least 6 volts and preferably to 9 volts for the last stage amplifier. With certain types of power tubes it will be necessary to change sockets or use an adapter whereas with others, the standard socket may be employed, but it will be found that more current will be drawn from the "A" battery. In such an event a suitable rheostat must be employed to handle this current.

Screen-Grid Amplifier

(174) Mr. G. A. Muldon, Rome, N. Y., writes:

Q. 1. Can the new 222-type screen grid tube be used to advantage on an audio frequency amplifier?

A. 1. Yes, the new screen-grid tube can be used to good advantage in the first stage of the audio amplifier. The advantage of using this tube is due to its extremely high "mu" or amplification constant. The possibilities of this new tube are many and a lengthy treatise might be written upon its uses and applications.

Q. 2. If it is possible to use this tube in the radio amplifier will you kindly give me instructions for its construction and use?

A. 2. The 222-type tube is intended primarily for radio-frequency work. In this function, it requires special layout of parts, real shielding, and the use of special circuits. As a detector, it has been found quite microphonic; in fact, so sensitive to mechanical vibrations that no information as to its ability as a detector could be obtained.

Properly used as a first-stage audio amplifier, however, this new tube offers most extraordinary rewards. It is an ideal first-stage amplifier of distant signals. This discovery, made while experimenting with the first of these tubes available, led to extended work on the application of the tube to a new distant-signal amplifier, which is here published in its final, perfected and simplified form.

The presentation at this time will undoubtedly be of special interest to those radio amateurs and broadcast listeners who strive each year to bring in Europe before the weather becomes warm. In the past a limited number of people have succeeded in getting European signals through the detector, only to have them so weak that they are practically inaudible. For those who want better volume on DX work, without going in for high-priced, elaborate amplifying equipment, this simple amplifier is recommended.

Comparative Amplification

Comparing its total amplification with that of a standard two-stage transformer-coupled amplifier, the superiority of the former becomes immediately apparent. The voltage amplification for a two-stage transformer amplifier (transformer ratio 3 to 1, a 201A-type tube in the first stage, and a 171-type in the second) is 216 as compared with 900 from the distant-signal amplifier shown in the accompanying schematic diagram.

It is obvious that we have more than four times as much amplification available with the 222 distant-signal amplifier; or, speaking roughly, on a weak DX signal, we should be able to receive the signal with at least four times as much volume on the speaker. Surely an amplifier with this extraordinary advantage appeals instantly to anyone interested in better distance reception.

It should be understood, however, that the use of the new amplifier is not restricted to DX work; as a matter of fact, this new audio system may be well employed with any standard set for both local and distance work. Considering the unusual amplification available, it is apparent that the amplifier should be worked nowhere near its full capacity. On a strong local signal, and with the amplifier going full tilt, there is no available output tube which will satisfactorily handle the load. Rather than any gain in this case, a distinct loss in tone quality will result. When properly handled, however, the amplifier gives excellent quality on strong signals; the only adjustment needed is to cut down on the 30-ohm resistor R1 (which is a potentiometer connected as shown in the schematic diagram).

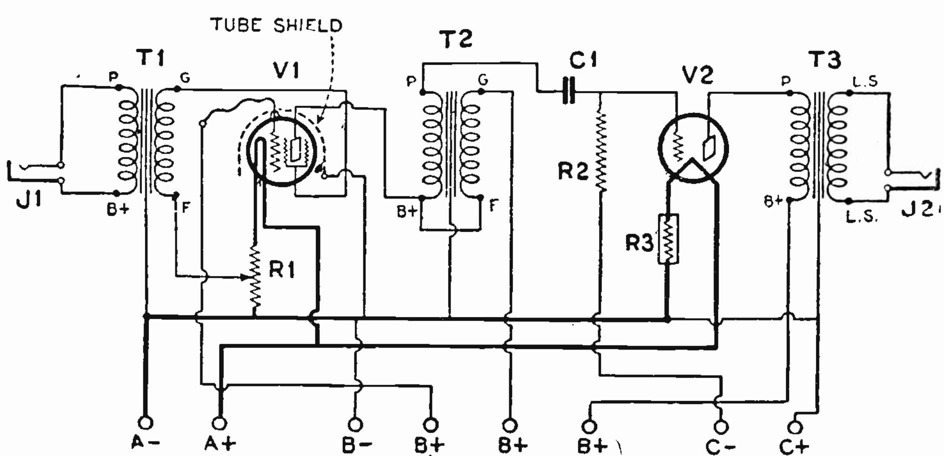


FIG. 174—Schematic diagram of the Distant-Signal Amplifier which utilizes a 222-type tube (V1) in the first stage.

The distant-signal amplifier is excellent also for use with an electric-phonograph pick-up. For this purpose, it can be connected to the receiving equipment in the regular manner, and an adapter placed in the detector socket of the set; or a plug from the pick-up can be run to the input jack of the amplifier, and the receiving equipment left unchanged.

Features of the Design

In starting the design of the distant-signal amplifier some months ago, a number of obstacles were encountered, and were overcome only after considerable work. The first problem centered about the type of coupling device to use in the amplifier. The first thought was of impedance coupling to work in conjunction with the 222 tube. Investigation showed that there were no available units with an inductance greater than 150 henries.

Straight transformer coupling was out of the question, inasmuch as no transformer is made with electrical characteristics suitable for work of this new tube.

Finally the idea of autotransformer coupling was considered, and one unit was found that had an inductance of over 300 henries; but this was not enough. After further investigation, the audio transformer (T2) named in the list of parts was selected for use as an autotransformer, not as a regular audio transformer. This choice resulted from the discovery that the transformer maintained a high secondary inductance, about 600 henries, with a high value of current through it. With this in mind, the transformer was selected as the ideal coupling device for the 222 tube, when used as an autotransformer with primary and secondary connected in series.

Construction is Simple

Once the problem of coupling was solved by finding a unit with a high value of inductance under high current load, the task of building the complete distant-signal amplifier became comparatively simple. Careful attention should be paid to the hook-up of the 222-type tube in the circuit, as well as to the layout of parts, and to small details such as the shield over this tube. The shield, incidentally, is essential as well as novel.

Resistance Vs. Transformer

(175) F. G. Nicholas, McCleary, Wash., asks:

Q. 1. Please compare a three-stage resistance coupled audio frequency amplifier with a two-stage transformer coupled unit.

A. 1. While a three-stage resistance coupled amplifier will give clarity far excelling the ordinary two-stage transformer coupled audio frequency amplifier, their volumes will be about equal one to the other.

Impedance Coupling

(176) E. Anderson, Hornell, New York, writes:

Q. 1. Will you please illustrate in your department the correct hook-up for a combination two-stage double impedance coupled and one stage transformer coupled amplifier with speaker filter using a UX201A, UX112 and UX171? What are the advantages of double impedance coupling over the usual impedance system?

A. 1. You will find illustrated on this page the schematic diagram for the impedance coupled amplifier. Double impedance coupling differs radically from the usual impedance coupled amplifier. "Blocking frequently occurs, particularly in the last stage tube of the ordinary impedance coupled amplifier. This is probably due to the fact that, in spite of precautions taken to adjust the grid bias properly, an occasional signal causes the grid to charge. Unless this charge has leaked off before the next impulse reaches the grid, "blocking" occurs. The high resistance leak used in the usual impedance coupled amplifier does not permit the charge to leak off rapidly enough. If the resistance is reduced to the point where "blocking" no longer occurs, signal strength suffers. The reactance type of leak of the double impedance coupler, on the other hand, combines a high impedance to alternating current with a low direct current resistance and the tendency to "block" is overcome.

Push-Pull Amplification

(177) Mr. Steven Jackson, Chiswick, Eng., asks:

Q. 1. What is the object of the push-pull method of audio-frequency amplification and what are its special advantages?

A. 1. Push-pull amplification is useful when proper power tubes, capbale of handling large volume without distortion are not available. It enables two separate tubes to handle the last stage of amplification, each tube receiving half of the input. In order to divide the output from the preceding stage, an audio-frequency transformer with a secondary tapped at its center is necessary. Or, alternatively, two audio-frequency transformers may be used, the primaries and secondaries being in series. The junction between the two secondaries can be used as a mid-point tap, and is to be connected to the grid bias battery in the ordinary way. The remaining ends of the secondaries go each to one grid, the respective tubes thus dealing each with its own half of the output. It is usual to use another similar transformer, with a ratio of 1:1, for the output. The "B" battery positive is connected to the mid-tap of the transformer primary, the outer ends of which go to the plates of the two tubes.

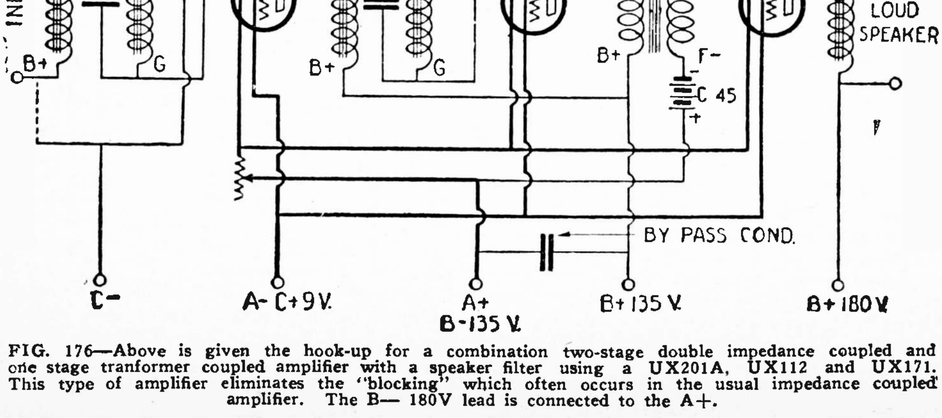


FIG. 176—Above is given the hook-up for a combination two-stage double impedance coupled and one stage tranformer coupled amplifier with a speaker filter using a UX201A, UX112 and UX171. This type of amplifier eliminates the "blocking" which often occurs in the usual impedance coupled amplifier. The B— 180V lead is connected to the A+.

Tube Combinations

(178) Mr. Marshall Austen, Athens, Ga., asks:

Q. 1. What do you recommend as the most efficient combination of tubes to be used in an audio-frequency amplifier?

A. 1. The answer to this question depends entirely upon the type of amplifier and the ouput desired. In the old days of radio, the only style of audio-frequency amplification which was used to any extent was the transformer coupled system. Transformers were comparatively inexpensive and fairly efficient so it became the custom to use them in all cases where tone amplification was required. In developing this type of amplifier, it was necessary to match the output impedances of the vacuum tubes to the average primary impedance of the transformers.

This led to the development of the standardized transformers and the 201-type amplifier tubes. The later 201A-type tube is simply a modification of the older type, having a lower filament current consumption and considerably greater stability. This tube is adapted for use in radio-frequency circuits, as a detector with a fairly high plate voltage and in transformer coupled audio-frequency amplification when used in the first stage of a two-stage amplifier. For best results it is necessary to use some sort of a power tube in the output stage. Where two stages of transformer coupled amplification are used, the second tube may be either a 112-type tube, a 171-type or—if an exceedingly large output is required—a 210-type tube.

The type 112 has a high amplification constant, and will carry a fairly heavy load. The type 171 is designed particularly for a large C bias to afford undistorted volume from large input. The 210-type is actually a transmitting tube, having an output of about 8 watts.

Where impedance coupling or resistance coupling is used in an amplifier, it is usually necessary to employ three tubes instead of two, to provide the extra amplification lost through the fact that transformers are avaided. For the first two tubes of an amplifier of this type, some type of hi-mu tube should be used. These tubes have a very high amplification constant and their impedance is adapted for use with high efficiency in connection with resistance and impedance couplers. The last tube should be a type 171 output amplifier which will furnish as great a volume as desired with undistorted clarity.

Push-Pull Amplifier

(179) Willie Robert Jones, Shreveport, La., asks:

Q. 1. Will the UV-199 type of tube work with push-pull transformers?

A. 1. UV-199s may be used quite successfully with push-pull transformers, although the same volume of sound should not be expected as with 201A tubes.

Q. 2. Do push-pull transformers amplify signals without distortion?

A. 2. The push-pull transformers go a long way toward eliminating distortion, especially in cases where the grids of the tubes are liable to become overloaded, if used with ordinary amplifying transformers.

Q. 3. Will a resistance coupled amplifier work satisfactorily with 90 volts on the plate?

A. 3. Owing to the high voltage drop across the coupling resistance, it is necessary to employ a higher "B" battery voltage with a resistance coupled amplifier than with one using transformer coupling. At least 135 volts of "B" battery should be used with a resistance coupled amplifier.

Testing Transformers

(180) H. F. Hayes, Nome, Alaska, writes:

Q. 1. Please tell me how to test audio

frequency transformers for short circuits and slight defects.

A. 1. Audio frequency transformers can be tested by means of a 40-watt light in series with the regular light lines and transformer windings The test is made for both the primary and secondary. The lamp should light with somewhat less than normal brilliancy when in series with the primary and should not light when in series with the secondary, there being a slight sparking at the terminals, when the connection is made and broken. If you do not want to try this, you can use a voltmeter or ammeter in series with the battery and the winding of the transformer. If a short circuit exists, the reading will be practically the same as if the two ends of the test leads were connected directly together. but if there is no short-circuit, the reading should be considerably less when the transformer is in the circuit.

A. F. Transformer Ratio

(181) Richard Wayne, Rochester, N. Y., asks:

Q. 1. In an audio-frequency amplifier, is it better to use a transformer having a 3 to 1 ratio in the first step and one having a 6 to 1 or 10 to 1 ratio in the second step or should both transformers have the same ratio?

A. 1. It is advisable to use the smaller ratio transformer in the second step rather than in the first stage. In order to avoid distortion, the ratios of both transformers should be as low as possible, consistent wits good volume.

Output Devices

(182) Mr. C. W. Hall, Philadelphia, Pa., asks:

Q. 1. Is there any advantages in using an output transformer to couple the loud speaker to the receiver, other than the protection that it offers?

A. 1. If it is not possible to match the impedance of the loud speaker to the impedance of the last tube in the receiver, it is advisable to use an output transformer to compensate for the difference.

In other words, if the loud speaker has a *lower impedance than the tube*, a transformer with a high-impedance primary and a low-impedance secondary would be used. In this case the transformer would have a step-down ratio and the *voltage of the secondary would be lower than that in the primary.*

If it is necessary to use a low-resistance tube with a high-resistance speaker, the characteristics of the transformer must be reversed. That is to say, the transformer should have a *small primary and a large secondary;* thus producing an *increase in voltage and a reduction in current.*

Simple Volume Control

(183) John Prince, Adams, Ala., writes:

Q. 1. I have a three-tube receiver with a detector and two transformer-coupled audic frequency stages, and I find that when the three tubes are used my loud speaker is overloaded, whilst signals are not quite loud enough when two tubes are used. Can you suggest a suitable form of volume control, so that the strength when using three tubes is cut down to a more agreeable value?

A. 1. The distortion to which you refer is due to overloading the third valve as well as to overloading the loud speaker and results will be much more pleasant if an adjustable volume control is fitted to enable you to reduce the volume to the desired strength. A simple but effective volume control consists of a variable high resistance shunted across the secondary of the first audio transformer. If this has a maximum value of about 500,000 ohms a very fine control of volume is obtained without impairing the quality in any way.

Filter Circuit

(184) Mr. J. Blackman, Baltimore, Md., writes:

Q. 1. I am using a double-impedance-coupled amplifier with a "B" socket-power unit, and I am experiencing a considerable amount of "motorboating" with this arrangement. Can you suggest some method which will help to overcome this difficulty?

A. 1. There are several methods which can be used to eliminate the trouble you are having. The use of a voltage-regulator tube in the power unit will probably overcome the difficulty and, if this is not practical, a filter circuit can be used. This filter consists of an audio-frequency choke in each of the "B+" leads, and a by-pass condenser between each of these filter coils and the "B—" terminal.

"Motorboating" is caused, in same cases, also by the use of incorrect "C" bias on the amplifier tubes in resistance-coupled and choke-coil-coupled amplifiers. The use of a high-resistance voltmeter to measure the output voltage of a "B" power unit is advisable; in this way, one can tell very easily what "C" bias is necessary, since the exact "B" voltage is known.

Laminated Cores

(185) A. T. Plottz, Erie, Pa., writes:

Q. 1. What is the object of building up the cores of audio-fraequency transformers from a number of thin laminations? What is thte objection to using a solid iron core?

A. 1. The iron core constitutes a mass of conducting material lying in the varying magnetic field set up by the varying currents flowing through the transformer windings. The core will, therefore, have induced currents set up in it which will represent so much energy withdrawn from the circuits in which the windings are included.

It is with the object of reducing the degree of these induced currents, and so restricting the wastage of energy, that the core is built up of laminations. As each lamination is insulated from those next to it, by being enamelled or by some other method, the induced currents can not circulate freely throughout the core.

Loud-Speaker Connections

(186) Mr. S. Gilbert, Washington, D. C., writes:

Q. 1. As the terminals on my loud speaker are marked positive and negative, I should like to know which is the correct way to connect the speaker to the set, and whether it really matters which way the loud speaker is connected.

A. 1. There are a right and a wrong way of connecting up a loud speaker; the former is usually determined by changing the connections of the loud-speaker cord. As a rule, reception will be somewhat better when the correct polarity is determined. However, although sometimes no difference in results will be noticed at first, there is danger of the magnetism of the permanent magnet being destroyed by the action of the magnetic field set up by the plate current. The correct way is to join the positive terminal on the loud speaker to that terminal on the set which is internally connected to the "B+," and the negative terminal of the loud speaker to the loud-speaker terminal on the set which connects to the plate of the last tube. If this is done, the magnetic field set up by the plate current will serve to strengthen the magnetism of the permanent magnet.

Q. 2. What is a "solenoid" coil?

A. 2. This is merely another name for a single-layer coil wound on any circular form.

Eliminating Distortion

(187) W. B. Schneider, Burbank, Calif., writes:

Q. 1. I am troubled in my radio receiver with distortion and would appreciate it if you could give me some hints as to its cause and remedy.

A. 1. Distortion is generally due to some trouble in the audio-frequency circuits and may be caused by a defective tube, a defective battery, a defective loud speaker, a broken down by-pass condenser which is connected across the loud speaker terminals, or it may be caused by overloading the vacuum tubes themselves. A vacuum tube of the soft or gassy type may cause distortion if used in the audio frequency stages. A worn out, or otherwise defective "C" battery may be so troublesome as to cause the audio frequency amplifier to produce squealing noises.

A "B" battery which is very much reduced in voltage may also cause sound distortion and if the voltage is very low there may be a more or less continual high pitched squealing. Distortion may sometimes be due to poor quality audio frequency transformers, such transformers will give very poor reproduction on the high and low musical tones. When the vacuum tubes used for audio frequency amplification are overloaded, there will be a blasting of loud tones. The obvious remedy for this is to reduce the amount of volume which the receiving set is delivering to the audio amplifier.

A volume control consisting of a high resistance should be placed across the secondary of the last audio frequency transformer. It is quite possible with the multi-tube sets used today, when installed near high powered broadcasting stations, to impress on the grid of the last tube sufficient voltage to swing the grid voltage beyond the limits of the straight line portion of the characteristic curve. Increasing the "C" battery negative potential, or the plate voltage on the amplifier tubes will tend to reduce this blasting but this is not recommended as good practice because of the possibility of increasing the grid potential to such a point as to cause distortion when the tube is operating with normal volume. Some amplifiers use a fixed condenser connected across the loud-speaker terminals. This condenser is known as a by-pass condenser and in this part of the circuit may be subjected to considerable peak voltages. Should this condenser fail a distorted signal will result.

Signs of Overcharging

(188) E. F. Kirckcaldy, Roxbury, Mass., asks:

Q. 1. What are the signs that a battery has been overcharged?

A. 1. One indication is the color of the plates; in a badly overcharged battery, the positive plates instead of being brown are much too dark and at times are almost black. The negative plates will then be a dark blue-grey. The condition of the plates also indicates overcharging, and the positive plates will often show disintegration.

Miscellaneous Apparatus

Metallized Resistors

(189) V. D. Renwick, Merchantville, N. J., writes:

Q. 1. Will you please give me some information regarding the method of "metallizing" glass, such as is used in resistors for radio purposes and advantages gained with this type of metallized resistor.

A. 1. The present type of metallized resistor, with glass core which fulfills the most exacting requirements that could be placed on a high resistance unit, has finally been produced after much experimentation. The glass tube, internally coated with a thin film, was abandoned. In its place a fine glass filament is used. This filament is spun by a most ingenious machine into lengths of 500 feet, which are entirely uniform from end to end.

The glass thread of filament is next passed through a solution of a salt, which will give a conducting coating when reduced by heat and a reducing agent, and then through a high temperature furnace through which a steady flow of gas is maintained. This process results in the production of a perfectly homogeneous conducting surface, thoroughly hardened upon one of the best insulators known. The externally coated filament, no larger than the usual lead-pencil core, has many advantages over the internally coated tube.

First, due to the small area of the filament, it is possible to give it quite a thick coating of conducting material and at the same time to have a very high resistance. Secondly, it is comparatively easy to put a protective layer over the conducting filament. Thirdly, it is relatively simple to measure the conductivity of the coated filament as it is fed out of the coating machine.

The ease of measurement obtained in the case of the coated filament insures a uniform product. After the coating has left the furnace, it is coated with a durable protective film of insulating varnish which is then thoroughly dried by the application of heat. This impenetrable coating completely protects the conducting filament against atmospheric changes.

Compressed Air Condensers

(190) J. Swoope, Albemarle, Tenn., asks:

Q. 1. Can you tell me if there is such a thing as a compressed air condenser and something of its construction?

A. 1. The dielectric strength of air is very considerably affected by the pressure to which it is subjected. The dielectric constant is not much altered by change in pressure, but the corona loss is considerably reduced at the higher pressures. The usual form of compressed air condenser consists of circular disks of metal alternately connected to the two terminals of the condenser. The whole condenser is contained in a steel tank and a pressure of 200 to 300 lbs. per square inch is applied to the air inside.

Dynamotors

(191) J. B. Clinton, Brooklyn, New York, asks:

Q. 1. How may I obtain high voltage in the nature of 350 to 400 volts suitable for running a 210-type tube or a pair of these tubes in push-pull. The house lighting current supplied here is from a 110 volts direct current circuit.

A. 1. "B" eliminators can be constructed to operate on 110 volts direct current, but it is impossible to secure a higher voltage from such eliminators than the line voltage. It is impossible to step-up direct current through the use of a transformer, but it is sometimes possible to secure 220 volts D.C. from the 110-volt three-wire systems, by having the electric company approve installing a special line from the meter switch box to the radio set. This permits using a 220-volt D.C. eliminator which will deliver at least 180 volts and operate a 171-type power tube.

The most efficient eliminators operate from alternating current To use these eliminators at a location where the power lines are direct current, it is necessary to change the direct current to alternating current. This

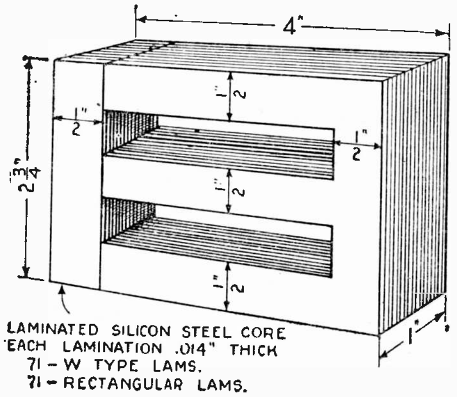


FIG. 192—The construction details of a ¼-henry choke coil suitable for "A" eliminator work are given in the above illustration.

can be best accomplished by using a dynamotor. The dynamotor is similar to a motor but has extra collector rings mounted at one end. One end of this device is a motor and the other end a generator. The dynamotor will run off the 110-volt direct-current lines and will deliver 110 volts, 60-cycle alternating current. This current can then be used to run the regular A.C. "B" eliminators.

It is suggested that the dynamotor be located in the basement of the house and controlled from a remote-control switch at the receiver. These dynamotors come equipped or not equipped with filters. The filters should always be included when the dynamotor is used to operate radio devices. The dynamotor requires very little care but has to be oiled occasionally.

"A" Eliminator Choke

(192) J. S. Nichols, Elizabeth City, North Carolina, writes:

Q. 1. Will you please publish constructional data for a ¼-henry choke coil capable of passing 2 amperes to be used with an "A" eliminator?

A. 1. On this page you will find illustrated the design of the steel core used. All dimensions have been marked on the illustration. The winding which is wound on the middle leg consists of 360 turns of No. 16 D.C.C. wire. The center leg of the core should first be taped and the winding put over this. The core is made of silicon steel .04-inch thick. Seventy-one rectangular laminations and 71 W-shaped laminations are necessary for the core. The core should be suitably clamped together after the choke coil is finished.

Battery Electrolyte

(193) G. B. Daniels, Ilion, New York, asks:

Q. 1. Can you give me some information regarding the renewal of solution in Edison cells?

A. 1. The potash electrolyte in Edison cells has a normal specific gravity of 1,200 at 60 degrees F. at the normal level. Throughout the total useful life of the cell, the electrolyte gradually weakens and may need renewal one or two times depending upon the severity of the service. The low limit specific gravity beyond which it is inadvisable to run an electrolyte is 1.160. Running a battery with electrolyte of lower specific gravity than 1.160 will produce sluggishness, loss of capacity and rapid breakdown on severe service. When ready to renew the solution, discharge the battery at normal rate to zero and short circuit for one or more hours. Then pour out half the solution, shake the cell vigorously and then empty. Do not rinse the cells with water, use only the old solution. Immediately after emptying each cell pour in the new solution to the proper height.

It may be necessary to add some more electrolyte after the cells have been standing, as some may have been absorbed by the plates. For replenishing any solution in these cells during operations, use pure distilled water. Do not allow the level of the solution to drop below the tops of the plates. It is important that the height of the electrolyte does not exceed the proper level. If filled too high, the solution will be forced out during the charge. The cells should never be allowed to stand empty for any length of time. When the new electrolyte has been put in the battery it should be given an overcharge at the normal rate.

Electrolytic Condensers

(194) Mr. R. W. Windsor, Oklahoma, City, Okla., writes:

Q. 1. Through your columns, will you please give us details on how to make an electrolytic condenser suitable for heavy-duty "B" power units.

A. 1. The theory of the electrolytic condenser is as follows:

When an electrolytic cell consisting of an aluminum and a lead plate and a suitable electrolyte is connected to a direct-current line, with the aluminum plate as the positive terminal, a uniform film, without pinholes, is formed over the entire surface of the aluminum plate. This film is a very good insulator and reduces the direct current almost to zero. In this case, there is no leakage current caused by sparking, as happens when the cell is used for rectifying purposes. The small leakage current at the point where the aluminum electrode leaves the solution can be reduced to an almost negligible amount by carefully insulating the aluminum plate where it enters the liquid. A cell of this type forms a very good high-capacity condenser, with the gaseous film acting as the dielectric.

This condenser is limited to a certain voltage at which the film breaks down, allowing current to flow again until a new film is formed. Because of this fact, the electrolytic condenser is not injured by breakdown, since it takes only a short time to form a new film. Various electrolytes have different critical voltages, and for high-voltage work some are more suitable than others. The critical voltages of some of the common electrolytes are as follows:

Sodium sulphate, 40; potassium permanganate, 112; ammonium chromate, 122; potassium cyanide, 25; ammonium bicarbonate, 425; sodium silicate, 445; ammonium phosphate, 460; ammonium citrate, 470; sodium biborate ("borax"), 480.

The critical voltage is approximately correct when aluminum plates and the electrolyte formed by a 1 per cent solution of one of the respective chemicals shown above are used. The approximate capacity obtained per square inch of condenser plates depends upon the formation voltage. The graph, Fig. 194-A shows these approximate values.

The construction of a condenser which may be used for "B" power units can be accomplished as follows:

A piece of extra pure or No. 1 aluminum, about six inches wide, should be cut from 1/16-inch or ⅛-inch material. The length of this aluminum sheet depends upon the capacity of the condenser and the size of the container. It should be bent back and forth. A lug should be left on the end of the plate, so that a contact can be easily made to this plate. The lug should be provided with a tight-fitting rubber tube generously covered with vaseline, to prevent sparking at the point where it leaves the solution. This lug can be cut as shown in the diagram; so that it will not be necessary to waste very much material in order to get this connection.

Types of Electrolytic Condensers

By referring to Fig. 194-B you will note that there are two general types of electrolytic condensers. The first (1) is to be used with alternating-current circuits and contains two sets of plates, arranged alternately in the electrolyte. In this case, the condenser should be "formed" with alternating current so that both sets of plates will have a film over their surfaces. The other (2) is the D.C. type and contains one set of aluminum plates and a lead plate. The lead plate serves only to make an electrical contact with the electrolyte, and should always be used as the negative terminal. This is the type of condenser to be used in "B" power units and other circuits supplied with direct current. An ordinary glass battery-jar or a large mason jar can be used as a container; although if the latter is employed it may be necessary to have more than one cell in order to obtain sufficient capacity for the circuit.

When used in "B" power units, these condensers must be "formed" with voltages higher than the output voltage of the rectifier tube, so that the condenser will not break down. Because of this, the capacity obtained is not as great as that of a condenser used for low-voltage work.

To "form" the plates of the condenser, it should be placed across a suitable current supply—either D.C. or A.C., depending upon the condenser—and should be left in the circuit for about 24 hours. A forming voltage should be applied which is somewhat above the maximum voltage that is to be applied to the condenser.

When low-voltage condensers are to be made, a system such as the one shown in Fig. 194-B at (3) should be used. The potentiometer should have rather high-resistance and be capable of dissipating the heat generated through its resistance strip.

Probably the most common electrolyte used, is sodium biborate, or borax as it is commonly called. A saturated solution of this chemical should be made and a small amount of glycerine should be added.

One of the main reasons why chemical condensers and rectifiers have not become more popular is because of the sloppiness and the necessity of renewing the water in the solution. At different times experiments have been made with a number of so-called "jelly" electrolytes, including fused sodium phosphate and several other chemicals. However, these jelly rectifiers have not been successful because, as the water evaporates, the jelly falls away from the electrodes; thus stopping the action.

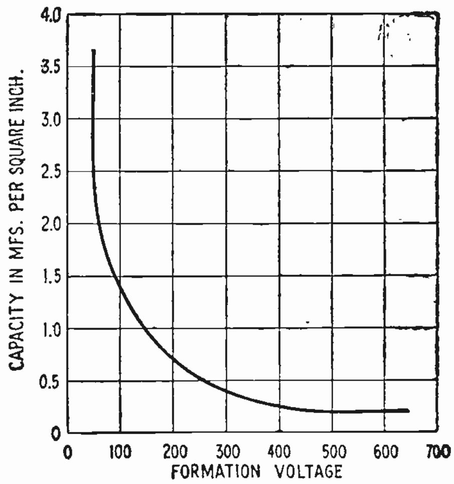


FIG. 194-A—This graph indicates the approximate capacity of an electrolytic condenser, the size of whose plates and formation-voltage are known.

R.C.A. Cone

(195) J. Constantine Vecchio, Rockville, Center, L. I., asks:

Q. 1. Can you tell me the thickness of the parchment diaphragm used in the R.C.A. loud speaker?

A. 1. The diaphragm parchment is about 7 mils thick. The first diaphragms however, were made of a good quality of wrapping paper.

The Uses of Choke Coils

(195-A) Mr. E. A. Johnson, Marlboro, Mass., asks:

Q. 1. The manufacturers seem to be using choke coils in their receivers, at present, more frequently than was the custom a few years ago. Can you explain the reason for this, and also supply information as to where they should be connected?

A. 1. There seems to be an increasing tendency, in radio design, to separate the radio-frequency component of the plate current, in vacuum-tube circuits, from the audio-frequency and direct-current components. In the plate circuit of the ordinary vacuum tube, we have two distinct components in the current flowing; because the normal direct current from the plate to the filament, due to the emission of electrons by the latter, is varied by the application of an alternating potential difference between the grid and filament of the tube. It is often found that beneficial results are obtained if the two components are kept distinct in R.F., as well as in A.F. circuits, and there is therefore an increase in the endeavor to separate them.

The usual method adopted to achieve this result in radio-frequency circuits is to connect a radio-frequency choke coil and a condenser in the plate circuit; so that the R.F. component of the current will be forced to go through the condenser circuit. The choke is designed to offer *a very high impedance to any radio-frequency variation of current,* but a resistance to direct current so low that it does not affect the "B" supply appreciably.

On the other hand, the coupling condenser forms a complete barrier to the direct component of the plate current, but offers a comparatively low-impedance path to the varying currents caused by the radio-frequency signal.

A "choke coil" is simply an inductance coil, of a value suited to the particular conditions encountered. It is well known that an inductor offers no impedance whatever to a steady direct current (neglecting, of course, the small resistance of the wire); but, if the current varies in any way, then opposing voltages are built up in the field of the coil and tend to restrict the variations of the current. In other words, an inductance coil always tends to maintain the current at a steady value. The magnitude of the choking effect in any circuit depends both upon the inductance and upon the frequency. Consequently, in order to provide a suitably high impedance, at very high frequencies, such as those used for broadcasting, comparatively little inductance is required.

In some cases a choke can be used successfully, even though it is not tuned to the exact wave of the incoming signal, when the effect is at maximum. A particular case is that of a choke coil which has a natural wavelength of about 1500 meters. This coil exercises a considerable choking effect at ordinary broadcast wavelengths although, really, in such cases it is acting like a small capacity with a resistance in parallel. The direct "B" current, of course, flows entirely through the resistance; but the radio-frequency current finds the small capacity too great a barrier and seeks alternative paths. Of course, if the capacity were very large, say as much as .0001-mf., then the choking effect would vanish altogether; but, since the self-capacity of the coil windings is comparatively small, an appreciable impedance is offered to the radio-frequency currents.

This arrangement has the advantage that it can be used over a very wide band of frequencies.

Sizes of Chokes

The only important difference between R.F. and A.F. chokes is the frequency to which they are tuned. Radio-frequency choke coils are tuned to frequencies generally between 500,000 and 1,000,000 cycles; while audio-frequency chokes are tuned to fre-

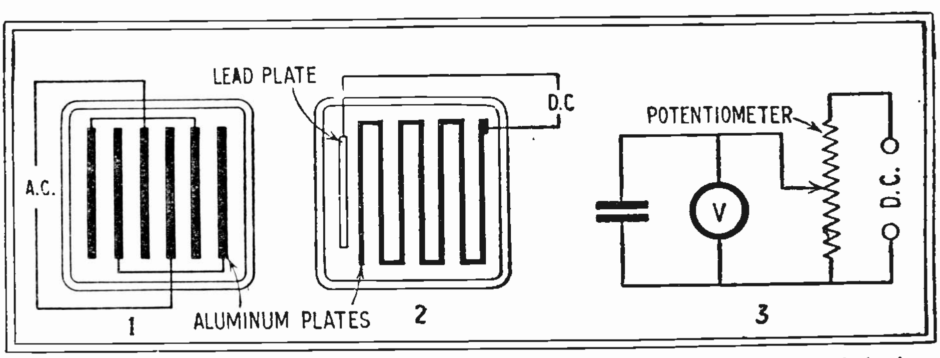


FIG. 194-B—Two types of electrolytic condensers: (1) for A.C. operation contains two sets of aluminum plates; (2) for D.C. operation has one set of aluminum plates and a small lead plate for making connection to the electrolyte. Diagram 3 shows how a low-voltage condenser can be "formed."

quencies between 100 to 5,000 cycles. An audio-frequency choke coil should offer an impedance very high at audio frequencies, but should be of a resistance sufficiently low so that direct current for the plate circuit is not unduly reduced. Since the inductive reactance of such chokes varies according to the frequency, it is a difficult matter to obtain sufficient reactance to act as a stop for the very low frequencies.

As an example, a choke, to offer a certain reactance in ohms at twenty-five cycles, would require about eight times the inductance of a choke offering the same reactance at two hundred cycles. If the low frequencies are to be held back, a very large coil is required. Audio-frequency chokes always have an iron core. They are generally formed with layer windings of enameled wire, although cotton-covered wire is more satisfactory from the standpoint of low distributed capacity. The gauge of wire employed is determined by the maximum current used. Audio-frequency chokes are made with an inductance between twenty-five and five hundred henries; the inductance depending, of course, upon the circuit in which the choke is to act. The audio-frequency current will divide, in proportions inversely related to the impedance, between two or more possible paths, the greater part of the current flowing through the path of least impedance.

Audio-Choke Coupling

In order to couple an audio-frequency amplifier so that the audio-frequency current will be forced through the condenser, the output of a preceding stage is connected to a loud speaker, or to the grid of the next tube, through a condenser of suitable capacity. The choke coil is connected in the "B" battery lead to prevent the audio-frequency currents from leaking off to the ground through this battery. The choke coil must be large enough to keep the very low-frequency signals back, as well as the higher ones, or the quality of the reproduction will be seriously impaired.

Another very important use of the choke coil is in the filter circuits of power-supply units. In this case it is used to filter out the hum of the power line. These chokes always have iron cores and are built in sizes of from ten to over one hundred henries. The wire used must, naturally, be of a size capable of standing any current which is liable to be sent through it. To prevent saturating the core in cases where large amounts of current are used, one or more air gaps are often built into the cores. The total air gap must be wide enough to avoid magnetic saturation of the core, which would prevent normal or proper action. Yet the gap must not be so wide as to reduce the inductance below the required minimum.

The operation of a choke coil may be described by an analogy which, though not entirely exact, may be useful for this purpose. The ordinary screen sifter used to separate crushed stone or gravel into sizes, may be compared in its action to a choke coil and condenser in the plate circuit of a vacuum tube. The short-wave, high-frequency impulses which pass the condenser are represented by the fine dust, sand, and water which drop through the holes in the metal screen. The large stones, which cannot fall through the openings in the sifter, may be compared to the direct current and very-low-frequency (long-wave) impulses, which are blocked by the condenser and pass through the coil from end to end.

Condenser Plate Shapes

(196) Walter Bode, High Barnes, Sunderland, England, asks:

Q. 1. Will you please tell me why variable air condensers have different shaped plates, and also, publish a drawing showing the plates which are most commonly used today.

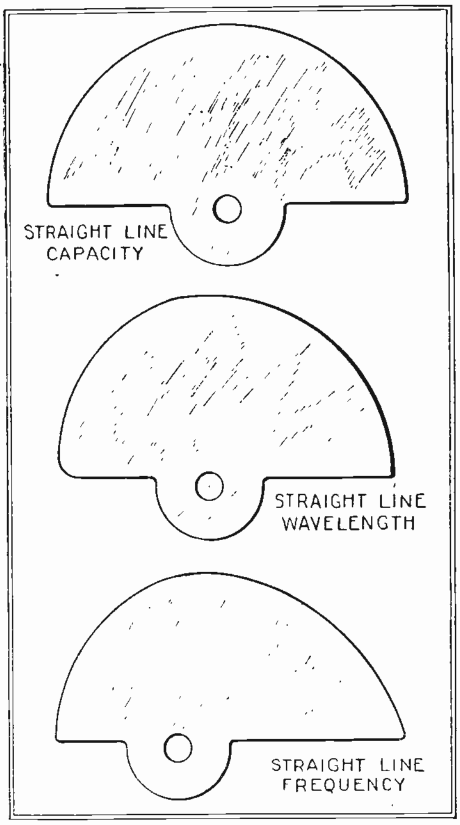


FIG. 196—The three types of condenser plates most generally used today, are illustrated in the above drawing. There are of course many modifications of these three general types but space does not permit them to be shown.

A. 1. Variable air condensers are made with three general types of plate shapes, although there are many modifications of each type. On this page you will find illustrated the three types most generally used.

The first rotary variable condensers were made with "straight line capacity" plates. These plates were semi-circular in shape and are called straight line capacity because the curve of capacity plotted against dial divisions (angle of rotation) is a straight line. The relation between capacity, wavelength, and frequency are such that this plate shape tends to result in the crowding of stations at the lower end of the capacity range. That is, there are more transmitting channels for each dial division at the lower end of the scale than the upper. This objectionable feature has led to a widespread use of other plate shapes.

The straight line capacity plates have however, one distinct advantage when used in single-control set ups. Where it is desired to tune several circuits with one control, some form of capacity adjustment is nearly always necessary to compensate for different zero capacitances in the several circuits. If semi-circular (straight line capacity) units are used, this adjustment can be made by slightly advancing one or more of the units. If this be done with condensers having other plate shapes, the capacities will become unbalanced as the control dial is advanced. This is due to the fact that if the plate shape is not "straight line capacity" the capacity variation per dial division increases as the condenser is turned toward maximum capacity, and the unit which was advanced gains capacity more rapidly than the others. This feature has caused at least one important manufacturer of uni-control receivers to return to the semi-circular plate shape.

It may be noted that the effect of "straight line wavelength" and "straight line frequency" condensers is strictly a slow motion action, having a variable reduction, gradually lessening as the condenser is advanced. The same result can be and, in fact, has been accomplished by a slow motion dial so constructed as to automatically vary its reduction ratio to give the effect of a "straight line frequency" plate when used with a "straight line capacity" condenser.

The disadvantage of the semi-circular plate shape was first realized in connection with the construction of wavemeters. This was long before there were enough broadcast stations for the problem of station separation to be serious. As the relation between capacity and wavelength is not a direct proportion, a dial calibrated in wavelengths will not have equal divisions over its scale if a semi-circular plate shape is used. This not only makes the instrument more difficult to read, particularly as to the estimation of readings which fall between divisions, but involves difficulty in calibration, as the space between two points, ten meters apart for instance, could not be divided into ten equal one-meter divisions.

A plate shape which would give equal divisions for equal wavelengths, *i.e.*, "straight line wavelengths" was highly desirable, and a condenser with such a plate shape was first used commercially in a wavemeter, introduced in 1916. When the multiplication of broadcast stations began, "the straight line wavelength" plate was introduced for condensers used in receivers, and became very popular, due to the better separation of stations resulting from its use.

Broadcast stations continued to multiply, however, until all channels in the wavelength range allotted to broadcasting were filled. The transmission channels were assigned on the basis of uniform frequency rather than uniform wavelength separation, and, as they all became occupied, the difficulty of crowding a great many more than half the stations into the lower half of the dial again rose. The obvious step was, of course, the "straight line frequency plate" shaped to give equal frequency divisions over the dial. This plate shape not only improves the distribution of stations over the dial, but is the only type of condenser which can be used in a single-control super-heterodyne, where there is a constant difference of frequency between the two circuits being tuned.

Electrolytic Condensers

(197) J. C. Stone, Butte, Montana, asks:

Q. 1. Will you kindly tell me the critical voltages and formation voltages with aluminum plates in an electrolytic condenser of high capacity and also give some construction hints?

A. 1. An electrolytic condenser of high capacity can be made by immersing aluminum, magnesium or tantalum plates in some electrolyte such as a solution of sodium and ammonium sulphate, of ammonium cirate, of potassium permanganate or of various other salts. This type of condenser is well known among electrical engineers as the Mershon condenser and has been used in crude form by amateur radio operators for years. The choice of electrolytes is somewhat dependent upon the voltage at which the condenser is to be operated. The critical voltages for various electrolytes is given in the following table:

Critical Voltages

Sodium Sulphate	40 Volts
Potassium Permanganate	112 Volts
Ammonium Chromate	122 Volts
Potassium Cyanide	295 Volts

Ammonium Bicarbonate	425 Volts
Sodium Silicate	445 Volts
Ammonium Diphosphate	460 Volts
Ammonium Citrate	470 Volts

This critical voltage is the maximum at which the condenser will stand without a large leakage current. With the aluminum condenser capacity varies inversely as the voltage. This means that if the voltage is doubled the capacity is halved. A list of formation voltages is given here:

Voltage of Formation

50 Volts	14.2 MF. Per Sq. In.
100 Volts	5.1 MF. Per Sq. In.
200 Volts	2.58 MF. Per Sq. In.
400 Volts	1.29 MF. Per Sq. In.

When a strip of aluminum is immersed in a solution of ammonium phosphate an oxide film is formed. Thus we have a pair of conductors with their surface relatively close together but separated by a di-electric which has a very high resistance. In passing from a lower to a higher voltage the thickness of the gas layer increases and arrives at a new value in a few minutes. However, in going back to a lower voltage, it takes many months before the thickness of the layer reduces to its first value. Thus the capacity is not the same with reversed currents. To have equal capacities both ways, both of the condenser plates must have equal areas and must be formed at the same voltages. In a condenser of this type the anode (positive) is made of a very large metal surface so as to get as great a capacity as possible. As an electrolytic condenser will arc violently from exposed metal to surface of electrolyte, the anode is carefully covered with insulating material from just below the surface of the electrolyte to its terminal binding post. A layer of oil prevents evaporation. Remember that the film di-electric can be healed after a puncture, as the gas will form again.

Raytheon Battery Charger

(198) Mr. E. J. Rhodes, Baltimore, Md., asks as follows:

Q. 1. I would like to construct a full-wave charger using the new Raytheon cartridge units. Can you supply the necessary information for building a transformer and show, also, how the units should be connected?

A. 1. Any well-made transformer of about 20 watts capacity, with a low-resistance secondary having an open-circuit voltage of between 8 and 9 volts, may be used. A transformer of this type may be easily constructed at home by obtaining some .014-inch core iron; you may either have this cut to the shape shown in the illustration or do the cutting yourself. This may be done easily with a pair of tin snips. Sixty-three pieces will be required for the complete core. The coils are wound on a cardboard tube, 7/8-inch inside diameter; and the windings are made as follows:

The secondary consists of two windings, wound directly on the cardboard tube, each consisting of 53 turns of No. 14 S.C.C. wire, wound in layer fashion. The end of the first winding and the beginning of the second are connected together, making a total on the secondary of 106 turns, tapped at the center. Several layers of empire cloth are wrapped over these windings and the primary coil is then wound; this consists of 750 turns of No. 24 enameled wire, also wound in layer fashion.

The small ends of the rectifying cartridges (type "A") are connected together and constitute the positive terminal (see Fig. 198); while the steel shells of the tubes are connected to the outer taps of the secondary winding on the transformer. The center tap

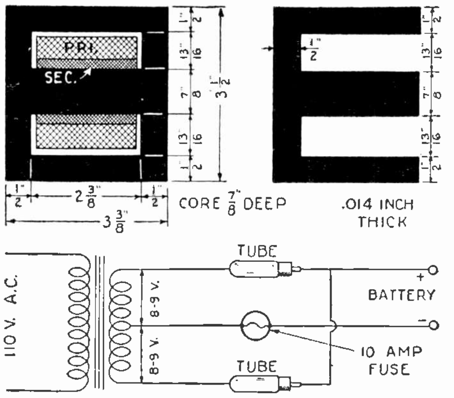


FIG. 198—The core of the transformer used with the Raytheon "A"-cartridge in a charger should be made from .014-inch material, cut to the shape shown.

of the secondary is connected to the negative terminal; in this lead a fuse of not over 10 amperes capacity must be inserted, to prevent damage should the output of the charger become short-circuited or the battery be connected incorrectly. Small automobile-type cartridge fuses are excellent for this purpose.

When the windings are completely assembled and have been bound in place with friction tape, the core pieces should be inserted. These are "staggered," by inserting, first, a piece from the left and then one from the right. When all the core pieces have been inserted, they should be fastened into place so rigidly that no vibration will occur. This may be accomplished by drilling holes in the four corners of the transformer filing down the rough edges so that the transformer core pieces will not be connected together); or else by constructing brass clamps which will fit over the ends of the core, which should be screwed down tightly.

The rectifying cartridges should be mounted, preferably, with the small end up and should be arranged in spring clips so that they may be readily renewed after their useful life is finished. These cartridges are guaranteed to give at least 750 hours of service and, under normal conditions, will give much more than that before replacement is necessary.

Interference Eliminator

(199) G. P. Graham, Ottawa, Canada, writes:

Q. 1. I am troubled by interference in my radio set which I believe arises from the small electric motor in the vacuum cleaner and other portable appliances found in the home. Will you please explain in your columns an efficient system for eliminating this interference and give data concerning the construction of the choke coil, if such is used in the filter circuit.

A. 1. Two high test condensers of about 1 mf. capacity each are connected in series across the A.C. line with the mid-point grounded. Two choke coils are then connected in series with each of the A.C. leads.

This filter arrangement will confine the radio frequency currents to the point of their origin. As in all cases where filters are used, the condensers should be placed as near as possible to the point where the noise originates. This precaution will prevent the broadcasting of interference with condenser leads acting as the antenna. The choke coil is wound on a wooden spool, finished with shellac, and consists of about 560 turns of No. 28 D.S.C. wire.

The brushes on the motors should be thoroughly cleaned, as dirt and corrosion cause the contact to become arratic, causing much sparking, and therefore interference will result. If the iron shell of the motor is grounded, this will help to eliminate the interference. However, old motor installations were frequently made on wooden supports and were thus insulated from the ground. Condensers specially made for filter purposes are now available in the radio market, as are condenser choke combinations mounted and ready to connect. It should be borne in mind when installing any of these devices that large capacity condensers contain wax, and therefore should be placed where heat generated by the motor will not affect them.

Experimental Volume Control

(200) J. Stree, Manila, P. I., writes:

Q. 1. I have been experimenting with a variable resistance in series with the loud speaker, in order to control volume. And it seems to me that not only the volume, but the tone of the loud speaker is altered in this way. Could a resistance like this alter the tone, or is it my imagination?

A. 1. The insertion of a series resistance would affect the tone of the output, and if a condenser is placed across this resistance the effect may be further altered by changing the capacity of the condenser.

In this way it is possible somewhat to emphasize either the high or the low notes, if one is prepared to experiment to find the correct values of resistance and capacity to suit the conditions of the output circuit.

Power Transformers

(201) Mr. F. P. Potter, Philadelphia, Pa., writes:

Q. 1. I would like to build a transformer for use with a Raytheon 85-milliampere rectifier tube, to supply the "B" current for my set. Will you please give me the necessary data for constructing this transformer?

A. 1. Such a transformer contains a primary winding connected to the 110-volt A.C. house line, two high-voltage secondary windings giving 250 volts for the "B" supply, and a secondary winding for the filament supply of the power tube in the last A.F. stage. The construction of such a transformer begins with the winding form. Out of fiber 1/32-inch thick, cut a piece of the dimensions shown in the illustration above and, with the aid of a block of wood 1-9/32 inches square and 2 inches long, bend the fiber as indicated by the dotted lines. Glue to the side the 5/16-inch flap, and when it is dry remove the wooden block. Two pieces of fiber 1/16-inch thick are then cut as shown, to form the end pieces of the spool. Bend up the four flaps on each end of the form and glue these outside of the end pieces.

Winding the Transformer

The primary winding is put on first and consists of 550 turns of No. 22 D.C.C. wire. At the 500th turn, a tap is taken off and the two ends of the wire and the tap are brought out through holes drilled in the spool ends.

Before putting on the next winding, place three layers of empire cloth over the primary winding. The next coil is the secondary; this consists of two coils of No. 30 enameled wire. Wind 1350 turns over the primary, bringing the leads out as before. Insulate this with three layers of empire cloth and wind 1350 turns more of the same wire. Place the beginning of this winding through the same hole as the termination of the first secondary winding; connect these two together to make the center tap. Over this winding, place three more layers of empire cloth, and then wind the filament secondary; for this use No. 16 D.C.C. wire. Wind 25 turns of this wire; it will make just one layer, if wound evenly.

If a rectifying tube of the 213 type is to be used, it will be necessary to wind another filament secondary. This also will consist of 25 turns of No. 16 D.C.C. wire, with a tap at the center. Wrap several layers of tape over this winding and the coil is finished.

The Core

The laminations of the core are cut from .014-inch transformer iron. Be sure that the iron is lacquered, at least on one side. The core pieces are of two types; one consists of rectangular pieces 3 13/16x5/8 inches. The other pieces are U-shaped, and cut to the dimensions shown in the illustration. Ninety pieces of each size will be required. These laminations can be cut with tin shears, then hammered flat; or may be cut to size by the dealer from whom they are purchased. Each piece should be filed so that no sharp points or edges are exposed.

The core laminations are then put in place in the coil form. They are staggered; one "U" piece is placed from the right, with the "I" piece at the end; and then the next "U" piece is placed from the left with the "I" piece at the right, and so on. When all the core pieces have been put into position, two brass clamps are made to hold the core firmly in place. A case for the transformer may be made from sheet brass or tin, to protect the windings.

"B" Battery Query

(202) Mr. J. Sharkey, Jersey City, N. J., writes:

Q. 1. I always make a practice of disconnecting the "B" batteries from my receiver after shutting off the set each night, and I notice that on reconnecting the leads a small spark is visible. Does this indicate that current is drawn from the batteries, even when the set is not in use?

A. 1. On the assumption that you are using by-pass condensers across some part of the "B" supply (as most sets do), we think that in all probability the spark is caused by the sudden flow of charging current into these condensers, and if so, the effect is quite normal. The charging current is so small that it is practically negligible and does not decrease the life of the battery to any extent whatsoever. There is no real need of disconnecting the "B" batteries each night, as the flow of current from them should cease as soon as the two filaments are extinguished.

Series vs Parallel Connection

(203) H. Maxine, Juneau, Alaska, asks:

Q. 1. Is there any advantage in connecting the filaments of the tubes on my receiving set in series rather than in parallel?

A. 1. A strange illusion persists that the mere connecting of vacuum tube filaments in series instead of the usual connection in parallel has some effect upon the working of the tubes. There is no truth in it. The sole idea of the filament in a tube is to provide a hot metal body which will emit electrons. It makes no difference whatever in the tube action whether the metal is heated by passing a current through it, building a fire under it or hitting it with a hammer, so long as the same temperature is reached.

The difference that is made by the series connection of filaments instead of parallel connection is not a difference in tube action but a difference in the requirements of the circuit hook-up. The grid return of each tube determines the grid bias of that tube. With series connection of filaments, if all the grid returns are made to one point, say minus lead of the supply, no two tubes will have the same grid bias. There is a drop in voltage in each filament and each tube will have a gradually decreasing negative bias. If each grid return is to its own negative filament each grid will have no bias relative to its own filament, but there will be an existing potential between the two grids. This of itself does no harm. The reason for parallel connection lies in the standard fixed voltage of the storage battery and the varying numbers of tubes in different sets, all of which are made for the same battery voltage.

Low-Loss Winding

(204) Stanley Tucker, Brooklyn, N. Y., asks:

Q. 1. What, in your opinion, is the most effective type of low-loss winding, particularly for short-wave inductance coils?

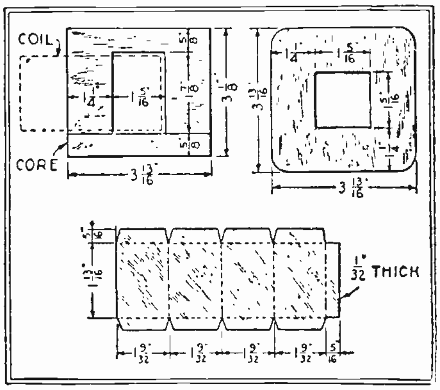


FIG. 201—The layout for the transformer spool is shown below; bend the fiber on the dotted lines. Above: right, end-pieces of spool; left, how the iron core is fitted into the windings.

A. 1. Undoubtedly a spaced solenoid type of winding holds the honors for this type of work. A comparatively large wire, about No. 14 or No. 16, should be used and the space between turns should be at least equal to the thickness of the wire. This type of winding is far superior to any of the so-called basket-weave or spider-web types, particularly for short-wave work. Its disadvantage on the broadcast waves is its bulk.

Dry Rectifiers

(205) Mr. R. R. Russell, Syracuse, New York, writes:

Q. 1. I would like to obtain some information about dry rectifiers of the cupric-oxide type. What chemicals and electrodes are used in this rectifier, and what pressures are employed to hold the various plates together?

A. 1. The operation of dry rectifiers of this type is based on the fact that when (relatively) highly electropositive and electronegative bodies are brought together and an alternating current passed through them, there is formed at the junction a "rectifying" film, which permits the passage of current in one direction much more freely than in the opposite direction. In order to maintain a continuous film, the electrodes are held tightly together, with a relatively high pressure, by a suitable clamp or other means. In each unit (cell) of the ordinary type of commercial rectifier two plates are used; one of magnesium and the other of *cupric sulphide* (a compound of sulphur and copper), united by a pressure of about 200 pounds per square inch. With this combination of cupric sulphide and magnesium, held under sufficient pressure, and an alternating current of proper value applied across the two plates, the rectifying film is formed almost immediately and is maintained indefinitely.

If the rectifiers are temporarily overloaded, the rectifying film is broken down. However, as soon as the excess current is removed, there is a chemical reaction which produces a new film almost immediately. With a rectifier of this type, comparative resistances of about 75 to 1 will be found when currents are sent through the rectifier from opposite directions. In other words, a rectifier having a resistance of half an ohm to currents in one direction will have a resistance of 37.5 ohms in the opposite direction.

In Fig. 205 will be found the relative positions of the parts used in a single cell of one of these dry rectifiers. It consists of a bolt, an insulating tube, a disc of cupric sulphide, one of magnesium and two radiating discs; the last named are used to separate the various cells and to conduct away excess heat. In actual practice, a number of these individual cells are connected in series to compose a rectifier, so that higher voltages may be employed. It is usually considered that a voltage of about 4 is correct for each cell; although voltages up to about 4¾ may be used without injuring the rectifier.

Commercial Devices

A number of these rectifiers have been placed on the market in both half- and full-wave arrangements. In the half-wave rectifiers, a number of rectifying cells are connected in series; the number of cells depending upon the voltage at which the rectifier is to operate. The full-wave rectifiers are so arranged that a full-wave rectifying action is obtained with a half-wave transformer; in other words, a transformer with a single secondary winding is used for full-wave rectification. This is accomplished by using a bridge circuit in which two of the rectifiers are operating on each half-cycle, while the other two operate on the other half. While two of the sections are in operation, the other two, which are connected in the opposite direction, have naturally 75 times the resistance of the rectifier

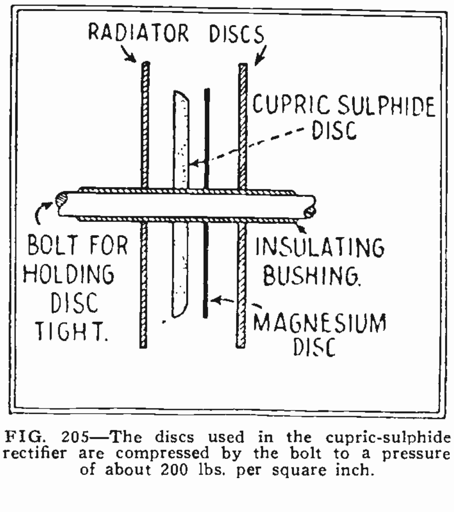


FIG. 205—The discs used in the cupric-sulphide rectifier are compressed by the bolt to a pressure of about 200 lbs. per square inch.

elements in operation. This system is particularly advantageous in "A" power units, since it is much easier to filter the output of a full-wave rectifier than one of the half-wave type.

The sulphide rectifier, under normal conditions, is operated at a temperature of about 90 degrees centigrate (194° Fahrenheit) and will operate at temperatures up to 150° C. (302° F.) for short periods without any injurious effects.

In designing apparatus to be used with these rectifiers, sufficient ventilation should be provided to maintain a temperature of about 90 degrees under normal load conditions. The life of the rectifier depends to a great extent on the current which is passed through it. For battery chargers and other apparatus not operated constantly, the life is much greater than when it is used for "A" power units and other apparatus requiring a steady output. A life of about 1500 hours can usually be expected from the latter type of apparatus when the rectifier is not overloaded.

Necessity of "B" Battery Switch

(206) Mr. R. Linden, Buffalo, New York, asks:

Q. 1. Why is it not necessary to have a switch in the "B" battery circuit to disconnect this battery when the set is not in operation? Most people are very careful to turn the "A" battery switch off when they are not using their receivers, but very few bother to disconnect the "B" batteries. What is the reason for this?

A. 1. The reason why this switch is not necessary is shown in Fig. 206. By referring to this diagram you will see that when the filament is not connected to the "A" battery, *no electrons are flowing between the filament and the plate.* Since the "B" battery circuit is completed through this electron-flow in the tube. "B" battery current can only flow when the filament is hot. It may be true that a very large amount of current passes through the circuit, due to leaks in the tube base, etc.; but for that matter, there are leakage currents through the battery cells themselves, even with the "B" battery entirely disconnected from the receiver. However, these leakage currents are extremely small and are not worth mentioning.

A.C. Receiver Data

(207) Mr. C. Lund of Seattle, Wash., writes:

Q. 1. I have several questions which I would like to have answered.

Kindly explain why the A.C. sets do not require rheostats in the filament circuits, to facilitate receiving close and distant stations?

A. 1. The reason why rheostats are not commonly used in alternating-current receivers is because the filaments in these tubes are not sensitive to slight changes in temperature. In other words, the electronic emission of the filament remains about the same although the filament temperature is not constant. In the heated-cathode tubes, this is due to the fact that the electrons are emitted by a small cylinder which is indirectly heated by the filament. Naturally, when the cylinder becomes hot, a slight change in the temperature of the filament will not immediately change the temperature of the cylinder. In the direct-filament A.C. tubes, a very low voltage and a high current are employed on the filament. This also tends to keep a steady emission, even though the filament voltage is changed.

However, the life of alternating-current tubes is reduced to a considerable extent when the filament voltage is increased over the rated value. For this reason, it is desirable to place a rheostat in each filament circuit so that the applied voltage can be controlled even though the line voltage changes. In this way, by operating the filaments of the tubes at a value slightly lower than that specified, the life of the tubes will be increased and the operation will not be affected.

Q. 2. Which filament circuit in an A.C. set is best to make connections with a pilot or dial light?

A. 2. The pilot light employed in an A.C. set can be connected to any of the filament circuits with equal results. However, since the bulbs supplied with these lights are usually designed for a five-volt supply, it is usually advisable to connect the dial light to the power tube; since this tube is usually operated from a five-volt filament supply. Of course, it is an easy matter to change the bulb to one which will operate from the lower voltages usually supplied to A.C. tubes; so that no difficulty will be encountered in this matter.

What Is Detection?

(208) Mr. R. J. Wentworth, of St. Louis, Mo., writes:

Q. 1. Will you explain how crystals and vacuum tubes operate, when used for "detecting" radio signals?

A. 1. The crystal detector, which was very popular several years ago, and is still used in a very large number, if not a majority, of the radio receivers outside of the United States, has the peculiar property of offering a higher resistance to electric currents passing through it one way than it does to those passing in the opposite direction.

The radio-frequency alternating current, which we call the *signal,* comes from the aerial (or possibly through an R.F. amplifier) and tries to pass through the crystal, first in one direction, and then in the other; but its flow is practically confined to one way, because of the increased resistance offered to the current whenever it is reversed. Thus, only one-half of the incoming current passes through the headphones in the simple crystal-detector circuit shown by the diagram in Fig. 208-A at (1).

When we use the well-known three-element vacuum tube as a detector, we have our choice of two methods of detecting or "rectifying" radio signals; they are called *"plate rectification"* and *"grid rectification."* While the first is more easy to explain diagrammatically, the second is more commonly used. In addition to its detecting effect, the tube introduces also the action of "amplification." A rather simple analogy may serve to convey the idea, though not with complete details, in a form easier to comprehend.

We may compare the radio signal to waves caused by agitating water; these will travel a considerable distance, and by this means we might, for instance, send a message. Disregarding the complexities which are presented by the very intricate sounds of music and speech, let us concentrate on the idea of sending a succession of impulses, in the form of waves, which are comparable to the dots-and-dashes which

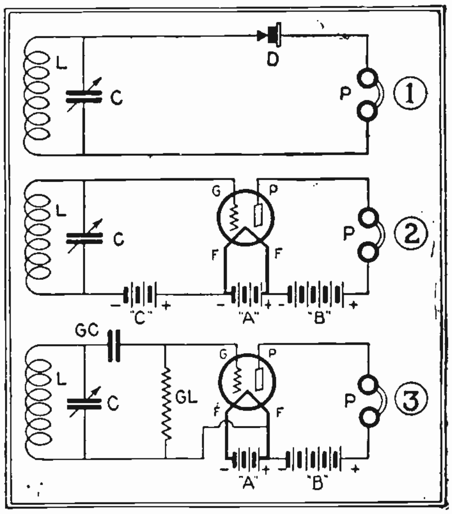


FIG. 208-A—Three radio circuits using common detection methods: 1, crystal; 2, plate-current or "bottom-bend" rectification, with negative grid bias; 3, grid rectification with positive bias regulated by grid leak and condenser.

puzzle, and occasionally annoy, the ordinary radio fan.

A Hydraulic Comparison

If we dip out and pour back a bucketful or so at more or less regular intervals from and into the body of water which is to be our medium of communication, we will set up waves; that is to say, we cause the water to rise and fall in rapid succession, for a considerable distance from our scene of operation. This is not a forward motion of the water, for the bucketful we pour in stays near us for a considerable length of time; it is a backward-and-forward, up-and-down motion, corresponding somewhat to that curve representing "voltage" changes that we picture when we talk of a "radio wave." We can put a small float on the surface of the water, at the point where we wish to receive the message carried on these waves; or let us make a little dam with its top at the exact water level, as shown in Fig. 208-B at (1) and (2). When the "trough" of a wave comes along, no water will spill over; but when the "crest" arrives, it will break over the top of our little dam. This action we may compare to that of our crystal detector, which responds to the radio wave by passing only the half of it which is "above the line"; that is, the impulse in one direction only.

But we desire to get something more than the very feeble little wave which we thus receive; we want to put in motion in one channel a much larger amount of water. Here is where the "amplifying" action comes in. A radio tube is truly a "valve," as they call it in Europe; a small voltage applied to its grid, under certain conditions, *turns on and off the current from the "B" battery,* which is much greater in its electrical effect.

To illustrate the action of a tube, we have what is known as its "characteristic curve." Without explaining too technically the action it represents this curve indicates

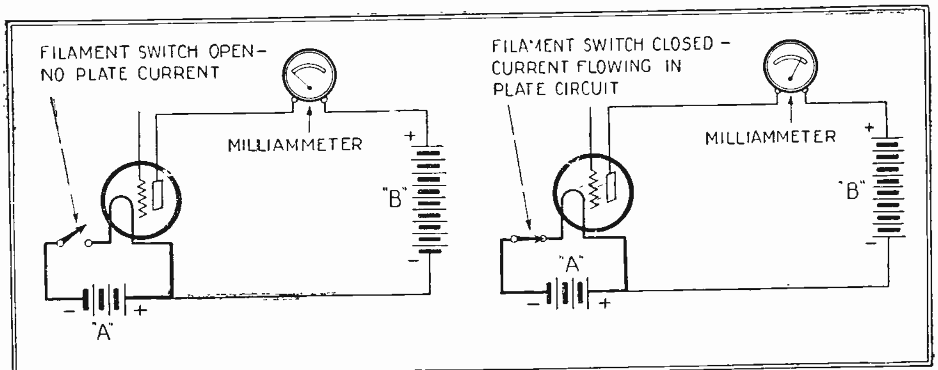


FIG. 206—The illustrations above show why it is unnecessary to use a "B" battery switch. As you will see, the plate circuit (which carries the "B" battery current) is incomplete until the filament is heated by the "A" battery, which sends out electrons which provide a path for the current.

the amount of "plate current" which the tube passes, for any given amount of voltage difference between its filament and the grid and with a fixed value of plate voltage. The plate current is proportioned to the *height* of any given point on the curve just above the point on the scale indicating the corresponding grid voltage. At the bottom we have shown the effect of a typical "train" of radio waves on the grid voltage, and in the horizontal curve the corresponding "wave" in the plate circuit of current which can be used to actuate the diaphragm of a telephone (See Fig. 208-C).

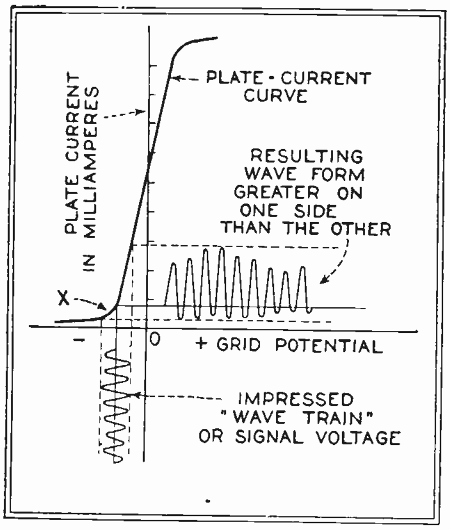


FIG. 208-C—The "characteristic curve" of a vacuum tube is a diagram of the amplification it gives, and every student of radio should be familiar with the idea represented. The "signal" in every tube comes in as voltage on the grid; it goes out as current through the plate circuit. A "characteristic curve," drawn for a given tube, at a given plate voltage, shows what response may be expected from it for any given grid bias.

Returning to our water analogy, the simple rectifier, such as the crystal, cannot put into the telephone any more energy than it receives—less in fact, as current is used up in overcoming its resistance. Just so our little dam in Fig. 208-B (2) must surround a depression kept lower than the water level, so that the incoming wave can spill into it.

The Hydraulic Amplifier

But we can use the rise and fall of a float on the waves to operate a gate and control the flow of water from a higher level to a lower, as in Fig. 208-B (3). Above our float we have an aqueduct containing a "weir," or water outlet, and a "sluice gate" regulating the flow of water. This gate, when it is perfectly level, permits a very slight amount of water to escape. It is pivoted far over to one side, so that tilting it one way permits a great deal of water to escape; while tilting it the other way practically cuts off the flow. We connect one end of this sluice to our little float.

When the float rises, as pictured at (4), a great deal of water escapes; when it falls (5), the flow is practically cut off. The result is that, as the waves come in and lift our float, they increase and decrease the flow of water, at a much higher level and to a much greater amount; but that flow is steady and in one direction, not the backward-and-forward motion of waves. This is also the difference between the radio wave and the direct-current impulse which operates our telephone diaphragm.

Plate Current Rectification

Returning to the electrical action, Fig. 208-C shows the *plate-rectification* effect which corresponds to the apparatus we have just described. It depends on the "bend" which we see at the bottom of the "characteristic curve" of our tube, and which corresponds to a limiting range of negative grid voltages, varying with the type of tube. In order to keep the grid at this negative voltage, compared with the filament, it is necessary to use a "C" battery or voltage-supply source with its positive terminal connected to the "A—": for the "A—" voltage alone is not far enough below that of all points on the filament. Such a "C" battery is usually composed of several dry cells in series; or the "voltage drop" between the ends of a resistor in a power unit may be used for the purpose. (Fig. 208-A at 2.)

At the bottom of the diagram, below the bend in the characteristic curve, we have pointed out the "voltage wave form" of the incoming radio wave. If we draw a line directly upward from any point on this curve, representing the *voltage on the grid at that instant* (the grid negative voltage or bias," *plus or minus* the voltage of the received signal, according as the incoming wave is at a positive or a negative stage) until it meets the characteristic curve, and then extend another line horizontally to the upright scale marked "plate current," we will get *the value of the current flowing between filament and plate at that instant.* If, for each value of the grid voltage, we find the corresponding value of the plate current, we can draw *the resulting wave form of the plate current—which is all direct current.* It will be seen that there is present some "distortion" of the wave form; that is, the variations in current are greater in one direction than in the other, when compared with the variations in voltage. In the diagram this result has been exaggerated to make it evident.

It is plain that we have in this case, not a true rectifying action, as with the crystal—but a relay or *amplifying* action. It will also be noticed that, with this method, no current flows in the grid circuit—unless the grid is allowed to become positive—and there is no drain on the "C" battery.

This is in contrast to the other method of detection, which is that used in most radio receivers, and which we will now describe.

Grid Rectification

When we refer again to Fig. 208-A, at (3), we find that the grid return has been changed from the "A—" to the "A+" filament lead, and that, in place of the "C" battery, we have a "grid leak" and a "grid condenser" in the grid-filament circuit. This places on the grid a positive bias of half the value of the voltage across the filament (when the grid is compared with the middle point of the filament); this is usually sufficient, without requiring an external application of positive voltage.

The action when this method is used is as follows: the incoming signal voltage tends to send a current through the circuit, from the grid to the filament, and back again. But this current can flow in only one way, *from the grid to the filament;* because of that property of the vacuum tube which permits electrons to travel only from a hot element (the filament) to a cold one (the grid or the plate). This current flow builds up an electric charge on the grid condenser, and causes the voltage on the plate of the condenser which is nearest the grid to become negative, as well as the grid itself.

Whenever the radio wave reverses, it merely stops the flow of electrons; for the space between the filament and the grid will pass a current in only one way. Thus the flow from the filament keeps increasing the negative charges on the grid until they oppose the incoming signal voltage and overcome it. The grid leak then allows the charge to leak off through the grid return to the filament. This cycle is repeated with each train of waves, the grid being in the same condition at the end as at the beginning. The resistance of the grid leak must be of a suitable value, to secure smooth operation, however.

This variation of the voltage on the grid, caused by the incoming signal, will also produce a variation in the plate current; as the grid becomes more negative, it decreases the flow of current from the "B" battery or power unit; and, as it becomes positive again, the flow of plate current becomes normal.

It will be, perhaps, more difficult to explain the difference between these two methods of tube detection by our hydraulic-gate analogy, to the satisfaction of our readers. They would correspond most closely to a readjustment of our wave-operated float, and of the point of pivoting in the sluice-gate which it opens and closes. In one method, we may say, the *rise* of the float closes the opening; in the other, the *fall* of the float closes the gate. Also, let us suppose that, to correspond with the grid-rectification process, the float is in a compartment into which successive waves spill, each raising the float a little more, until

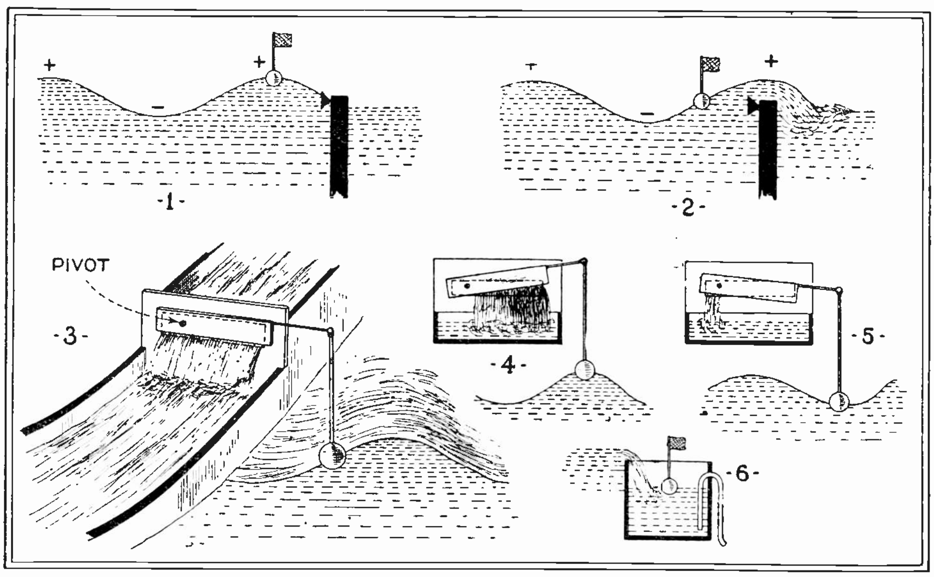


FIG. 208-B—Above is a comparison of radio detection with that of water waves. In 1 and 2 we have simple "half-wave" rectification; only the top half of the wave spills over the dam. In 3, 4 and 5, the float represents the tube grid, and the water in the aqueduct the plate current. In 6 the tank represents the grid condenser; it discharges through the "siphon" (the grid "leak") when the pressure becomes high enough.

the water rises above an overflow level and discharges through a *siphon* (6).

In comparing this system to radio waves, we must suppose that these waves are created in series or "trains" by the millions, in regular succession with varying intervals and heights; and it is our desire to gauge, not the height of single waves, but the respective rapidity of the changes which are made in the rate of their production and the height of their crests. This corresponds to "modulation" in radio; and the reverse process is "detection."

There are several differences between these two types of tube rectification. Plate rectification does not consume any grid current, normally; but with grid rectification there is a flow of current (drawn from the "A" battery) in the grid circuit. Another difference is that the plate-current method produces the sounds in the phones by an *increase* in the plate current; the grid-current method by a *decrease* in the plate current. The latter actually rectifies the incoming signal in the *grid* circuit, because the changing bias on the grid allows the grid current to flow in only one direction; the former rectifies the current in the *plate* circuit, because it is possible for it to flow there in one way only.

The sum of the current changes, with either method of detection, over a period of thousands of cycles of the radio wave, will be found to correspond very closely to the electrical modification caused at the microphone of the broadcast station by the sounds of speech or music which were being broadcast. For this reason, the phones or loud speaker in the output of a detector circuit will reproduce these sounds very closely.

Electrolytic Rectifiers

Q. 2. I would like to obtain some information about electrolytic rectifiers and the solutions used in them. What is the best electrolyte, and what are the comparative advantages of ammonium phosphate and ammonium borate over the usual borax used in aluminum-lead-type rectifiers?

A. 2. In the usual home-constructed rectifiers, a saturated solution of commercial borax ("sodium biborate") is employed. This electrolyte is suitable in most cases; but if the borax is not entirely pure, considerable trouble may be encountered. Ammonium phosphate or ammonium borate dissolved in distilled water is much more suitable. The former is prepared by dissolving as much "primary" or acid ammonium phosphate as the water will take up, thus making a saturated solution. Crystals should be added until they fall to the bottom, and then the liquid should be filtered off and used. A similar procedure may be followed with the borate; care should be taken to procure a chemically-pure "salt."

The ammonium-phosphate electrolyte may be allowed to stand idle for a long period of time without injury. The ammonium-borate electrolyte, during an idle period, will increase its internal resistance, which causes the voltage to drop off considerably. In some cases, it is necessary even to scrape the electrodes to make the rectifier function. The ammonium-borate solution reacts upon the lead plate; thus forming "lead peroxide," which gradually falls to the bottom of the container. No such trouble is encountered with ammonium phosphate. The aluminum electrode should be of the purest metal obtainable; since any slight impurity will cause a "local action" which will ruin the rectifier. It is advisable to place a rubber tube over the aluminum plate at the point where it leaves the solution, so that oxidization cannot take place at this point.

There is still another type of electrolytic rectifier which is very efficient. This consists of a tantalum plate and a lead plate in a solution of sulphuric acid and distilled water; this solution should have approximately the same specific gravity as that used in storage batteries. The advantage of this type of rectifier is that the tantalum does not corrode as quickly as the aluminum, and naturally the electrodes last longer. Another advantage is that this type of electrolytic rectifier does not heat up as quickly as the other.

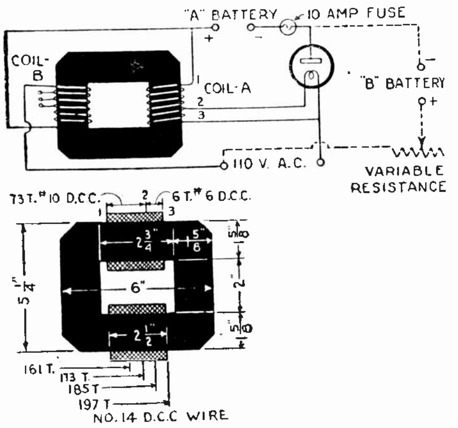


FIG. 209—A tungar charger which uses the five-ampere tube can be made with spare parts from the junk box of most amateurs.

Five-Ampere Charger

(209) Mr. R. D. Leady, Syracuse, N. Y., writes:

Q. 1. I would like to construct a battery charger using a tungar five-ampere bulb. Can you publish the necessary information for building a charger of this type, including the details for making the transformer?

A. 1. The operation of the tungar or other thermionic rectifier is fairly simple. It is well known that a heated filament in a vacuum will emit electrons which under a stress of potential, will flow in the direction of the applied positive voltage. In other words, if the hot filament be made the "cathode" and the cold plate the corresponding "anode," a stream of electrons will flow from the cathode to the anode. However, no current will flow in the reverse direction, from plate to filament. This effect is utilized in the type of charger which is described here.

To construct the core, 230 pieces of .014-inch core iron will be required. These pieces should be cut "L" shaped, 4⅜ inches long, 5¼ inches wide and 1⅝ inches deep (See Fig. 209). The coils are wound on cardboard or fiber forms 1⅝ inches square and 2½ inches long. Coil A consists of 73 turns of No. 10 D.C.C. wire. To place the wire on the form, it will be necessary to insert a wooden block in the fiber form because of the large size of wire used. When the 73 turns have been wound, the coil should be tapped and 6 additional turns of No. 6 wire wound over the others. The wooden block should then be removed and the coil fastened securely. The end of the first coil and the beginning of the second are then connected together and the three wires brought out from the coil.

The other winding consists of 197 turns of No. 14 D.C.C. wire wound on a fiber tube similar to the one used in the first coil. This coil is tapped at the 161st turn, the 173rd turn and the 185th turn. It should be tapped in like manner to the other one.

The next point in constructing the transformer is the assembly of the core. This is done in staggered fashion. Insert the short legs of two of the pieces into the coil forms and make the edges of the two meet. Two more pieces are then inserted from the opposite side, so that the completed core is bonded. When all of the core pieces have been inserted, a clamp should be constructed, so that the core cannot vibrate. This should be made of strip brass bent to the shape of the core and arranged with screw holes so that it can be clamped tightly in place.

The other apparatus necessary to complete the charger comprises a 5-ampere tungar bulb, one "jumbo" and one standard lamp socket and a 10-ampere fuse. This apparatus should be connected as shown in the diagram. The charger is then ready for operation. If it is desired to use it for charging "B" batteries, a 50-ohm resistor, capable of dissipating at least ½-ampere, is connected as shown in the dotted lines. A storage "B" battery of 50 volts can be charged in this way.

Operation

The complete charger can be installed in a metal container if desired. If this is done, care should be taken to insulate all the apparatus from the container so that no short circuits can occur. The variable resistor and the switches can be mounted on one of the sides of the can, if desired, so that they can be easily varied. When the charger has been assembled and connected to the battery for charging, inspection should be made of the initial performance. If possible, the charging rate should be measured, if only with a Ford-dash ammeter or similar device. When charging a 6-volt battery, the charging rate should be 5 amperes; on a 12-volt battery the rate will be about 2½ amperes.

If the charger delivers less current than the above amounts, and still gives more current than zero, the taps on the coils B should be varied until the correct one is found. In case the charger fails to work at all, look first for broken or loose connections. Then try reversing the battery connections to see if charging ensues. Occasionally it will be necessary to add a small amount of wire to the filament winding, in order to obtain satisfactory starting of the tungar arc; but this should be necessary only if the transformer has been assembled or wound carelessly. The extra turns are necessary to offset the excess leakage-flux from the transformer core.

When the charger has been adjusted so that it appears to charge at the proper rate, it should be left charging for two hours, under inspection, before it is pronounced satisfactory. During the inspection period, tests should be made of the temperatures of the core and coil. They will normally run at such a temperature that the hand can just be held upon the hot parts without burning. If any of the parts becomes any hotter than this, look for short-circuited turns, low-quality steel, or careless assembly of the core. Any of these three faults will be sufficient to warrant rebuilding the transformer.

250 Power Amplifier Data

(210) Mr. J. A. Keller, San Diego, Calif., writes:

Q. 1. If possible I would appreciate your publishing the diagram and constants for making a power amplifier using the new 250-type power tube and a "B" power unit with a half-wave rectifier using the 281-type tube. I would like to have the output circuit arranged with resistors to supply variable taps for a five-tube receiver. I intend to use a half-wave transformer with a secondary voltage of about 600 for the plate supply and two filament windings of 7½ volts each. I would like also to obtain "C" bias for the 250 tube from the power unit so that no extra "C" battery will have to be used.

A. 1. You will find in Fig. 210 the diagram of a power unit of the type that you require, employing one 281-type rectifying tube and one 250-type as a power amplifier. The transformer supplying current to this rectifier should have an output rating of about 200 watts and the output leads should be very carefully insulated to prevent any danger due to short circuits. The two choke coils L1 and L2 should have an inductance of about 15 henries each and be provided with an air gap, because of the high current which is passed through them.

The filter condensers C1, C2 and C3 should have a working voltage of at least 800 or 1,000 volts D.C. C1 and C3 should have a capacity of 4 mf. each, and C2 a capacity of 2 mf. The output resistor R1 should have a total resistance of 30,000 ohms and be capable of passing at least 125 milliamperes without overheating. A wire-wound resistor with sliding contacts will probably be the most satisfactory. The center-tapped resistor R2 is used to obtain the center point of the filament circuit of the rectifier. This resistor should be wire-wound and have a total resistance of about 40 ohms. The resistor R2 should have a similar resistance value, and be provided with a variable-tap arrangement, so that the point can be found at which the least hum is noticed in the speaker when the amplifier is in operation. The 2,500-ohm resistor, R4, shunted by the 1-mf. fixed condenser C9, is used to provide the bias for the 250-type power tube. Condensers C4, C5 and C6 have a value each of 1 mf., and should be designed for a working voltage of at least 200 volts D.C., so that there will be no danger of a short circuit. The audio transformer should have a low ratio, about 2 or 3 to 1.

The output filter arrangement consists of the heavy-duty choke coil L3 and the condensers C7 and C8, which have a capacity of 2 mf. each. The choke coil should be similar in construction to the choke coils employed in the filter circuit; it too should have an inductance of about 15 henries and should have a D.C. resistance of about 250 ohms.

In constructing the power unit, straight point-to-point wiring should be employed; well-insulated, flexible, rubber-covered wire should be employed for this purpose. The apparatus should be laid out in approximately the positions shown in the schematic diagram, so that the wiring will be as short as possible. When making any adjustments on this power unit and amplifier it is necessary to turn off the electric-light current, since the high voltage produced by this unit is rather dangerous. In connecting the power amplifier to the receiver, the two terminals "P" and "B+" on the transformer T2 should be connected to the plate of the first audio-frequency amplifier tube in the receiver, and to the corresponding "B+" voltage of the power unit, respectively.

It is advisable to place two 3-ampere fuses in the primary leads of the power transformer; so that the 110-volt current will be turned off automatically if a condenser breaks down or a short circuit occurs in the power unit. In first operating the power amplifier, the resistor R3 should be adjusted so that the A.C. hum is at a minimum and a D.C. milliammeter should be placed in series with the plate lead of the amplifier tube. This meter should have a range of about 0-100 milliamperes.

The amplifier should then be connected to the receiver and a signal should be received. If the milliammeter shows a very wide fluctuation when the signal is being received, the resistor R4 should be adjusted. It will be found that there is a point on the resistor R4 at which the plate current fluctuates to the minimum extent; this is the correct operating point and the tube is correctly biased. The variable output terminals for the "B" supply in the receiver should then be adjusted until the correct voltage is obtained on each of the tubes in the set.

Transformer Losses

(211) W. S. Preston, Red Creek, N. Y., writes:

Q. 1. What is meant by the hysteresis loss in an audio frequency transformer?

A. 1. Hysteresis losses occur in the iron core of an audio frequency transformer. That is due to the fact that iron, although readily magnetized, has a tendency to retain its magnetism. When the current through the primary of the transformer rises or flows in one direction, the core is correspondingly magnetized; and when the current in the primary is reversed, the direction of flux through the core is reversed also. But, owing to the slight tendency of the iron's magnetism to "remain behind," a certain amount of the energy of the alternating current is expended in overcoming this lagging magnetic effect. This wastage of energy is the hysteresis loss, and although it is of some importance in transformers used for transmitting, it is negligible in the audio frequency transformer as used for reception.

Calculating Antenna Wavelength

(212) E. G. Bigwell, Cheswick, Pa., writes:

Q. 1. Will you give me a method whereby I may calculate the wavelength of my antenna?

A. 1. There is a definite relation between the total length of the antenna system and the natural period or wavelength for which the system is best adapted. In this calculation the length of the antenna, the lead-in wire (including any extensions of the lead-in wire used as antenna), and the ground wire are effective parts of the system. The wavelength or natural period of the antenna system may be calculated in meters by the following approximate rule: Add together the length in feet of the antenna, the lead-in, and the ground wire, then multiply the total length of all three by 1.5. For example, if the antenna is 100 feet long, lead-in 30 feet, and ground wire 20 feet, the total length is 150 feet. Multiplying the 150 by 1.5, the result is 225, the natural period or wavelength of antenna system in meters.

Abox Filter

(213) John Hannigan, Painted Post, New York, writes:

Q. 1. I recently purchased an Abox filter from a friend, and as he lost the diagram that came with it, I am unable to connect it properly. Will you please describe the correct method for using this filter with D.C. current?

A. 1. Connect three ordinary lamp sockets in parallel and then connect the bank in series with one side of your direct current supply and between the line and the Abox filter. By varying the rating of the lamps, receivers consuming varying amounts of current may be operated. The following table shows the rating of lamps to be used in the bank for varying amounts of current required by the receiver:

Current required in set	Rating of lamps in bank
1 ampere	140 watts
1¼ "	165 "
1½ "	190 "
1¾ "	220 "
2 "	250 "
2¼ "	275 "

Note that it will be necessary to place a ¼ to 1 mfd. fixed condenser in series between the ground connection and the set and another fixed condenser of similar capacity between the set and the antenna. A direct current charger can be used with the Abox filter to operate your radio set. However, if the current supplied by the charger is more than ¾ amperes in excess of the current required by your set, we do not recommend its use as it will run up your light bill and cause the Abox filter to require very frequent additions of distilled water. If a direct current charger is used it should be connected through the Abox filter to the set, the same as any other type of charger, and ¼ mfd. to 1 mfd. fixed condensers should be connected between ground and set, and between antenna and set as shown in the diagram.

"A" and "B" Batteries

(214) Mr. H. Richard Miller, Lititz, Pa., asks:

Q. 1. Why is it that radio sets require two different kinds of batteries, and why it is that they are called "A" and "B" batteries?

A. 1. To explain why we have "A" and "B" batteries in a receiving set, the functions of each, and why one high-voltage and one low-voltage battery is used, it is necessary to go into an explanation of the principle of the vacuum tubes as used for radio purposes. We will attempt to make this explanation as clear and non-technical as possible. For a technical and lengthly

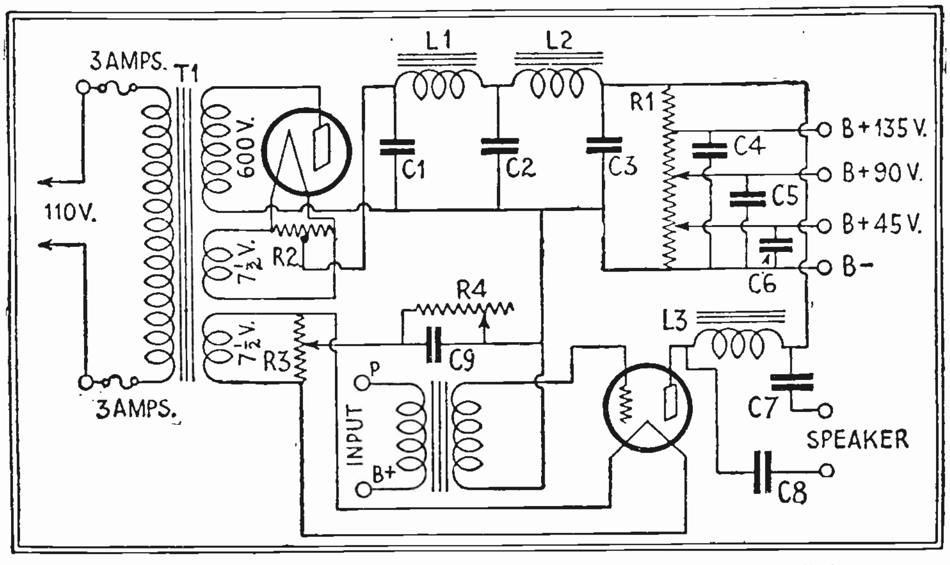


FIG. 210—A UX-250 tube, used as a power amplifier with a suitable plate supply, will improve most receivers. The plate supply can also be arranged to operate the other tubes in the set.

explanation of the evolution and functions of a vacuum tube, the reader is referred to Morecroft's "Principles of Radio," or Van Der Bijl's "Thermonic Tubes."

Through the researches of scientists, such as Thomson, Richardson and Millikan, we know that when certain metals are heated to incandescence, quanta of negative electricity are emitted, which particles are called electrons.

In 1904 Fleming (another scientist) was granted a patent on the device called a "Fleming valve," which consists of a filament-and-plate element enclosed in an evacuated glass vessel. The filament was heated to incandescence. In school, in the physics or science class, we learned that positive attracts negative, or vice versa, depending upon which has the greater strength. Fleming inserted in his device a battery of high potential. The positive side of this battery was connected to the plate within the vessel, thus making the plate highly positive, thereby enabling it to attract the electrons which were thrown off by the heated filament. This device was of little practical use as far as radio (in those days called "wireless") was concerned, until 1906 when DeForest inserted the third element called the grid," thereby making the most sensitive detector known. The current from cold plate to heated filament is due to the Edison effect, discovered by the great inventor.

Now to show how "A" and "B" batteries are concerned. The battery required to heat the filament to incandescence is called the "A" battery (probably because it is the first battery to be taken into consideration), or primary battery. The battery required to give the plates its positive potential is called the "B" battery. The filament passes in typical tubes a current of ¼ ampere, a large current compared to the plate current of the tube, (current from plate to filament).

The battery necessary to heat the filament must have a relatively high amperage capacity, and ranges from 120 ampere-hours up, its period of life depending upon the number of tubes used in the receiving set and the type of tubes. In the early days tubes were manufactured with filaments which required six volts and consumed about an ampere. At present, due to research and developments made by the General Electric engineers, we have radio tubes which operate from a dry cell or two, and consume only from .06 to .25 of an ampere.

The "plate" current of the tube is very small as we said above, but requires a relatively high potential, varying from 22½ volts for a "soft" or detector tube to 90 volts for the ordinary amplifier tube, and about 135 volts for a power-amplifier. Ordinary "B" batteries are constructed (by assembling a number of very small cells) so that their amperage capacity is very low. Their life ranges from 2 to 7 ampere-hours of total output, the voltage delivered is high because of the small cells, each of which delivers only 1½ volts, which are connected in series.

R.F. Oscillator

(215) O. Berjeau, Arlington, N. J., asks:

Q. 1. Will you publish the necessary data for the construction of an R.F. oscillator deriving power from the lighting mains?

A. 1. A diagram of a simple oscillator that takes all of its energy from the power mains is shown on this page. A unit such as this is quite useful to the home constructor in making tests on receivers. It sends out energy in much the same way as any broadcasting station, and it can be tuned to deliver this energy at any frequency between 500 and 1500 kc. (600 and 200 meters). It makes use of a 201A tube and will operate on 110 volts either A.C. or D.C. If the latter is used, the device will only function when terminal No. 2 is connected to the positive side of the line. The coils, L1 and L2 may be wound on a single piece of tubing 3½ inches long, having an outside diameter of 2¾ inches. L1 consists of 50 turns of No. 26 D.C.C. wire, and L2 spaced ¼ inch from L1, consists of 40 turns of the same size wire. Both coils are wound in the same direction.

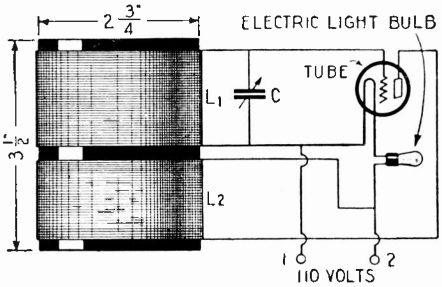


FIG. 215—The hook-up of the radio-frequency oscillator.

The condenser, C, should have a maximum capacity of .0005 mfd. Any ordinary electric light bulb of 25 watt rating is shown in the circuit. If by any chance the oscillator is to be used on a 220 volt circuit, the electric light bulb should be replaced by one suitable for use on this voltage, and should be rated at 50 watts. If this oscillator is supplied with alternating current and is placed within a few feet of the receiver, it will be possible to tune in the signal generated by it if the receiver is in good condition. The note heard will be a low pitched hum. If the unit is supplied with direct current it will not be directly audible. However, if the receiver is of the regenerative type it will be possible to produce a heterodyne whistle, when the set is oscillating.

Railroad Interference

(216) Alfred Martin, Akron, Ohio, writes:

Q. 1. Why is it that whenever a train passes within the vicinity of my home, the signals which I am receiving fade out and return after the train has gone by? I have observed that only signals coming from stations located in the same direction as the train fade out, while all other signals are practically constant in intensity.

A. 1. When a train or other large metallic object is situated between a broadcast station and a receiving set, the train absorbs a good deal of the energy which the radio set would otherwise pick up. If the train is sufficiently close to the receiving set, it may absorb so much of the radio energy, that practically none reaches the receiver. Signals coming from any other direction will not be affected to the same extent, since the receiver antennae intercepts the transmitted radio waves before they reach the train or other metallic body located in the vicinity of the set.

Resistance Feedbacks

(217) Philippe Sarrano, Westmount, Canada, asks:

Q. 1. What causes resistance feedbacks and how are they eliminated?

A. 1. Whenever two circuits come in contact at a resistance, there exists at that particular point a resistance feedback, due to resistance coupling. Connecting the plate circuits of two or more tubes to a common "B" battery, causes a coupling between these tubes which is provided by the resistance of the plate battery. If the grid returns of a number of turns are connected to the same "C" battery, a resistance coupling through the resistance of the battery will result. It will be seen therefore, that with these resistance couplings, energy from one stage or tube can be transferred to the preceding stage.

These resistance feedbacks, of course, can be eliminated by using separate batteries for each tube. This, however, is not desirable from an economic standpoint and because of the space necessary. It is, however, possible to complete each grid and plate circuit without going through the batteries. A large capacity condenser should be placed across the "B" battery, or between the tube filament and plate supply end of the coil or resistance.

The current will then flow from the plate to the coupling coil or resistance, through the condenser to the filament. Radio-frequency energy is thus kept out of the "B" supply. When each tube is provided with a by-pass condenser, the resistance coupling will be practically eliminated. The capacity may vary between .006 to .01 mf. when used with radio-frequency tubes. In detector and audio circuits, the condenser capacity recommended is 1 mf. The coupling through "C" batteries is eliminated by connecting a condenser of ½ to 1 mf. capacity between the negative filament terminal of each audio-frequency tube and the filament terminal on the audio-frequency transformer which precedes the tube. The grid terminal of the transformer connects to the grid of the tube in question. In the radio-frequency stages where the grid returns are made to the battery side of a rheostat controlling these tubes, there will be a coupling through this rheostat, unless by-pass condensers are used between the grid return and filament.

Fading of Signals

(218) C. A. Orr, Jordan, N. Y., writes:

Q. 1. I have a five-tube receiver in which I use a CX-300-A detector tube. The reception is good, but frequently I am troubled with the gradual fading of signals and often complete stoppage of reception. At such times the signals may be restored by switching a light or the trickle charger on and off. I experience this trouble all day up until eight o'clock at night. I have changed the set to a new location, likewise the antenna and ground, but with no effect. Can you suggest the cause and a possible remedy?

A. 1. Make sure that your trickle charger is charging the "A" battery. Charging is often taken for granted because the charger is connected to the battery. Test your "B" battery for voltage. A 45-volt unit should not be used after it drops below 34 volts, if the best results are to be expected. Change the tubes around in the sockets. Partial or complete stoppage of signals may result when a powerful nearby receiver is tuned to the same wave you are receiving. The ordinary remedy for this condition is the relocation of your antenna, receiver and ground connection. Place your antenna at right agles to the other antenna, or vertically. Also check over your receiver for bad connections.

Shielding in Radio Sets

(219) E. R. Flynn, Rockville Center, L. I., N. Y., asks:

Q. 1. What is the advantage of using shields in radio receivers and what materials may be used for this purpose?

A. 1. Shielding has become popular with radio set builders. By the use of intelligent shielding, receivers can be made more sensitive than would otherwise be possible. Primarily, the advantage of shielding is to reduce the feed-back or to advance the point of self-oscillation so that increased amplification may be obtained. In this way, it is possible to make receivers far more sensitive and capable of receiving over greater distances.

At present, shielding is the only reliable method of definitely limiting the extent of the external electro-magnetic and electrostatic fields between coils. By using shielding and thus advancing the point of self-oscillation, it is possible to employ a greater number of radio-frequency stages without undue difficulty in preventing or controlling self-oscillation. Grounded rotor variable condensers have made receivers free from body capacity effect, but in some receivers, especially on short wavelengths, this annoying action is still experienced. Thorough shielding will eliminate this trouble entirely. Changes in the field between the body and the interior of the receiver which may be caused by moving the hand or body toward or away from the panel will not influence tuning if shielding is used.

A good conductor will dissipate stray charges or currents more easily than a poor one. Since copper has a low resistivity, it is a very efficient shield. Experiments have shown that strong magnetic fields will pass through very thin sheet metal. Any opening in the shield will entirely ruin the effect of the shielding material. Present day broadcasting, with its numerous and powerful stations, requires perfect magnetic insulation. In some cases aluminum plates have been used between adjacent radio-frequency stages, and while they serve the purpose fairly well, they do not provide the full insulation that complete box shields of aluminum or copper do. Brass may also be used for shielding, but is not as good as copper or aluminum. Iron or steel must never be used for shielding high-frequency currents or circuits.

Iron and steel have a high resistance as compared with copper, and will not absorb readily the energy from field lines of force. Furthermore, iron and steel introduce magnetic effects and then have fields of their own which would make matters worse than ever. If audio frequencies are to be shielded, the shields will have to be thicker than those effective at radio frequencies. A thin shield is effective at high frequencies, because these short waves do not go through any shield as readily as the lower frequency waves. A thickness of metal, from No. 6 to No. 30 gauge may be used satisfactorily for shielding.

It is impossible to build a perfect shield because any metal used for this work will have some resistance and therefore could not absorb all of the radiated lines of force. The fewer the openings in the shield, the more effective it will be. All joints in the shield should be crimped and soldered their entire length. To prevent the passage of any lines of force into a shield, the wires may enter and leave through bent copper tubes. The extent of capacity effects between the shield, coils, wiring, condensers and the like within the shield is increased when any or all of these parts are placed close to the shield. So far as space limitations will allow, the shield should be kept at least two inches away from all shielded parts. The best results in the preventing of feed backs will be secured if the shields enclosing the radio-frequency stages are allowed to be insulated from all other circuits.

Circuit Testing

(220) Mr. J. R. Lopez Sena, New York, N. Y., asks:

Q. 1. Can you furnish me with the circuit diagram and specifications for a circuit tester, which is capable of testing the various circuits in my receiver and is similar to the commercial testers on the market. This unit does not need to be as simple in operation as the commercial products, since I would not be able to employ a multi-pole switch such as they use.

In these units a milliammeter is arranged with series and shunt resistors to measure the plate voltage, the plate current, the filament voltage, and the comparative plate-current values for different grid biases. The unit is equipped with a plug which is inserted in the tube socket of the set, so that the circuit can be tested while the set is in operation. The tube is placed in the unit and its operation is controlled with the various switches in this unit.

A. 1. You will find the diagram of a tester of this type on this page (see Fig. 220). An 0-to-1-scale milliammeter is used; and it will be necessary to obtain a shunt from the manufacturer of the meter so that it can be adapted to readings from 0 to 20 milliamperes. If desired, an 0-to-20-scale milliammeter may be purchased and the shunt removed and used externally.

The other apparatus required comprises a four-pole double-throw switch (B), a double-pole double-throw switch (D), a single-pole double-throw switch (E), a single-pole single-throw switch (C), and a multi-pole switch (A) used for testing the various voltages of the plate supply. The last may be of the ordinary panel-mounting type with an arm and switch points mounted in the panel.

It will be necessary to use also a tube socket, an old vacuum-tube base, and several fixed resistors to convert the milliammeter into a voltmeter. With a milliammeter with a scale reading from 0 to 1 milliamperes, it will be necessary to use an 8,000-ohm resistor for the 8-volt tap, an 80,000-ohm resistor for the 80-volt tap, and a 200,000-ohm resistor for the 200-volt tap. If an 0-to-20-scale milliammeter is employed with the shunt removed, it will be necessary to be sure that the milliammeter registers 0 to 1 milliamperes over the complete range, since it cannot be used if this is not true.

Use of the Tester

The various tests that can be accomplished with this unit are made as follows:

(1.) To measure the plate voltage, turn the switch B to the voltage side and turn the switch A to the 80- or 200-volt tap; that is, to point 3 or 4. Switch C should be open and switch D should be in position 1, unless the wiring is reversed in the receiver. This can easily be determined by throwing switch A to point 2, and closing switch C. If the meter registers correctly, the switch (D) should be left in that position. If it does not register on the positive side, the switch D should be reversed. When measuring the voltages, switch E should be in position 1.

(2.) To measure the plate current, switch B should be in the milliammeter position, and switch A should be at point 1. Switch C should be open, switch D in the positive position, depending upon the wiring of the set, and switch E on point 1.

(3.) To compare the grid currents of the tube with and without bias or with a positive bias, leave the switches in the milliampere position, and change switch E from point 1 to point 2. This places the grid return of the tube directly on the "F—," and removes any bias which might be obtained through the set. By reversing switch D, it will be possible to place a positive bias, equal to one-half the value of the "A" battery, on the tube. While these grid measurements do not show any direct values, they are helpful in comparing the plate-current consumption of a vacuum tube under different grid conditions; and *comparative* values can easily be determined with tubes of known value. They will indicate whether the tube is operating correctly or not.

(4.) To measure the filament voltage, switch B should be in the voltage position, switch A should be in position 2, switch C should be closed, and switch D in the position which supplies the positive reading.

(5.) To use the meter and resistors in the unit separately, the external binding posts should be employed. For milliammeter readings, the negative binding post and the milliammeter binding posts are used. If a range of 0 to 1 milliamperes is required, the switch B should be open; and if a range of 0 to 20 milliamperes is required, the switch B should be closed on the milliampere side. To use the various voltage scales, the switch B should be opened and the correct voltage binding post in conjunction with the negative binding post should be used. When using the external section of the unit, the plug-in tube base should be removed from any socket in which it has been previously used.

This unit is quite useful for use in testing radio sets, vacuum tubes, etc.; and, since the meter with the resistors described above produces a voltmeter which has a resistance of 1,000 ohms per volt, the unit is also valuable for use with sets employing power units, for measuring the output of "B" power units, etc.

The resistors used in the voltmeter section of the unit should be as close to the value shown as possible. Fortunately, there have been recently placed on the market some resistors which are accurate within plus or minus one per cent. This is close enough so that the voltmeter readings will be sufficiently accurate for ordinary work. It

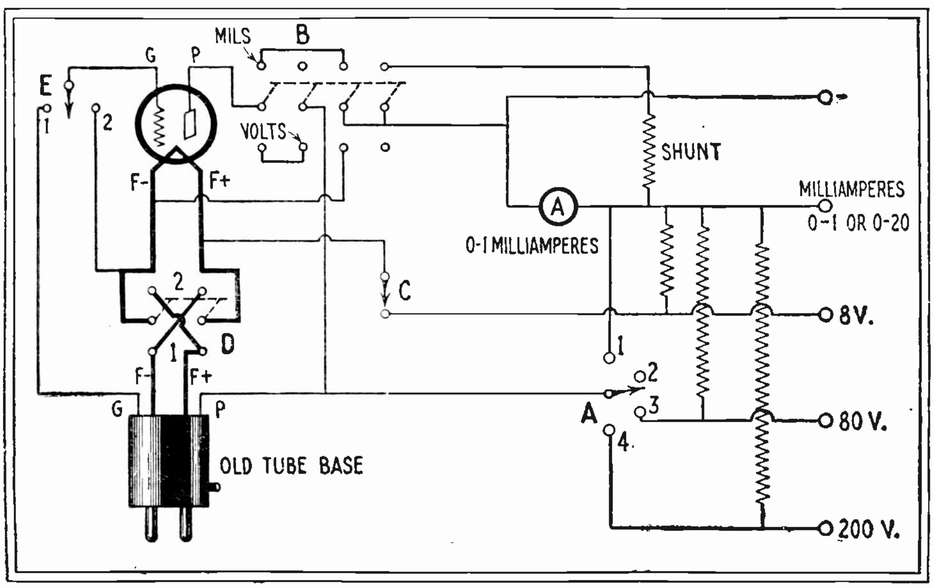


FIG. 220—A universal set tester is shown here; its switch system allows the set to be tested while in operation. The plate voltage, plate current, filament voltage and comparative dial readings can be obtained with a unit of this type.

will be necessary to recalibrate the meter; either by making comparative points equal to a given value for each of the resistors and plotting a graph of the readings, or by taking the glass front from the meter and inserting a new scale.

Broadcasting Studios

(221) Fred T. Barton of Chillicothe, Ohio, asks:

Q. 1. Please describe the construction of a modern broadcast station studio.

A. 1. The walls may be constructed of gypsum block. Over this is placed a layer of lith. This is a sound absorbing material. It is also applied to the ceiling. A triple wall construction should be used. Between the walls a thick layer of sound-deadening material is laid. The furniture should be wood-doweled, not nailed.

Q. 2. Should draperies be used to prevent echoes?

A. 2. A certain amount of reverberation is required. By use of a partial drapery, the correct balance between reverberation and a total absence of echo may be easily obtained. If the special wall construction described above is used, no drapery is required.

Q. 3. What is the difference between reverberation and echo?

A. 3. Reverberation is a type of echo so closely spaced to the original sound that the separation cannot be detected by the ear. An echo is so timed that the separation can be readily detected.

Exponential Horn

(222) A. V. Herbert, Hackensack, N. J., writes:

Q. 1. If possible, will you kindly illustrate in your columns, the construction of a folded exponential horn, similar to those developed by the American Telephone and Telegraph Company, having a cut-off frequency of about 64 cycles.

A. 1. On this page you will find illustrated the plans for this horn, showing the layout of the baseboard and central portion. All dimensions have been marked upon the illustration. The heaviest pieces of timber required are those for the heart-shaped blocks.

Single blocks of timber of this size are usually not readily obtainable, and they will, in most cases, have to be built up from whatever wood is obtainable, the laminations being carefully glued and screwed together.

The principal requirement is that the inner walls of the sound channels be as smooth and correctly shaped as possible. For this reason the use of hard wood is preferable, so that the inner walls can be polished after using a grain filler, thus making the air resistance of the surface as low as possible. Throughout the entire assembly care should be taken to see that all parts are cut accurately, so that the shape of the sound channels will not be distorted and so that no cracks are left between the blocks. The unit itself is placed at the back of the horn. The completed horn is twelve feet long and has a mouth four feet square. The plywood sides should be screwed to the wooden blocks. During the final assembly all parts should be glued together, under pressure, as well as screwed, so that there will be no danger of them moving out of place.

The mouth of the finished horn may be covered with wire gauze stretched over light grill work, or the whole speaker may be fitted into a console cabinet. Probably the best possible unit for use with an exponential horn is the moving coil type, especially for high-powered work; but the balanced armature type performs very well, and almost any kind of a unit will show an improvement in its performance when connected to a properly designed exponential horn.

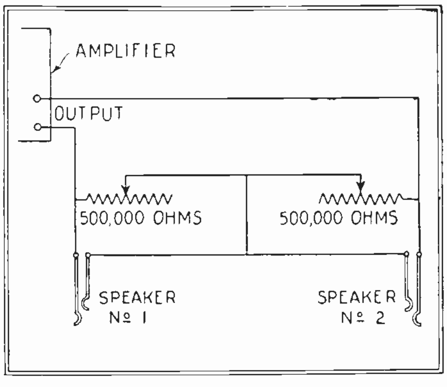


FIG. 223—By this arrangement two loud speakers may be so balanced that better quality will result. Individual volume control for remote loud speakers can also be obtained in this way.

Matching Loud Speakers

(223) Mr. E. A. Seip, Charleston, S. C., writes:

Q. 1. I have seen, in several magazines, methods of using cone and horn loud speakers together to improve the quality of reception. However, the methods of controlling the volume of each loud speaker were not given, and coupling the two speakers together without this control does not improve the tone quality. Can you show me how this may be done?

A. 1. The diagram (Fig. 223) shows how two speakers may be connected so that either one may be controlled without affecting the operation of the other. Two variable resistors are shunted across the

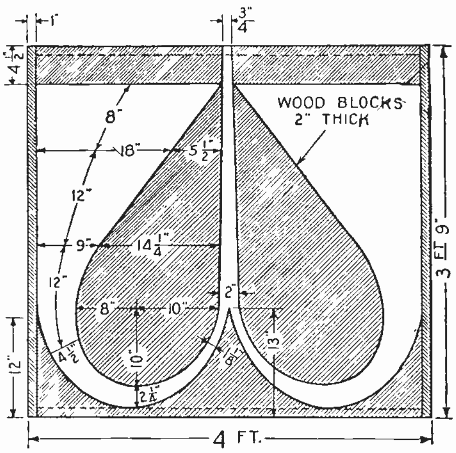


FIG. 222—The plans for the exponential horn showing the layout of the baseboard and central portion.

speakers and serve to control the volume of each. By placing speakers of the cone and horn types together and carefully balancing the volume of each, remarkable fidelity of reproduction may be obtained. This is due to the fact that most cone speakers reproduce the lower notes better than the high ones; while most ordinary horn speakers tend to weaken the lower tones. (This statement does not apply to large horns of the true exponential type).

This method of coupling is of service also when two loud speakers in separate rooms are being used with the same receiver. If the speakers are coupled together in the normal manner, both must be operated with equal volume. Very often it is desirable to have one speaker operating very softly and the other loudly. This control can be obtained quite satisfactorily by the method described.

Directional Properties of Loops

(224) Mr. H. Valentine, Teaneck, N. J., asks:

Q. 1. Why is a loop aerial directional?

A. 1. If the plane of the loop is at right angles to the direction of the transmitter, the waves from the transmitting station will reach both sides of the loop simultaneously. The currents, induced in every part of the winding under these conditions, will cancel out exactly and no difference of potential will set up across the ends of the winding. If the plane of the loop is not at right angles to the direction of the transmitting station, the waves will reach one side of the frame before the other. The currents produced in each side of the loop will then be out of phase with each other, and therefore, cannot cancel out. The more nearly the plane of the loop winding is made to coincide with the direction of the transmitting station, the greater the phase difference and, of course, the greater the potential differences set up across the ends of the winding.

Q. 2. For what purpose are grid leaks used in resistance-coupled amplifiers? I understand the function of a grid leak when used in conjunction with a detector tube, but when rectification is not required, I do not see what purpose the grid leak serves.

A. 2. A grid leak, whether used for the detector tube or in a resistance-coupled amplifier, fulfills one important function—that of allowing the grid of the tube to which it is connected to retain its mean potential at a suitable value. If the leak were not present, electrons reaching the grid from the filament through the space in the tube would, by accumulating there, give the grid of the tube such a high negative potential that the tube would be unable to operate efficiently.

Q. 3. Can two 75-turn honeycomb coils connected in series be used instead of a single 150-turn coil? Will the tuning range be the same?

A. 3. If the two 75-turn coils are connected in series and are coupled together very closely, in such a way that the fields of the coils reinforce each other, the inductance of the combination will be nearly equal to that of a 150-turn coil of the same type. This means that both coils must be placed next to each other, in such a way that the direction of the windings is the same.

Volume Control

(225) Fred J. Simpson, Lincoln, Nebraska, asks:

Q. 1. What are some of the methods for controlling the volume of a radio receiving set?

A. 1. One way to control the volume of a set is by detuning the set. This method is not very satisfactory in cases where several stations are broadcasting on approximately the same wavelength, since this would result in interference when the set is detuned from the resonance point.

Another method sometimes employed is to vary the filament current of the tube by means of the rheostats. The volume of the set may be controlled successfully in this manner, but the depreciation in quality is very marked when the filament current falls below a certain value. An efficient way to control the output of a set is to connect a variable resistance having a range of approximately from 10,000 to 100,000 ohms across the secondary of the first audio frequency transformer. This resistance absorbs power from the circuit and allows the output to be regulated to the desired value without causing distortion.

Locating Interference

(226) Mr. C. G. Shattuck, Juneau, Alaska, writes:

Q. 1. Radio fans in this city have recently organized the Juneau Radio Club, with the perfection of local reception and the education of radio owners, so they will be able to better understand their sets, as our aims.

It was brought up at a meeting some days ago, that your magazine answered questions asked by fans. We would like information on the instruments best adapted for finding squealers and other local interference sources.

We would be glad to hear from you on this matter, as interference is sometimes very had here, and your help would mean a great deal to us.

A. 1. When locating oscillating receivers and other sources of interference, such as you mention above, it is necessary to use a receiver which is entirely portable, yet sensitive enough and selective enough to pick up signals from only one direction with a loop aerial. The set employed for this purpose must be completely self-contained, including batteries and all other equipment except the loop aerial. The cabinet enclosing the apparatus must be completely shielded, top, bottom and sides, with no openings at any point.

A receiver for this purpose may comprise only one stage of tuned-radio-frequency amplification, a non-regenerative detector, and one audio-frequency stage as shown in Fig. 226. Of course, it is not necessary to use a receiver of exactly this type; since any shielded set which is sufficiently sensitive and portable will serve. The receiver illustrated employs two tuning condensers, .0005-mf. capacity, and a tuning inductor with 10 turns for the primary and 50 for the secondary, both wound on a single 3-inch tube with about ¼-inch spacing between the two coils. A loop aerial sixteen inches square with 15 turns of No. 20 or larger wire with ¼-inch spacing between turns will be satisfactory. The values of the other apparatus are all indicated on the diagram. The "B" voltage should be between 45 and 90; small "B" batteries should be employed, since the receiver has to be portable in order to be of service.

"Triangulating"

In operation, the receiver is either carried or transported in an automobile, and the loop aerial is revolved until the sound of the interference is at its maximum volume. The loop aerial is then pointed directly at the antenna of the interfering set or other source of interfering noise. This operation should be repeated from several points, as shown in Fig. 226-A. By laying off lines in the direction of greatest signal strength form each of the three or four points, the exact position of the source of the interference can be found.

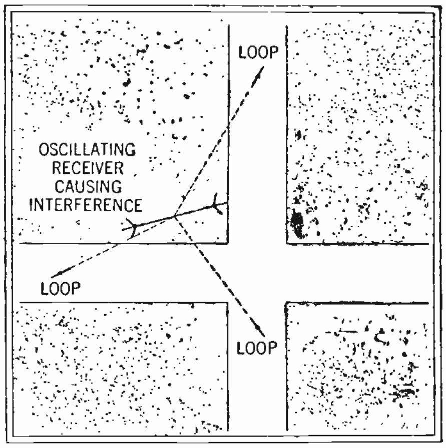


FIG. 226-A—The method of "triangulating" is shown above. The loop aerial is revolved until the sound of the interference is at maximum value.

The receiver should then be taken close to this indicated point, and moved around while the loop is rotated. It will finally be possible to move the receiver all the way around one location, with the loop continually pointed towards the center of this small area. The cause of the trouble is somewhere near this point. It is then a simple task to locate the exact source of the interfering noise.

Types of Noises

Beside the regular howl of an oscillating receiver, there are several other noises which can be recognized when employing this device. Rapid and regular clicking noises can, usually, be attributed to vibrating battery chargers or other electrical devices which employ vibrators. Intermittent rasping and scratching noises which vary in intensity may be caused by defective insulators or loose contacts in power lines. A more or less steady and continual crackling noise may come from arc lamps or some types of medical devices employing heating coils or arcs. A rapid whirring noise is usually caused by sparking at the contacts of commutators in motors, generators, etc. Crackling noises which occur at regular intervals are generally due to electric sign flashers. There are several other noises which can be recognized, but the above are the most common. Of course, the rather musical long and short dashes which are often heard in receivers, are due to radio-telegraph stations, on land or sea. These are usually found on the longer wavelengths.

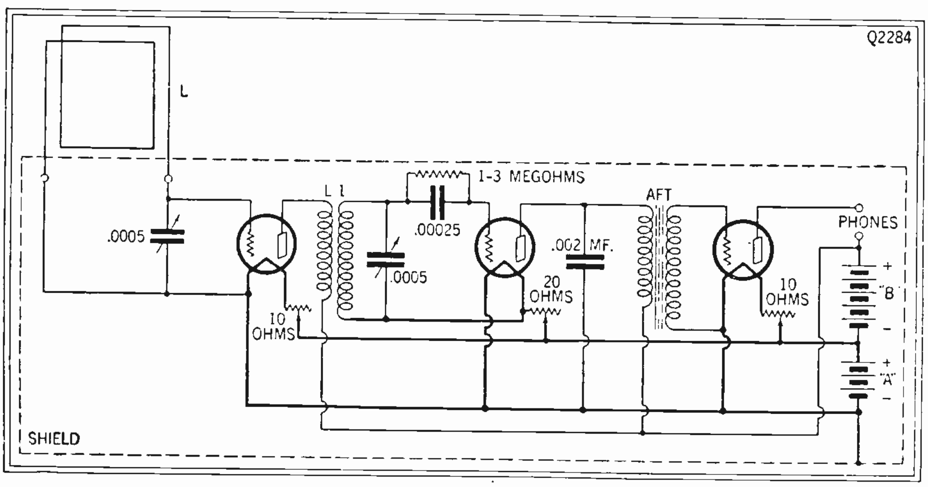


FIG. 226—Circuit of a three-tube portable set, adapted especially for the detecttion of "bloopers" and other sources of interference. It must be completely shielded, as indicated. See the text for coil data.

Polarity Determination

(227) Mr. A. F. Johnson, Brooklyn, N. Y., writes:

Q. 1. I have a storage battery which is not marked on either the positive or negative terminals, although one of the terminal screws is painted red. How can I tell which wires to connect to the positive and negative, respectively, on the set?

A. 1. The red terminal is always the positive. In some cases the terminals of batteries and chargers are not marked in any way. This usually makes it very difficult for the fan to tell which wire is positive and which is negative. If a small amount of salt is dissolved in a glass full of water, and the two wires dropped into the solution, the wire giving off most bubbles is the negative.

Telephone Line Induction

(228) Anton Schleck, Bridgeport, Conn., writes:

Q. 1. For the past year the writer has been listening to various telephone conversations, by means of a radio receiving set; conversations between people in this city on the ordinary telephone line. The other night, while listening to a radio station, a loud dialogue broke in on the concert and assumed such a volume that the radio program was almost drowned out. The antenna and ground are not very near the telephones and I cannot understand how this can happen. I would be glad if you could give me an explanation of this phenomenon.

A. 1. This is a plain case of induction. The telephone wires produce an electromagnetic field around them, which varies in intensity just as the voice currents travelling over the wires vary. Your antenna is probably within the range of these fields and a feeble current is either induced in it or directly into the input of the audio-frequency amplifier. Such an occurrence happens quite often and we receive many of these letters on this particular subject. The cause is ordinary electromagnetic induction, the same thing that causes the transfer of energy between the primary and secondary coils in your receiver.

Shielding Radio Sets

(229) Mr. J. Fenworth, Bangor, Me., asks:

Q. 1. What is the best metal for use in shielding radio-frequency amplifiers?

A. 1. Copper, aluminum and brass are the metals best suited for use as shields. A shield must be of good conducting material so that eddy currents may be formed within its mass. Lead foil and tinfoil have resistances too high to make good shields. Iron and steel must never be used for shielding high-frequency circuits; these meals have relatively high resistance and, furthermore, they introduce magnetic effects of their own which make matters worse than before. Any thickness of metal from No. 6 down to No. 30 gauge may be used satisfactorily for shielding.

The best results will be secured if shields enclosing various radio-frequency stages are insulated from all circuits in the receiver. On the other hand, the best protection against pickup of outside interference will be obtained with grounded shields. If the receiver is equipped with both interstage and complete-cabinet shielding, the interstage shielding may be insulated and the cabinet shield grounded; thus affording almost complete protection.

Radio Beacon Station

(230) S. M. Morford, Brooklyn, New York, writes:

Q. 1. I recently received a rather strange code signal over my experimental radio receiver, which consisted of a group of four dashes with a silent period between each group. Can you tell me what this station was and something of its schedule?

A. 1. According to the information which we have available, it seems that you have received a signal from the radio beacon station of the Nantucket Shoals Light ship, Massachusetts, situated at a latitude of 40 degrees, 37 minutes North, and a longitude of 69 degrees, 37 minutes West. The call letters are WWAH and the signal consists of a group of four dashes, transmitted over a 60 second period with a silent period of 120 seconds intervening between each 60 second period. The station transmits for the second 15 minutes of each hour in clear weather. A radio operator stands watch for the first 15 minutes of each hour from 8 A. M. to 10:15 P. M. in clear weather, and from 10:00 to 10:15 A. M. and from 4:00 to 4:15 P. M. in thick or foggy weather, at which intervals the radio beacon is not used. The operator stands watch on a frequency of 500 kilocycles or 600 meters at the periods stated. The radio beacons are operated on a frequency of 300 kilocycles or 1000 meters continuously during thick or foggy weather. The time is given as local standard time.

Horn vs. Cone-Type Speaker

(231) W. H. Berman, Severn, Md., writes:

Q. 1. Will you list briefly the comparative merits of the horn and cone-type loud speakers and the outstanding features which are claimed for these instruments?

A. 1. First of all let it be stated very definitely that substantially perfect reproduction can more easily be obtained with a diaphragm type of loud speaker, that is, one which is not provided with any form of sound conduit. However, a well-designed horn speaker may give far more pleasing results than an inferior cone or diaphragm type, and, unfortunately, there are many instruments of the latter type now being manufactured.

Let us consider the mode of operation of a horn-type speaker. It is provided with a small metal diaphragm rigidly clamped round its periphery; this is under a steady pull from the permanent magnets and the driving mechanism, and it can be very easily shown mathematically that a diaphragm of this nature cannot give a linear response over the entire band of speech and music frequencies. To begin with, the diaphragm will have a natural resonance of its own. At the upper and lower frequencies its response will be very poor.

Next we have to consider the effect of the horn. The object of the horn is partly to set into vibration a larger volume of air than can be energized by a small diaphragm. A horn is somewhat similar to an ordinary organ pipe, and its acoustic properties can easily be examined by the mathematical equations which are commonly used in acoustics. From such analysis it is found that it will tend to have certain definite resonances, and also will almost completely cut off certain frequencies.

A response curve of a horn-type loud speaker is most illuminating, and it is really rather surprising that the ear can appreciate the sound output as tolerable speech and music. Broadly summed up, a good horn speaker can be made to give surprisingly equal reproduction over a useful frequency range, in spite of its cutting off both top and lower registers, and introducing at certain points certain undesired resonances, in addition to a certain amount of characteristic coloration.

With the cone or diaphragm type of speaker the air is energized by the direct vibration of a diaphragm of appreciable area. The mode of vibration of the diaphragm will be determined by the manner in which the edge is fixed; it may be either "fixed" or "free." If the diaphragm has a fixed edge its mode of vibration will not be a direct function of the manner in which it is energized by the driving mechanism. If, however, the diaphragm is reasonably rigid, and has a perfectly free edge, then its vibration will be nearly equivalent to that of the driving mechanism. It is, however, vastly more difficult to produce a good speaker of the diaphragm type than it is to produce a good horn type.

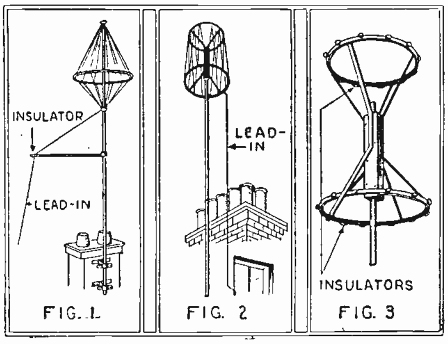


FIG. 232—The constructional details of two of the simplest types of vertical aerials are shown in the above illustration.

Many diaphragm type of speakers which the writer has examined are very deficient in their response to the higher frequencies, and many of them tend to produce harmonics very badly. This has the effect of making the whole characteristic of the transmission high-pitched and tinny, and the result is certainly not so pleasing as that obtained from a good horn speaker. But the difference between a good diaphragm type and a good horn type is an individual choice, and anyone with only a reasonable ear for music can soon determine which type loud speaker they prefer.

Vertical Aerials

(232) G. F. Sargent, Seatle, Wash., asks:

Q. 1. Will you please illustrate on your pages some of the simplest types of compact vertical antennas which can be constructed by the amateur and also give some information regarding their construction?

A. 1. You will find illustrated on this page two types of the above mentioned aerials. Fig. 1, shows one of the simplest forms which is made with the aid of an old bicycle wheel or barrel hoop. The wires are attached to two insulators and lead back and forth with the wooden circle in the center, or nearer the bottom portion. The lead in is taken from one end of the antenna wire as shown. Fig. 2 shows another of these aerials and the form for the construction of this is shown in Fig. 3. In this case two wooden hoops are used with insulators spaced around their circumference to which the wire is attached. These are but two of the simplest types of compact vertical aerials which can be constructed by the amateur, and will give good results with any multi-tube receiver.

Interference From Electric Cars

(233) Mr. S. Woolley, Indianapolis, Ind., asks:

Q. 1. How can I minimize the interference caused by the passage of trolley cars which go directly in front of my house? Every time a car passes, terrific noises which completely obliterate reception are heard in my loud speaker.

A. 1. This kind of interference is sometimes very difficult to overcome, especially since you are located so near the trolley line. Much depends upon the kind of set you are using, and it would be better to use as little audio-frequency amplification as possible, since a disturbance of this type is usually amplified more than the incoming signals. The use of a counterpoise in place of the ground will greatly help by getting rid of any interference due to earth currents; but, if the trouble is very persistent it may be necessary to resort to the use of a loop aerial, with a resulting decrease in signal strength. It may even be necessary to shield the entire receiver to completely remove the annoyance.

Q. 2. In my study of the different diagrams of radio receivers, I have noticed that the grid leak has sometimes been placed between the grid and filament of the detector tube. I had always understood that the grid leak should always be connected directly across the grid condenser. Is there any advantage in either way?

A. 2. It will be found in most cases that very little difference is noticeable whether the grid leak is connected directly across the grid condenser or from the grid to the filament. In certain receivers, however, it has been found that slightly better results are obtained by using the grid-to-filament connection. In this case, the end of the grid leak farther from the grid of the tube should go to the "A+," in order to give the grid the positive bias necessary for grid-leak detection with special tubes.

If the detector is the first tube of the set and the grid return is connected to the positive side of the filament circuit, the leak may be used directly across the grid condenser, since the grid will obtain its positive bias through the tuning coil. The same applies when the detector tube follows a stage of radio-frequency amplification, if the grid return of the R.F. transformer goes to the "A+." Since this is the usual connection of the grid return in most receivers, the placing of the grid leak across the grid condenser will probably prove most satisfactory.

Lack of Selectivity

(234) C. L. Angstrom, Freeport, Ill., asks:

Q. 1. Briefly, what are the chief causes for lack of selectivity in the radio receiver?

A. 1. The chief causes for lack of selectivity may be divided into three main classes. The first class contains all the faults that introduce excessive resistance in the radio circuit. Reducing this resistance to the lowest possible value will not only increase the selectivity, but at the same time, will multiply the sensitivity and volume of the receiver. The second class of faults includes mistakes in coupling between the various circuits. Usually, loosening the coupling between any two of the radio-frequency circuits will increase the selectivity. Too loose a coupling will reduce the sensitivity of the receiver. The third class includes the faults of poor proportion between inductance and capacity in the tuned circuits and in the antenna circuit. Many non-selective receivers have too little inductance in their circuits. Increasing the ratio of inductance to capacity will improve the sensitivity and selectivity. The effect of shock excitation from nearby broadcasters whose signals tend to blanket all other reception may be greatly reduced by the use of proper shielding or by tuning the antenna circuit.

Wavelength Formulas

(235) Mr. A. Cador, Ossining, N. Y., asks:

Q. 1. Could you furnish me with some simple formulas for the calculation of the wavelength of a coil and condenser combination, when the capacity and inductance are known, and the approximate inductance of a toroid coil?

A. 1. The following are several formulæ from which the wavelength or frequency of a coil and condenser circuit can be determined with fair accuracy:

$$\text{Wavelength } (\lambda) = 1884 \sqrt{LC}$$

To find the frequency (in kilocycles) of a circuit consisting of a coil and condenser use the following formula:

$$\text{Frequency } (f) = \frac{159.2}{\sqrt{LC}}$$

In both cases L is the inductance of the coil expressed in *microhenries*, and "C" the capacity of the condenser in microfarads.

To find roughly the inductance of a coil of the toroid type, the following formula is employed:

$$L = .01257\ N^2\ (R - \sqrt{R^2 - A^2})$$

In this instance R is the radius of the toroid from the center of the doughnut to the center of winding. A is the radius of the turns of the winding, and N is the number of turns.

T.R.F. Trouble Shooting

(236) Mr. A. Silverman, Dayton, Ohio, asks:

Q. 1. Please tell me the reasons for a tuned-radio-frequency set having high and low dial settings for the same station; seemingly acting on the same principle as the oscillator dial on a super-heterodyne?

A. 1. The phenomenon you describe is a very unusual one as far as T.R.F. circuits are concerned. It probably is not due to any action in the receiver itself, but rather to re-radiation on the part of the broadcast stations in your vicinity or to the existence of strong harmonics of the weaves to which the transmitters are tuned. Under some conditions it may be caused by too close coupling between the primaries and secondaries of the R.F. transformers, but it is more likely the fault of the transmitters.

Farm-Lighting Interference

(237) Mr. A. F. Jensen, Stamford, Conn., writes:

Q. 1. We are having quite a lot of trouble with our radio receiver, because the 32-volt lighting installation which we are using causes a lot of interference. Since there are a number of relays and spark gaps in this installation, we are at a loss to know how to reduce this noise

A. 1. The interference caused by a Delco or similar generating plant may be caused by the spark at the spark plug of the gasoline engine, sparking at the distributor, sparking at the relays and governing mechanisms, or motors or other appliances connected to the installation.

There are three general ways of reducing this interference. First, the entire generating system may be enclosed in a metal box, being careful to keep all of the wiring insulated and ground the box. Secondly, the disturbances may be eliminated by the use of condensers, resistors, etc., in the generating plant. Thirdly, we may change the frequency of the disturbances so that they will not be annoying on the broadcast band.

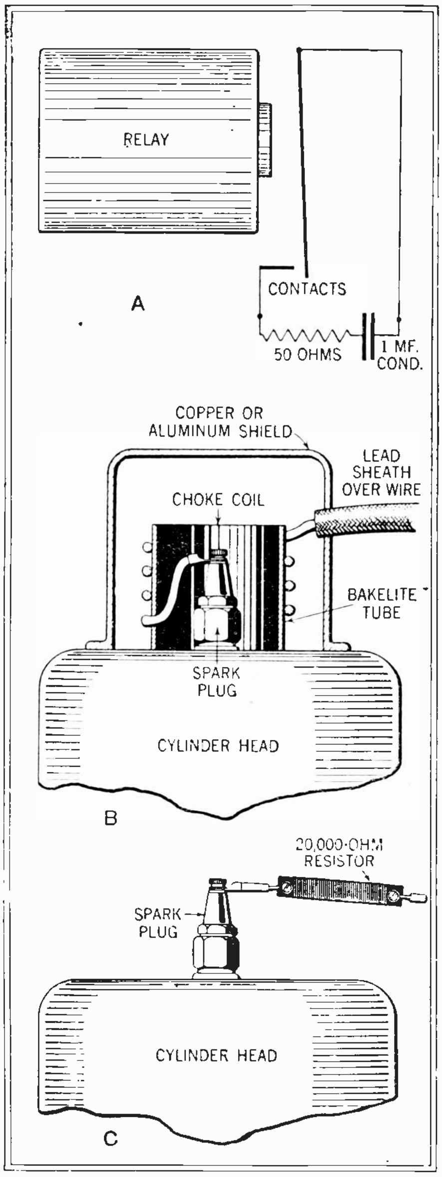


FIG. 237—Three sources of electrical interference from a farm-lighting system, which can be greatly reduced by following the plan outlined below.

Fig. 237 shows at A how sparking at the contacts in the relays may be prevented by shunting the contacts with a 1-mf. condenser and a 50-ohm resistor. In the case of the generator commutator, two condensers connected across the terminals of the brushes and the center point grounded, will tend to prevent the disturbance. The high-voltage wiring sometimes causes trouble, and the only way to overcome this difficulty is to shield carefully all of this wiring and ground the shield.

Disturbances from the spark plug are sometimes more severe on some wavelengths than others.

Fig. 237-B shows how a shielded choke coil can be connected in the circuit to overcome this difficulty by changing the wavelength of the disturbance. A choke for this purpose may be wound with a few turns of No. 16 wire on a form 1½ inches in diameter, and a small can mounted over it. In some cases, a carbon resistor of about 20,000 ohms can be used as shown at C in place of the choke coil. In this case, the shield is not necessary. This method suppresses the interference rather than changes the wavelength.

It may be advisable, in some cases, to shield both the high-voltage wiring running from the spark plug to the high-voltage distributor, and the low-voltage wiring from the distributor to the generator, in order to reduce the volume of the noises.

The methods mentioned above will be satisfactory for overcoming disturbances caused by the lighting installation itself but, naturally, these suggestions will not overcome interfering noises *caused by apparatus connected to the line*. These noises come from a number of different types of apparatus, including fans, vacuum cleaners, violet-ray machines, irons, percolators, motors, X-ray machines, etc. A very interesting booklet on this subject has been prepared by the Radio Manufacturers Association, 1265 Broadway, New York City, and may be obtained from this organization for 25 cents.

Loud-Speaker Construction

(238) R. W. Anderson, Traverse City, Michigan, asks:

Q. 1. Will you kindly give me the essential construction of the new loud speaker which recently was used in throwing sound across the Hudson River.

A. 1. The speaker to which you refer is undoubtedly that which was perfected by the Bell Telephone Laboratories, and is now being used successfully in Vitaphone and Movietone productions. In its present form, the loud speaker is of the horn type. The engineers who developed it say that it is capable of converting into sound about 50 per cent of the electrical energy supplied it.

The moving diaphragm or armature of its unit is not made of a magnetic material but consists of a sheet of very light aluminum alloy, about two-thousandths of an inch thick, and so constructed that it moves laterally, somewhat like a piston. Attached to the diaphragm is a small coil of aluminum strip wound edgewise and insulated with varnish. This coil lies in the magnetic field produced by a powerful electromagnet.

Telephone or voice current passing through the small aluminum winding causes the diaphragm to vibrate. The plunger-like motion of the diaphragm and the special shaping of the air chamber between the diaphragm and the mouth of the horn result in an efficiency many times greater than that obtained with other types of loud speakers. The load carrying capacity of the device arises from the fact that the small aluminum coil lies very close to the heavy iron pole-pieces of the field magnet. In addition to its large capacity, the loud speaker is notable for its fine reproducing qaulities. It encompasses the range of frequencies from 60 to 600 cycles per second without distortion and reproduces down to 40 cycles and up to 8000 cycles with a distortion so slight that it is doubtful if the ear can detect it.

Fading of Signals

(239) C. A. Orr, Jordan, New York, writes:

Q. 1. I have a five-tube receiver in which I use a CX-300-A detector tube. The reception is good, but frequently I am troubled with the gradual fading of signals and often complete stoppage of reception. At such times the signals may be restored by switching a light or the trickle charger on and off. I experience this trouble all day up until eight o'clock at night. I have changed the set to a new location, likewise the antenna and ground, but with no effect. Can you suggest the cause and a possible remedy?

A. 1. Make sure that your trickle charger is charging the A battery. Charging is often taken for granted because the charger is connected to the battery. Test your B battery for voltage. A 45-volt unit should not be used after it drops below 34 volts, if the best results are to be expected. Change the tubes around in the sockets. Partial or complete stoppage of signals may result when a powerful nearby receiver is tuned to the same wave you are receiving. The ordinary remedy for this condition is the relocation of your antenna, receiver and ground connection. Place your antenna at right angles to the other antenna, or vertically. Also check over your receiver for bad connections.

Potassium Hydrate Batteries

(240) Newman Stern, New York, N. Y., writes:

Q. 1. Kindly give me the specific gravity necessary in mixing a new solution of potassium hydrate for Todd storage "B" batteries. Is the distilled water poured upon the potassium hydrate or the hydrate dropped into the water?

A. 1. The electrolyte solution consists of one part of potassium hydrate to four parts of distilled water. This is approximately one pound of hydrate to a quart of water. The specific gravity will be from 1200 to 1250. The condition of this type of cell is tested by a voltmeter and not by a hydrometer, as is the case with an acid battery. When fully charged each cell has a potential of 1.4 volts and drops during its use to 1.2 volts. The 100-volt battery uses two quarts of water and the 140-volt battery three quarts of water. Put the hydrate into the water very slowly and use an earthen jar as the container, because great heat is evolved and other containers might crack.

Obtaining Selectivity

(241) Mr. C. B. Douglas, Chicago, Illinois, asks:

Q. 1. What are the important points in obtaining selectivity from a receiver?

A. 1. There are a number of general points which may be watched in building and improving receivers for increasing the selectivity. The following series of rules may be followed in almost every case, except for a few special receivers, such as super-regenerative sets, etc.

1. Employ loose coupling between the primary and secondary of the tuning coils.
2. Keep wide spacing between the parts in the receiver and between the wires.
3. All wiring should be as short as possible, and grid and plate wires should not be run parallel.
4. Keep all plate and grid wires far apart, and separated from other wiring in the receiver.
5. Watch soldered joints and keep all terminals clean and tight.
6. Keep the contacts on tube bases and sockets clean.
7. Avoid material and construction which will cause losses in coils, such as metal in the field, too-fine wire, etc.
8. Keep the condenser plates clean.
9. Do not use, for controlling oscillation and regeneration, methods which introduce losses into the tuned circuits.
10. Solder all antenna connections and use good insulation.
11. Keep the aerial clear of all objects.
12. Make a good ground connection to a water pipe or metal buried in the ground.
13. *Use tuned circuits with large inductance and small capacity.*
14. Use a short aerial, well insulated.
15. Use regeneration in the detector stage when properly controlled and when at least one radio-frequency stage precedes the detector (this is advisable, since the set will cause interference in the neighborhood if the regenerative detector is coupled dirctly to the antenna).

There are three main classifications of causes of lack of selectivity in a receiver. The first is excessive resistance in the tuned circuits and in the antenna. The second class includes mistakes in coupling between any of the circuits in the set; loose coupling should be employed wherever possible in tuned-radio-frequency circuits. The third class includes faulty relationship between the inductance and the capacity of the tuned circuits. As a rule, the inductance should be very great in comparison with the capacity of the tuning condensers. Increasing the ratio of inductance to capacity will often improve both the selectivity and the sensitivity at the same time.

Induction From Telephone Lines

(242) Anton Schleck, Bridgeport, Conn., writes:

Q. 1. For the past year the writer has been listening to various telephone conversations, by means of a radio receiving set; conversations between people in this city on the ordinary telephone line. The other night, while listening to a radio station, a loud dialogue broke in on the concert and assumed such a volume that the radio program was almost drowned out. The antenna and ground are not very near the telephones and I cannot understand how this can happen. I would be glad if you could give me an explanation of this phenomenon.

A. 1. This is a plain case of induction. The telephone wires produce an electromagnetic field around them, which varies in intensity just as the voice currents travelling over the wires vary. Your antenna is probably within the range of these fields and a feeble current is either induced in it or directly into the input of the audio-frequency amplifier. Such an occurrence happens quite often and we receive many of these letters on this particular subject. The cause is ordinary electromagnetic induction, the same thing that causes the transfer of energy between the primary and secondary coils in your receiver.

Diaphragm Vibration

(243) R. A. Rounsavell, Humboldt, Kansas, asks:

Q. 1. Can you tell me how it is possible for a telephone receiver diaphragm to reproduce so many different vibrations simultaneously?

A. 1. In the first place, the diaphragm of a telephone receiver or radio loud speaker is a very imperfect device and in any case, only a partial vibration is produced when more than one frequency is impressed upon the diaphragm. For example, if two sound waves are picked up by a microphone and the resulting currents of say 500 to 1,000 cycles frequency per second are impressed upon the windings of a loud speaker, then manifestly it is impossible for the diaphragm to produce both of these frequencies at the same time. What the diaphragm does do is to make an attempt at the job of performing this dual function, and the result as heard by the ear is really a combination of the two notes; that is, the diaphragm vibrates at a mixed frequency, combining both the 500 and the 1,000 cycle note.

You could add as many more frequencies as you cared to the problem in question and the diphragm will give a resultant frequency or note which will contain a compromise between all of the frequencies impressed upon it. If you have ever studied the compound nature of musical notes, and chords, you will readily understand what happens in the case of a radio telephone receiver or loud speaker when more than one frequency is impressed upon it. Assume for instance, that a band is heard on a loud speaker. At a given moment you hear a certain pleasing chord made up of many different notes known as harmonics by the physicist. Every resultant note in music is made up of many partial notes or harmonics and the fundamental note. This is the one we finally hear. This is the case with the diaphragm as aforementioned; it will strike a happy medium between all of the frequncies impressed upon it and gives you the resultant note.

The diaphragm produces a wave form that conforms to the general contour of the high frequency amplitudes received. This is termed the modulation of the carrier wave, and it should be noted that it is achieved by a mechanical and not by an electrical process.

The receiver or speaker unit is one of the most delicate instruments of the whole radio set and it should not be handled freely or abused. A study of its construction brings one to realize that it should always be most carefully handled and protected against jars and shocks of all kinds, no matter how slight. Shocks are the greatest enemies of permanent magnets and nothing will cause them to lose their magnetic properties faster.

Trolley Car Interference

(244) The Ipswich Wireless Company, Ipswich, England, writes:

Q. 1. We would be grateful if you could inform us of any single instance where overhead trolley interferences have been minimized to such an extent that they warranted the expense entailed by using condensers, etc.

A. 1. Overhead trolley intereference is a difficult matter to eleminate satisfactory, as it calls for choke-condenser interference filters on each separate motor of each trolley car, both the driving motors and air compressor motors, if there are any. These arrangements have to be capable of carrying a good deal of current if chokes are used which means large wire, but sometimes condensers alone are sufficient.

If the trolley company is sincerely willing to go to some expense, fixed condensers of proper voltage rating should be placed in series across the leads to the motors, two being used on each motor with the mid-tap grounded. This will probably assist considerably, although it would be better still to put air-core chokes on each side of the line leading to the motor as well, consisting of 150 to 250 turns of wire of the proper size to carry the current, wound on an insulated tube.

The most difficult thing to take care of is the sparking at the trolley wheel. By fitting three trolley wheels on the end of a trolley pole, following each other, this sparking can be considerably reduced and a further improvement might be effected by grounding the trolley wire, through fixed condensers at each pole, in the neighborhood of worst interference.

Measuring Dielectric Strength

(245) Ralph Quinn, Cogswell, No. Dakota, writes:

Q. 1. Will you kindly give me a simple method of testing dielectric materials for breakdown value.

A. 1. One method which can be easily employed is to machine two recesses, spherical segments, on opposite faces of a sheet of the dielectric. These two recesses should have the same radius of curvature as two spherical electrodes which will be used in the test. It is essential to eliminate the air film between the dielectric and the electrodes.

The two spherical electrodes are supported from an insulated framework and clamped rigidly, so as to press tightly into the recesses on the sheet of dielectric material under test. The test itself may be carried out in air or in oil, and if the latter is used, the whole specimen, as well as the electrodes, should be submerged in good insulating oil. Without the oil, flashover on the surface of the dielectric frequently occurs, unless the specimen is rather large.

In making the test, the two electrodes should be connected to the secondary of a step-up transformer which should have a rating of 1 KVA (1KVA = 1 kilo-volt-ampere). A larger one can, of course, be used if available, but for stability, a rating of not less than 1 KVA is recommended. A resistance connected in the supply circuit will serve to regulate the voltage fed to the primary. In order to measure the voltage across the specimen under test, when breakdown occurs, it is preferable to connect a high voltage electrostatic voltmeter directly across the specimen.

Another way is to connect an adjustable air gap across the specimen, making use of spark electrodes of known form, as needle points or spheres. The flashover voltages of spark gaps in air with electrodes of definite form are known, and a gap of this sort can be used in place of the voltmeter. With a calibrated spark gap, the gap is first set to a figure below the expected breakdown voltage and the transformer voltage raised until a spark jumps across the gap. The current is then turned off and the gap opened slightly and the test repeated. If this process is continued, a setting of the gap will be found where the discharge passes through the test piece instead of across the air.

Another way in which the calibration spark gap can be used is with an ordinary A.C. voltmeter connected across the primary of the transformer. The test is made on the dielectric specimen without the spark gap connected, and the primary voltage is raised until breakdown occurs. At the moment of breakdown, a reading should be taken on the meter. The specimen may then be removed and replaced by the spark gap and a series of readings taken with different settings of the gap, until the high-tension voltage corresponds with the reading of the voltmeter. This gives the breakdown voltage of the dielectric.

For most purposes the high-tension voltmeter and spark gap can be discarded and the primary voltmeter reading taken as the measure of secondary voltage when the ratio of the transformer is known.

This method is of course subject to corrections, but for breakdown tests of this nature these corrections can be neglected. When testing thin materials, such as paper and mica, the spherical electrodes are not suitable and it is much better to employ flat-plate electrodes. A book containing further information on the testing of dielectrics and condensers is entitled "Electrical Condensers," and if you are at all interested in this subject, we would suggest that you obtain a copy.

Noisy Batteries

(246) Raymond J. King, Lincoln, Neb., asks:

Q. 1. Is it possible for a dry "B" battery to cause noises in a radio receiving set?

A. 1. This is sometimes possible and is more often noticed in cheaper types of batteries than in those of standard well-known manufacture. Some authorities claim that it is impossible for a dry "B" battery to cause noises in a radio receiving set due to any intermittent or interrupted chemical action that may take place within the cells. It is, however, very true that a mechanically poor connection may exist within a "B" battery due to insecure soldering and then this joint causes fluctuations of the current which, of course, will give rise to disturbing noises in the reproducing element. This, however, is a rather rare case, but must be taken into consideration.

Vacuum-Tube Voltmeter

(247) Mr. A. J. Stewart, Richmond, Va., asks:

Q. 1. Can you explain the use and construction of a vacuum-tube voltmeter. I have noticed quite a number of references to this instrument in recent magazines and technical books. I also believe that it is possible to use a milliammeter with a resistance in series to make a direct-current voltmeter. Can you explain how this is done, if possible?

A. 1. The vacuum-tube voltmeter is a very useful instrument, and finds wide use in an electrical laboratory. The simpler type is not at all difficult to make up, and

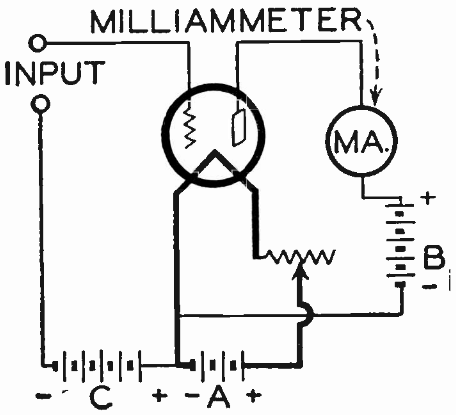


FIG. 247—Wiring diagram of the vacuum-tube voltmeter described in the accompanying article.

with it some interesting measurements can be made. For best results, it should be calibrated; but even without calibration it is still possible to make a number of measurements with it that will give a general indication of the comparative merits of various coils, amplifiers and other units.

The circuit diagram of a vacuum-tube voltmeter is shown above. See Fig. 247 The "B" battery voltage need not be more than 22½ volts and the indicating instrument in the plate circuit should be a D.C. milliammeter with a maximum-scale reading of not more than 1½ milliamperes. The "C" battery voltage should be adjusted until the meter reads about one-tenth of a milliampere when, the terminals at the input are short-circuited.

The tube is now operating on the lower bend of its characteristic curve, a condition similar to that under which a detector operates with the use of a "C" battery. Now if any voltage, whether direct or alternating, is impressed across the input terminals, the plate current will change. If a calibration is to be carried out, it is accomplished by impressing various known values of voltage across the input terminals, and reading the corresponding deflections of the milliammeter. Then, if the input terminals are connected across any unknown voltage, it is possible to determine the value of this voltage by noting the deflection of the plate milliammeter. The actual voltage is determined from the previously-made calibration curve.

As mentioned above, even though instruments are not available with which a calibration can be made, it is possible to make comparative tests. For instance, by placing the same input current on several amplifiers under test and then connecting the vacuum-type voltmeter across the outputs, comparative readings can be obtained. Obviously, the amplifier which produces the greatest deflection has the greatest amplification. When testing receivers for the amplification obtained, the "slide-back" method can be used. In this case, a potentiometer is connected across the "C" battery and the center terminal of the potentiometer is connected to the input terminal. In this way, if a head set is connected in the plate circuit, the potentiometer can be adjusted until the signal just fades out, and a comparison made as to the point on the potentiometer scale at which this occurs.

A Voltmeter from a Milliammeter

It is possible to make up a very useful and fairly accurate voltmeter, using a milliammeter and a good fixed resistor. Actually a voltmeter consists of a sensitive milliammeter in series with a high resistance. In calibrating, the meter, with the resistance in series, is placed across known voltage sources, and its scale marked off in volts instead of milliamperes. Suppose we have a meter with a full-scale reading of 2 milliamperes, and we want to use it as a voltmeter for use on power-supply devices which supply voltages up to 220. To determine the value of the resistance, necessary in series with the meter, we divide 200 by .002, and the quotient, 100,000, is the required resistance in ohms. If we place the milliammeter in series with a 100,000-ohm resistor across an unknown voltage, the needle will deflect over an angle proportional to the voltage. We have made a voltmeter in which the meter reads 2 milliamperes when the voltage is 200. Then, if the meter reads 1½ milliamperes, the voltage is 150; and, if the meter reads 1 milliampere, the voltage is 100. This calculation may be carried on throughout the complete scale.

It is not always possible to obtain accurate resistance units; so that it is in general, wise to calibrate the voltmeter to allow for errors in the fixed resistor. The calibration is accomplished by placing the fixed resistor and meter across the different known voltages, and plotting a curve showing the deflection of the meter for different voltage values. If no voltmeter is available so that comparative readings may be made, a new "B" battery can be used, since the voltage of a new battery is fairly accurate. Readings should be taken at 22½, 45, etc. It will not be necessary to calibrate the full scale of the meter, since the calibration curve will be a straight line. The graph should be made on ordinary square graph paper, with the milliampere readings across the bottom in units of one, and the voltage readings on the vertical side in units of 100.

The simple caluculations above disregard the slight resistance of the milliammeter but, unless extreme accuracy is necessary, the results obtained will be sufficiently close.

Methods of Volume Control

(248) Mr. Steve Briggs, Rochester, N. Y., writes:

Q. 1. Please explain fully the respective merits of the different methods of controlling receiver volume by means of variable resistors.

A. 1. The method by which volume is to be controlled in a radio receiver deserves considerable amount of attention. When listening to a local station it will be usually found necessary to utilize this control on the receiver to reduce the signal somewhat, so that the reproduced program will not be too loud. Therefore, the method used should be one which will regulate the volume without affecting the performance of the receiver in any way.

We may define the ideal volume control as one which will control the volume output of a receiver without affecting in any manner the receiver's selectivity or fidelity of reproduction. Few of the methods usually adopted measure up to this standard; but there are several which are quite satisfactory. In the following paragraphs we will indicate the characteristics of the various types; so that the reader will be able to determine, by examining his receiver, whether that employed is really the most satisfactory one.

To make our discussion systematic, we will begin by dividing volume controls into two broad classes, according to their positions in the circuit. The first group will include all the methods whereby the volume is controlled by some device in the radio-frequency circuit. The second group includes all controls that function in the audio-frequency circuits.

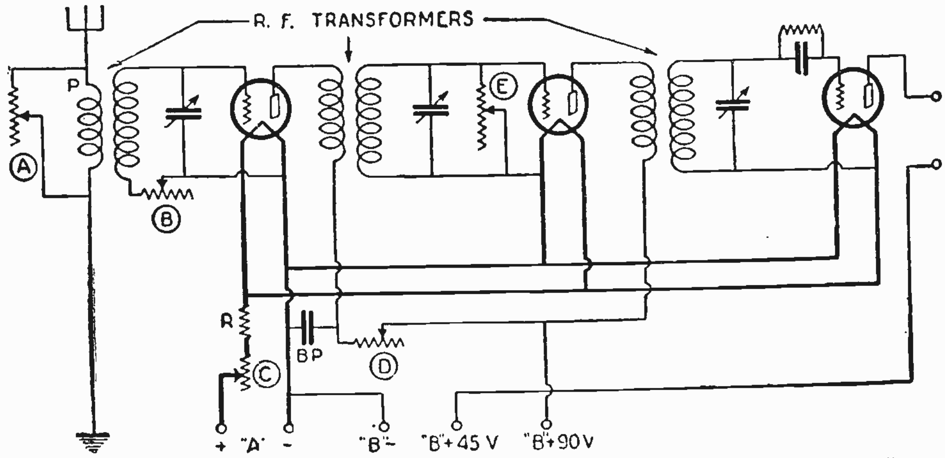


FIG. 248-A—Five different methods of controlling the volume are indicated by letters in this diagram of an R.F. amplifier and non-regenerative detector.

Methods in the R.F. Amplifier

In Fig. 248-A is shown a conventional circuit consisting of two stages of tuned-radio-frequency amplification, followed by a non-regenerative detector. In this single circuit we have indicated five volume controls, as follows:

(A) A variable resistor across the primary coil (P) of the antenna coupler.

(B) A variable resistor in series with a tuned circuit.

(C) The filament rheostat.

(D) A variable resistor in series with the "B+" lead to the R.F. tubes.

(E) A variable resistor across a tuned circuit.

Method A, utilizing a variable resistor of about 200,000 ohms connected across the antenna coil, is generally quite satisfactory. However, if the receiver is unshielded and is being operated close to one or more broadcast stations, it is possible that the coils themselves will pick up quite some energy; and therefore the output of the receiver will not be zero even when the volume control is set for zero resistance. This is a distinct disadvantage, for the control is not effective on those stations (powerful nearby locals) where it is most essential. This type of volume control is not recommended unless the receiver is shielded so that there is no coil pick-up, or unless the receiver is being operated at a point sufficiently distant from the nearest broadcast transmitter so that there is negligible pick-up by the coils. You can determine whether this effect will be bothersome by disconnecting aerial and ground and tuning the set to receive the station whose signals are normally the loudest. Under these conditions a good healthy signal indicates that there is coil pick-up, and volume-control method A should not be used.

A resistor in series with one of the tuned circuits, as indicated at B in Fig. 248-A, is frequently an effective means of controlling volume where the selectivity problem is not severe. When resistance is introduced into a tuned circuit the selectivity of the circuit is seriously reduced, and it is possible that interference will be experienced between stations operating on adjacent channels.

Regulating "A" and "B" Voltages

A rheostat controlling the R.F. tube filaments (C, Fig. 248-A) is frequently used as a volume control and really proves very satisfactory, except, of course, with A.C.-filament tubes. As the filament current is reduced, the emission from the filament is decreased and the resultant increase in the plate impedance of the tube causes the amplification to decrease; the signal finally reaching the detector is thereby reduced. It is a good idea, when such a control is used, to place a fixed filament resistor R (Fig. 248-A) in series with the volume-control rheostat. This resistor protects the tubes from an overload of filament voltage for then, even with the rheostat resistance all out, the filament voltage is limited to the correct value for the tube.

Since this control functions by limiting the emission current, thereby increasing the plate impedance of the tube, it follows that it must produce *some* distortion. By experience, however, we know that the distortion created is not generally noticeable and the method can therefore be considered a good one.

At D in Fig. 248-A we have indicated another volume control arrangement which functions by lowering the amplification in the R.F. amplifier through a reduction of the plate voltage. When this type of control is used, a by-pass condenser (BP) should always be connected from "A—" to that side of the variable resistor or leading to the primary of the R.F. transformer. The condenser should have a value of .005-mf. or more.

Method E, utilizing a variable resistor across a tuned circuit, falls into the same class as method B. A resistance of given value *across* a tuned ciruit is equivalent to a smaller resistance connected *in series* with the tuned circuit. Methods B and E therefore fall heir to the same objections and neither of them can be considered a really satisfactory method of volume control. This completes our story on volume controls functioning in the R.F. portion of a receiver. The various controls listed are grouped in the table; you will find listed there the major facts concerning each method.

In A.F. Circuits

We now come to the method of controlling the volume by means of some adjustment in the audio amplifier of a receiver. First, let us consider a two-stage, transformer-coupled amplifier (see Fig. 248-B). Here we have indicated three controls, F, G and H. Methods F and G are really similar; a very high resistance across the secondary of a transformer being equivalent to a lower resistance across the primary. The method used is optional, the major difference being that a variable resistor across the *primary* for volume control should have a maximum value of about 100,000 ohms, and a resistor across the *secondary* should have a value of about 500,000 ohms. Method H is not satisfactory, except in special cases; as. for example, when the receiver is located some distance from the loud speaker.

Volume control in a resistance, or impedance-coupled amplifier can easily be accomplished by using a high-resistance potentiometer (Fig. 248-C, A) or by simply using a variable high resistor for the grid leak (Fig. 248-C, B). The method indicated at A is somewhat preferable.

Socket-Power Devices

(249) Mr. Harvey Sanderson, Buffalo, N. Y., asks:

Q. 1. Will you please explain the action of "B" socket-power devices and discuss the necessary components of such apparatus:

A. 1. If an investigation were made, of the various steps which have been taken

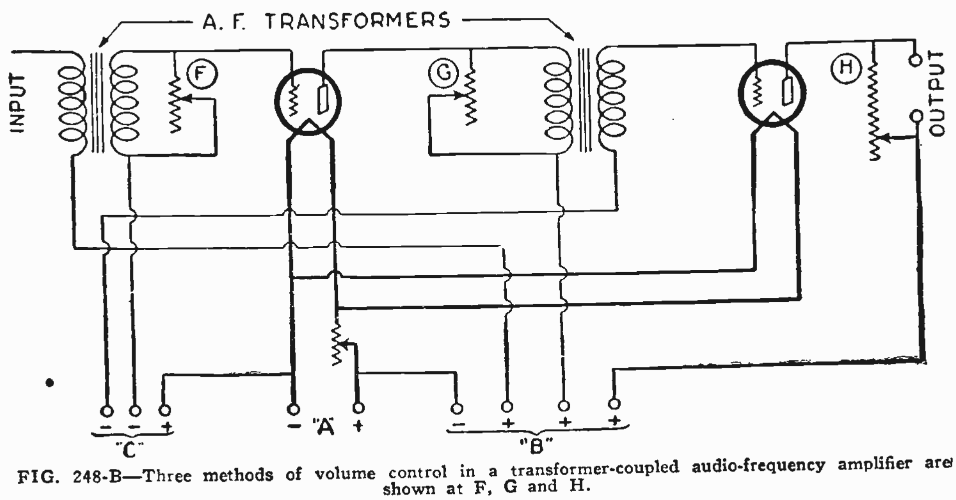


FIG. 248-B—Three methods of volume control in a transformer-coupled audio-frequency amplifier are shown at F, G and H.

in the progress and development of radio receiving sets, an interesting story would unfold itself. Even our now-commonplace "B" battery has behind it some interesting history which, to the majority of broadcast listeners, is unknown.

Toward the end of the crystal-detector era, when attention was turning to the de Forest bulb and the audiotron, there was no such unit as a 22½- or a 45-volt "B" battery. A set-builder who was so bold as to employ one of these new-fangled tubes relied chiefly on a bank of 4½-volt flashlight cells for his plate supply. Today we have quite efficient heavy-duty "B" batteries; but still the quest goes on for something in the line of "B" power-supply devices with which to obtain "B" potential for the tubes in a radio receiver, via the light socket.

The last few years have seen great strides of progress in the "B" socket-power field. In fact, the advance has been so rapid as to leave the majority of listeners-in without an understanding of the principles embodied in these devices; with the result that unscrupulous manufacturers and dealers have unloaded on an unsuspecting public a great deal of worthless and useless junk labeled as "B" power-supply apparatus. It is the aim of this article to acquaint our readers with a simple, non-technical explanation of the function of the component parts of a representative "B" power-supply device.

The House Current

If our houses were powered with direct current, of say, 180 or 220 volts, there would probably be no need for any more complicated device than a smoothing or filter device and a voltage divider; so that various lower values of voltage might be obtained in addition to the voltage value of the house supply. However, in only a few sections of the country is direct current available, and then it is usually not of sufficient voltage to be useful as a "B"-battery substitute. Alternating current is decidedly cheaper to distribute than direct; but with alternating current we encounter a number of conditions which make its ultimate using for powering a receiver somewhat complicated.

The voltage that is supplied to the plates of radio vacuum tubes must be of a direct-current nature, be steady in value, and free of pulsations that produce hum. Alternating current is usually considered as steady in value, not fluctuating appreciably; but it is not of direct-current nature and it does produce considerable hum. Therefore, in utilizing alternating current for a "B" substitute, a number of electrical changes must take place before it is satisfactory for use.

In the first place, the line-voltage of a house supply is usually too low for imme-

Table of Recommended Resistance Values for Volume Controls

See Fig	*Position of Resistor*	*Average Value in Ohms (Maximum)*	*Characteristics*
(1 A)	Across antenna coil	200,000	Very good, except for an unshielded receiver in a congested broadcast area.
(1 B)	In tuned R.F. circuit	400	Decreases selectivity.
(1 C)	Filament rheostat	†	Very good.
(1 D)	In series with R.F. "B+" lead	200,000	Satisfactory with most types of receiver.
(1 E)	Across tuned R.F. circuit	200,000	Decreases selectivity.
(2 F)	Across A.F.T. primary	100,000	These methods are generally less satisfactory, as they permit the detector and A.F. amplifier to be overloaded by strong signals, with consequent distortion.
(2 G)	Across A.F.T. secondary	500,000	
(3 A)	*Potentiometer-grid leak	500,000	
(3 B)	*Variable grid leak	1,000,000	
(2 H)	Across loud speaker	25,000	

*In resistance-capacity-coupled A.F. amplifier.

†Depends on number and types of tuebs.

diate use. When a receiver employs a power tube of the 171 variety, at least 180-volt "B" potential is desirable and a 40.5-volt "C" battery is employed. To obtain both the "B" and "C" voltages from a "B" power-supply device is not difficult; yet immediately we see that at the output of the device at least 220 volts are required. Since this is just double the value of the line or

Smoothing Out the Current

Rectifiers may roughly be divided into three classes: chemical, gaseous and thermionic. While they operate somewhat differently, they produce the same general results, and have the same purpose; that is, they pass current in one direction only, thereby changing an applied A.C. to a

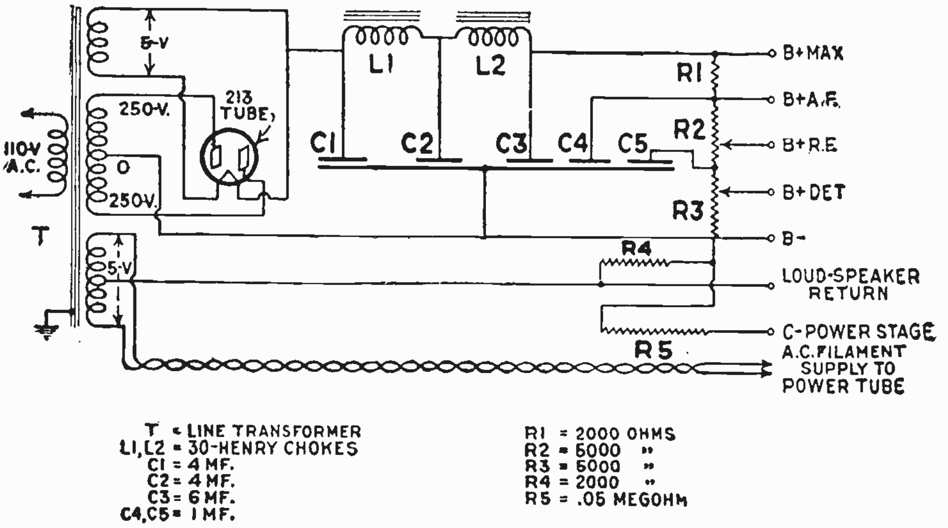


FIG. 249-A—In this schematic diagram we have indicated the use of a thermionic rectifier tube for converting the A.C. to pulsating D.C. Appropriate circuit constants are given.

house voltage, a transformer unit is employey to "step up" this line voltage. Engineers can, by calculation, determine the electrical and physical dimensions of a transformer that will step up the line voltage to a predetermined value. Now, one step of progress has been made toward the ultimate goal, that of changing the low-value alternating-current to a higher value, suitable for use as "B" supply. Yet, even in its stepped-up state, the alternating current is not immediately suitable for use. It is necessary to change the A.C. to D.C., this operation being accomplished by a "rectifier" unit.

pulsating D.C. While rectifiers generally take the form of one of the three types mentioned, it is possible that any of these three may be of the "full-wave" or the "half-wave" type of rectifier. In the half-wave rectifier only half of the alternating-current impulses is used.

In the full-wave type of rectifier tube, the elements are so arranged within the tube as to utilize that half of the wave unemployed in the half-wave type of tube; with the result that the number of pulsations in the resulting direct current is doubled; thus making the job of "filtering" not so difficult.

Still, this pulsating direct current is not ready for use. The pulsations would produce a disagreeable hum in the loud speaker; so it is necessary to smooth them out. The unit used for this purpose is called a "filter" and consists of large choke coils and large fixed condensers. The choke coils have the property of retarding the flow of alternating or pulsating current, but quite readily pass direct current; while the condensers act as a storage tank or reservoir, so that the current may build up to a usable value and not immediately dissipate itself, as would be the case if these condensers were not included in the circuit. The action of the filter unit might very well be likened to a tank, which receives at its top a series of charges of water from a pump. The tank stores up these periodic charges and then, through an outlet at its bottom, discharges the water in a strong, steady stream.

Three of the four necessary steps have now been described. That is, the original 110-volt alternating current has been stepped-up, it has been rectified or changed to a pulsating direct current, and finally it has had these pulsations eliminated or

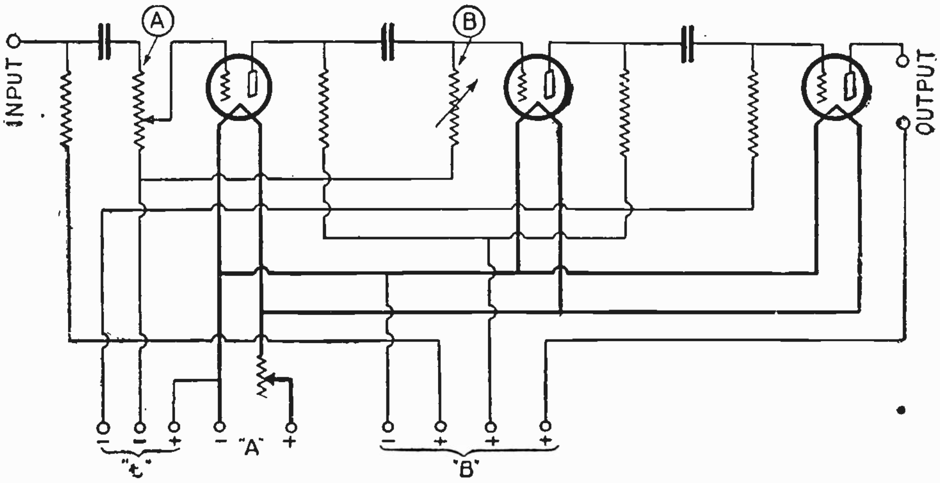


FIG. 248-C—Two ways of controlling the output volume of a resistance-coupled amplifier. A—potentiometer-type grid leak; B—straight variable grid leak.

ironed out by means of a filter system; leaving only pure, non-pulsating direct current of the correct voltage value.

Dividing the Voltages

Now if only one value of "B" voltage were required by a receiver, the job would end here; but the various tubes in a re-receiver require different values. For instance, the radio-frequency amplifier tubes may require 67 or 90 volts; the detector may operate most satisfactorily at 45 or 67 volts; the first audio amplifier may take 90 volts and the final or power stage may require 135 or 180 volts—depending on whether a 112 or a 171 type of tube is employed here. Therefore, it becomes necessary to utilize the maximum output of the "B" power-supply device in order to make possible the use of these intermediate values of voltage. This is best accomplished by means of a series of fixed or variable resistors located in the circuit, directly across the output terminals of the filter section.

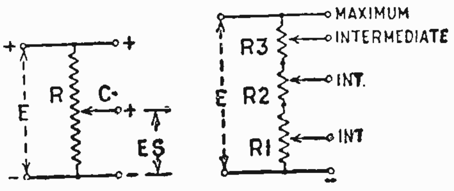


FIG. 249-B—These two diagrams illustrate how different voltages are obtained from the maximum output of the rectifier.

It is one of the laws of electricity that, if a resistance R be placed across a source of voltage, E, as in Fig. 249-B, any intermediate value of voltage (Es) can be obtained. This will vary from zero to maximum volts, depending upon the position of the movable contact arm C; it will be least when this arm is brought nearest to the negative side of the output. This "potentiometer" principle is applied in the "voltage-divider" units employed in "B" power-supply devices; with the addition that, not alone one contact arm, but as many as there are intermediate voltages required are used. Usually the resistance does not consist of one unit but of several individual units, as shown in the second half of Fig. 249-B.

Things to See To

To recapitulate: there are a number of requirements which the several units comprising a "B" power-supply device must possess. In the matter of the transformer, one should be selected that is well made, mechanically, and has sufficient windings, not only for the "B" supply, but also for the rectifier tube (should the latter be of the filament type), and for the filament of the power amplifier tube.

The rectifier tube should have a guaranteed life of 1,000 hours or more; it should have the proper current rating in milliamperes to insure its suitability for use with the other appartus employed. Nowadays it is possible to purchase rectifier tubes which are entirely satisfactory for use in "B" power-supply devices and have current ratings ranging from 85 milliamperes to 300 and 400 milliamperes; the latter type is suitable for "A" or filament-current supply.

In the filter unit, caution must be exercised in choosing the condensers and chokes which go to make up this very important part o fthe complete device. The chokes should have a sufficient current-carrying rating, in excess of what will ultimately be drawn from the "B" device, so that at no time is its carrying peak reached. When the current rating of a choke is exceeded it rapidly decreases an inductance value, and does not then measure up to the requirements of a satisfactory choke.

High operating-voltage rating of the filter condensers is essential to the successful operation of a "B" power-supply device. Here again, as with every part of the device, reliable apparatus should be employed. A rating of 600 volts, D.C., for the condenser nearest the rectifier part of the circuit is not too great, and lower operating-voltage values for this particular condenser should be avoided. The condensers in the remainder of the filter circuit may be of the 400-volt rating.

In the voltage divider, we are presented with the problem of selecting resistance units that are constructed in such a manner that they will not only carry the maximum current under full load but also dissipate the heat generated by the passage of the current through them. There are a number of types of resistor now obtainable, which fall generally into two classes: (1) the wire-wound type; and (2) the carbon-compression type.

In summarizing, we find that all A.C. "B" power-supply devices can be analyzed as follows: first, there is a transformer which steps up the line voltage to a value in excess of what will ultimately be employed at the output (this high starting voltage is necessary because of voltage "drops" in the rectifier and filter systems); secondly, there must be a rectifier, of either the half- or full-wave type, which converts or changes the stepped-up alternating current into pulsating direct current; thirdly, there is a filter system which smooths out the pulsations and acts as a storage tank or reservoir; and fouorth, there is a voltage-divider system wherein the use of variable or tapped resistors makes available intermediate values of output voltage, satisfactory for application to the plate of the different tubes in a radio receiver.

In Figs. 249-A and C are shown representative "B" power-supply circuits, employing the thermionic and gaseous type of rectifiers.

Peridyne Data

(250) Mr. Chas. Krayner, St. Louis, Mo., writes:

Q. 1. Will you kindly help me with my Peridyne Five, which I constructed according to design and instructions? I used the specified parts except for the audio transformers, sockets and oscillation control. I have been reading the letters of Peridyne builders and the results they have obtained with their sets.

I am sure that my receiver is not working correctly. My desire is to correct it as follows: First, when the local stations are on the air, I cannot separate them. Each station requires 10 to 15 degrees on the dial. Secondly, there are a number of whistles indicating distant stations, but it is impossible to clear them up so that the stations can be heard. I am using a storage "B" battery for the plate supply and an outside aerial about 75 feet in length. I constructed the coils and shields exactly to your specifications and I am sure that they are satisfactory.

A 1. Because some Peridyne constructors are having trouble with their sets, we are giving a list of suggestions to overcome all of the difficulties which might be encountered with the popular receiver. We are sure that you will be able to clear your own trouble with the aid of these suggestions.

Broad Tuning

This may be caused by the use of too long an aerial or one which is not insulated very carefully. Use an aerial between 75 and 100 feet in length. This will give the correct amount of selectivity and sufficient signal pick-up so that you can receive both local and distant stations. Also, make sure that the ground connection is a good one; the use of a poor ground will greatly reduce the volume and selectivity of any set.

The main cause of broad tuning in the Peridyne receiver is lack of circuit resonance. You must match the radio-frequency stages within five per cent, so that the Peridyne plates can then bring the set into exact resonance. To do this you must have the coils matched very closely—within about three per cent—before they are placed inside the shields.

You can match the coils by using them with a crystal detector as a small crystal receiver. Connect the small winding or primary of the first coil to the aerial and ground. If your local stations are very close by, place a small fixed condenser of about .00025-mf. in series with the aerial wire. This will reduce the volume slightly and increase the sharpness of tuning considerably. Then connect the Carborundum detector or other crystal detector to one of the wires from the larger or secondary coil. The other terminal on the crystal is connected to a pair of phones and the phones are in turn connected to the other side of the secondary.

You may have to connect a .001-mf. fixed condenser across the two wires to the head

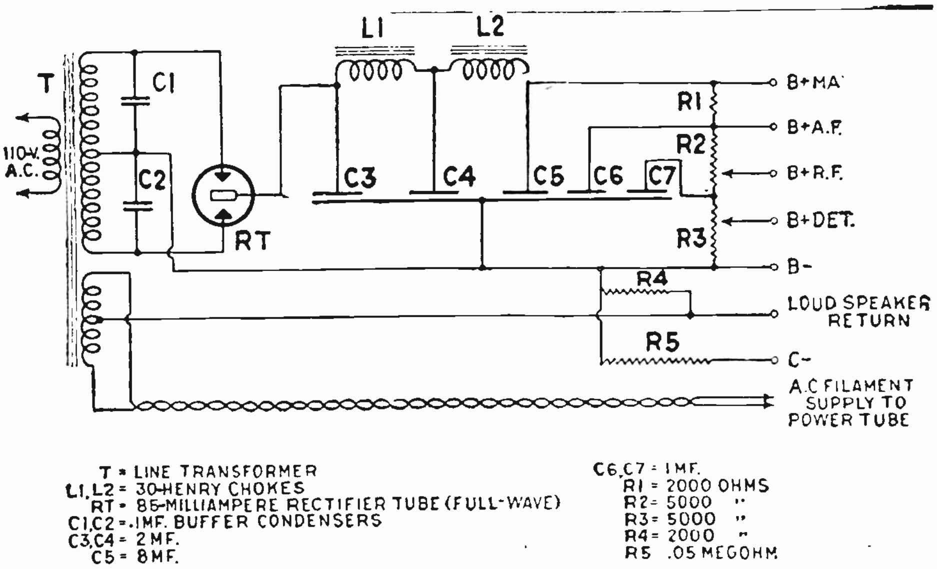


FIG. 249-C—A gaseous tube, RT, is the rectifier used in this "B" socket-power unit. Appropriate values for all parts are given.

phones in order to hear the radio signals. One section of the gang condenser should be connected across the secondary coil, to time it.

Tune in a local station to the maximum volume. If the tuning is not very sharp, use the small fixed condenser in the aerial wire, as explained above; or, if one is being used already, try a smaller one. After you tune in a station sharply, disconnect the first coil and try the other two in turn. If they are matched correctly you will not have to readjust the variable condenser. If you find that the signals with one coil are stronger when the variable condenser is turned higher (with the plates further in mesh), remove a small amount of wire from the secondary until the signal comes in strongest with the condenser set at the exact position required for the other coils. Add wire to the secondary if the condenser setting is lower than that required for the other coils.

After the set is assembled, you should match the tuned circuits again. This time, remove the first radio-frequency tube from its socket and bridge the crystal circuit across the secondary winding of the first R.F. transformer. The shields should be in place with the adjustable plates at the highest point, when balancing in this case. Note the exact position of the gang condenser for a local station. Then remove the aerial and ground wires from their binding posts and connect them (temporarily, by means of clips) to the primary of the second radio-frequency transformer, and repeat the foregoing test with the crystal across the second transformer, of course. Repeat with the third transformer. If the condenser readings do not match exactly, add or remove wire from the secondary windings, as advised in the previous paragraph.

Use a triple condenser in which each section has exactly the same capacity as the other sections on each part of the scale. The specified condenser was equipped with small condensers to adjust each section of the condenser individually. If one of the tuned circuits has a higher reading than the others for a local station, separate the wiring further or reduce the number of turns on the secondary coil slightly until the signal is loudest when the condenser is tuned to exactly the same point required for the other coils. When the circuits are all in resonance, a very slight fraction of a turn on the Peridyne plates will change the operation of the circuit.

Broadness of tuning might also be caused by too close coupling between the primary and the secondary coils. When constructing the coils for this set, keep the spacing between the turns of wire on the secondary coil very accurate. If the spacing between the turns of wire on the different coils is not exactly the same, the capacity between the turns of wire will be different, and this will be sufficient to change the tuning characteristics of the coils. When building them, follow the instructions given in the December issue of *Radio News*, both for winding the secondary coils and for placing the primaries in the correct position in reference to the secondaries.

You will notice this to some extent by broadening of the tuning. The radio-frequency circuits will oscillate violently when perfect resonance is reached, although this action is under perfect control by varying resistor R3 in the set. This resistor must have the correct value, 0-100,000 ohms.

Improper wiring might also cause broad tuning, since it might introduce interactions between the circuits, which should be kept entirely separate. Follow the exact layout specified and wire the apparatus according to the instructions given in the constructional article and in the picture diagrams. The final cause of broad tuning is improper adjustment of the shield plates. If the plates are too close to the coils, losses will be introduced which will be sufficient to dampen the circuits.

If the dial reading for one of the coils is lower than the other two, this coil can be brought to resonance by moving it a little to one side of the center of the shield. This will increase the capacity between the wire in the coil and the wall of the shield and will increase the tuning range of the coil. Fig. 250-A, indicates this effect. Notice that a capacity exists between the side of the coil and the shield, and when the coil is moved closer to the wall of the shield, this capacity is increased. This also shows why the coils must be centered very carefully in the shields after they have been matched previously.

Volume and Sensitivity

If the set does not have the "pep" that is is expected from it, the trouble is due to poor tubes, too high a "B" voltage on the plates of some or all of the tubes, incorrect "C" bias, lack of circuit resonance, defective parts or the incorrect placement of the crystal detector. If the tubes are suspected, the only thing to do is to try new ones. However, first check the plate and grid voltages on the tubes in order to be sure that these values are correct. The lack of circuit resonance can be overcome as explained previously.

Distortion

This is usually due to the first (detector coupled) audio-frequency tube being overloaded. If a 201A tube is used in this socket, the plate voltage should never exceed 22½ volts. The results can often be improved by reducing this value.

A 112A tube can be used in this position with slightly better results and the "B" voltage may be increased. In this case, however, it may be necessary to insert a "C" battery between the negative filament side of the last radio-frequency transformer and the negative "A" battery terminal. The value of this "C" battery depends upon the plate voltage, but a value of 1½ to 3 volts will usually be sufficient. The negative terminal of the battery should be connected to the secondary terminal of the coil and the positive terminal of the battery should be connected to the negative filament terminal. Connect a by-pass condenser of about 0.5 mf., across the "C" battery.

You must also adjust the filament rheostats very carefully. Distortion may arise from overloaded audio-frequency tubes in the other stages, or from poorly designed audio-frequency transformers. The choke coil and the by-pass condenser in the plate circuit of the first audio-frequency tube, if they are of the wrong value, will also cause distortion. Use the specified parts in these positions.

Interflex Detector

The Carborundum crystals used for detection do not all work equally well, and most of them will only work in one way. By reversing the position of the crystal, the volume and clarity can often be increased considerably. In order to obtain clear reception, in some cases, you may have to place a small by-pass condenser between the crystal and the negative "A" battery terminal on the tube socket. This condenser should be connected to the side of the crystal which is connected to the grid terminal on the tube socket. A small semi-variable condenser, between 20-mmf. and 500-mmf., can be employed for this purpose. By adjusting this condenser the required capacity can easly be obtained.

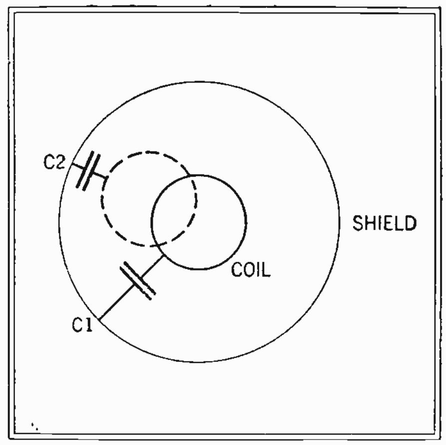


FIG. 250-A—The centering of the coils in the shields is very important. The change in the capacity between the coil and the shield when the former is off center is shown by C2. C1 is the normal capacity.

Wiring

The wiring in the Peridyne set is extremely important and you must do it very carefully. Considerable interaction can be prevented by separating the grid and plate leads as far as possible. The plate and "B" plus leads can be bunched together if desired. At the points where the grid and plate leads across, an angle as close to 90 degrees as possible should be used. All of the grid and plate leads should be as short as possible.

Coils and Condensers

The distance between the bottom of the R.F. transformers and the bottoms of the shields can vary between 1 inch and 1¼ inches with no great change in the efficiency, providing all of the coils are exactly the

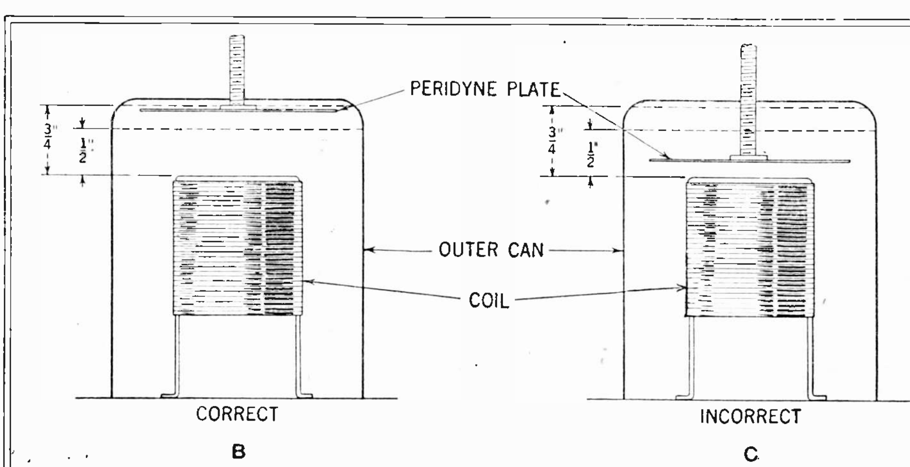


FIG. 250-B—To get the greatest efficiency from the Peridyne 5, the adjustable plates must be in the correct relation to the coils. If they are closer than ½-inch, the results will be poor.

same distance from the bottoms. You must place the coils in the exact center of the shields (when looking from the top), so that the capacity between the coils and shields will be the same in each case. This position can be changed slightly, if necessary, as explained under "Broad Tuning."

If the circuits do not match within five per cent, you will not be able to get the correct balance, and the Peridyne plates will apparently have no effect on the operation of the set. This is due to the fact that the capacity between the Peridyne plate and the top of the coil has a very small value. It was found on test that the maximum capacity was approximately .000013-mf. when the Peridyne plate was touching the top of the coil, and the minimum capacity .00000775-mf. when the shield plate was as far away from the coil as possible.

Peridyne Shield Plate

The constructional article on the Peridyne receiver explained that when the Peridyne shields were used in other circuits, the shield plate should never be closer than one inch. The article also explained that because of the method of stabilizing used in the Peridyne, this value can be decreased to within one-half or three-quarters of an inch. (See Fig. 250-B.) Less than one-half of an inch will result in a considerable absorption of the current from coil, and as the distance is decreased, the efficiency of the circuit will fall off greatly. The normal position for the shield plate in the can is very close to the top, usually not more than 4 complete revolutions of the adjusting knob when the No. 32 screw is used. When the set is completely balanced, a quarter of a turn of the adjusting knob will be sufficient to throw the coil in and out of resonance.

A.C. Volume Control

(251) Mr. W. O. Pearce, Bayonne, N. J., writes:

Q. 1. In constructing an A.C. set, I am encountering difficulty in knowing just how to control the volume. The usual filament control method is, of course, out of the question because of the sluggish operation of the filaments in A.C. receivers. Can you help me out in this matter?

A. 1. The tube manufacturers suggest a system which is a very convenient and satisfactory one. It consists of a potentiometer connected in the aerial circuit, according to Fig. 251, A or B. In the first case, a potentiometer of about 3,000 or 4,000 ohms resistance, with the slider connected to the grid circuit and the two outer terminals to the aerial and ground, is employed. This method is usually used when a new set is being constructed. It eliminates one of the tuning controls. The other method makes use of a potentiometer with a resistance of about 25,000 ohms. The slider in this case is connected to the primary of the antenna coupling coil, while the two outer terminals are connected to the aerial and ground. This method is more suitable for equipping an existing receiver.

There are several other methods which are satisfactory for controlling the volume of sets of this type, including the use of a 50,000 ohm variable resistor connected across the secondary of one o fthe radio-frequency transformers, and the use of a high resistor in series with the positive "B" battery terminal supplying current to the radio-frequency tubes. The last mentioned method, however, may cause trouble with hum.

A Short-Wave Superheterodyne

(252) Mr. C. O. Lorenz, San Antonio, Texas, writes:

Q. 1. Can I take an eight-tube Ultradyne receiver, remove the antenna coil and oscillator coil, and replace them with plug-in coils for short waves? Will the oscillator work correctly with these few turns and could the tickler coil in the modulator circuit be wound to cover all of the short-wave bands? If the Ultradyne circuit will not work correctly in this matter, will you give me the constructional details for a suitable short-wave superheterodyne, specifying the correct intermediate-frequency amplifier and giving the values of all the parts used?

A. 1. We do not believe that the model L-2 Ultradyne would be satisfactory for receiving short waves, since the values of the tuning condensers, both in the aerial and oscillator circuits, would have to be changed; and we doubt if the oscillator would operate correctly on the very short wavelengths. The .0005-mf. tuning condensers employed in this set have too great a minimum capacity to be used successfully with a short-wave set, and this would necessitate removing them and replacing them with .00015- or .00025-mf. condensers. On the broadcast band, the set would not operate satisfactorily with these smaller condensers.

We are printing the diagram and specifications for a short-wave superheterodyne which will work very efficiently on wavelengths up to about 150 meters. The set was constructed by the writer with a second oscillator coupled as shown to the last I.F. transformer. This can be used to receive continuous wave code signals. The set employs four tubes in the radio-frequency section, which would make a total of six tubes in the complete receiver. Three or four stages of intermediate frequency amplification may be used instead of the two specified, thereby increasing the radio-frequency amplification and also the sensitivity.

This short-wave superheterodyne consists of a short-wave regenerative detector circuit of the usual type, coupled to an intermediate-frequency amplifier operating on a rather low frequency. When dealing with waves below 125 or 150 meters, the detuning to an incoming signal offered by an oscillating detector is not sufficiently great to cause any appreciable loss in signal strength. For this reason, we can make the first detector self-hetrodyning. In this way, it can be made to furnish the intermediate frequency, by beating on the incoming signal. This arrangement is similar to that used in the usual superheterodyne, except that with the latter a separate oscillator is used.

In Fig. 252, A, the coils L, L1 and L2 are the primary, secondary and tickler respectively of the input circuit; they can be almost any form of coil designed for short-wave work. The tuning condenser C1 has a capacity of .00015-mf., and the regeneration control C2 a value of .00025-mf. The radio-frequency choke coil in the detector plaet lead is extremely important, and a very good one should be used.

As you will notice, the grid return of the detector is placed on the negative "A" battery terminal. It was found that this method gave more stable operation than the usual positive return, although both methods should be tried and the better one used. If you desire to make the radio-frequency choke coil, it can be wound on a one-half inch tube with approximately 150 turns of No. 30 to 36 double cotton covered wire.

Intermediate-Frequency Amplifier

The intermediate-frequency amplifier in this receiver is of the usual type, with two broadly tuned transformers and a rather sharply tuned filter. A potentiometer is used for controlling oscillation.

The filaments are controlled either by a rheostat or by automatic filament ballasts. The potentiometer should have a resistance of about 400 ohms, an ordinary 10-ohm rheostat will be satisfactory for controlling the filament current. The detector is coupled to the last I.F. transformer through a grid condenser and grid leak, C6, R2. The condenser C6 has a value of about .00025-mf.; the value of the grid leak depends upon the characteristics of the detector tube. A resistance of about 2 megohms will be suitable for most tubes.

The primary and secondary of the filter coupler are shunted by .005-mf. fixed condensers. These condensers must be matched closely in order to produce satisfactory results; it may be advisable to use semi-variable condensers so that the two circuits can be adjusted correctly. The filter coupler is wound on two separate spools, as shown in Fig. 252-B. Wooden discs two inches in diameter and three-quarters of an inch wide are used for the cores; the sides are fiber discs four inchs in diameter. The two spools are fastened together with a long brass screw and several nuts, as shown. By adjusting the distance between the two coils, the tuning can be made sharper or broader, as desired. Both the primary and secondary are wound with No. 32 D.C.C. wire and each contains 50 turns. The wire should be wound jumble fashion and not in layers.

The broadly tuned intermediate-frequency transformers are constructed with iron cores. A piece of three-quarter inch fiber tubing about ⅞ inch long is used to hold the core. Soft iron wire of about 24 gauge is packed into this tube until no more can be forced in. It is advisable to use enameled wire or to insulate the wires with shellac before placing them in the tube. The spools are made by forcing fiber discs 2 inches in diameter over the ¾ inch tube, as shown in diagram Fig. 252-C. The primary is wound with 2,500 turns of No. 36 enameled wire and the secondary with 2,600 turns of the same wire.

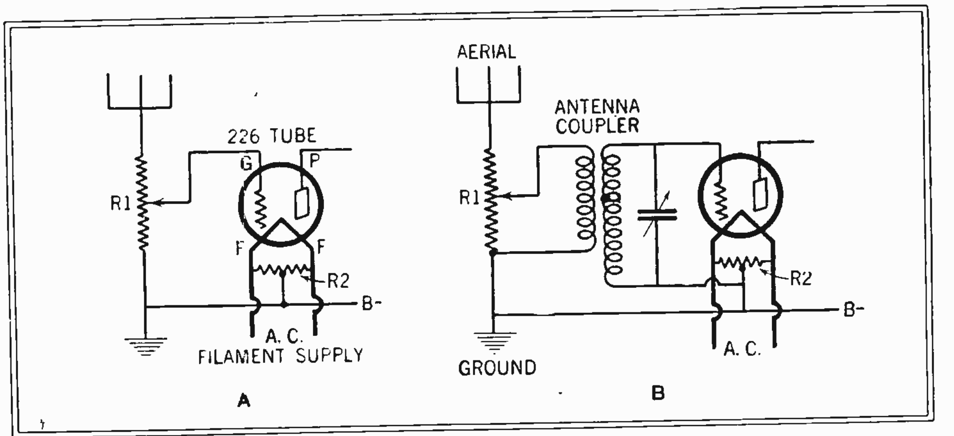


FIG. 251—Two methods of coupling the aerial of an A.C. receiver to the first tube are shown here. In A, the resistor, R1, has a value of 3,000 ohms; in B, the resistor, R1, is about 25,000 ohms. R2 in both cases is the center-tapped filament resistor.

The intermediate-frequency transformers should be spaced about 2 inches apart and the cores should be at right angles. In the original receiver, an external oscillator was coupled inductively to the last intermediate-frequency transformer. This oscillator was used for the purpose of receiving continuous-wave code signals. The audible beat note is produced by the signal in the intermediate-frequency amplifier, mixing with the current of the oscillator. In the usual regenerative receiver, of course, the oscilla-tion produced by the feed-back coil is used to produce this audible frequency.

The oscillator was of the standard Hartley type, with two 600-turn honeycomb coils for the inductors. A tuning condenser of .001-mf. maximum capacity was used to obtain the exact frequency desired. This frequency should be between 600 and 1,000 cycles higher or lower than the intermediate frequency used in the amplifier; the best adjustmnt is found by trial.

The audio-frequency amplifier has been omitted, since any good type of amplifier may be employed. It is advisable to use separate batteries for the detector-oscillator and the intermediate-frequency amplifier. If desired, the "A" battery can be common, but much better results are noticed when a separate "B" battery is used for the first tube. This battery should have a value between 22 and 45 volts, the correct voltage, of course, depending upon the tube used in this circuit. The condenser C3 in the grid circuit of the short-wave unit should have a capacity of .0001 mf.; the grid-leak value will have to be found by experiment.

Piezo-Electric Crystals

Q. 2. What is the piezo-electric effect and how is it used in radio? I have often heard of quartz crystals and piezo-electric crystals being used in transmitters but I am at a loss to know where to find information on the subject.

A. 2. A flat, smooth, piece of quartz, which is usually called a quartz crystal, may be used to control the frequency of an oscillating circuit and will maintain the frequency so constant that it is difficult to measure the slightest variation. This action is often used to control the carrier waves of radio transmitters. The crystal is used for frequency control in many other applications of radio circuits, including wave meters, laboratory oscillators, etc. This effect, called the piezo-electric effect, is due to the electricity generated by pressure on the crystal.

When a piece of quartz of the correct shape is placed between two metal plates a condenser is formed with the quartz as the

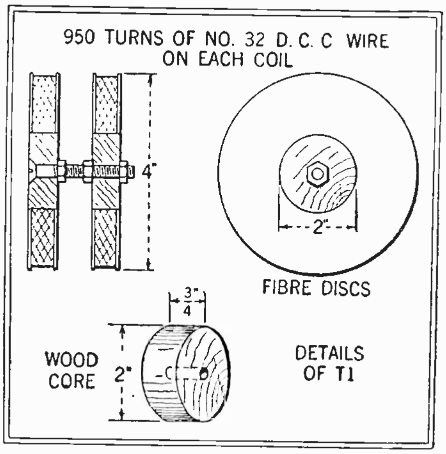


Fig. 252-B—The tuned filter for an intermediate amplifier of about 30 kilocycles can be made as shown above.

dielectric and the metal pieces as the plates. When the plates are connected to a source of alternating current, the quartz is found to expand and contract; as the charges on the plates increase and decrease, due to the changes of polarity. It is also found that an alternating potential is generated by the crystal itself; this can be detected if a sensitive galvanometer is connected to it. From this explanation it will be seen that the action is reversible: alternating electric currents cause the crystal to expand and contract, and lengthening and shortening of the crystal cause it to produce electric impulses in the plates.

Although this action takes place to some extent on any frequency, the action is much greater on one frequency, depending on the size and thickness of the crystal. The thinner and shorter the crystal, the higher the natural or resonant frequency. When a crystal is placed in the grid circuit of a vacuum tube and an exciting voltage is impressed on it, it immediately starts to expand and contract, which causes the plates to become charged. If the vacuum-tube circuits is tuned to a frequency close to that of the natural frequency of the crystal, the crystal will feed currents of this frequency to the grid of the tube, whose plate circuit will deliver more powerful impulses at the same frequency. These currents are then amplified and impressed on the antenna, in the case of a transmitter.

Another explanation of the action of the crystal is as follows: the actuating voltage from a "C" battery causes the crystal to get thinner and to become longer between the metal plates. Because of the strained position of the crystal, it starts to release or get thicker and this starts a pendulum-like action which is maintained by the exciting voltage and the alternating current in the grid circuit of the tube. The expansion and contraction of the crystal produces an alternating current, as explained above.

In making the crystals, they are cut very carefully on planes determined by measurements with optical instruments and they are then ground down with the opposite sides perfectly smooth and parallel. The thickness of the crystal is generally used to determine the frequency, and manufactured crystals are finished either round, square or oblong. The crystal mounting consists of two plates of a good conducting metal, such as copper or brass. The surfaces of the metal between which the crystal is held are ground smooth, and the crystal is usually held in place by the pressure of a spring on one of the plates.

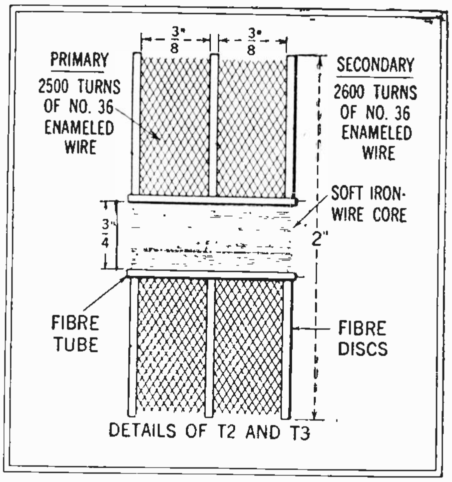


Fig. 252-C—Broadly tuned transformers with iron cores for the amplifier may be constructed around a ¾-inch tube in this manner.

Schematic Diagrams

(253) Mr. G. Burnette, Wolcott, N. Y., writes as follows:

Q. 1. Please explain what is meant by a schematic diagram and how one should be used. What are some of the more common symbols used in preparing these diagrams?

A. 1. Schematic circuit diagrams provide practically the only accurate and easily-read method of presenting graphically an electrical system, especially of the type used in radio receivers. Schematics may be described as abbreviated picture diagrams of the simplest type; they possess many advantages not found in the usual form of pic-

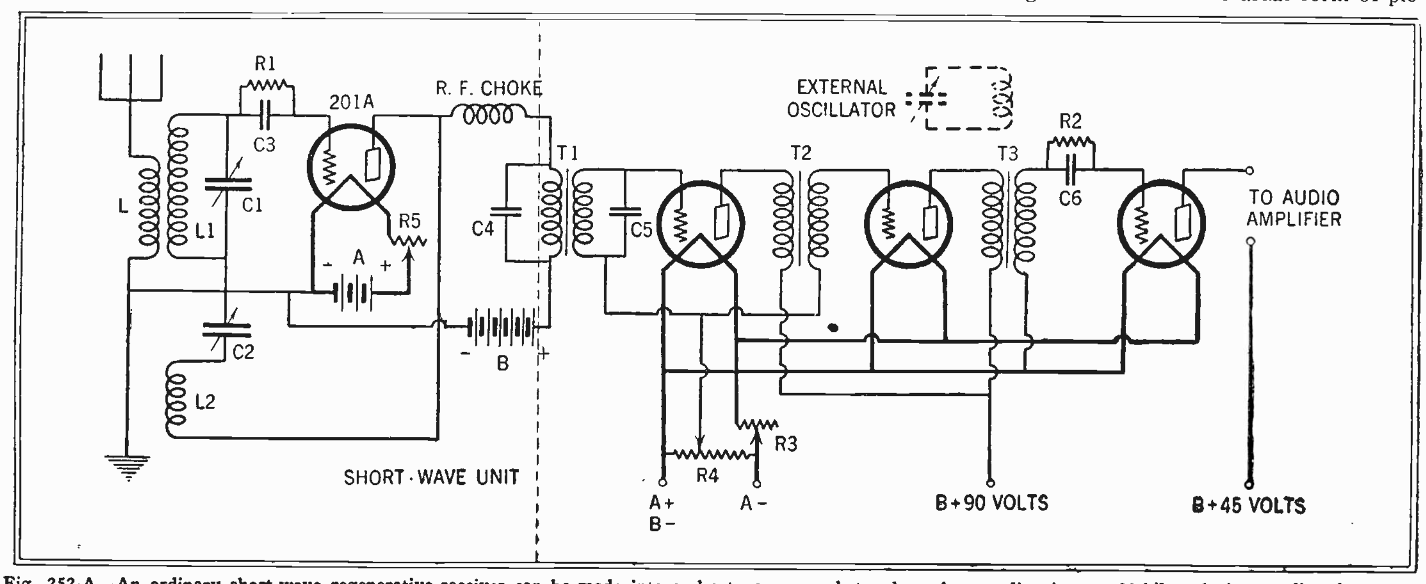


Fig. 252-A—An ordinary short-wave regenerative receiver can be made into a short-wave superheterodyne, by coupling it to a 30-kilocycle intermediate-frequency amplifier. A separate "B" battery is used for the first tube.

torial wiring drawings and are very easily understood. If properly drawn, these diagrams are not ambiguous, and they may be interpreted equally well by all engineers, regardless of the language they speak.

Before continuing further with this discussion, in order to prevent any confusion of terms, it is desirable to consider the differences between the two types of diagrams mentioned above. The *schematic* circuit diagram of a receiver, for example, is made up of "conventional" symbols, which do not bear any direct relationship to the physical appearance of the parts used in the set. These diagrams show only the essential *electrical* circuit, and disregard the mechanical construction wherever it does not effect the electrical design.

On the other hand, pictorial wiring drawings are based on the appearance of the completed receiver, and the wires leading to the various terminals of the parts are indicated by solid lines. These drawings do not show the electrical circuit of the set, but merely indicate how the wires are connected with the component apparatus. When drawn to scale, they are entirely accurate if the parts specified are employed; but when imprtant substitutions have been made from the specifications, the drawings have little value.

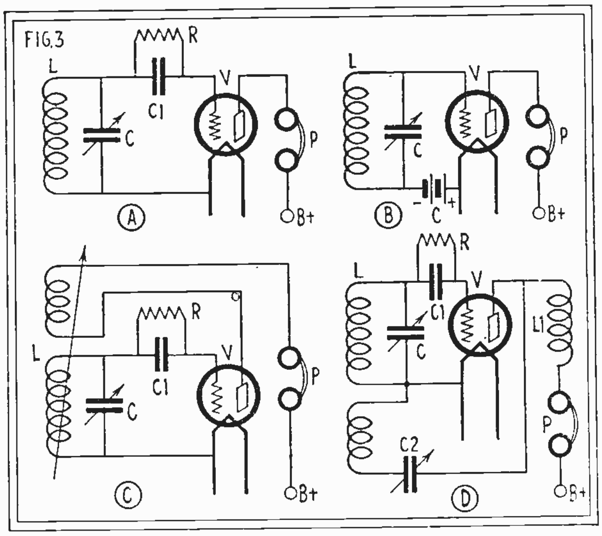
Many radio fans will take exception to some of the statements contained in the preceding paragraphs, and they will desire to dispute particularly the fact that schematics are pictorial diagrams of the simplest type. However, this does not indicate that schematic diagrams are imperfect, but merely shows that the critics have not taken the trouble to investigate the principle on which these drawings are constructed.

Starting "On His Own"

When starting in the radio field, the average beginner is impatient for knowledge on the subject, and anxious to secure all information possible in the quickest and easiest way. Usually, he will start by reading the general articles on radio subjects, in newspapers and current magazines. In this way, he will discover the type of receiver which appears best to satisfy his requirements; he will find an article describing the construction of such a set. When reading articles. the average beginner will always avoid anything of a technical nature; that is, he will not read articles which are illustrated with schematic diagrams or study the mathematical formulas. This is because he either lacks the previous education or the ambition to study these articles, or he suffers from an inferiority complex. Nevertheless, by limiting himself in this way, he also limits the satisfaction which he may gain by building a radio receiver.

The writer does not wish to give the impression that the beginner's articles illustrated with pictorial wiring drawings are not usually accurate. for this is not true. Many excellent receivers are described in articles of this type. However, the person who finds it necessary to follow the pictorial diagram and is unable to understand the schematic, has no choice but to construct the receiver exactly as it is described; whereas, if he were able to understand the schematic diagram, it would be possible for him to make changes in the parts and the design of the set as he prefers.

Understanding schematic digrams may be compared with learning the radio "code." In the case of the latter, there are 26 symbols which represent the 26 letters of the alphabet; these smybols may be used in hundreds of thousands of different com-



Four methods of connecting the detector tube are shown at the right. Circuits A and B are non-regenerative, while C and D are regenerative. A majority of all receivers in use employ the system indicated at A.

binations, each of which represents a different word. In order to understand "code," it is necessary only to memorize the 26 symbols and, after these have been learned, all of the combinations may be understood.

With schematic diagrams, there is also a set of symbols, and these are combined in different ways to make different circuits. Each piece of electrical apparatus is given a symbol, and in diagrams the symbols are connected by lines which represent the wires of the set. After the symbols have been memorized, all diagrams may be understood without difficulty. In reality the symbols used in schematic diagrams are much simpler to memorize than the "dots and dashes" of the radio code, and in a very short time anyone should be able to familiarize himself thoroughly with diagrams of this type.

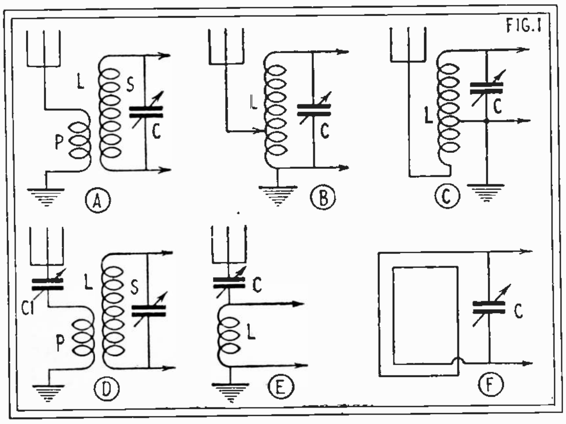
The Symbols

The full-page chart which accompanies this answer shows the symbols for schematic diagrams which have been adapted by *Radio News*. It was published first in the February, 1928, issue, and an amplified list is shown here. With the symbols shown in this drawing all diagrams, including those used for television receivers, may be drawn. The symbols closely resemble those used by other publications throughout the world, although slight changes in design have been instituted to make diagrams easier to follow.

A careful study of the chart of radio symbols will show that there are very few basic smybols; although there are several variations of each to illustrate different types of apparatus. For example, all condensers are indicated by two parallel black lines, separated by a narrow space. Coils of all kinds are represented by a spiral line and all resistors are shown as zigzag lines. These are the three basic symbols. However, there is a particular method of drawing the symbol for each type of condenser, coil or resistor. A variable condenser, for example, is shown with an arrow drawn through the two parallel lines. A triple variable condenser is one long curved line terminating in an arrowhead with three short lines parellel to it, thus indicating that the three sections of the condenser have one set of plates in common.

With coils, there are any number of variations in design to indicate the various types in use. A simple coil is shown as a spiral; if it has two windings, such as those of an R.F. transformer, two spirals are drawn parallel to each other. If the coil is one of variable inductance, such as a variometer, two spirals are crossed at right angles and connected in series. If there is a variable coupling between two coils, as in a variocoupler, the two coils are drawn parallel to each other (or one above the other) with an arrow connecting them. When a coil has a variable number of turns, this is indicated by a line connecting the spiral to an arrowhead, on the lead whereby the connection is made.

The symbol for coils is used also for such parts as intermediate-frequency transformers, audio-frequency transformers and



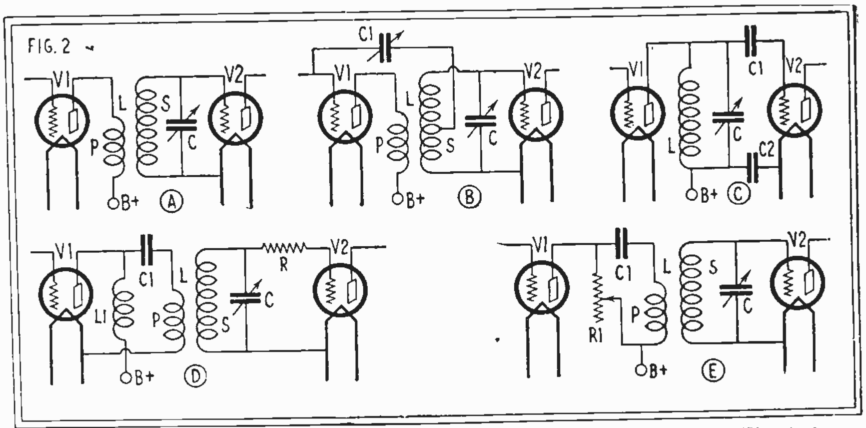


Fig. 1 shows the six popular methods of coupling the antenna circuit with a radio receiver. Circuit A is most often employed in broadcast sets. Fig. 2 shows five systems of interstage coupling in R.F. circuits. Circuit A is standard; B is the neutrodyne arrangement and C is most desirable for use in screen-grid sets. D and E are special stabilizing methods.

power transformers; in each case, as with the R.F. coils, one spiral represents the primary and the other represents the secondary. Intermediate-frequency transformers are frequently wound over a core of iron filings and this is indicated by a single line between the two spirals. In the case of audio-frequency transformers and power transformers, three lines are drawn between the two spirals to indicate an iron core. Another interesting thing regarding coils in schematic diagrams is that the comparative size of the windings may be indicated by the number of loops in the spiral. For example, in a step-down transformer the primary spiral may be made twice as long as that of the secondary, thus indicating that the primary has more turns of wire.

A resistor in a radio circuit is indicated by a zigzag line. If a resistor such as a rheostat has a variable resistance, an arrow is drawn through the line, or a line joins the zigzag line near the midpoint to an arrow head on the connecting lead.

New Devices Found

Tubes of all kinds are indicated by circles, in schematic diagrams, within which the various elements of the tube are shown schematically. The grid is always shown as a zigzag line, the plate as a four-sided figure, and the filament as a continuous line passing through the tube. This covers the usual three-element vacuum tubes; but there are many special types having different symbols which must be memorized, such as gaseous rectifiers, voltage regulators, neon lamps, photoelectric cells, screen-grid amplifiers, etc., for which modifications of the symbol are devised as they are brought out.

The four types of symbols thus far discussed cover most of the apparatus shown in an ordinary schematic diagram. However, there are many other symbols for individual parts, which must be learned. Among these, the most common are those indicating the aerial, ground, loop, counterpoise, batteries, headphones, etc. Solid lines in the diagrams always indicate wire connections; where solid lines cross there is a connection between the two wires if a dot is placed at the point of intersection, and there is no connection if one of the lines loops over the other. Dotted lines represent either shielding or mechanical construction. If heavy dotted lines enclose a circuit it shows that the parts within the lines are enclosed in a shield; where light dotted lines enclose one or more parts it shows that these parts are one unit within a case. Dotted lines are used also to indicate mechanical coupling, such as a link motion used to gain one-control operation of several condensers.

Working Without Specifications

An interesting thing regarding schematic circuit diagrams is that, after the fan has familiarized himself with radio circuits, he will find it possible to build a receiver from the diagram without even a list of specified apparatus. Of course, where the schematic diagram is accompanied by a list of parts the problem of building the set is somewhat simplified for the beginner; but the more advanced set constructor seldom finds it necessary to look for more data than is furnished with the usual article on a new circuit. Even when a complete novelty is presented, it is possible to estimate the values of the apparatus needed rather accurately.

On the other hand, this is not true of pictorial wiring diagrams, for they are of no value whatsoever without a list of the exact apparatus used in the original model of the receiver. This is because they indicate only the mechanical connections, and it is impossible to trace the circuit unless one is familiar with the construction of the parts. For example, in a pictorial diagram wires may be shown connected to eight terminals of a transformer which are marked 1, 2, 3, 4, etc.; but this does not aid the builder in connecting a substitute piece of apparatus in the circuit, if its terminals are marked A, B, C, D, etc.

In reality, there is much similiarity between all radio circuits. Even if a circuit is described as entirely new it will be found that a majority of its features are commonly used in other sets. For example, in a new, "revolutionary" tuned-R.F. receiver it may be found that all connections in the set are exactly the same as in a standard R.F. receiver with the exception of an automatic grid-biasing control, which constitutes the revolutionary feature. Therefore, upon examining the circuit the fan would know the proper value for practically all of the parts, and it would be necessary only to experiment slightly with the biasing control.

In order to fully appreciate the similarity between radio circuits it is necessary to study carefully a number of circuits and then compare their various parts. Often it will be found that two receivers which are considered very different have many points in common, such has identical audio amplifiers, similar detector circuits, etc.

Practical Points

In looking over a number of circuit diagrams, the first thing that will strike the beginner will be the similarity between the antenna connections of the various different types of sets. In most sets these are practically the same and the differences between the various types is very slight. Fig. 1 shows six different antenna-circuit arrangements and these include all the systems which will be found in the usual receiver.

The circuit shown in diagram A of Fig. 1 is the usual arrangement, and may be used with practically any receiver operated from an outside aerial; L is a standard antenna coupler with the primary (p) in series between the aerial and ground, and the secondary (s) connected to the grid and filament of the first tube. The secondary coil is tuned to the desired wavelength by a variable condenser connected in shunt with this winding, and the primary winding is tuned aperiodically, because of its proximity to the secondary coil. In mechanical design the antenna coupler usually is wound on a bakelite tube approximately three inches in diameter. The secondary coil consists of approximately 60 turns of No. 24 to No. 28 gauge wire, and the primary winding has from 10 to 15 turns of the same size wire. The coil may be made with the primary and secondary windings on the same tube and separated by a space of ¼-inch, or with the primary on a slightly smaller tube which is placed inside the secondary. In either case the primary winding is located *near the filament end* of the secondary.

Design of Coils

The exact number of turns of wire to be used on the secondary winding of an antenna coupler, or of any R.F. inductor, is dependent upon a number of conditions; including the waveband to be covered, the capacity of the tuning condensers used, the diameter of the coil form, and the thickness of the insulation on the wire. The most important consideration is the capacity of the variable condenser; for the broadcast waveband condensers having a maximum capacity between .0003-mf. and .0005-mf. may be employed, but an .00035-mf. condenser is now selected as being generally most satisfactory. If manufactured coils are used it is possible to buy a set designed for use with condensers of the particular capacity which has been selected. However, if the coils are homemade, it is best to wind more than the required number of turns on the secondary and then, after the coupler has been connected in the circuit, turns of wire may be removed until the coil tunes to the highest desired wavelength when the condenser is adjusted to its maximum capacity.

The number of turns on the primary winding of the antenna coupler is determined by the desired selectivity aind sensitivity of the circuit. As the number of turns on this winding are increased the sensitivity is increased and the selectivity is reduced, and *vice versa*. Therefore if, with 15 turns of wire on the primary winding, the circuit tunes broadly, a few turns of wire should be removed, and if ten turns of wire does not permit the reception of distant stations the addition of a few turns will improve the sensitivity.

In connection with aerial circuits of the type shown in Fig. 1A, the important thing to remember is that the coil and condenser must be designed to work together in order to cover a desired waveband. The specifications of a circuit may call for a .00035-mf. condenser with a given coil; but practically the same results may be secured by using a .0005-mf condenser and removing the required number of turns of wire from the coil. Also, when coil specifications call for a three-inch tube with 60 turns of No. 26 D.C.C. wire on the secondary, it should be understood that these are not all absolutely unbreakable rules. If a 2½-inch diameter tube and No. 24 D.C.C. wire are available, these may be used with satisfaction, provided a greater number of turns of wire is used for the winding.

Aerial Connections

Diagrams B and C in Fig. 1 show two common variations of the circuit shown in diagram A. At B the coil has the same number of turns of wire as the secondary coil in diagram A, and a tap is provided between the 10th and 15th turns (from the filament end of the winding) for connection to the aerial. At C the portion of the coil tuned by the condenser is the same as the secondary coil and diagram A, and an additional 10 or 15 turns is wound for the aerial circuit. All three of these circuits produce practically the same results.

At D the antenna coupler is exactly the same as that used in diagram A, and a condenser shown connected in series with the aerial is a *sensitivity* control. This system is frequently used in factory-made receivers, to fascilitate increasing the selectivity without reducing the number of turns on the primary winding. The condenser may be variable or fixed, but in either case it does not require frequent adjustment. In sets which tune broadly, a .00025-mf. condenser connected in this position frequently will correct the conditions..

Diagram E shows a method of aerial tuning which was popular in the early days of broadcasting; but this circuit is now unsatisfactory as it is not sufficiently selective for present conditions. The condenser C tunes the aerial and grid circuits simultaneously. The coil has the same number of turns as the usual antenna-coupler secondary, and the condenser a capacity of .0005-mf.

The circuit in diagram F shows the method of connecting a loop aerial to a receiver. In this circuit the loop acts as an inductor and it replaces the usual secondary winding of the antenna coupler. The condenser should have a capacity of .0005-mf. and the loop should have enough turns to permit tuning over the entire wave band. The number of turns on a loop aerial may be determined in the same manner as the turns on the secondary winding of an aerial coupler.

R.F. Tube Coupling

A more careful study of circuit diagrams will show that there is a great similarity between practically all interstage R.F. coupling circuits. Fig. 2 shows the five most popular systems in use; in circuits A, B, D and E a radio-frequency transformer (L), the secondary winding of which is tuned by the variable condenser C, is used for coupling the plate circuit of one tube with the grid circuit of the following tube. This radio-frequency transformer and its tuning condenser are of exactly the same design as the antenna coupler and its tuning condenser, shown at A in Fig. 1.

A shows the usual method of connecting the R.F. transformer in the circuit; at B the R.F. transformer is connected in exactly the same manner, except for a small neutralizing condenser (C1) connected between the grid of the first tube and a tap at the midpoint of the secondary winding. This is the system used in the neutrodyne receiver for the prevention of oscillations. The neutralizing condenser is adjustable and has a capacity range of 2 to 20 mmf.

At D another method of preventing oscillations is used; in this circuit a fixed resistor (R) is connected in series with the wire to the grid of the second tube. If the set employs two stages of R.F., a 700-ohm resistor is connected in the grid circuit of each R.F. tube; while, if three stages are employed, a 1,500-ohm resistor is used in each grid circuit. These resistors are known as grid suppressors. Another unusual feature of the circuit shown at D is that the plate current for the tube does not pass through the primary winding of the R.F. transformer. As shown in the digram, an R. F. choke coil (L1) is connected between the "B+" binding post and the plate, and an R.F. by-pass condenser (C1) is connected between the plate and the primary of the R.F. transformer. The choke coil helps to prevent coupling between the R.F. stages and in this way reduces the tendency of the circuit to oscillate; while the by-pass condenser allows the R.F. signal to pass to the primary of the R.F. transformer —— choke-coil may be of the usual 85-mmf.-henry type and the by-pass condenser has a fixed capacity of .006-mf.

A third method of preventing oscillations is used in the coupling circuit illustrated at E. In this circuit a variable resistor is connected between the "B+" side of the R.F. transformer and the plate of the tube, and a by-pass condenser is connected between the plate of the tube and the "P" terminal of the R.F. transformer primary. The variable resistor has a maximum resistance in the order of 10,000 ohms and the by-pass condenser acapacity of .006-mf.

An impedance-coupled R.F. circuit is shown in diagram C. This type of circuit is more efficient than the transformer-coupled type for certain types of tubes, such as the "hi-mu" and "screen-grid" types, but is unsatisfactory with the usual 201A-type tube. In this diagram the coil L has similar characteristics to the secondary winding of an R.F. transformer and the variable condenser (C) has the usual capacity. The unusual characteristics of the arrangement are that the plate and grid circuits of the two tubes are coupled in the same coil; and that two R.F. by-pass condensers must be connected in series with the wires to the grid and filament of V2 to prevent the "B+" potentials from being applied to these circuits.

Detection Systems

In progressing from left to right in a receiver's schematic diagram, after passing the aerial circuit and R.F. stages, the detector circuit is reached. The diagrams in Fig. 3 show the four systems most generally used; A and B are non-regenerative circuits of the type used in sets employing two or more R.F.. stages, and C and D are regenerative circuits which are used in sets employing not more than one R.F. stage.

Probably ninety per cent of the detector circuits in broadcast receivers of the average type are of the type shown at A. In this circuit the grid method of rectification is employed, and this is indicated by the presence of the grid condenser (C1) and grid leak (R). The coil (L) is the secondary of an R.F. transformer and the variable condenser is the usual tuning instrument. As may be seen, the only way in which this circuit differs from the usual R.F. stage is the presence of the grid leak and grid condenser. The grid condenser has a capacity of .00025-mf. and the grid leak a resistance of 2 to 9 megohms, dependent upon the tube employed. This is the most sensitive type of non-regenerative detector circuit known.

The circuit shown at B is known as a plate-("*anode*") rectification dectector. This type of circuit is not so easily overloaded as the leak-and-condenser (grid-rectification) circuit shown at A and, therefore, it is used in large sets such as three-stage tuned R.F. sets and superheterodynes; however, the method is not as sensitive as the other. The plate-rectification circuit is practically the same as the usual R.F. amplifying circuit, except that a grid-biasing ("C") battery must be connected in the grid-return lead. This battery is shown at "C" and it has a potential of 4.5 volts when 45 volts of plate potential is used.

The two regenerative-detector circuits are similar to the non-regenerative circuit A, except that an additional ("tickler") coil is connected in the plate circuit to cause regeneration, and this coil is coupled to the grid circuit. In the circuit C the coil L shows the secondary and plate windings of a detector-circuit tuner. The detector-circuit tuner has a primary and secondary similar to the usual R.F. transformer, but an additional *plate* or tickler winding has been added. The important feature of such a detector-circuit tuner is that the plate coil is mounted on a shaft in such a way that it may be rotated. By turning the shaft the coupling between the secondary and the plate coil is changed and regeneration is increased or decreased, as desired. The number of turns of wire on the plate coil is not critical, as just enough turns to produce regeneration on the highest wavelength are required. Usually 50 turns of wire on a two-inch tube are sufficient. Also, in the circuit of C, a by-pass condenser with a capacity of .002-mf. should be connected between the filament and the plate side of the phones.

At D we have the Reinartz regenerative circuit; in this the plate coil is fixed and regeneration is controlled by the variable condenser C2, connected between the plate of the tube and the plate winding. In this case the number of turns on the plate winding is determined by the size of the condenser. Any condenser with a maximum capacity between .0003- and .0005-mf. may be used and enough turns should be placed on the plate winding to cause regeneration at the highest desired wavelength. The plate winding may be located on the same coil form as the secondary and should be placed at the filament end of the latter coil. Also, in regenerative circuits of this type, an R.F. choke coil must be connected in series with the output circuit, to prevent the R.F. current from returning to the filament through the phones rather than through the plate coil.

Standard Radio Terms

(254) Mr. A. L. Alexander, New York City, writes:

Q. 1. Can you give me an authoritative list of standardized radio terms and abreviations which are now in general use?

A. 1. The only authoritative list of standardized radio terms, abbreviations and graphical symbols in existence is the 1926 Report of the Committee on Standardization of the Institute of Radio Engineers. As far as it goes, it is a useful pamphlet; but it is woefully incomplete on its treatment of the numerous radio expressions used in the popular and technical press and by hundreds of thousands of radio enthusiasts of all degrees. Because of this shortcoming, there now exists a widespread confusion, among enditors of radio magazines and radio editors of newspapers, as to the proper use, spelling, and particularly abbreviation of these common radio terms.

The editorial practices of some publications suffer from the lack of definite authority to such an extent that they are not consistent even in themselves. Even so accurate an agency as the Bureau of Standards, in its monumental book, "The Principles Underlying Radio Communication," spells *radio telephony* as two words in the table of contents and as one word (*radiotelephony*) in the text. The Institute of Radio Engineers itself, in its *Monthly Proceedings*, has been guilty of the same editorial looseness into which most of the less technical radio periodicals have helplessly lapsed. For example, in the September, 1927, number of the *Proceedings of the I. R. E.* the terms *microfarad* and *micromicrofarad* are abbreviated in no less than five separate and distinct ways; three of these different abbreviations appear within eight lines of each other on the very same page (778). Hundreds of similar quotations from other widely-read sources could be given, but they would be merely repetitious and boring.

What This Purposes

We are listing here some of the most widely-used terms and abbreviations.

It must be stated that the compilation of the following list was not easy; for, paradoxically, *the only consistent feature of popular radio terminology is its inconsistency*. However, very few compromises with engineering accuracy have been made, and then only in the cases of expressions so immovably fixed in the public (and also the technical) mind that any attempt to change them would be perfectly futile.

No definite alphabetical order is followed herein; instead, subjects are taken in groups and discussed conveniently together.

Radio: The Bureau of Standards (hereinafter referred to as the Bureau), says *radio* is a word and not a prefix, hence *radio telephone* should be two words and not one. However, its own Signal Corps manual, as mentioned earlier, uses *radiotelephone* as one word in the text. The compound word looks awkward, and is contrary to the general newspaper practice. *Radio telephone* and *radio telegraph* look more readable and are easier to handle. As nouns, these words should be used without hyphens; as adjectives, with them.

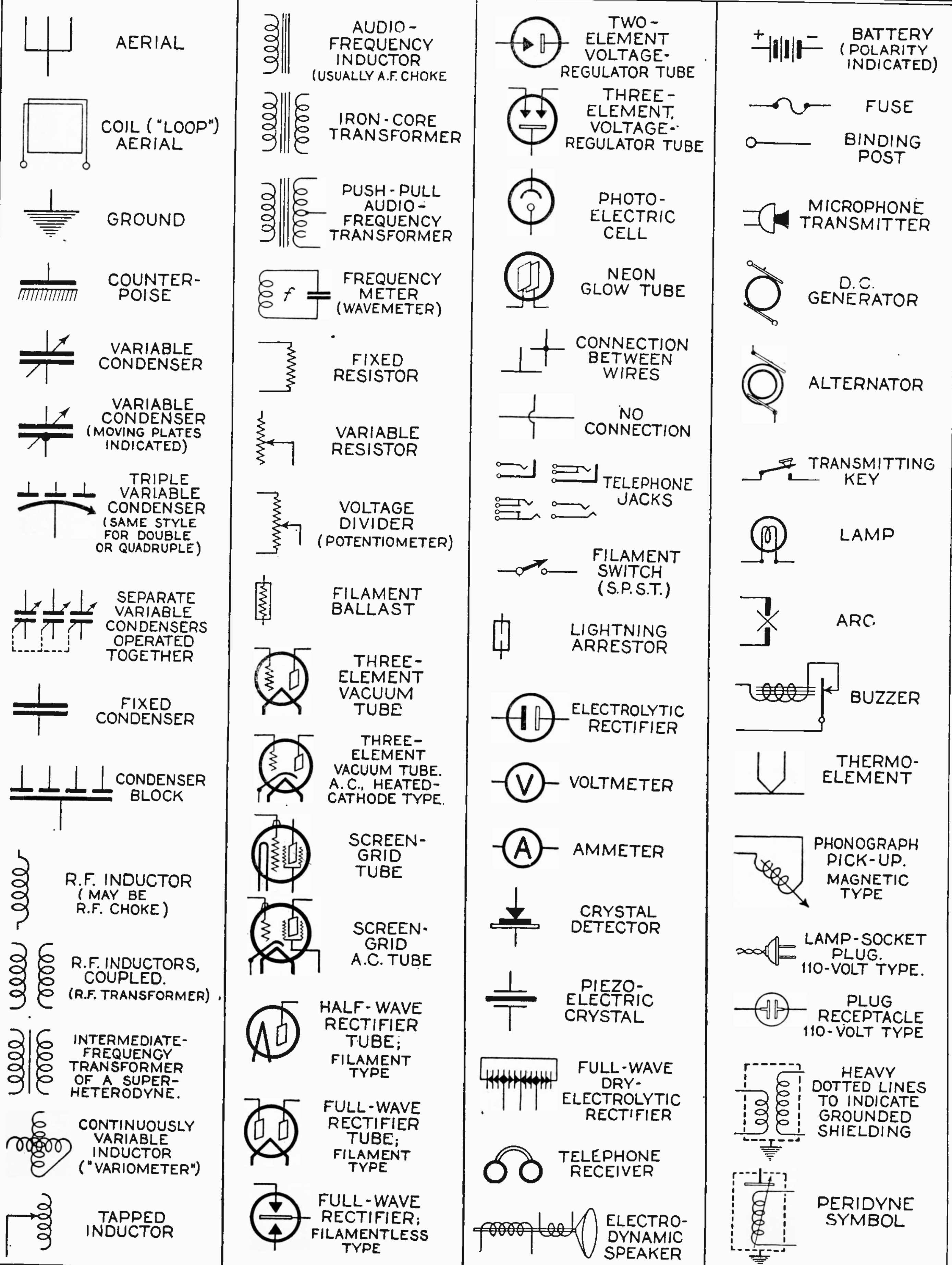
Receiving Set, Receiver: The Bureau advises against *receiver*, without giving a reason. However, the word is too firmly established to be dislodged, as also *radio set*.

Socket-Power: The ambiguity of the expression *battery eliminator* is recognized. *Socket-power* is, of course, much better, and has been adopted officially by the National Electrical Manufacturers' Association; it is defined as "any device suitable for supplying 'A,' 'B' and or 'C' battery voltages to a radio receiving set from the house-lighting supply by the throw of a switch." Thus we have *"B" socket-power unit* as a

(*Continued on page* 91)

STANDARD RADIO SYMBOLS

AS ADOPTED BY "RADIO NEWS"



(*Continued from page* 89)

much more descriptive term than "B" *battery eliminator.*

To improve the advertising and merchandising of radio receiving sets, and to aid the public in its purchases of "electric," "socket-powered," and other receiving sets, the Radio Manufacturers' Association, in co-operation with other radio trade associations, has presented a list of radio-receiver definitions.

These were developed by the R. M. A. Engineering Division, of which Mr. H. B. Richmond, of Cambridge, Mass., is director, with the assistance of technical committees of other organizations. They were adopted and approved unanimously by the R. M. A. Board of Directors at its meeting at Buffalo, N. Y., in May, and are expected to receive the official approval of other radio trades association.

The new and official radio merchandising definitions of the R. M. A., are as follows:

Battery-Operated Set: A radio receiver designed to operate from primary and/or storage batteries shall be known as a *Battery-Operated Set.*

Socket-Powered Set: A radio receiver of the Battery-Operated type, when connected to a power unit operating from the electric-light line, supplying both filament and plate potentials to the tubes of the receiver, shall be known as a *Socket-Powered Set.*

Electric Set: A radio receiver operating from the electric-light line, without using batteries, shall be known as an *Electric Set.*

A.C. Tube Electric Set: A radio receiver employing tubes which obtain their filament or heater currents from an alternating-current electric-light line without the use of rectifying devices, and with a built-in tube rectifier for the plate and grid-biasing potentials, shall be known as an *A.C. Tube Electric Set.*

D.C. Tube Electric Set: A radio receiver employing tubes which obtain their filament or heater currents from a direct-current electric-light line without the use of rectifying devices, and with a built-in power plant for the plate and grid-biasing potentials, shall be known as a *D.C. Tube Electric Set.*

This terminates the present list of technical trade definitions suggested by the R.M.A. To continue:

What Is An Aerial?

Antenna, Aerial: Both the I. R. E. report and Lauer & Brown's *Radio Engineering Principles* define the *aerial* as the elevated portion of the *antenna*, which is taken to mean the whole system for radiating or absorbing radio waves. The Bureau, on the other hand, makes the words synonymous. Since *antenna* serves a useful purpose in designating all of an important system, the I. R. E. difference should be observed and *aerial* used to specify the elevated wire alone. Practically everybody knows that an aerial is a wire on the roof, or sometimes one inside the house; but few will recognize the word "antenna."

For the plural of *antenna*, *antennas* is unquestionably easier to use than *antennae*, the pronunciation of which stumps many a radio man. The Bureau approves of this form, which is a natural one for Americans to use.

Wavelength: Much unnecessary confusion surrounds this simple word. The entire press uses *wavelength*, *wave length* and *wave-length* with little discrimination, although "wavelength" seems to be the preferred form, as it should be. Any daily newspaper furnishes examples of the uncertainty of its proofroom and of its radio editor in its use of this expression.

Meter: Should be spelled out at all times. Abbreviation of so short and widely-used a word is senseless.

Kilocycle: One word, of course. Should be abbreviated only when used with a number and then into simple *kc; hence*, 1610*kc.* Abbreviations like *k.c., K.C., KC* are advised against; the first two obviously are wrong, because "kilocycle" is one word.

In general, it is best to avoid the abbreviation altogether and to prevent confusion by spelling out the full word wherever possible. Radio listeners hear the word *kilocycle* spoken frequently by station announcers, but many would find difficulty in recognizing it in print as kc.

Superheterodyne: The general practice is to make this one word, although the I. R. E. makes it hyphenated. It is so widely used as one that it is easier to leave it as such than it is to change it.

Broadcast Station: The common expression is *broadcasting station*, but *broadcast station* is shorter, more convenient and more nearly correct. We speak of telephone stations and telegraph stations, not telephoning stations or telegraphing stations.

Loops, Not Coils

Coil: The Bureau says: "Do not use *loop* for a coil or circuit consisting of more than one turn," and the I. R. E. bolsters this admonition by defining a *coil antenna* as one consisting of one or more complete turns of wire. However, anyone who tries to alter the universal conception of such antennas as "loops" is attempting the impossible. The word *loop* has simply taken root and has been strengthened by the repeated advertisements of scores of *loop antennas.* This is one concession to popular usage that must be made.

A.C. and D.C.: The capital letters are preferable to lower-case, because they are more easily recognized. When written "ac" or "dc," they look like typographical errors; "a.c." and "d.c." are somewhat better, but two lower-case letters with periods look somewhat awkward. When the expressions are used as nouns they should be spelled out to produce a readable sentence; when used as adjectives the abbreviations are more convenient.

R.F., T.R.F., A.F., and I.F.: Radio frequency, tuned radio frequency, audio frequency and intermediate frequency. The abbreviations are unmistakable in capital letters, and should not be made in lower case; for the same reasons given for A.C. and D.C.

As with *radio telephone*, the expressions *audio frequency, radio frequency* and *intermediate frequency* should be written without hyphens when used as nouns, and with hyphens when used as adjectives. Thus, "The intermediate frequency selected for the superheterodyne was 30 kilocycles"; but "Intermediate-frequency transformers tuned to 30 kilocycles were used."

C.W. and I.C.W.: For continuous waves and interrupted continuous waves. The I. R. E. makes them *cw. and icw.*, but these are rather illogical. If a period after the *w*, why not periods after the other letters, which also represent individual words? The capital-lower-case-letters argument applies again. Transmitting amateurs have been using for years the capital-letter form, because it is more easily recognized.

Micro-, Milli-: More trouble centers around the units *microfarad, micromicrofarad, microhenry, millihenry, microampere*, and *milliampere* than around any others. Of these, the microfarad is used in general radio work more frequently than all the others put together; for, while the sizes of condensers are usually marked on the devices or can often be guessed through more observation, the electrical values of coils are invariably unknown quantities. Now the most commonly-accepted abbreviation for *microfarad* has been *mfd.;* although occasionally one may see *MFD, M.F.D.,* or *m.f.d.;* the last two are foolish, since the periods after the "f" split up a simple two-syllable word. Even *mfd. is* longer than necessary. The word is *microfarad; micro* meaning one-millionth, and *farad* being the actual unit. By the same reasoning through which kilocycle was derived, we obtain *mf.* for *microfarad.* This form is short, simple, and unmistakable. It has been in use in *Radio News* now for more than a year, and has proved to be a most logical abbreviation.

Properly speaking, the symbol for "micro" is the Greek letter which we call *mu;* the letter *m* correctly indicating "milli," one-thousandth. A few technical magazines and bulletins use μf. for microfarad; but from the standpoint of the radio public and even many experienced radio experimenters, this combination is hopeless. Few people know what the odd Greek letter represents and fewer still can pronounce it. Of course, they eventually learn that it stands for *micro;* they can usually guess that much. However, the general aversion to mathematics in popular radio practice (shared by a past president of the I. R. E., whose open admission of his attitude before a crowded Institute meeting, in 1926, brought forth a rousing round of approbative applause) has completely eliminated the symbol and the abbreviation from ordinary use. We find *mf.* or *mfd.* in almost universal use, except in such precise works as the Bureau of Standards' circulars, in which all the terms are spelled out and confusion is thereby avoided altogether.

Now with *mf.* irrevocably established as one-millionth of a farad, how can we abbreviate millihenry into *mh.*, which it is, properly? We should make microhenry μh, and then *mh*, would be millihenry; but the μ simply will not be accepted, for reasons already mentioned. The same dilemma arises in connection with *milliampere* and *microampere.*

The most practical idea is to use *mch.* and *mca.* for *microhenry* and *microampere*, respectively; and *mlh*, and *mla.* for *millihenry* and *milliampere*, ditto. The presence of the extra *l* and *c* identifies the abbreviations beyond mistake. Of course, the best thing to do is to spell out the units altogether, but it is frequently expedient to use abbreviations; for instance, in mentioning a number of different current or inductance values in the same paragraph. Discussion on this subject is highly in order. (*Note:* a *mil* is one one-thousandth of an inch; do not use it for milliampere. Also: the plural of *henry* is *henries*).

"A," "B" and "C": Batteries or circuits. The quotation marks should be used at all times. Without them, the letter "A," in particular, is often mistaken for the indefinite article. I. R. E. listing agrees.

Confusion Worse Confounded

Inductance, Resistance, Capacitance, Impedance: All four terms are definitely defined as certain properties; the first three of electrical circuits and devices, and the fourth as *a resultant of the other properties in combination* under certain circumstances. Now, is it certainly not more correct to call a coil possessing the property of inductance an "inductor," rather than an "inductance"? How can it be "an inductance," if inductance is rigorously defined as an intangible property or quality? And why not "resistor" to designate a device possessing the property of resistance? "Inductor" and "resistor" are rapidly increasing in favor; they should be encouraged heartily.

Instruments possessing the property of capacitance most logically would be designated as *capacitors.* This term is being used in the advertisements of one condenser manufacturer, but it is unlikely to become anything more than a good second to *condenser;* because the latter word is much too firmly entrenched in our common vocabulary to yield to change.

For the common use of the word *impedance* as a designation for a specific inductor, usually of comparatively high value, there is little excuse; since the definition of impedance is iron-bound. Impedance is the property of A.C. circuits that corresponds to the plain resistance of D.C. circuits. It may comprise resistance and inductive reactance, resistance and capacitive reactance, or resistance and both varieties of reactance; in view of this, how can the word be used for a single piece of apparatus? If an inductor is an impedance, so is a condenser, and so, for that matter, is a resistor.

However, the practice of designating iron-core choke coils as "impedances" is so common that there is little hope of reform in this particular direction. The use of these choke coils in "impedance"-coupled A.F. amplifiers is rapidly increasing, and along with it the use of the term *impedance coupling.*

Filament Ballast: For mechanically fixed resistors of various kinds (that is, devices not manually controllable) used to regulate the current to the filaments of vacuum tubes. This is the only expression that covers all existing devices of the kind; the term "automatic rheostat" being the exclusive legal property of the company that manufactures the well-known "Amperite."

By-Passing Audio Amplifier

(255) Mr. R. W. Wilson, Portland, Maine, writes:

Q. 1. I understand that most audio-frequency amplifiers can be improved by the correct use of by-pass condensers. Can you explain where these condensers should be used, their values, and just what advantage they supply to an amplifier of this type?

A. 1. Audio-frequency amplifiers are often constructed in such a way that a common coupling is unavoidably formed by the power unit or common "B" battery. This coupling provides an excellent path for feedbacks from which a large amount of distortion may result. This trouble may be reduced very easily by the proper use of by-pass condensers between the various circuits. These condensers provide a lower resistance path for the audio-frequency currents than the artificial coupling. Of course, the direct current passes through the usual circuits, since it is blocked by the condensers. You will find two diagrams showing how by-pass condensers should be used in an audio-frequency amplifier in Figs. 255-A and B. The first represents any audio-frequency amplifier with transformer coupling, resistance coupling, or any type of "impedance" coupling. Condenser C1 is the usual by-pass condenser connected between the plate of detector V1 and the negative filament. The plate circuit of each amplifier tube is completed by connecting a 1-mf. by-pass condenser between one of the filament terminals and the positive "B" terminal of the transformer. These condensers are shown at C3 and C5. A separate path is also provided for the grid current by placing by-pass condensers of ¼-mf. or more capacity between the transformer secondaries and the filament terminals. These condensers are represented at C2 and C4.

The diagram in Fig. 255-B represents the usual transformer-coupled audio-frequency amplifier and shows how the by-pass condensers should be connected in order to improve the results. The condensers should be placed close to the transformers, so that the audio-frequency currents will not have to travel through much of the wiring in the amplifier or through any of the leads to the power units.

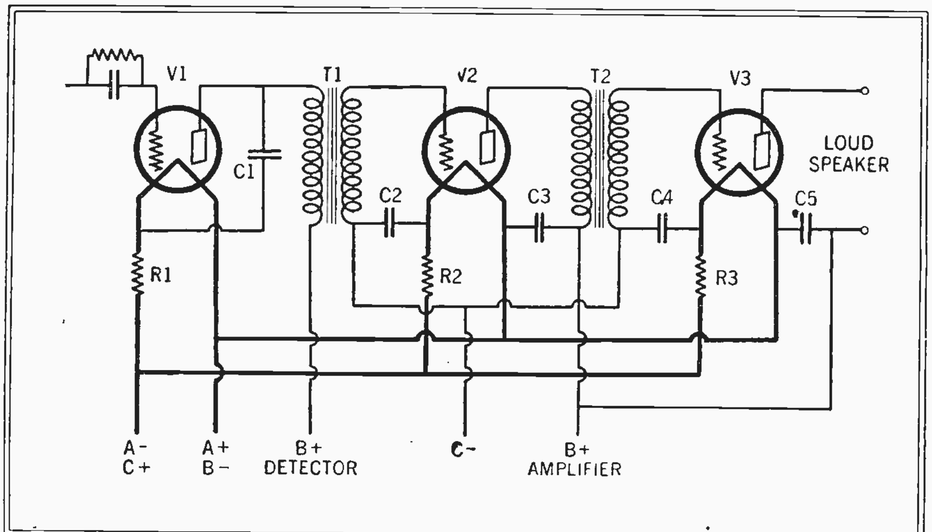


Fig. 255-B—The schematic diagram showing the method of connecting by-pass condensers in any standard amplifier.

Reducing the Hum on A.C. Sets

(256) Mr. B. Brown, Miami, Florida, writes:

Q. 1. I am constructing a receiver with two stages of radio-frequency amplification and two of audio-frequency amplification, using the 226 tubes in the radio-frequency and first audio-frequency positions, a 227 in the detector and a 171 in the last audio-frequency stage. I am rather puzzled about the grid returns and the methods of keeping the A.C. hum at a minimum. Can you give me any data on this subject?

A. 1. The method of balancing out the audio-frequency noises in an A.C. receiver is a rather puzzling problem for the average radio fan. The usual method of connecting the grid return directly to one side of the filament supply circuit is not satisfactory with A.C. sets, since it unbalances the filament circuit and introduces a considerable hum. The grid returns for the 226 tubes may be connected according to several easy methods. The balancing consists merely of finding the exact electrical center of the filament circuit, so that no alternating voltage from the power supply will be impressed on the grid. Naturally, since this current is an alternating one, it must be kept entirely out of the grid circuit.

Three methods of obtaining the electrical center of the filament circuit are shown in Fig. 256-A, B and C; these methods are the most common in use at the present time. Fig A shows the use of a resistor with a sliding contact which can be adjusted for the minimum amount of hum. This resistor usually consists of a potentiometer of about 15 ohms shunted across the center of the filament transformer. This method is a very good one, since it is often found that the electrical center of the filament circuit is slightly to one side of the mechanical center.

Fig. B is similar to Fig. A except that a fixed center tapped resistor is used. This method is not quite as efficient as the one shown in Fig. A, since if the center tap of the resistor does not balance the secondary of the power transformer in reference to the ground, the filament circuit will be unbalanced. However, in most cases it is very satisfactory. Another method is shown in Fig. C, which has the same defect as the method shown in Fig. B. This method employs a center tapped filament transformer for the filament supply, but is also very satisfactory for general uses.

It is best to use a separate resistor for each grid return rather than try to use one resistor for all of the tubes, since in this way, each tube is balanced in respect to its own filament circuit. The wiring to the filament circuits of the A.C. tubes should be done with twisted wires, well insulated and

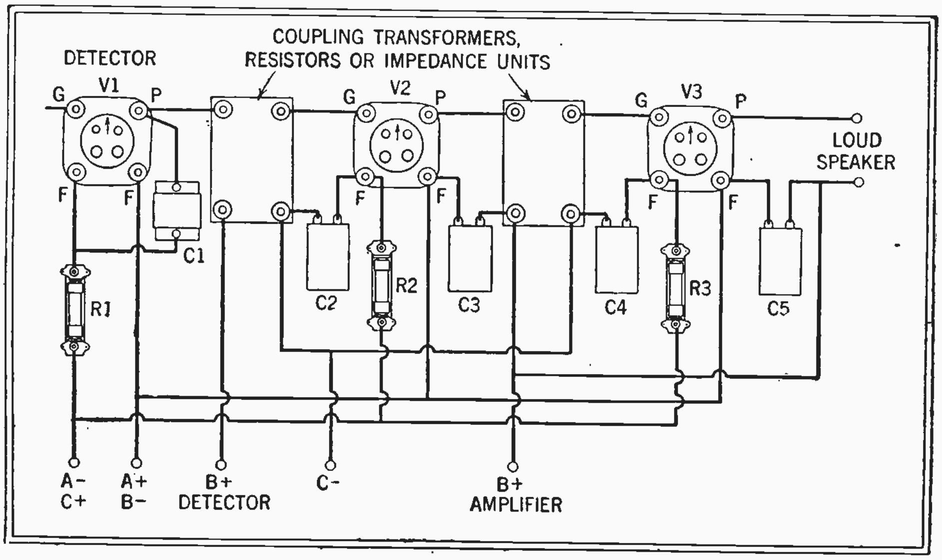


Fig. 255-A—The method of connecting the by-pass condensers in a transformer coupled audio amplifier is shown above.

kept as far away from the grid circuits as possible. This wire must be quite heavy (No. 14 at least) since the filaments of the A.C. tubes draw a considerable amount of current.

The use of resistors for the grid returns of tubes in a radio-frequency amplifier sometimes results in instability or oscillation in the amplifier. However, this difficulty can easily be overcome by connecting fixed condensers between the center tap of the resistor and each side. These condensers should have a value of .005-mf.

Grid Bias

This is another point which causes considerable confusion in the construction of A.C. receivers. When the negative grid bias for the radio-frequency amplifier and audio-frequency amplifier tubes in an A.C. set is to be obtained from the "B" power unit, a separate resistor may be used to supply the voltage to each grid or one common resistor with the correct taps may be used for the complete supply. When 226 tubes are used in a radio-frequency amplifier, the plate voltage should be 135 volts and the negative bias 9 volts, in order to give the greatest amplification and the quietest operation. Because each of the tubes requires the same bias, a single resistor can be used for all of the tubes. The method of connecting this resistor is shown in Fig. 255-D. It will be noticed that the grid returns and the center filament terminals of each of these amplifier tubes are connected to one side of resistor R1, while the other side connects to ground and to the negative "B" battery terminal.

The value of resistor R1 can be easily determined with the aid of Ohm's Law, wherein R equals E divided by I. R represents the unknown resistance required, E represents the biasing voltage, and I the plate current of the tubes for which the grid bias is required. To give the least amount of hum, the plate current should be 3 milliamperes and the plate voltage 135 volts, for each tube. The correct value of the "C" bias for this plate voltage and current will be found to be 9 volts. If we have three 226 tubes requiring "C" bias, the total plate current will be 9 milliamperes, or .009 ampere. Substituting these values in the equation given above; R equals 9 divided by .009, or 1,000 ohms, which is the correct value for the resistor R1. The condenser C6 in the digram is used to by-pass the radio-frequency currents around resistor R1. This condenser should have a value of about 1-mf.

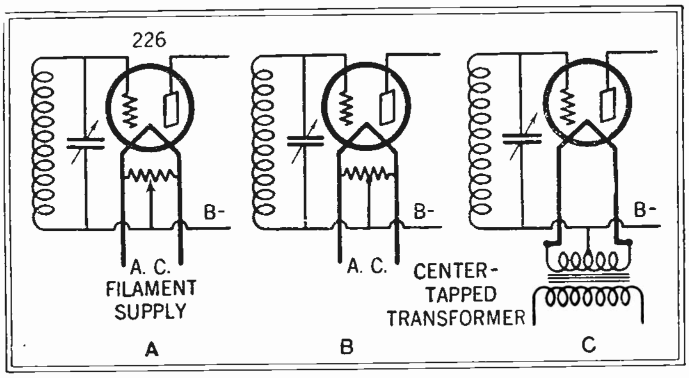


Fig. 256. Three common methods of obtaining the electrical center of the filament circuit. These methods are in general use at the present time.

Changing Type of Tubes

(257) C. E. Dengler, Brockport, N. Y., writes:

Q. 1. If I decide to substitute UX-199 vacuum tubes for those contained in my set at the present time, will any changes have to be made? The tubes I am using now are a UX-200-A detector and a UX-201-A amplifier.

A. 1. In regard to the use of UX-199 tubes in your radio set, we would say that no radical changes will be necessary. You will, however, have to either substitute sockets for these tubes as they have different bases than the standard tubes, or else obtain adapters for the 199 tubes. You will also have to substitute three dry cells for your present "A" battery and it is advisible to use 30 ohm rheostats.

Amplifier Trouble

(258) P. A. Frank, Lakewood, Ohio, writes:

Q. 1. I am inclosing the diagram of my detector and two-stage audio amplifier. I have placed the transformers quite a distance apart, but I am still bothered with a whistling noise during reception. Can you tell me what the trouble is?

A. 1. The whistling noise is probably caused by the way you placed your transformers in an endeavor to cut it down. The long leads necessary between your transformers have a capacity effect on the circuit, thereby causing the howling. In connecting up your set, do not have the grid and plate circuits cross each other. Also try reversing the leads on the transformers, grounding the filament and shielding the apparatus.

Your circuit diagram is O. K., but would suggest that you connect the fixed phone condenser directly across the primary of the first amplifying transformer. Variable grid leaks and condensers are always preferable in any type of set and we would advise you to try various resistors and capacities.

Set Noises

(259) Mr. Robert Lundy, New York City, writes:

Q. 1. When I tap the table upon which my radio set is resting or tap the cabinet, a loud noise is heard in the receiver or loud speaker. What is the cause of this and how can it be eliminated?

A. 1. Regarding the noise which is heard when your set is tapped we would advise that the same is caused by the vibration of the elements contained within the tubes. This can be eliminated or at least reduced to a considerable extent by suspending the sockets of the tubes on springs or rubber bands so that they will not vibrate excessively.

Q. 2. I occasionally experience trouble in tuning out radio telegraph transmitting stations, and wish you would tell me how this can be eliminated.

A. 2. Regarding the tuning out of radio telegraph transmitting stations, we would advise the addition of a series, inductively coupled wave-trap. We do not believe that this trouble could be eliminated by the purchase of a better vario-coupler or variable condenser. However, if the primary and secondary coupler are wound with wire smaller than No. 20, we would advise you to rewind them with larger wire, placing thereon the same number of turns you have removed. *(Q. and A. Cont'd on page 104)*

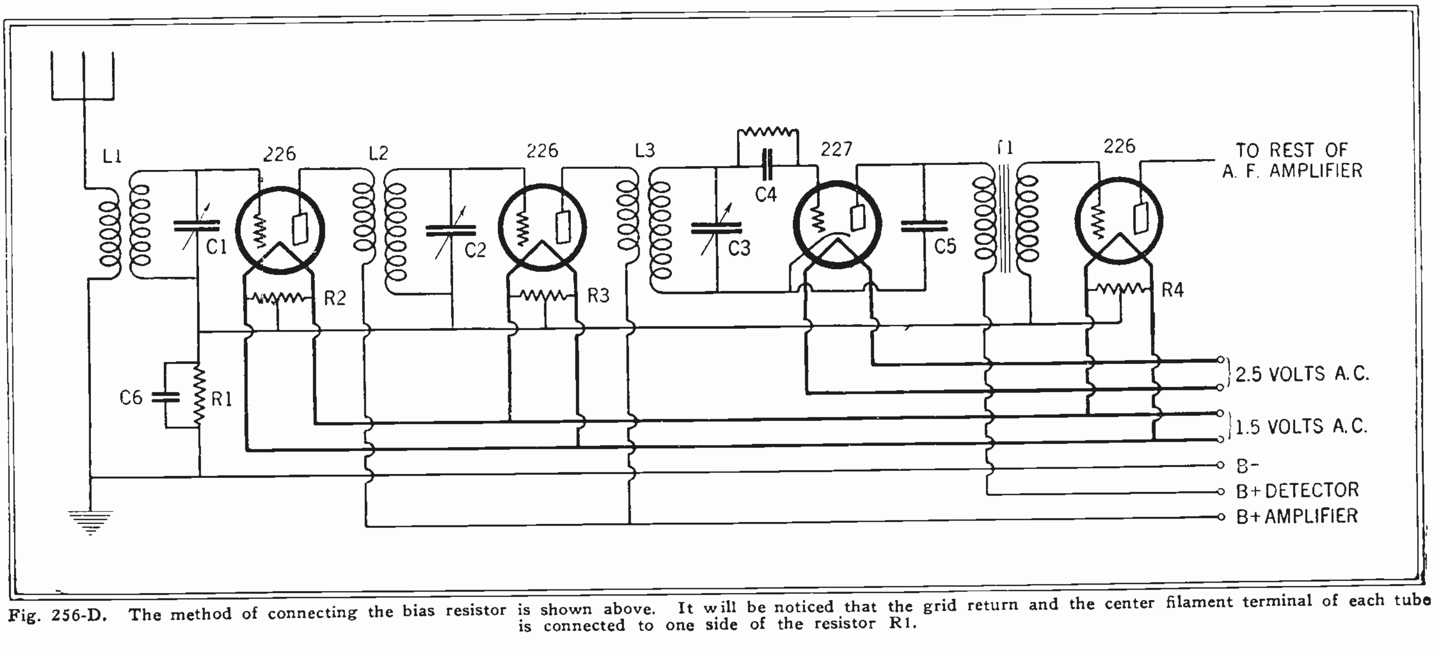


Fig. 256-D. The method of connecting the bias resistor is shown above. It will be noticed that the grid return and the center filament terminal of each tube is connected to one side of the resistor R1.

How the Shielded-Grid Tube Obtains Its Sensitivity

Reduction of "Space Charge" and Internal Grid-to-Plate Capacity by "Screen Grid" Secret of Operation

By R. P. Clarkson

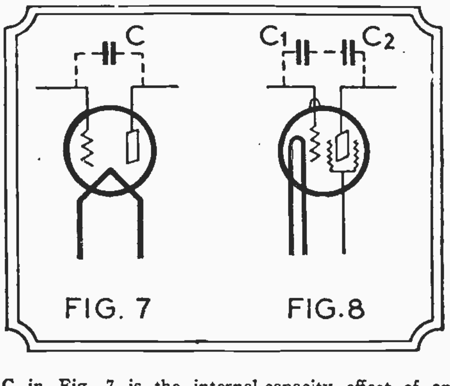
ONE of the question most frequently asked is, why does not any positive potential on the plate of a three-element vacuum tube, whatever its amount, attract all the electrons that are emitted from the filament? The reason why it does not is because of the so-called "space charge."

The number of electrons emitted depends on the particular filament temperature, but electrons appear to be shot off at different velocities. Especially is this true of filaments not uniformly heated, and, generally speaking, all filaments are cooler near their supports than in their center.

THE "SPACE-CHARGE"

Slower electrons just shoot off a little into space and come back to the filament. There is always a cloud of them around the filament, with the result that new ones emitted are repelled by those already in the space. Some of them, having a high velocity, shoot off through this negatively-charged cloud and are then repelled from behind by the cloud and drawn from in front by the positive charge on the plate; and so they join the stream passing from filament to plate.

This space charge (which is the negative charge of the hovering cloud around the filament) is much nearer the filament than is the plate. See Fig. 1. Increased plate voltage decreases the space-charge effect and hence increases plate current; which means that more electrons join the stream and fewer stay near. Not only is the space charge partly nullified but it is also actually decreased; so that the result becomes cumulative.



C in Fig. 7 is the internal-capacity effect of an ordinary tube. This is split into two components, in series, in a shielded-grid tube, Fig. 8.

The grid is nearer the filament than the plate. Therefore, variation in the grid voltage has a greater effect, proportionally, on the space charge than a change in plate voltage. Hence, small grid-voltage variations make large plate-current variations and we have an amplifying effect, *whether the tube acts as a detector or as an amplifier.*

WHY "SHIELDED GRID?"

Just why the name "shielded grid" is being applied to the type of four-element tube which has just appeared on the market is a mystery. It is also puzzling to determine why this type of tube, well known years ago, has been presented to the public abroad and used so extensively among the European amateurs, yet has not been adopted here in America until now. The development is credited to a German experimenter, but almost any treatise on tubes discusses the functioning of these tubes and the advantages that would result from their use. However, since shielded-grid tubes are now available and are being designated as such, let us study them and learn to understand their fundamental action.

First let us review the working of the three-element tube to refresh our memories. The incandescent filament sends out electrons. These are negative in polarity. The plate, being positively charged, attracts these electrons, forming a plate current or a plate-current path, as you wish (see Fig. 1). In this path is inserted a grid, which, by its variation of polarity or potential, controls the element flow.

If the grid is negative it repels the electrons and overcomes a portion of the plate's attraction for them; thus cutting down the plate current (see Fig. 2). As it is much nearer the filament, a slight negative grid potential overcomes a considerable positive plate potential. The relative effects vary inversely as the cubes of the relative distances between the elements in the tube.

THE AMPLIFYING FACTOR (MU!)

We are used to thinking and saying that a slight grid-potential change causes a considerable plate-current change. This is the amplifying effect of the tube, the ratio of which, in theory, is 6 to 8 in the ordinary all-purpose amplifier tube. Let us recall that the usual plate voltage required for such a tube is 90.

But there is another controlling feature of the tube, mentioned previously; it is the "space charge," and is the effect of the mass of electrons which hover around the filament. This cloud is negative and repels the electrons attempting to fly out from the filament. Being closer to the filament than is the grid, it has a greater effect.

The existence of the space charge has many effects on the working of the tube, but for our present purpose we mention two. First, because the repelling effect of this charge is added to the repelling effect of the grid, *any slight change in the grid potential is only a partial change in the whole repelling potential.* In other words, the fact is that the grid effect would be many times what it is now, and (with nothing else happening) the amplification value of the tube would be raised from 6 or 8 up to 30 or 40. The effect of the space charge in ordinary three-element tubes is far greater than the effect of the grid, and this space-charge repulsion is a constant factor not affected by the incoming signal. It is a load on the tube and the cause of its low efficiency.

REDUCING THE PLATE VOLTAGE

The second thing is the effect of the space charge on the plate potential. As in the case of the grid, the effect of the space charge compared to the effect of the plate charge is inversely proprotional to the cubes of their distances. The plate is far away. The space charge is almost at the filament surface. To overcome the constant repulsion of the cloud of electrons surrounding the filament, almost the entire plate voltage is utilized. With our usual tubes, over 85% of the plate potential goes into overcoming the space charge; 15% or less into establishing a plate current. If the space charge could be destroyed, therefore, the plate voltages required for tube operation would be only 15% of what they are now. In place of using 90 volts on the plate we would use 13½ volts or less.

It is rather amusing, though irritating, to observe that, just as devices are being widely introduced to do away with the plate batteries, manufacturers should be getting ready to produce tubes, well known for years, in which the current required would be an entirely negligible quantity.

With the advantages of increasing the amplifying value of the tube and decreasing the plate voltage required, we should be content. That we can do it without increasing the plate-to-grid capacity is remarkable; for, of course, we can produce high-mu tubes by placing the elements close together, thus increasing plate to grid capacity enormously. Such tubes are on the market and have been for some time, but are usable

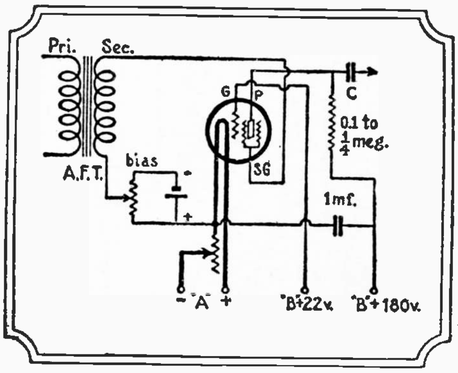
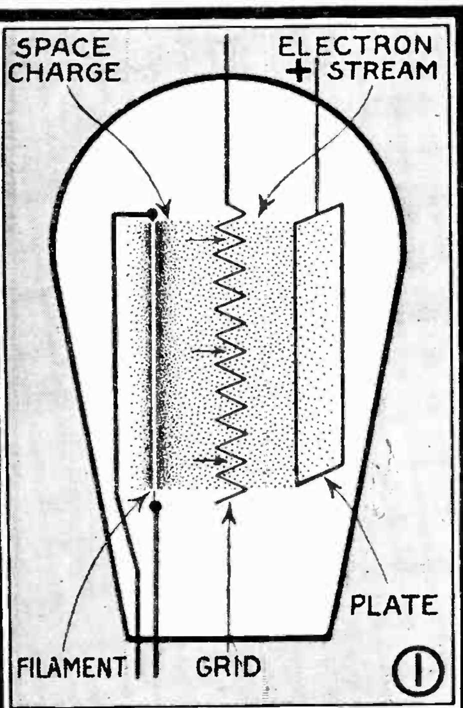


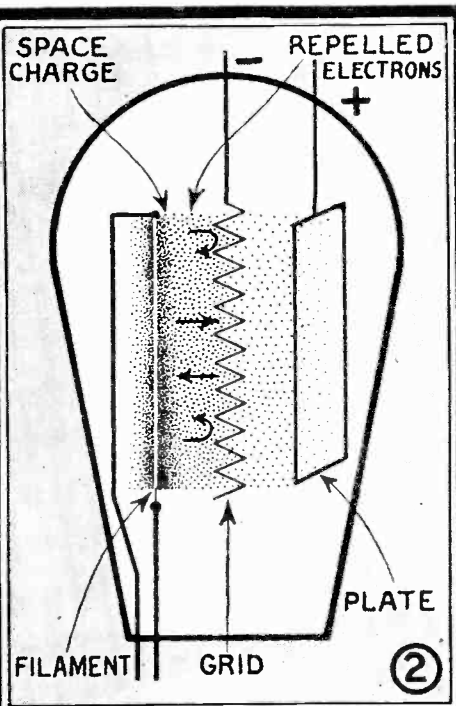
Fig. 9—In an A.F. circuit the normal, control grid G is used as a space-charge element; the screen-grid (SG) now acting as the control-grid.

only in A.F., not in R.F. circuits. That we can do all this and actually lower grid-to-plate capacity in this new tube makes us sit up and take notice.

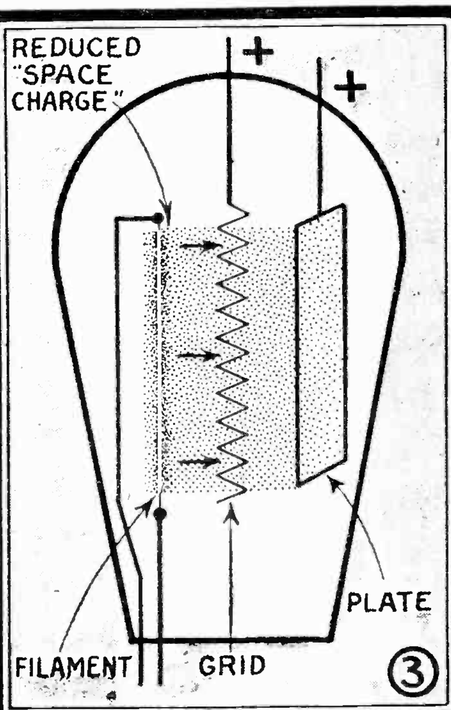
The way in which the space-charge effect is overcome is the simple one of putting *a positive charge at the point where the negative charge accumulates*, or near that point. In other words, we introduce a fourth electrode into the tube, having no purpose in the radio circuit; it is simply devised to perform *a part of the work of the plate*, but to do this more efficiently because of its being nearer the troublesome cause. That means, of course, that here is a detector or radio-frequency amplifier which is far more efficient and far more easily controlled than any thing we have had heretofore.



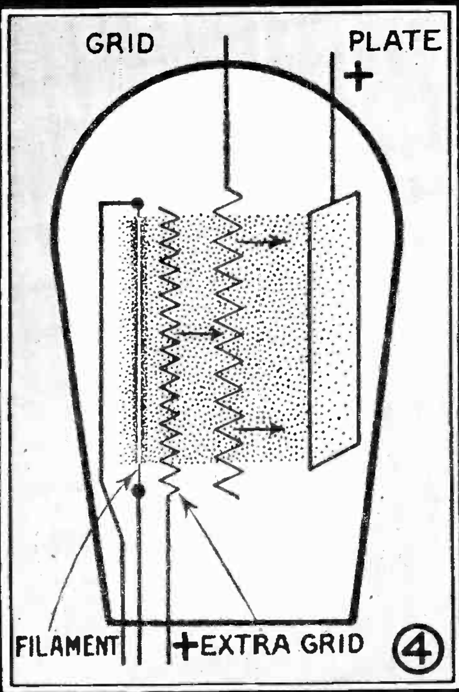
In a three-element tube, with the grid at zero potential, only a limited number of electrons reach the plate under the influence of the positive charge on the latter. The limiting factor is a cloud of electrons surrounding the filament, and forming what is known as the "space charge." These are negative in polarity and tend to drive other electrons back into the filament.



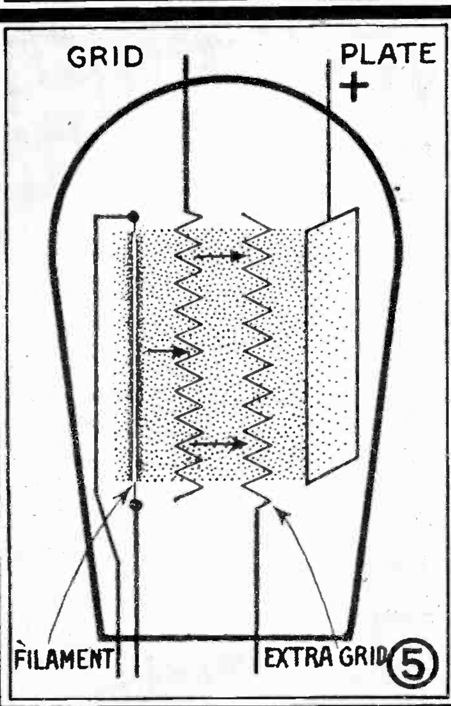
When the grid is changed negatively, it repels some of the electrons approaching it, and thus reduces the total number reaching the plate and, consequently, reduces the plate current. As the grid is considerably closer to the filament than is the plate, it exerts a greater influence on the electron flow and also on the space-charge density than does the latter element.



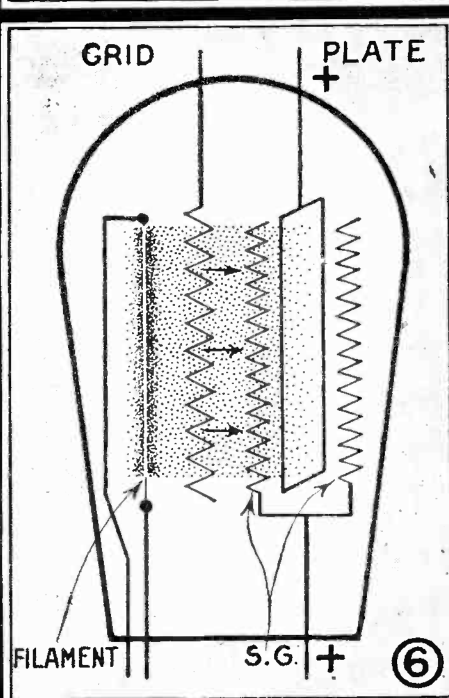
When the grid is charged positively, it increases the total electron flow far more than would the plate, if the positive charge on the latter were increased this same amount; because it is closer to the filament, and its positive charge breaks up the negative space charge more effectively than the comparatively-distant plate can.



The sensitivity of the control exerted by the grid (and hence the amplifying value of the tube) is defintely limited by the electrons surrounding the filament. If an extra grid is interposed between the filament and the regular control-grid, and charged positively, it will, by virtue of its proximity to the filament, break up the cloud and increase the control range of the regular grid.



The extra grid may also be located between the control-grid and the plate. Here it will require a higher positive charge than before, but it now also serves another purpose; namely, to reduce the troublesome capacity effect between the grid and plate. It acts as a grounded center plate splitting the "fixed condenser" formed by the grid and plate into two smaller condensers in series.



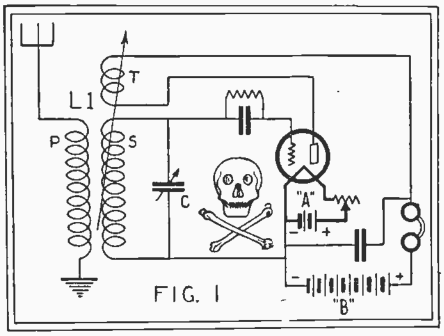
In commercial models of the four-element tube (222-type), the extra grid, known as the "screen-grid," encircles the plate completely. The inner section acts both as a space-charge disrupter and as a capacity reducer; while the outer section (which has nothing to do with the stream electrons because they stop at the plate), serves merely to reduce the capacity between the outside of the plate and the connecting leads, etc.

Regeneration—What It Is and What It Does

A Semi-Technical Discussion of One of the Most Important Circuit Actions Known to the Radio Art; Its Theory and Application

By Fred H. Canfield

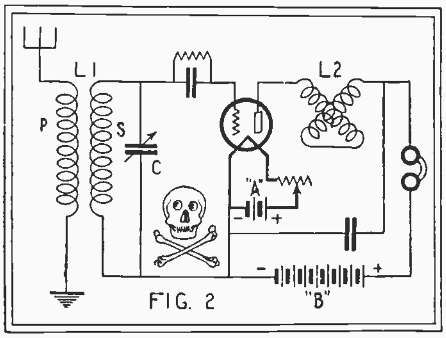
THE designer of the radio-frequency circuits of a broadcast receiver finds that the problem of regeneration is one which he must always take under the most careful consideration; whether he desires to utilize this phenomenon or to suppress it does not affect the fact that it must be reckoned with. In some instances regeneration is employed to give additional amplification in the stages affected; in others the attempt is made to gain stability of operation by eliminating, as far as possible, the effects of the regeneration which exists, to some extent at least, in practically all R.F. tube circuits. But, in any event,



Regeneration is produced in this simple circuit by feed-back from the tickler (T) to the secondary (S). As a broadcast receiver, it is poison to nearby listeners.

to keep regeneration under positive control is the aim of every radio engineer.

It is difficult to say whether regeneration is one of the most desirable or most undesirable characteristics of vacuum tube circuits; for, when rightly employed, it is a great aid, but, when undesired, it is a great annoyance. With a circuit in which regeneration is used properly, it is possible to obtain an amplification of as high as 25, which is approximately three times as great as may be obtained from an R.F. stage without regeneration. On the other hand, the existence of regeneration increases the selectivity of a circuit, and in some cases it causes the set to tune so sharply that the sidebands of a wave are excluded, resulting in badly-distorted reception. The ideal



In the variometer-type regenerative receiver, feed-back takes place through the capacity between the plate and grid elements of the tube. It is deservedly obsolete.

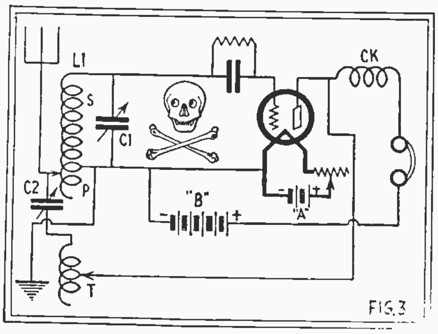
solution to the problem would be to develop a system which would provide exactly the desired amount of regeneration on all wavelengths; but an entirely satisfactory means for obtaining this condition has not yet been discovered.

It is necessary, in order to understand the theory of regeneration in radio circuits, to have first a general understanding of the way in which vacuum tubes function in amplifying circuits. A brief summary of the facts will be given in the next paragraph.

THE VACUUM TUBE

The ordinary vacuum tube used in radio comprises three electrical "elements"—filament, plate and grid—together with the fine wires or "leads" which run from them to the prongs set in the tube base, by which contact is made to the rest of the apparatus in a receiver.

The filament, in the center of the tube, is a thin wire of special composition, which is heated to "incandescence" or nearly so



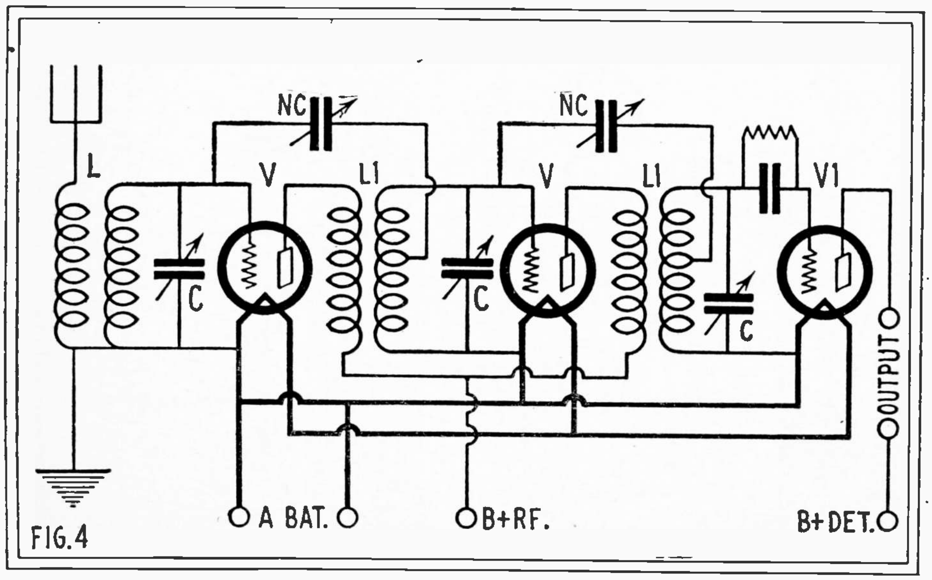
A combination of inductive and capacitative feed-back is used to produce regeneration in the Reinartz circuit, shown above. Suitable only for short-wave work.

by the "A" battery, which is often a storage battery, or by special devices furnishing a low voltage.

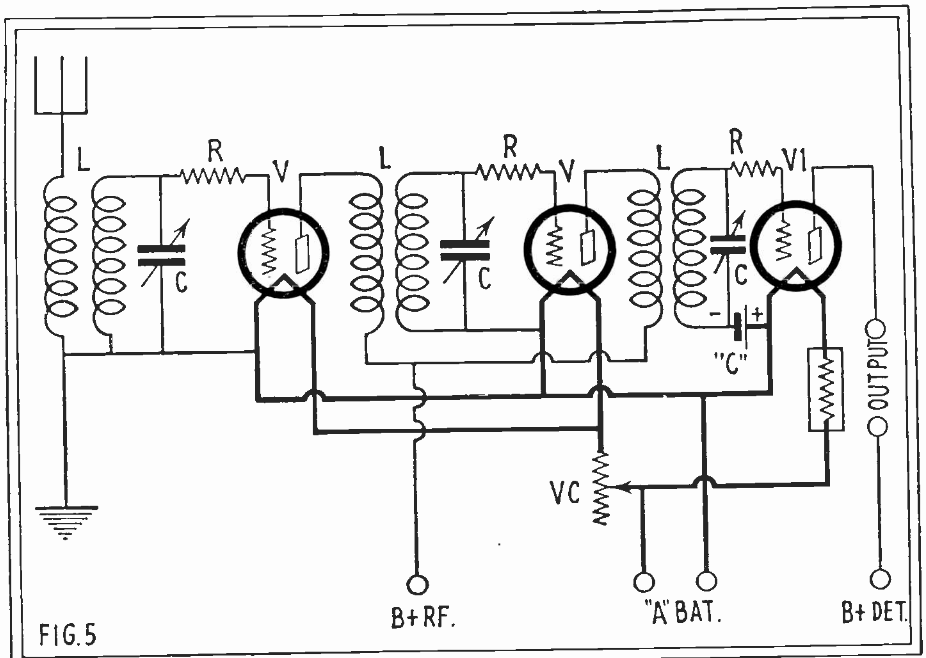
The plate, which is nearest the bulb of the tube, is usually in the form of a thin metal cylinder surrounding the filament; between the outside wires connecting to their leads is applied the voltage from a "B" battery or power unit, with the "B+" terminal attached to the plate lead.

The grid is a coil or screen of very fine wires, close together, which is placed in the space between the filament and the plate, inside the tube. Upon the *voltage* which is applied to the grid depends the action of the tube, other things being equal.

When the filament is heated it gives off electrons; these are attracted by the positive charge on the plate, and there results a flow between these elements of "plate current." When the voltage on the grid (as measured from the filament) is zero the flow of current reaches a certain value determined by the plate voltage and the "characteristic" of the tube; when the grid voltage is negative, the plate current decreases, and when the grid voltage is positive, the plate current increases up to a certain limit. It requires a very small change of voltage (and almost inconceivably little current) to cause considerable changes in the plate current, and it is this fact which enables the use of a vacuum tube as a volt-



The fundamental R.F. circuit of a standard two-stage neutrodyne with a non-regenerative detector. L, antenna coupler; L1, other R.F. transformers; V, R.F. amplifier tube; V1, detector tube; C, tuning condensers; NC, neutralizing condensers, which are small in capacity, to offset the tube capacities.



Oscillation in R.F. amplifiers may be prevented by the introduction of losses; and in this circuit fixed-resistor units are used for the purpose. L, R.F. transformers; C, tuning condensers; V, R.F. tubes; V1, detector tube; VC, volume control.

age amplifier. In the case of the standard 201A-type tube the amplification factor under correct operating conditions is approximately 8; and, therefore, if the incoming oscillations cause the grid voltage or "potential" to "swing" 2 volts, the variations in the plate circuit will be eight times as great, or 16 volts.

THE "FEED-BACK"

In a *regenerative* circuit, the voltage variations of the grid affect the plate current exactly as they do in the usual amplifier; but the effect of voltage changes produced by the varying current in the plate circuit is returned to the grid circuit. This action is called *"feed-back."* As the voltage changes in the plate circuit are *"in phase"* with those in the grid circuit, the grid-voltage variations are increased by feed-back from the plate circuit, and in this way the amplification of the tube is greatly increased. The amount of extra amplification which may be obtained in this way is determined by two factors; first, the amount of plate-current energy which is returned to the grid circuit; and second, by the *"critical point," at which the tube enters a state of self-sustained oscillation.*

From the above description it is easy to see that the amplification of the circuit increases as the transfer of energy from the plate circuit to the grid circuit is increased; for, regardless of how much energy is returned to the grid circuit this energy is again amplified by the tube with the result that the plate-current variations are increased—that is if the tube does not start "oscillating." However the point which is difficult for the beginner to understand is that the entire operation described above takes place almost instantaneously and, as a result, under normal conditions has no effect upon the signal which is being amplified. On the other hand, when one endeavors to obtain too much amplification through regeneration the signal is *distorted;* but this will be discussed at greater length in another paragraph.

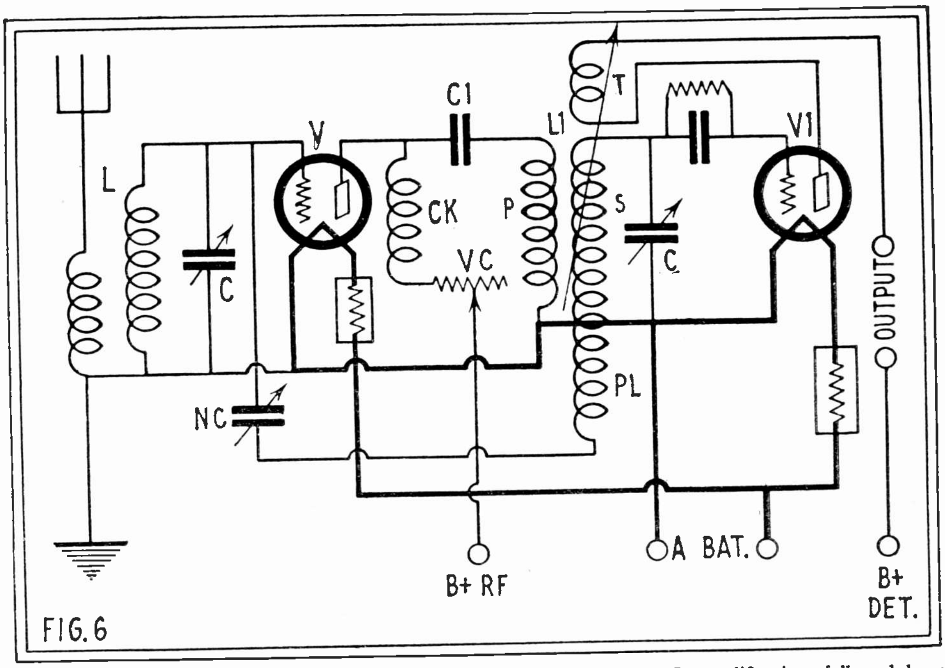
In order to explain the effect which regeneration has upon a circuit many authorities use the term "negative resistance"; *i.e.,* they say that introducing regeneration into a circuit has an effect similar to reducing the resistance of the circuit. In many ways this explanation is very satisfactory; but it has often caused experimenters to believe that the resistance in regenerative circuits need not be considered, because it may be decreased by increasing the amount of regeneration. However, this belief is not true. Theoretically, however, when the tube breaks into a state of "oscillation," the position (actual) resistance of the circuit has been reduced to zero by the "negative resistance."

EFFECT OF OSCILLATION

Regeneration not only produces the effect of reducing the resistance of the circuit by increasing the strength of the signals, but also greatly increases the *selectivity* of the circuit. When regeneration is not present, the receiver may tune so broad that it is impossible to receive stations without interference; but, as the regeneration is increased, it will be found that the selectivity is ample for all usual requirements. Also, when the detector tube is operated on the verge of oscillation, the selectivity is often so extreme that music is badly distorted because the *"sidebands"* of the wave are excluded, thus cutting off the higher notes. Under these conditions the harmony will be supplanted by rough blasting tones, while the volume of the signal is often much greater than when the musical tone is preserved. After the tube enters a state of oscillation, the volume of the signal is usually greatly reduced, but the distortion remains. Music received when the detector tube is oscillating often sounds like escaping steam and is accompanied by whistling sounds.

Before continuing with the discussion on regeneration, the wiring diagram of a regenerative receiver will be considered. Fig. 1 shows the circuit of a simple "three-circuit tuner" (more properly "two-circuit") in schematic form; this represents what was once one of the simplest, most popular and most frequently-used receivers. It is easy to operate, as there are only two tuning controls, and it provides amplification which is practically equal to that of a two-stage tuned R.F. receiver with a non-regenerative detector. Of course, the overpowering disadvantage of this system of reception is that, when it is not properly operated, it will oscillate and the radiated energy from the antenna will interfere with reception in nearby receiving sets. For that reason, operation of an oscillating regenerative set is in some places punishable by law; and might be in this country under the Radio Act.

Although this circuit is no longer in general use as a first stage of broadcast reception, its operation will be considered, as it is a basic regenerative circuit and is often employed to advantage when placed after one or more stages of tuned R.F. amplifi-



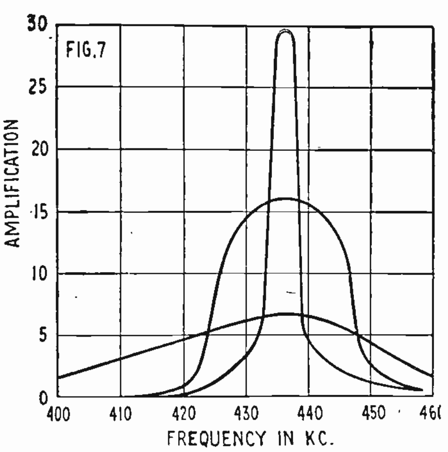
High efficiency may be obtained by employing a stage of neutralized R.F. amplification, followed by a regenerative detector. L, antenna coupler; L1, detector-circuit coupler; V, R.F. tube; V1, detector tube; C, tuning condensers; VC, volume control.

cation, which prevents radiation from the antenna. The essential piece of apparatus is the three-coil coupler (L1). This consists of a primary coil (P) of a few turns which is connected directly in the antenna circuit or preceding R.F. circuit, a secondary coil (S) tuned to the desired wavelength by a variable condenser (C), and a tickler coil (T). The primary and secondary coils are usually wound on the same tube form and are coupled "tightly." The tickler coil is found on a separate tube, and the coupling between the secondary and the tickler is adjustable by rotating the tickler on its shaft. As may be seen from the diagram (Fig. 1) the secondary is connected in the grid circuit of the receiver and the tickler is connected in the plate circuit. By adjusting the coupling of the tickler the feed-back or regeneration may be increased.

MODES OF REGENERATION

In the circuit described, the method of obtaining regeneration is called *inductive feed-back* because the energy from the plate circuit is returned to the grid circuit *inductively; i.e.*, by virtue of the close proximity of the tickler coil to the grid coil. In the operation of this receiver signals are to be tuned in by adjusting the condenser C, as this governs the wavelength of the grid circuit; then, after the signal has been tuned in, its strength may be brought up by carefully increasing the coupling between the tickler coil and the secondary coil—that is, turning the tickler tube until it comes more nearly straight with the tube of the secondary.

Another popular regenerative receiving circuit will be found in Fig. 2. This type of receiver is known, properly, as the "three-circuit tuner," and in the early days of broadcasting it was almost as popular as the tickler-feed-back system just described. In this receiver feed-back is obtained through the grid-plate capacity of the tube, and this feed-back takes place when



This graph clearly shows that as regeneration increases the sensitivity (height of the curve) and selectivity (sharpness of the curve) are also increased.

the plate circuit is tuned to approximately the same wavelength as the grid circuit.

From the diagram it will be seen that energy from the antenna circuit is transferred to the grid circuit in exactly the same way as in Fig. 1; that is, the primary coil (P) of the antenna coupler (L1) is connected between the aerial and ground, and the secondary coil (S) is connected between the grid and the filament of the tube. As there is an *inductive* relation between these coils, energy is transferred; and the condenser (C), which is connected in shunt with the secondary coil, tunes the circuit to the desired wavelength.

The *"variometer"* (L2) connected in the plate circuit of the tube is the interesting feature of the circuit. This unit is a *continuously-variable inductance* and it is equivalent to a coil of wire shunted by a variable condenser.

In operating this receiver the grid circuit was tuned to the wavelength of the desired station, and the variometer employed to control regeneration. As the wavelength of the variometer was adjusted to approach the wavelength of the grid circuit, the regeneration increased. This is because the alernations in the plate circuit were forced to return to the grid circuit through the small *capacity* (condenser) formed by the close proximity of the grid and plate elements of the tube. Of course, in this circuit regeneration would produce an effect upon the signal identical with that obtained by using the circuit in Fig. 1. Also, regeneration would cease and the tube breaks into oscillations when the feed-back passed a certain critical value.

Regenerative circuits using a variometer in the plate circuit of the detector tube are called *tuned-plate* or *capacity-feed-back* receivers. In addition, it may be pointed out that the regeneration which is found in the average tuned R.F. receiver is usually produced by this method.

THE REINARTZ CIRCUIT

There are three basic ways in which regeneration may be produced in a radio receiver; the first two are illustrated in Figs. 1 and 2, and the third in Figure 3. The last is popularly known as the Reinartz circuit, as it was first introduced for the reception of short-wave "C.W." signals by the well-known amateur experimenter, John L. Reinartz. This circuit, which employs a combination of inductive and capacitive feed-back methods, has been found excellent for the reception of continuous-wave (code) signals but is not as satisfactory for the reception of phone signals as the two circuits previously described. It is only one of a number of different circuits which use this system of regeneration, but is probably the best known of its type.

In this circuit the grid and antenna circuits are arranged in much the same way as in Figs. 1 and 2; the chief difference being that the primary coil (P) and the secondary coil (S) of the coupler (L1) are coupled together conductively as well as inductively. However, the plate circuit is very different. First, it will be noticed that there is an R.F. choke coil connected between the plate of the tube and the phones. This prevents the R.F. current from being short-circuited through the phones to the filament. Next, it may be seen that there is a wire which connects the plate of the tube to one end of the plate coil (T) of the coupler, and that the other end of the plate coil is capacitively coupled to the primary and secondary coils through the variable condenser (C2).

In this circuit the choke coil (CK) in the plate circuit prevents the R.F. current from passing through the phones, and, therefore, this current follows the path of least resistance, which is to the plate coil (T). As the plate coil is both inductively and capacitively coupled to the secondary or grid circuit, feed-back takes place and regeneration is produced. In this case regeneration may be controlled in two ways; first, by changing the number of turns in the plate coil and, second, by changing the capacity of the condenser (C2). Increasing the number of turns in the plate coil and increasing the capacity of the condenser both tend to increase regeneration by increasing the inductive and capacitive feed-backs, respectively.

MODERN BROADCAST RECEIVERS

Thus far in this article the writer has discussed simple regenerative receiving circuits, but he does not wish the reader to consider using sets of this type for broadcast reception. It is practically impossible to operate a regenerative receiver without causing considerable interference to nearby broadcast listeners. Also, modern receivers are capable of providing much better performance.

In order to continue this discussion of the effect of regeneration in tuned, radio-frequency circuits, it is necessary to study the schematic wiring diagram of a typical tuned-R.F. circuit. Fig. 4 presents the wiring diagram of a standard neutrodyne receiver employing two stages of tuned-R.F. amplification and a non-regenerative detector. In this circuit, if the two neutralizing condensers (NC) were removed it would be the wiring arrangement of a standard tuned-R.F. set with no provision for the prevention of regeneration.

In the wiring diagram L is the antenna coupler and the two coils L1 are the other radio-frequency transformers. All three coils are the same size, and have the same number of turns on each winding. The two tubes V are radio-frequency amplifiers and V1 is the detector. The three condensers C tune the grid circuits of the three stages.

During reception the three condensers are adjusted so that the grid circuit of each stage is tuned to the same wavelength. The "signal" from the broadcast station is transferred to the grid circuit of the first tube by the antenna coupler and is amplified by that tube; then it is transferred to the second stage by the first R.F. transformer and is again amplified, and then it is transferred to the detector stage by the second R.F. transformer and "rectified" or detected by V1.

The problem in a circuit of this type arises from the fact that the condenser in the grid circuit of each stage must be tuned to the wavelength of the signal in order to obtain maximum efficiency and because the primary and secondary windings of the R.F. transformers are closely coupled together.

Before concluding this article, it should be pointed out that there is another entirely satisfactory method of obtaining the beneficial effects of regeneration, and known as the Roberts circuit (see Fig. 6). In this circuit a stage of neutralized radio-frequency amplification is combined with a regenerative detector of the type in Fig. 1. Only two tubes are used in the circuit, yet the results will be equally satisfactory from which may be secured with a three-tube circuit of the type shown in Figs. 4 and 5.

What a Radio Tube Is, and What It Does

By Clyde A. Randon

A THOROUGH understanding of the functions of the vacuum tube, the heart of broadcast transmitting and receiving apparatus, is of fundamental importance to the radio beginner if he wishes to understand even the most elementary principles under which his equipment operates. Articles explaining the action of these tubes have been published many times in this and other magazines; but they have been usually so technical that the ordinary listeners, the rank and file of the vast audience which now enjoys the pleasure of radio entertainment, find considerable difficulty in apprehending the meaning. Too often a valuable article is made puzzling for them by the presence of electrical terms which, though elementary, are not frequently used in ordinary conversation.

In this article the writer will attempt to explain the operation of a vacuum tube, in language which the average reader is able to understand; and he will avoid, as far as possible, the special terms used by scientists. Of course, it will be impossible to explain here some of the more complicated applications of radio tubes, as these require a fundamental knowledge of radio circuits in order to learn what takes place; but the way in which a tube functions as an *amplifier* will be described. This is the use of the majority of tubes in radio receivers and, therefore, this explanation should clear up many problems which perplex the mind of the beginner.

USE OF THE FILAMENT

A tube consists of a filament, a grid and a plate, all "hermetically" sealed in an "evacuated" bulb, which is provided with convenient external terminals for making contact with these three "elements" inside.

The filament is simply a thin wire of special composition which usually becomes "incandenscent" when in operation, but not necessarily so. Some filaments must be heated to incandescence (glowing whiteness) for best results, while others perform more satisfactorily when operating at a cherry-red heat; different filaments require different temperatures for highest efficiency, but all operate in a similar manner. A filament may be looked upon as composed of a "volatile" substance, which evaporates when heated and thus gradually disappears. Water at ordinary room temperatures, for example, evaporates slowly but, as it is heated, more and more evaporates; and finally there is violent "ebullition" (boiling) and the water becomes steam and passes into the atmosphere. The action of evaporating water and the escape of particles of matter from a heated filament are very similar. (See Fig. 1.)

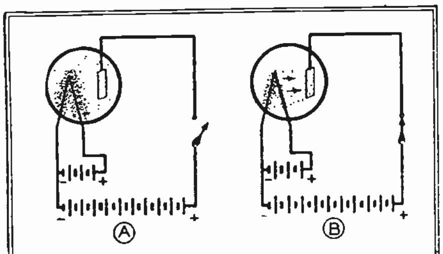


FIG 2

At A, the "B" battery switch is open, and the electrons gathered in an aimless crowd around the filament. At B the plate is positively charged by connection to the "+" of the "B" battery, and electrons are attracted in a steady stream from filament to plate.

All substances are composed of almost inconceivably small particles called "molecules." At ordinary temperatures, these small bodies are continually colliding with each other, and in a liquid or gas they are traveling in random directions. If a body is heated, these molecules speed up and thus bombard their neighbors with greater velocities. At high temperatures, ("high" for one substance may be "low" for others; this is only relative) the molecules reach such velocities that some are capable of breaking away from the influence of the others, and thus pass away from the substance, in the form of *vapor!* that is, "evaporation" takes place.

Due to the influence of neighboring molecules, there is a tendency on the part of a solid or liquid substance to "cohere," or hold on to its constituent parts. In the case of water, for instance, there is what is called "surface tension"; that is, the surface of the liquid acts like a *stretched membrane* and it is thus made more difficult for molecules to escape (or the liquid to evaporate) at ordinary temperatures. (One can easily perform a simple experiment in this connection. A small needle can be made to float by laying it carefully and perfectly flat on the surface of a glass of water; thus showing that there is "surface tension." The needle must be perfectly dry or even oily; otherwise the water will "creep" around the needle and it will sink.)

"EVAPORATING" THE FILAMENT

If water is heated, the molecules reach such velocities that the surface tension is no longer strong enough, and they simply break through in large numbers and leave the liquid—as we have explained, *evaporate*. This is almost exactly what takes place in a heated filament. At high temperatures (very much greater than the boiling point of water, of course) the velocity of the "electrons" or particles of *negative* electricity in the filament becomes so great that they simply shoot out into the surrounding space, with relatively large velocities.

If another element (such as the "plate," found in all radio vacuum tubes) were placed around the filament, but *insulated* from it, some of these electrons would strike the plate; the rest would tend to form a "cloud" around the filament, some electrons leaving the filament and others again en-

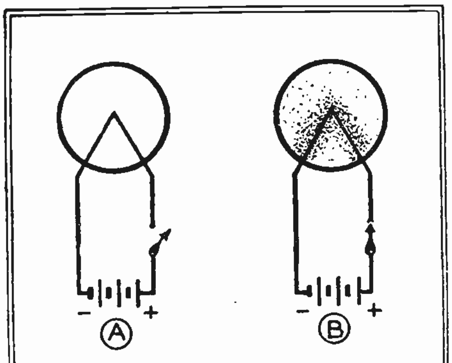


FIG. 1

At A we have no current in the filament, no electrons evaporating. At B, with the battery switch closed, the filament is lighted and from it electrons in countless billions are escaping.

tering it. A condition approaching *equilibrium* would be reached; that is, there would be the same number of electrons leaving the filament as returning, and no useful result would occur. (See Fig. 2.)

If, however, a *positive* charge (compared with that on the filament) or voltage is placed on the plate, electrons will flow to the plate and continue to do so as long as the filament is heated and the positive charge maintained; since electrons constitute *negative* electricity, they are attracted by a positive voltage (for *unlike* electrical charges attract each other.)

THE ELECTRON STREAM

In the vacuum tube, when connected in this way, there would thus be a *continuous flow of electrons*, and this constitutes an electric "current." It is to be noted that such a stream can proceed in only one direction, from filament to plate—negative to positive. It is often said that the current travels from positive to negative, and this is because in the early days the scientists

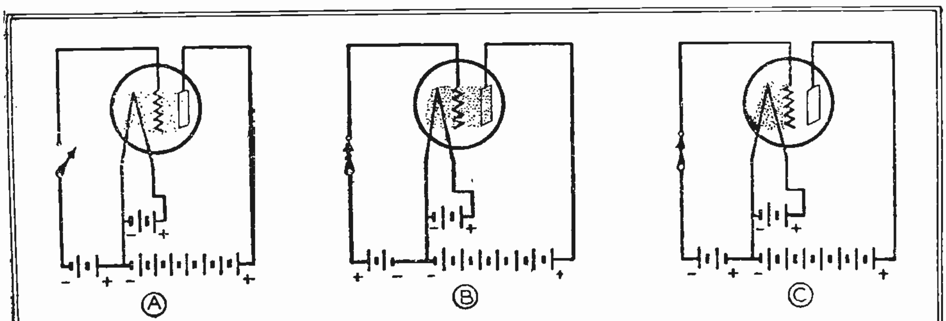
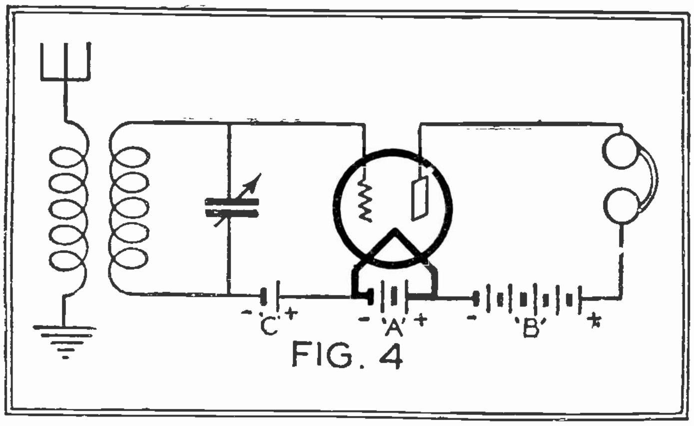


FIG. 3

At A, the disconnected grid has little effect on the electron flow from filament to plate; but at B the "+" charge on the grid adds attraction and greatly increases the flow. On the contrary, the "—" charge on the grid, shown at C, will drive back the electrons and let few or none reach the plate.



This diagram shows the simplest way to "hook up" a tube to make a radio receiver. The "A" battery lights the filament; the "B" battery "puts volts on" the plate and causes a flow of current, the changes in which are heard in the phones as sounds. The "C" battery puts on the grid the voltage, commonly called a "bias," which is needed because this tube must be a "detector" as well as an "amplifier."

had their choice of two guesses and they guessed wrong. To this day, this erroneous assumption is still prevalent, in common speech, just as we say "the sun rises;" but if the reader will remember that *the electrons proceed from filament to plate*, there need be no confusion in his mind.

THE ELECTRON-CONTROL GRID

By introducing a third element, called for short a "grid," the stream of electrons between plate and filament can be *controlled*. The grid consists only of very fine wires, spaced at definite distances apart so that a large proportion of the electrons can pass between them. Just as the positive charge on the plate tends to cause a flow of electrons from the filament, so a *positive charge on the grid will also tend to increase this flow*. (See Fig. 3.)

The grid, however, is much nearer to the filament than the plate is; and any charge or "voltage" on the grid will thus have a much greater effect on the electron flow than an equal charge on the plate. A *negative* charge on the grid will decrease the electron flow to the plate (the "plate current") and the amount of decrease will depend upon the strength of the charge on the grid.

It is readily seen, therefore, that the grid acts as a delicate control of the plate current. Since a very small charge on the grid has a relatively large effect on the plate current, the tube "amplifies" the small electrical impulses which are "impressed" on the grid. Very small effects thus give large response.

USE IN A RECEIVER

In the simple circuit shown in the diagrams, the tube is used to amplify the weak "signal" impulses which arrive from a broadcast station. A passing wave *induces* a small current in the antenna and this flows through the coil between the aerial and ground. (Note that the current *oscillates* [reverses its direction, back and forth] between the aerial and ground and, therefore, for best results the ground connection must be well-designed also). The current in the primary coil gives rise to a *magnetic field*, which induces another current in the secondary. This gives rise to a difference of voltage between the filament and grid which may be compared to placing a charge on the grid.

As explained before, the plate current is continually changing in accordance with whatever variations are present in the original signal from the broadcast station; and, therefore, these electrical variations are transformed into *sound variations* which may be heard in the telephones, and reproduce the sounds originally converted into electrical variations by the "microphone" in the broadcast studio. A vacuum tube used in this manner is called a "detector."

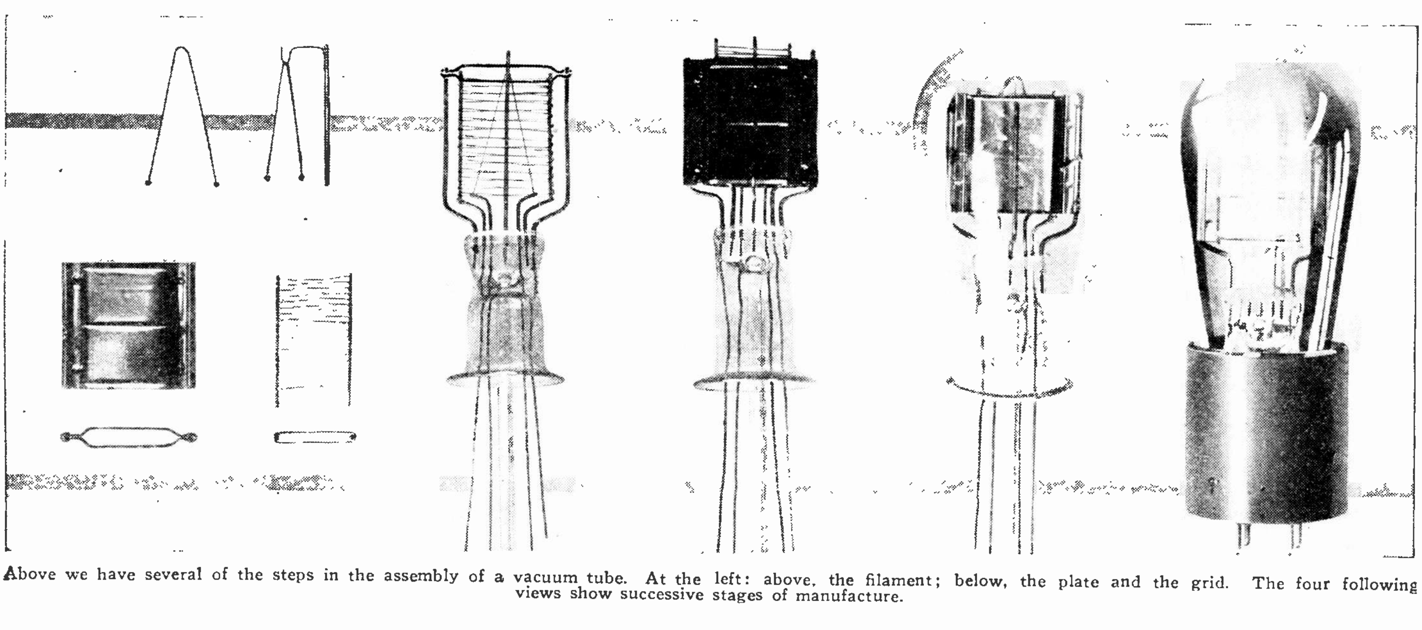
No matter how rapid are the fluctuations that are impressed on the grid, the plate current faithfully follows these. Even such extremely rapid variations as "radio frequencies," thousands of times more rapid than the musical or speech ("audio") frequencies, may be successfully amplified also. For further amplification, it would be necessary only to connect the grid and filament of another tube in the position occupied by the head telephones in the case described in the previous paragraph, and the incoming audio-frequency pulsations could be still further amplified by the second tube. There is no limit to the amplification that can be obtained, but various "extraneous" or outside noises are also amplified; so that enormous amplification may give too much importance to useless noises.

VARIOUS USES

Although the action of all common radio tubes is the same in principle, there are other factors which determine which *type of tube* should be used for a given purpose. Certain features of construction or the spacing of elements may adapt a tube to some particular use. Different materials and designs in filament wires may be used; so that different tubes require different battery voltages to operate them. Certain filaments require more current than others for proper heating and "evaporation;" some tubes successfully operate from alternating current merely "stepped down" from the house-lighting circuits, while others require batteries or power units which contain rectifiers.

For *detection*, a small quantity of certain gases, introduced into the glass bulb, often gives a tube greater sensitivity to small grid charges, "weaker signals." A tube to handle large amounts of power, and such are necessary for good loud-speaker operation, must be of special construction so that the plate voltages necessary and the power handled will not *overload* the tube; overloading may give rise to tube failures, or distortion in the speech or music.

One of the governing factors in the use of a tube as a radio-frequency amplifier is the *capacity* between the elements of the tube. A special construction may, therefore, give better results for such purposes. It is evident, therefore, that the design of a tube is greatly influenced by the use which is to be made of it; it may justly be said that there is a particular tube for each and every use in a radio receiver if best results are to be obtained.



Above we have several of the steps in the assembly of a vacuum tube. At the left: above, the filament; below, the plate and the grid. The four following views show successive stages of manufacture.

CARE OF TUBES

The filament of a tube is designed to give best results at a definite voltage or current, and at this value, a certain length of life for the filament is obtained. If the tube is operated at a filament voltage higher than the rated value, the electron evaporation is greatly increased, with little useful gain; but the life of the filament is very greatly reduced. Some filaments do not actually burn out when the voltages are exceeded, but they become "deactivated"; that is, the useful material has disappeared from the surface of the filament. This may often be restored by turning on the tube with somewhat above normal voltages on the filament, and *with the plate ("B") battery temporaily disconnected;* but prevention is much easier than a cure.

The new "screen-grid" tube makes use of a second grid, which surrounds the plate completely, and shields the first or control-grid from the plate. It thus makes negligible the *"capacitive"* effect between grid and plate, which causes complications in the use of ordinary tubes for radio-frequency amplification. The screen-grid tube, when used as a radio-frequency amplifier, has this second grid connected to a source of positive voltage, about one-third as high as that applied to the plate. The capacitive effect within the tube is thus reduced to a negligible amount. The action of this tube is otherwise the same as that of the ordinary tube, which has been described.

THE ACCESSORIES

The tube socket is designed so that the tube may be easily removed from it, in case replacement is necessary, and is equipped with convenient screws for attaching the "lead" wires from the external circuits to the socket; the *springs* of the sockets in turn complete the connection to the tube's *prongs*, which lead by wires inside the tube to its elements, respectively.

Two prongs in the ordinary tube connect to the ends of the filament, sometimes designated as "plus" and "minus" when in use, and one each to the grid and to the plate.

The most common type of socket is the "UX." It is often necessary to have a socket which is "spring-supported" or "cushioned"; so that ringing or "microphonic" noises from tubes are eliminated. Proper internal construction, resulting in greater rigidity of the tube's elements, has done much toward eliminating this effect.

All common types of tubes fit into the ordinary "UX" sockets; but different tubes require different resistances *in series with the filaments* to reduce the voltage.

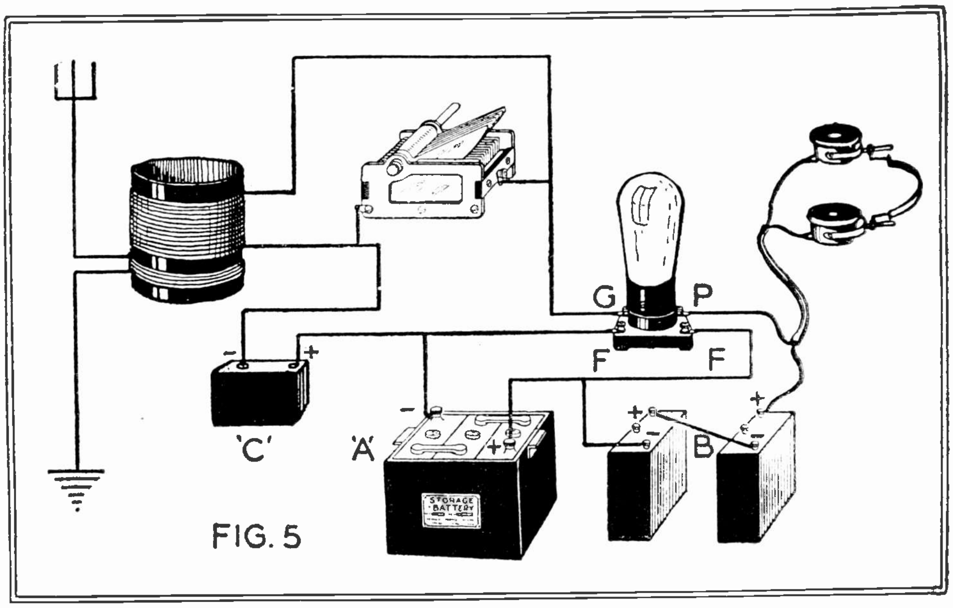


FIG. 5

This type of circuit drawing explains more clearly the meaning of the different parts diagramed in Fig. 4, the connections being exactly the same.

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How to Use the New A. C. Tubes

Advice on the Adaptation of Receivers to Use These Latest Products of Radio Design

By Victor L. Osgood

"WHY can't I simply replace my old tubes with the new A.C. type (the UX-226 or CX-326), attach a transformer secondary to the filament binding posts, and thus have an electric power set?" This question, while perhaps not exactly the same in words, is quite prominent in the minds of a multitude of set owners today. "And why do I have to have for the detector a different tube using a five-prong base?" is another question puzzling the aforementioned portion of the American public.

It is not a difficult question to answer, as those who try it will quickly find out; the deafening roar from the loud speaker that will greet the experimenter will more than suffice to demonstrate the impracticability of this method of remodeling. But a study of the information contained in this article will show that it is not a difficult job to adapt the set to the new tubes—if the owner has had any experience whatever in following schematic circuit diagrams.

An explanation of the causes of hum will be timely here, with the method of reducing each to a minimum to follow. It will probably be a surprise to those who have had little experimental experience to know that there are two "kinds" of hum. That is, two separate frequencies exist independently of each other; one being equal to the frequency of the A.C. current and the other being double the first, though not because of harmonics, as will be seen.

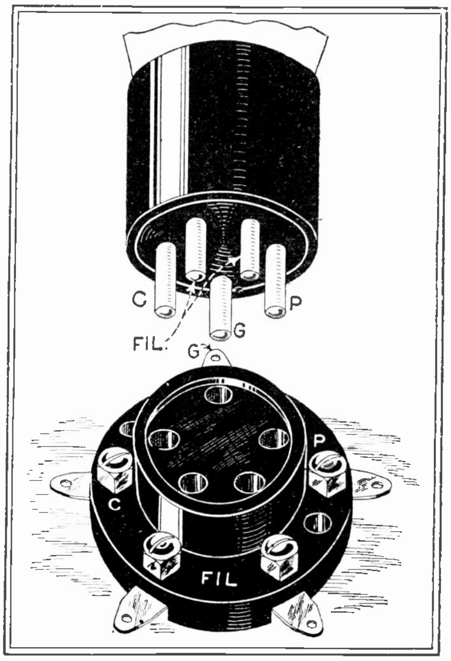
THE 60-CYCLE HUM

The chief cause of the fundamental-frequency hum (let us say 60-cycle, 110-volt power is being used) is what is called the grid-and-plate effect. By this is meant the effect of the A.C. filament voltage upon the plate and grid respectively when the grid return and "B—" are connected to one side of the filament, as shown in Fig. 1. S is the low-voltage secondary of a transformer supplying the current necessary to heat the filament. This supply is alternating and therefore voltages at the filament terminals, A and B, are constantly alternating, plus and minus. Since the average voltage of the filament is one-half the applied voltage, then C, the center of the filament, is at a constant potential with respect to the terminals collectively. For when C is negative with respect to B, it is positive with respect to A, and *vice versa;* always by the same amount.

Both the grid and plate have the effect of operating directly on the center of the filament. Consequently, if alternating current is applied to the filament, it is evident that one alternating voltage will be on the grid and another on the plate; each equal to one-half the voltage applied to the filament. These voltages are naturally treated by the tubes as a signal voltage and are amplified accordingly.

USE OF POTENTIOMETER

From the above it may easily be seen that a grid-and-plate return to the center of the filament will eliminate this source of hum. But we cannot get to the center of the filament, because it is enclosed in the tube. True, but if we find a point outside whose potential is the same, we have an equivalent connection. This is known as a bridge effect, from the "Wheatstone bridge" circuit shown in Fig. 2A, and may be accomplished by connecting across the filament voltage a small potentiometer and adjusting it to the proper position as shown in Fig. 2B.



The base of a heated-cathode tube of the new A.C. type, and the special five-prong socket into which it fits. The contact marked C is for the cathode, or source of the electrons.

With a five-volt tube, however, the adjustment of the potentiometer is very critical, especially since we have lost the bias possessed by the grid with direct current on the filament. So by designing the tube for lower

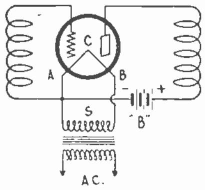


FIG.1

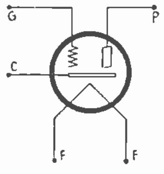


FIG 3

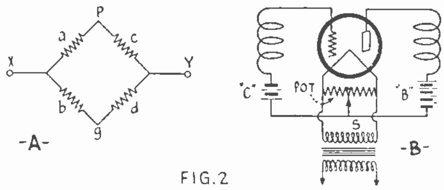


FIG.2

Fig. 1 is a circuit which will let through the A.C. hum. In Fig. 2A is a Wheatstone bridge, illustrating the principle of the circuit in 2B which remedies this fault. Fig. 3 illustrates the elements of the A.C. tube.

voltage and inserting the "C" battery shown in Fig. 2B we have a quiet tube operating on A.C. This accounts for the fact that the UX-226 or CX-326 tube is designed to burn at 1.5 volts.

THE 120-CYCLE HUM

But why the heavy current that is used to heat the filament? The answer is, to eliminate the cause of the 120-cycle disturbance. It is well known that a small piece of metal will cool much more quickly than a large piece; also that the more cubic contents the metal has per unit of radiating surface, the more slowly will it cool. A small "ribbon" filament heated by A.C. has a decided tendency to allow its heat to fluctuate with the current value in it; and this current value is constantly changing, being at zero 120 times a second and also at maximum at an equal frequency. There is a consequent variation of plate-filament resistance, which modulates the plate current and produces a note in the speaker. This is especially noticeable when a strong signal is being received. The radio-frequency signal is being modulated with 120 cycles, thus creating more amplification of the disturbance than when it originates in the audio tubes.

A heavy filament of circular cross-section will obviously be the remedy for this trouble; since its circular form reduces its ratio of surface to cubic volume, and the increased size reduces heat variations. Since the cross-section of the filament is larger, its resistance will be less and naturally more current will flow. But from a viewpoint of watts (which is the expense factor) there is but very little increase in the new tube over the old quarter-ampere, five-volt tube. (Watts are equal to the product of volts and amperes.)

There is another source of hum known as the "*stealing effect,*" from the fact that one end of the filament, when positive, attracts electrons from the other end, thereby depriving the plate of that amount. This applies especially to the inverted-V type of filament, because the ends are close together; but is easily remedied by simply making the filament straight. The reduction in the voltage used also helps to cure this source of trouble.

PROBLEMS OF THE DETECTOR

Up to this point the solution has seemed very simple, in view of the fact that millions in

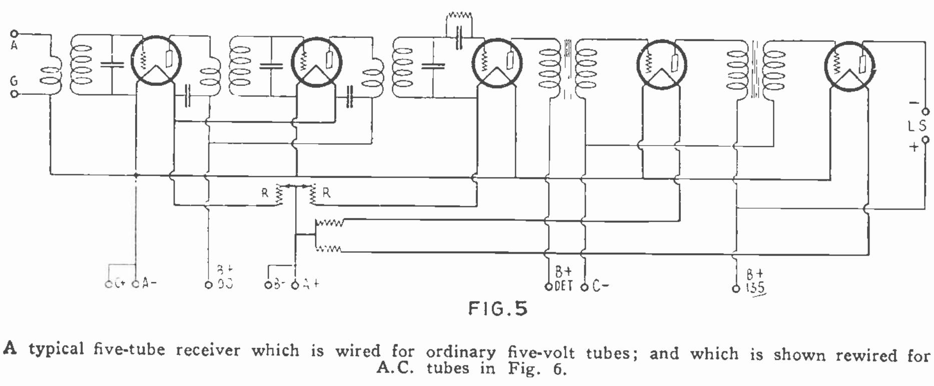


FIG.5

A typical five-tube receiver which is wired for ordinary five-volt tubes; and which is shown rewired for A.C. tubes in Fig. 6.

time and money have been spent during the past five or six years to arrive at it. And it really is very simple, now that it is understood; as is so often the case. But, when we try to aply these ideas to the detector tube, we run into some serious complications. Not that it is impossible to light the detector on

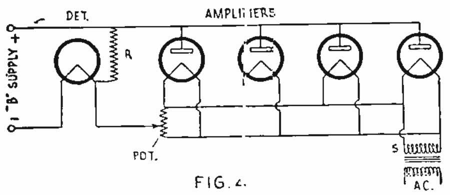


FIG. 4.

Using the plate-supply of the amplifier tubes for heating the filament of a 199 detector tube. The grids are omitted, for simplicity.

A.C. without a disagreeable hum, but other drawbacks enter that make this impractical.

The grid condenser and leak, since they offer extremely high impedance to low-frequency alternations, isolate the detector grid and make it very susceptible to any stray 60-cycle electric fields. If it is shielded from these hum sources, a positive voltage must be applied to the grid to get the most sensitivity; and this will bring out a hum which the negative bias eliminated, as mentioned in the first part of this article. Consequently either hum elimination or sensitivity must be sacrificed if A.C. is applied directly to the filament; and neither of these alternatives is to be preferred to the two methods explained below.

The new UY-227 detector is known as the "heater-cathode" type For those who are unfamiliar with this type, which has become quite popular of late, a few words of explanation will be timely here. Current is needed in filaments for but one purpose; *viz.*, its heating effect. A gas flame could be applied to a filament and enable the tube to operate. Since heat is the only requirement, then the problem boils down to working out the best method of applying heat. If we heat one body and a second is close by, conduction of heat from the first will heat the second body. So if one filament is heated by A.C., and another strip of metal is placed alongside and heated by thermal conduction, the latter may be used as the cathode in a vacuum tube, corresponding to the filament in other types. This is shown by Fig. 3, in which F-F is the filament to which the heating voltage is applied; C, the cathode to which the plate and grid returns are attached; G, the grid, and P, the plate connection; thus making necessary the five prongs that are found on the UY-227 tube.

UTILIZING THE PLATE CURRENT

Another method of detection is to use a UX-199 tube and heat its filament with the plate current of the other tubes, adding what additional current is needed to make up 60 milliamperes by connecting a resistor, R, in the "B" supply, as shown in Fig. 4. This method should not be employed except when a "B" socket-power unit is used; and then only when the user is absolutely sure it will deliver the 60 milliamperes at the voltage required without being ruined by the load.

The chief difference between the two methods is in the amount of time required after turning on the switch before the set will function. In the case of the heater-cathode tube about forty-five seconds will elapse; while the UX-199 heats immediately, as though connected to a battery.

REWIRING A SET

The changes necessary to install the new tubes are not numerous. The grid and plate returns are shifted, a few condensers are inserted and the filament wires enlarged by replacing with new wire; and two additional leads are connected to the detector socket. This socket must be changed to accommodate the five-prong tube. Let us say Fig. 5 is the circuit to be changed over, for it is typical of the five-tube sets in use today. Fig 6 is the same circuit re-wired.

The two rheostats (R—Fig. 5) may be converted into potentiometers (P—Fig. 6) by making a connection to the open end. thereby saving the price of these devices and avoiding the removal of the rheostats from the panel. If it is necessary to buy new potentiometers, they should not be over 20 ohms in rating, and should be of a physical size that will permit them to be installed in place of the rheostats, thereby avoiding any open panel holes. The potentiometers will not need constant adjustment; but setting them at the center is the way to eliminate the hum once the change-over has been made. The two extra binding posts shown are for the detector-heater leads; or these may extend clear to the transformer without installing these binding posts at all.

Since each tube draws 1.05 amperes, the four in parallel will draw 4.2 amperes. Ex-

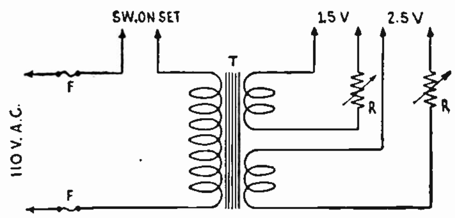


FIG. 7

Two rheostats marked R are placed in the A.C. mains, leading to the tubes in the set, to regulate the voltage.

amination of the wire chart below will show that No. 16 should be used to carry this current. Remove old filament wires (or disconnect only if in cable form) and put in new wire; remembering to twist every pair of leads carrying A.C. and to keep them all well away from the detector grid and plate.

WIRE CHART

Gauge (B&S)	Current Capacity amperes
12	20
14	11
16	6
18	3
20	1.5

Of course, the switch is disconnected from the old battery line and put in the A.C. primary circuit. Fig. 7 shows the power supply as it should be hooked up. Quarter-ampere fuses will answer for F-F very well when the load is no more than that just discussed.

The rheostats R shown in Fig. 7 should be used to get the proper voltage at the tube terminals. It should be read with a good A.C. meter and, after once adjusted, forgotten. Do not try to operate the set with one tube out, for in that case the others will be overloaded and their lives decreased. The rheostats must be capable of carrying the current used, and should be about ½-ohm in value. Many good transformers designed specially for use with the new A.C. tubes are now on the market.

It will be noticed that the two grid returns in Fig. 6 run to opposite sides of the filament voltage (that is, through the by-pass condensers), as do also the plate returns (through the "B+" by-pass condensers). This is advised, though not necessary when the capacity in the by-pass condenser is not over .006 mf. These condensers should be of at least that size.

"B" AND "C" SUPPLY

Those having a "B" socket-power device, which delivers sufficient voltage and a little to spare, may eliminate the "C" battery also, if desired, and thus have a completely electrified set. This is done by inserting in the "B—" lead resistors, which set up a voltage drop of the proper polarity to provide a negative bias on the grid. Fig. 8 shows the way to connect in these resistance units, and the method of determining how much to use is given below.

The plate current of the four amplifier tubes returns to "B—" through R and R1 and sets up a voltage drop whose numerical value is equal to the product of the current in amperes multiplied by the resistance in ohms. Or, reversing the operation, the amount of resistance to be used is the quotient obtained when the voltage value is divided by the current value. For example, if 135 volts is used on the audio plates, using UX-226s throughout as amplifiers, and 90 volts on the radio amplifier plates, by consulting the data sheet supplied in each tube carton it is found that each audio tube is drawing 7.5 mils (.0075 ampere) and each radio tube 3.7 mils; a total for the four tubes of 22.4 mils. At 90 volts on the plate the tube should have 6 volts on the grid. Therefore, R in Fig. 8 is equal to 6 divided by .0024 or 268 ohms (250 to 280 ohms tolerable); and, as we need 6 more volts to make up the 12 required for the grids of the audio tubes, another resistance unit exactly like the above will suffice for R1. The two 6-volt drops, being in series, are added together and supply the bias of 12 volts to be used with a plate voltage of 135.

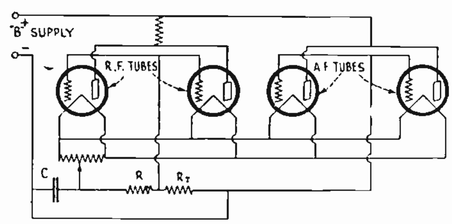


FIG. 8

The filament circuit of the R.F. and A.F. amplifiers. The values of the resistors are given in the accompanying text.

Detailed specifications obviously cannot be given here, because of the large number of sets in use; therefore, the judgment of the constructor must be relied upon to a large extent.

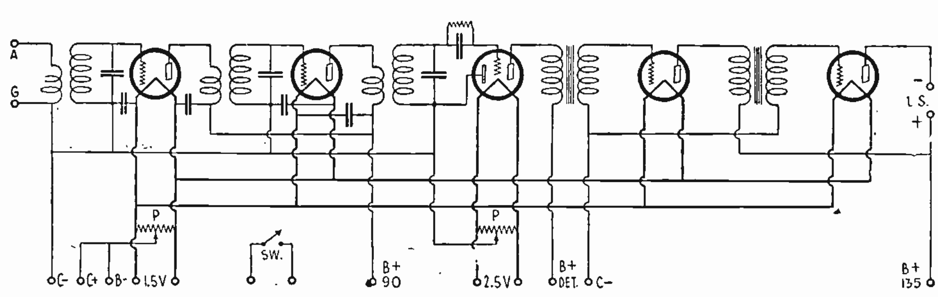


FIG. 6

The set shown in Fig. 5, is here rewired for A.C. tubes.

Capacity Shunts

(260) J. B. Taylor, Port Jervis, N. Y., asks:

Q. 1. Why are fixed condensers sometimes used across the primaries and secondaries of audio-frequency transformers.

A. 1. By using by-pass condensers across transformer primaries or secondaries, the response to high frequencies will be noticeably lessened. Increasing the capacity increases the cut-off of these higher frequencies. With poor audio transformers or with resistance or impedance coupled amplifiers, where it is desired to reduce the cut-off frequency in order to eliminate the rushing or hissing sound, by-pass condensers may be employed advantageously. The value of such a condenser ranges from .0001 to .001 microfarads if connected across the secondary of the audio-frequency transformer. Condensers from .001 to .01 microfarads across the audio-frequency transformer primary will serve the same purpose. Condensers having a capacity of .01 to .1 microfarads, if placed across the loud speaker will have a similar effect and will cut off the higher frequencies and seemingly accentuate the lower ones. Condensers and resistances operate additionally as loads on the amplifying stages and will serve to stabilize the audio amplifier.

Adding Regeneration to the Super-Heterodyne

(261) H. Lamb, Brooklyn, N. Y., asks:

Q. 1. Can I add regeneration to my super-heterodyne receiver which uses a loop antenna?

A. 1. A super-heterodyne designed to be operated on a loop may be changed so that regeneration is obtained. This loop regeneration takes place in the circuit of the first detector or frequency changer tube and has no effect on the intermediate amplifier. It is usually possible to obtain regeneration in the intermediate amplifier by bringing the grid returns to a potentiometer connected across the "A" battery. An intermediate frequency amplifier of this sort will be more effective when used at a rather high intermediate frequency and with air-core transformers. Regeneration may be applied to the second detector circuit when using an air-core filter transformer. Since the amount of energy collected by a loop antenna is comparatively small even under the most favorable conditions, it is of great advantage to employ regeneration. This will greatly reduce the effective resistance of the loop circuit at the particular frequency being received. Regeneration may be obtained in a loop by any of the methods which allow regeneration in a tuned radio-frequency transformer. Energy from the plate circuit of the first tube may be fed back into the loop through a variable condenser of small capacity. One end of the loop is connected to the grid of the first tube, and about two turns away from the filament end of the loop a tap is taken and from this tap a connection is made to one side of a small variable condenser and from the other side of this condenser, a connection is made to the plate of the first tube. Another method consists in winding a few turns of insulated wire around the loop and using this as the tickler winding. Regeneration may be controlled by a variable high resistance or a variable condenser.

Broadcasting Studio Acoustics

(262) J. Geddes, Marion, O., asks:

Q. 1. Can you give me any information concerning experiments which are now being made with multi-layered walls used in radio broadcasting studios?

A. 1. According to recent experiments by Dr. E. C. Wente, and E. H. Bedell, of the Bell Telephone Laboratories, described in *Science*, multi-layered walls are the most efficient absorbers of deep musical sounds. In radio studios where echoes are troublesome and must be carefully controlled, better acoustic properties can be obtained through the use of a thin perforated partition set a short distance from the main wall.

Formerly such sound studies had to be made in a large room, with good-sized pieces of the material to be tested. Dr. Wente and his associate have invented a way of testing in a small tube, and they claim that it gives results as satisfactory as with the older method. At one end is a telephone receiver to furnish the sound of any desired pitch. Sliding in the other end is a piston, with which the material undergoing test is covered. The echoes formed are studied with a still smaller tube that goes into the main tube at the end near the telephone receiver. On the outside, at the end of this small tube, is a telephone transmitter with which the sounds can be picked up and analyzed.

Sounds of high pitch are largely absorbed by layers of felt, porous "acoustic tile" or wood fiber mixed with felt. Deep or low frequency sounds pass through rather easily. But if the wall is covered with felt, and then, an inch away, a piece of perforated building board is placed, the low frequency sounds are much more completely absorbed. Still better is the effect of two layers of building board, with two air spaces.

Somewhat similar to this is the method recently adopted by engineers of the National Broadcasting Company in designing the new studios of station WRC in Washington. In order to make a sound-proof window between the studio and the control room, three layers of glass of different thicknesses are used. Each piece has its natural frequency and sounds of a similar pitch would be transmitted. But sounds that get through the first layer are stopped by the second, while any that might still leak through are stopped by the third.

Direction Finder

(263) M. Howe, Bronx, New York, writes:

Q. 1. Can you tell me something about the accuracy now made possible with the latest direction-finding equipment.

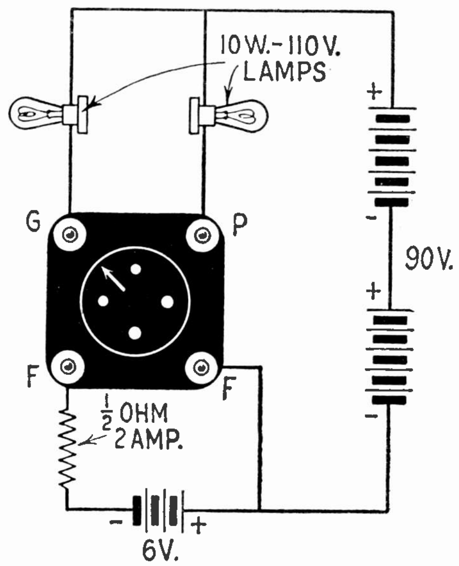
A. 1. The guarantee limit of accuracy of a direction-finding station is usually about one degree for a shore station and about two degrees when used on a ship. Greater accuracy can be procured on a short station over large sectors of the arc over which the station operates, but there are usually a few residual errors and an accuracy of one degree is all that is normally required. It is difficult to obtain as high a degree of accuracy in a ship direction-finding station, but the same accuracy is not required at sea. The function of a station of this nature in a ship is primarily to establish a check on the other methods of navigation and to provide the navigator with relative bearings by means of which he is often able to find his position. It is possible to make a direction-finding station which, by careful attention to detail and thorough shielding, will have a directive effect so accurate that variations of a quarter of a degree can be detected, but this is no proof of the accuracy of the instrument as a direction-finder. The accuracy depends upon a large number of other factors in addition to the quality of the apparatus used.

Power Tube Tester

(264) J. H. Morales, Wichita, Kansas, writes:

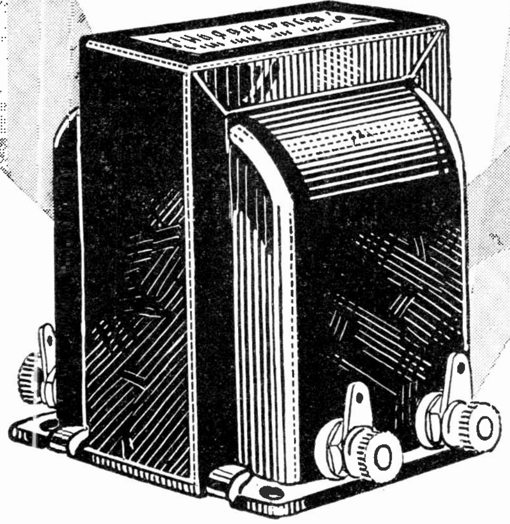
Q. 1. Kindly publish a circuit of a tube tester suitable for use with rectifiers of the thermionic type and for 210-power tubes. A simple inexpensive tester is desired which uses no meters, if such is possible.

A. 1. On this page you will find an illustration of a tube tester which we believe will meet with your requirements. Two 10-watt 110-volt lamps are used as indicators. When testing a 210-power tube, No. 1 should burn a dull red and No. 2 dull orange. With the 213 tube, both lamps should light to a dull orange color. When testing a 216 B, No. 1 should be dark and No. 2 dull orange, with a 280, No.'s 1 and 2 should be dull orange, and with a 281, No. 1 should be dark and No. 2 dull orange.



TYPE	IND. FOR GOOD TUBE
210	NO. 1 DULL RED NO. 2 DULL ORANGE
213	NO. 1 DULL ORANGE NO. 2 " "
216 B	NO. 1 DARK NO. 2 DULL ORANGE
280	NO. 1 DULL ORANGE NO. 2 " "
281	NO. 1 DARK NO. 2 DULL ORANGE

A NEW NOTE IN AUDIO AMPLIFICATION



THORDARSON R-300 AUDIO TRANSFORMER

SUPREME in musical performance, the new Thordarson R-300 Audio Transformer brings a greater realism to radio reproduction. Introducing a new core material, "DX-Metal" (a product of the Thordarson Laboratory), the amplification range has been extended still further into the lower register, so that even the deepest tones now may be reproduced with amazing fidelity.

The amplification curve of this transformer is practically a straight line from 30 cycles to 8,000 cycles. A high frequency cut-off is provided at 8,000 cycles to confine the amplification to useful frequencies only, and to eliminate undesirable scratch that may reach the audio transformer.

When you hear the R-300 you will appreciate the popularity of Thordarson transformers among the leading receiving set manufacturers. The R-300 retails for $8.00.

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

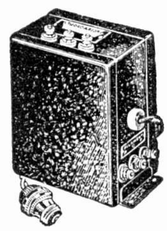
Power Supply Transformers

These transformers supply full wave rectifiers using two UX-281 tubes, for power amplifiers using either 210 or 250 types power amplifying tubes as follows: T-2098 for two 210 power tubes, $20.00; T-2900 for single 250 power tube, $20.00; T-2950 for two 250 tubes, $29.50.

Double Choke Units

Consist of two 30 henry chokes in one case. T-2099 for use with power supply transformer T-2098, $14; T-3099 for use with transformer T-2900, $16; T-3100 for use with transformer T-2950, $18.

Power Compacts



A very efficient and compact form of power supply unit. Power transformer and filter chokes all in one case. Type R-171 for Raytheon rectifier and 171 type power tube, $15.00; Type R-210 for UX-281 rectifier and 210 power tube, $20.00; Type R-280 for UX-280 rectifier and 171 power tube, $17.00.

Speaker Coupling Transformers

A complete line of transformers to couple either single or push-pull 171, 210 or 250 power tubes into either high impedance or dynamic speakers. Prices from $6.00 to $12.00.

Screen Grid Audio Coupler

The Thordarson Z-Coupler T-2909 is a special impedance unit designed to couple a screen grid tube in the audio amplifier into a power tube. Produces excellent base note reproduction and amplification vastly in excess of ordinary systems. Price, $12.00.

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Gentlemen: Please send me your constructional booklets on your power amplifiers. I am especially interested in amplifiers using..................tubes.

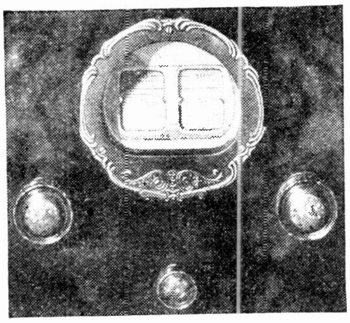
Name..................

Street and No...................

Town.................. *State*..................

INDEX TO QUESTIONS

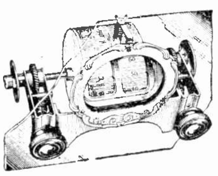
TYRMAN Laboratory Tested Products



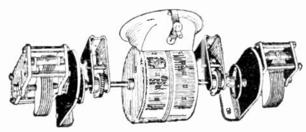
Tyrman Illuminated Worm Drive Double Drum

Isn't this a good looking dial? It's just as efficient as good looking. Universal in its application. Almost every condenser fits without filing or sawing. Worm Gear Drive—positive and sure in action. Insulated mounting for condenser is provided, also an insulated coupling disk which prevents body capacity. A translucent window reflector provides indirect illumination.

The Tyrman Worm Drive Double Drum comes completely assembled. You need only to connect your tuning condenser by fastening set screw. Includes two matched knobs for tuning and one for volume control. Complete only $12.00.

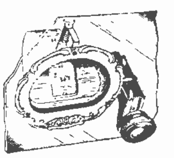


Cut away front view of Tyrman double drum dial showing how it looks when mounted on panel. Volume control knobs not shown.



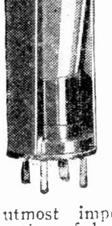
Rear view of the Tyrman Double Drum Dial ready to mount.

Tyrman Illuminated Single Drum Dial



The same general design of the Double Drum except knob for volume is on the left so only two knobs are needed. Packed complete with two matched knobs, price only $8.00

Tyrman Shielded Socket Automatically Grounded



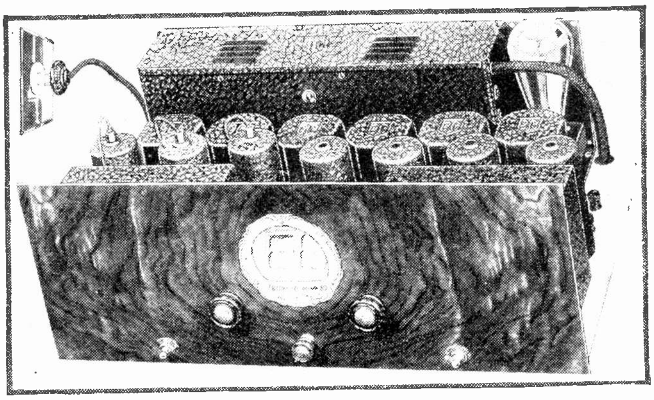
An advanced and perfected design of shielded Socket with an *automatic contact* for grounding shield when used with Shield Grid Tubes. Ventilated and built of heavy aluminum. Readily dissipates heat generated by the filament of new heater type A.C tubes. Of utmost importance considering reaction of heat from the neighboring R.F. apparatus. Shields, complete with sockets, Type 2-26 for four prong tubes, or Type 2-27 for five prong heater type tubes—Price $1.25.

Tyrman Imperial "80"

Custom-Bilt Shielded Grid

Complete A.C. Socket Operation Using A.C. Shield Grid Tubes

The Tyrman Imperial "80" is designed for those who want to build only the finest in complete A.C. socket-operated receivers. The Shield Grid principle in circuits, developed and pioneered by Tyrman, is now further advanced by the use of the Duo System of Amplification, a new Tyrman development, insuring the efficient use of the tremendous amplification possibilities of Shield Grid Tubes.



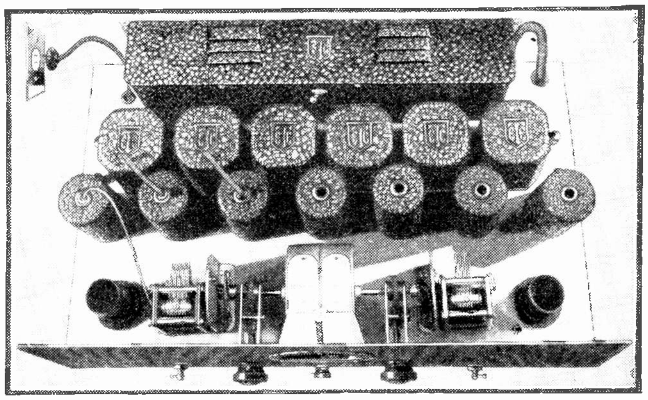
Unsurpassed tonal quality results from the use of UX250 power amplifier tube and Tyrman Audio System. 10 K.C. Selectivity throughout entire broadcast waveband, without sacrifice of volume. Brings in "DX" like local without oscillation. Plug-in short wave coils. Stability—Sensitivity—One Spot—100% Shielding. Power Supply an integral part designed solely for the "80," mounted on platform with all apparatus, only 13½"x20½". Individual in appearance. Panel 8"x21" of genuine butt-walnut, impressed on steel. Illuminated Worm Drive Double Drum. Quickly and easily assembled by special method. Receiver parts factory packed, complete only $134.50. Power Supply factory wired, price $65.00. Complete parts and wired power supply only **$199.50**

Tyrman "72"

Custom-Bilt Shielded Grid

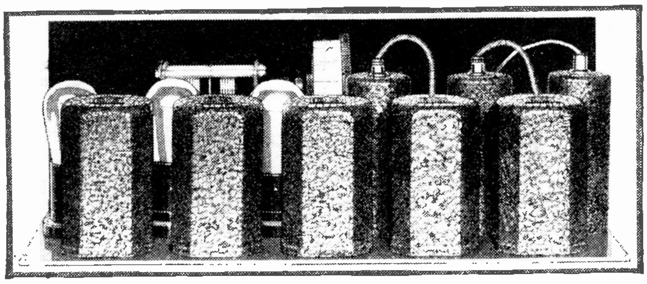
Tyrman "72" BATTERY OR A.C. SOCKET OPERATED

The Tyrman "72" can be assembled either for battery or complete A. C. socket operation using A. C. Shield Grid Tubes. Like the Imperial "80" the Tyrman "72" incorporates many advanced features. When assembled for A. C. operation uses special "72" power supply mounted on platform with other apparatus. The Tyrman Duo System of Amplification as adapted to the "72" together with Tyrman Audio gives full, rich, tonal quality. Selectivity, Sensitivity, Stability, Power and Distance without oscillation. Attractive front panel, walnut finish on steel, equipped with Illuminated Worm Drive Drum. Tyrman "72" receiver parts for Battery or A. C. operation, factory packed ready to assemble only $98.50. "72" Power Supply for A. C. operation factory wired, only $55.00.



Tyrman "60"

Custom-Bilt Shielded Grid



Battery Eliminator Operation

The Tyrman "60" sets a new standard of comparison for efficient Shield Grid Receivers at a moderate price. Like all Tyrman Shield Grid receivers the "60" is designed especially for Shield Grid Tubes which assures that efficient use is made of the enormous amplification of Shield Grid tubes. Panel only 7"x18" equipped with Tyrman Single Vernier Drum Dial. For appearance, tone quality, distance, selectivity, sensitivity, stability the "60" is comparable only to other Tyrman Shield Grid receivers. Parts factory packed ready to assemble, complete only $69.50.

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Money Makers for You

Not only are Tyrman receivers outstanding in performance but they are equal in appearance to highest priced radio equipment, and at a price range within the means of the average buyer. Experience of set builders all over the country proves that Tyrman receivers are money makers. Send coupon for FREE descriptive literature so you can judge for yoruself. There is no better time to send the coupon than now while it is before you.

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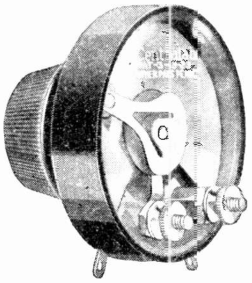

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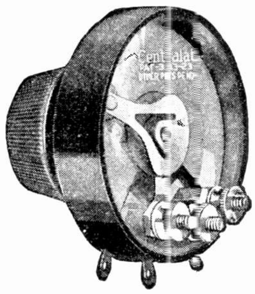
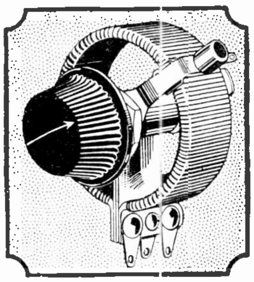
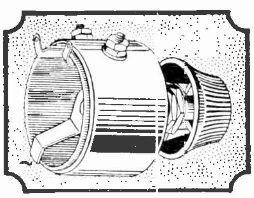


Potentiometer and Modulator



Power Rheostat, Potentiometer, 4th Terminal Potentiometer



Heavy Duty Potentiometer

Volume controls are now conceded by radio engineers to be one of the most essential parts of radio receivers. So much of the success of a set—the quality of reception—is dependent upon them. Centralab Volume Controls assure absolute smoothness of control—a big factor in satisfactory operation. This smoothness of Centralab Controls results from the tilting disc construction—with no sliding contacts in the electric circuit.

A Centralab Volume Control, in one of the many new tapers, is ideal for any set. Many prominent manufacturers specify them. They are in demand, also, for replacement on old sets. Centralab Wire-Wound Resistors will give better voltage regulation of Power-supply units. Their construction is heat-proof and warp-proof and provides for greater current carrying capacity. The Centralab Heavy Duty Potentiometers have an additional feature—they are non-inductive.

Write for complete descriptions, prices, etc., of Centralab Volume Controls and other Radio devices.

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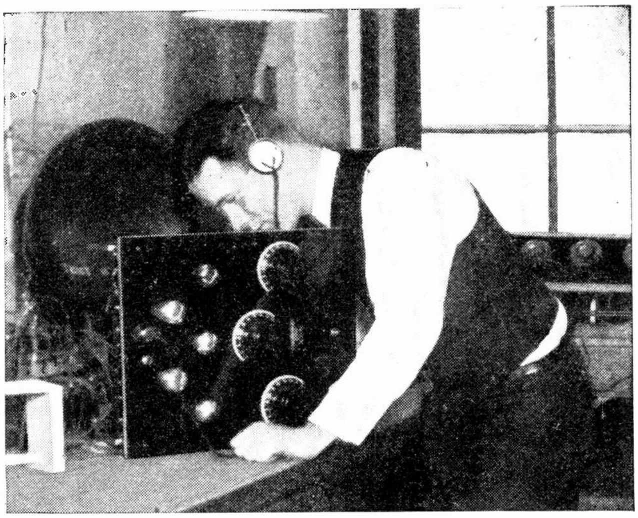

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( ) Mechanical Engineer
( ) Mechanical Draftsman
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( ) Concrete Builder
( ) Railroad positions
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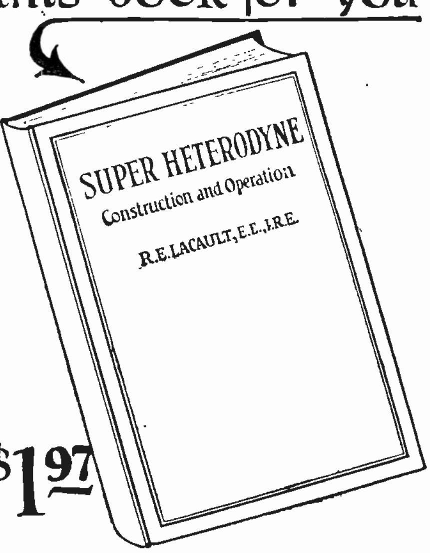
SUPER-HETERODYNES

*Originator and designer of the nationally known 'ULTRADYNE,' Radio Engineer, and former Editor with many years practical experience on Super-Heterodynes.

He has written this book for you



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R. E. LACAULT has been an Editor of Radio magazines for many years. He has specialized in the greatest and most powerful of all Radio Circuits, "The Super-Heterodyne." He has studied, originated and developed to marvelous perfection the "ULTRADYNE" Super-Heterodyne. He has advised thousands of set owners and builders in Super-Heterodyne problems.

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Many illustrations showing various eliminators and parts.
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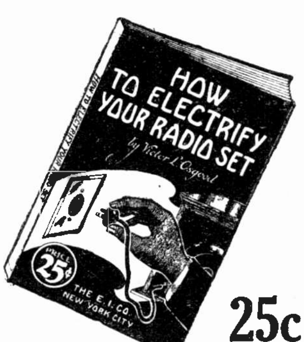

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TOWNSEND
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Delivers up to 100 volts on any set. Full tone, Clarity, Volume, Distance.

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(Signed) WM. SCHULTZ,
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Lincoln Place, Penn.
The Townsend "B" which I received about five months ago has given excellent results and I like it very much. —Lee H. Thomas.

Knoxville, Tenn.
Your Eliminator is a "bear cat." Have used it for eight months now on my Atwater-Kent without any trouble. Fred W. Schuler.

Orlando, Fla.
Have had fine reception with the Eliminator purchased from you last September. L. E. McConnell.

Louisville, Ky.
I have tried four different types (two high-priced ones) and find your Eliminator the best. —W. S. Payne.

Houston, Texas.
After using your Eliminator for a month I find it works just as good as a $30.00 one. I have had no trouble at all with it. —W. P. Kriegel.

Thorold, Ont.
Have had more than eight months' continuous service, with more volume than when I used batteries, both dry and wet. I am perfectly satisfied with your Eliminator. —Percy E. Winfield.

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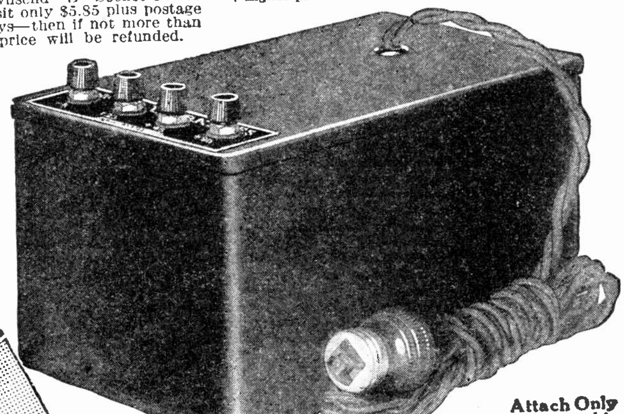

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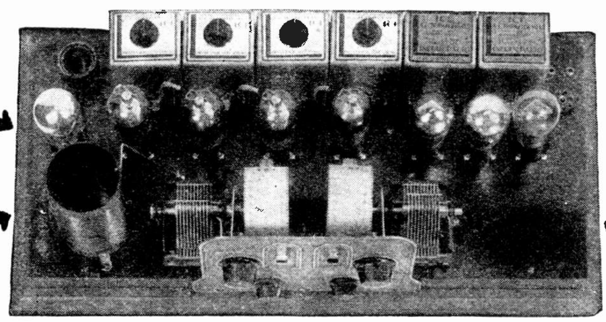
THE NEW LINCOLN 8-80 DOES IT—

4 SCREEN GRID TUBES

ONE SPOT



TUNABLE I.F. STAGES

NEW AUDIO

400 MILES IN DAYLIGHT 2000 MILES AT NIGHT

ON A 15-FOOT ANTENNA!

INSIDE A STEEL BANK BUILDING

THE Lincoln 8-80 gets its remarkable results from a new principle as simple as it is radical—just merely that *you* tune the "one-spot" intermediate amplifier stages after *your* set is built, instead of our doing this at the factory when we don't know how you're going to build your particular set! If you've ever built a super, you know what it is to use "laboratory matched" transformers that turn out to be away off when your set is done—you get squeals, broad tuning, station repeats—but try as you will, you are at the mercy of "factory matching."

In the 8-80 four screen grid tubes are used, three in the *tunable* "one-spot" intermediate amplifier. And that's the heart of the set. In it are four new Lincoln 101 Transformers, each with its own little tuning knob on top. And when you finish building your set you don't pray that your i.f. amplifier is matched—you just turn the knobs and match it for *your own particular tubes and circuit conditions.*

And at the same time you are correcting for all variations in peak frequency due to built-in transformer capacity, varying constants in different tubes, and various capacity and feed-back reactions due to slight differences in wiring layout—all these things which have helped to ruin the team-work of so many sets of "laboratory-matched" transformers. Every such influence is immediately overcome, once you have tuned the four stages to peak with each other. To do that is just as simple as tuning *once* the several dials on the t.r.f. set—and when it's done *once* your i.f. stages are *permanently* matched. Then if you want to change your intermeditae frequency, you can do so by another turn of the same four knobs—selecting anything from 300 to 500 kc.—all "one-spot" frequencies. Yet this obviously sensible amplifier is entirely different from anything that has been offered in the past.

Not alone in selectivity, though, is the 8-80 supreme. Its new Clough audio system gives it better tone, more volume and less distortion than any old-style transformers possibly can—an effective transformer ratio averaging 4.4 to 1—50% greater in each stage than many more expensive transformers. And with all this—a true tone fidelity, giving positively uncanny realism.

Even for "eye value"—hardly to be hoped for in the average super—the 8-80, when neatly housed in the beautiful Lincoln 112 two-tone metal shielding cabinet ($9.25 extra) compares favorably in appearance with the most beautiful factory jobs.

It is these features that make the 8-80 the sweetest eight-tube super you've ever tuned. And that's it positively is. In the Lincoln offices in a steel-reinforced-concrete building—the most difficult type for radio reception—the 8-80 plays stations 1,000 to 2,000 miles away on a hot summer night, and several hundred miles away during the day! All this is with all Chicago stations operating, and with only a 15-foot *inside* antenna! Pittsburgh, Davenport, Nashville, New Orleans—generally these and more come in without any antenna at all!

The price of the complete kit for the 8-80 is $92.65. And the set you build from it will give these same results, for every set built tunes easily and positively to peak efficiency, thanks to the new principle of William H. Hollister—an old-timer in the game who demonstrated "wireless," to college professors before Marconi first bridged the Atlantic. And all his experience, ranging over a quarter of a century, has gone into the 8-80. It ought to be some set—and it is!

Lincoln guarantees that the 8-80 will give better results than any other eight-tube super you can build.

If you want an evening full of straight-from-the-shoulder super-heterodyne dope written by an engineer who has played with every super going in the last few years, send 25 cents for William H. Hollister's "Secret of the Super," using the coupon below.

Have you seen the new Lincoln power supplies? There are two: one for B voltage only and one for A, B, and C voltage for A.C. tubes. Each one comes in a beautiful brown crystalline steel shielding case. B current of 50 to 60 m.a.—plenty for any ten-tube set—at 180 to 200 volts, with 22½, 90, and 135 available—also 22-90 variable. Type 110B lists at $36.00, type 110ABC at $39.00. They're fully guaranteed and are described in detail in the big catalog which the coupon below will bring you.

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JOIN THE RADIO ASSOCIATION

EARN $75.00 a week — in Your Spare Time

JOINING the Radio Association enables you to cash in on Radio *now*! Follow its success-proven plans and you can earn $3 an hour, in your spare time, from the very first. Over $600,000,000 is being spent yearly for sets, supplies, service. You can get your share of this business and, at the same time, fit yourself for the big-pay opportunities in Radio.

Founded on a New Idea

Members of the Association do not wait for months before they make money out of Radio. Without quitting their jobs, our members are earning $25 to $75 a week spare time by building "tailored" radio sets, serving as "radio doctors," selling ready built sets and accessories, or following one of the many profit-making plans of the Association.

Earned $500 in Spare Hours

Hundreds earn $3 an hour as "radio doctors." Lyle Follick, Lansing, Mich., has already made $500 in spare time. Werner Eichler, Rochester, N. Y., is earning $50 a week for spare time. F. J. Buckley, Sedalia, Mo., is earning as much in spare time as he receives from his employer.

We will start you in business. Our cooperative plan gives the ambitious man his opportunity to establish himself. Many have followed this plan and established radio stores. Membership in the Association has increased the salaries of many. Scores are now connected with big radio organizations. Others have prosperous stores.

A year ago Claude De Grave knew nothing about Radio. Today he is on the staff of a famous radio manufacturer and an associate member of the Institute of Radio Engineers. He attributes his success to joining the Association. His income is 350% more than when he joined.

What a Membership Can Do for You

1—Enable you to earn $3 an hour upwards in your spare time.
2—Train you to install, repair and build all kinds of sets.
3—Start you in business without capital, or finance an invention.
4—Train you for the $3,000 to $10,000 big-pay radio positions.
5—Help secure a better position at bigger pay for you.
6—Give you the backing of the Radio Association.

A MEMBERSHIP NEED NOT COST YOU A SINGLE CENT

Doubled Income in Six Months

"I attribute my success entirely to the Radio Association," writes W. E. Thon, Chicago, who was clerk in a hardware store before joining. We helped him secure the managership of a large store at a 220% increased salary.

"In 1922 I was a clerk," writes K. O. Benzing, McGregor, Ia., "when I enrolled. Since then I have built hundreds of sets—from 1-tube Regenerative to Superheterodynes. I am now operating my own store and my income is 200% greater than when I joined the Association. My entire success is due to the splendid help it gave."

Easiest Way Into Radio

If ambitious to become a Radio Engineer, to fit yourself for the $3,000 to $10,000 opportunities in Radio, join the Association. It gives you a comprehensive, practical and theoretical training and the benefit of our Employment Service. You earn while you learn. You have the privilege of buying radio supplies at wholesale. You have the Association behind you in carrying out your ambitions.

ACT NOW—if you wish Special Membership Plan

To a limited number of ambitious men, we will give Special Memberships that may not—need not—cost you a cent. To secure one, write today. We will send you details and also our book, "Your Opportunity in the Radio Industry." It will open your eyes to the money-making possibilities of Radio. Write today.

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Now-Make Your Radio Clear as a Bell-with Marvelous New GROUND AERIAL!

Sub-Aerial Endorsed by Experts

May 8th, 1928

"I am very glad to state that after testing many Aerials in my Laboratory I find your Sub-Aerial is the best for clarity of tone and elimination of static, also for greater volume and selectivity.

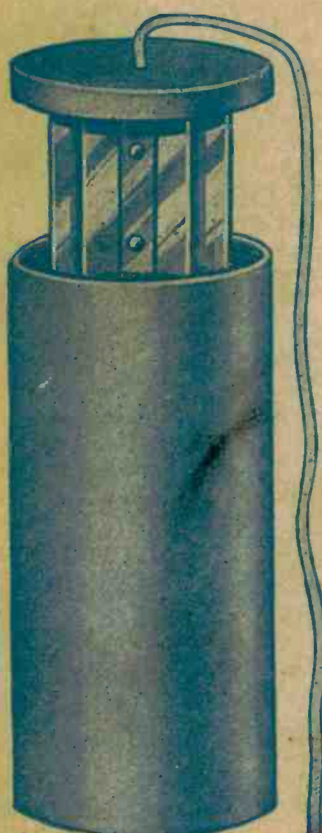
Your Sub-Aerial will fill a long-felt want among the Radio Fans."

A. B. Johnson,
Radio Engineer

Chicago, May 9th, 1928

"Received my Sub-Aerial and it has been installed as per directions. We are more than satisfied with the results. The tone is marvelously clear without static interruptions. We would not consider changing back to an outdoor aerial under any circumstances.

M. H. Grey,
1416 Juneway Terrace.



Get Amazing Distance—Greater Volume and Finer Selectivity Without Distortion

Why go on listening to terrible static and other maddening outside noises? Now you can get the real music your present Radio is capable of giving, by hooking your set on to the clear, practically static free ground waves with Sub-Aerial. The air is always full of static and your overhead aerial picks it up and brings it to your speaker. So why stay in the air—when you can use the whole earth as a static and noise filter with Sub-Aerial?

SUB-AERIAL is a scientific, proven system of taking the radio waves from the ground, where they are filtered practically free of static. It brings these filtered waves to your radio set clear of static and interference common with overhead aerials. The result is positively clear reception, remarkable selectivity and greatly increased volume. The overhead aerial is a thing of the past because it is the weak link in radio. SUB-AERIAL has replaced overhead aerials because SUB-AERIAL is 100% efficient. How can you get good reception without one?

Low Original Cost—No Upkeep Cost

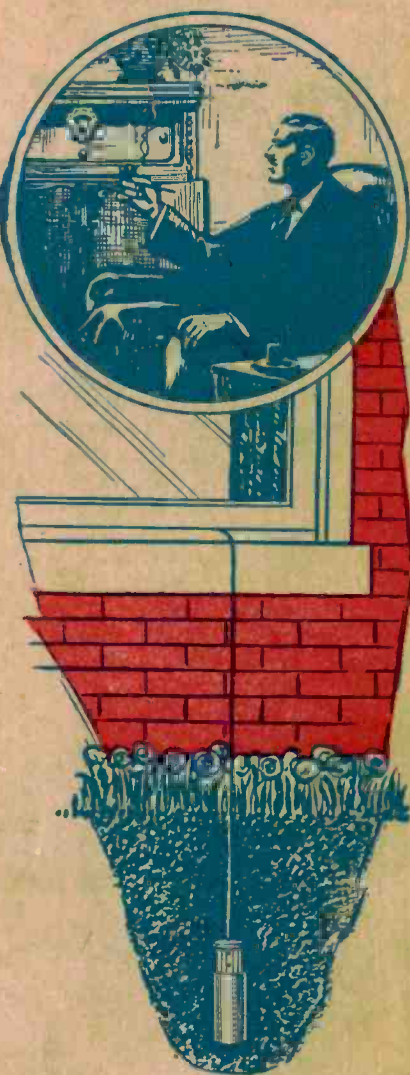
SUB-AERIAL costs no more than an overhead or loop aerial and less than many. Its first cost is the only one. SUB-AERIAL is permanent. No trouble—no hard work, or risking your neck on roofs.

25 Year Guarantee

SUB-AERIAL is guaranteed against any defects in workmanship or material and against deterioration for 25 years. Any SUB-AERIAL which has been installed according to directions and proves defective or deteriorates within 25 years, will be replaced free of charge; and also we will pay $1.00 for installing any such new replacement.

TRY IT FREE!

We know so well the surprising results you'll get that we'll let you put in a Sub-Aerial entirely at our Risk. You be the Judge. Don't take down your overhead Aerial. Pick a summer night when static and noise interference on your old Aerial are "Just Terrible." If Sub-Aerial doesn't Sell Itself to You Right Then on Performance—you needn't pay us a cent. Send for "all the Dope on Sub-Aerial." You'll be surprised. Do it NOW.



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