1001 RADIO QUESTIONS and ANSWERS

COMPILED BY THE STAFF OF

RADIO NEWS

1930

EDITION

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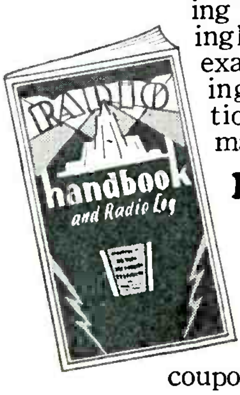

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IN THIS ISSUE

Read *Page*

Printed in the United States of America

How To Use This Book

IN response to popular demand we present the 4th 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 puprpose 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 tothe 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 93. 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 covere by this book.

—EDITOR.

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RADIO NEWS

Edited by
EDWARD W. WILBY

Price 50c

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

D. C. to A. C.--And How

How a Receiver Ordinarily Using D. C. Tubes can be Converted into an Electric Set by the Use of Adapters and A. C. Tubes

THERE is considerable confusion in the mind of the general public as to what constitutes an A.C. radio set. Various interpretations may be made of the degree to which a particular power combination can be considered an A.C. unit; it is not the purpose of this article to discuss this question, for its answer is to some extent a matter of opinion. We will briefly describe, however, what is generally accepted as the nearest approach to alternating-current operation; namely, the use of raw A.C. directly on the filaments or heaters of all the tubes in the set. Some people have been led to believe that the use of A.C. tubes does away with transformers, "B" power units and the like. Such is not the case, however.

For the benefit of a great many experimenters and home set builders who wish to convert their present battery-operated sets to the use of A.C. tubes, this article covers the changes required in an average six-tube set of the tuned-radio-frequency type.

The Transformer

For equipment, a step-down transformer for filament or heater current is the first requisite. The choice of this transformer depends upon whether the constructor wishes to use only the separate-heater tubes of the 227 type; or whether the raw A.C.-filament tubes of the 226 type are to be used for R.F. and first A.F. amplifiers. If only separate-heater tubes of the 227 type are to be used, the transformer should be capable of delivering 1.75 amperes per tube, at 2.5 volts, without any material drop in voltage; it is preferable to have at least a 15% overload factor above these requirements. If the 226-type is to be used in the R.F. and first A.F. amplifying stages; the transformer should deliver also 1.10 amperes per tube, at 1.5 volts.

It is advisable to use for the last audio stage a 171-type tube, which is operated on raw A.C. at 5 volts. The transformer should have an additional 5-volt winding for this tube.

Unfortunately, A.C. line voltage throughout the country varies a great deal in two ways. The designed standard voltage of the particular distributing system may be 104, 110, 115, 125 volts or some point between; and, under certain load conditions, the actual voltage at any given point also may vary from hour to hour, above or below the standard voltage of the power station. This latter condition is not common in large communities, where the load is handled efficiently. However, the situation is a difficult one from the standpoint of transformer manufacturers, but several have met the problem by designing step-down transformers which will deliver full voltage at the *lowest* primary potential that may be expected. This, in turn, means that primary taps, rheostats or resistors of some sort will be necessary when the primary voltage is higher than this minimum.

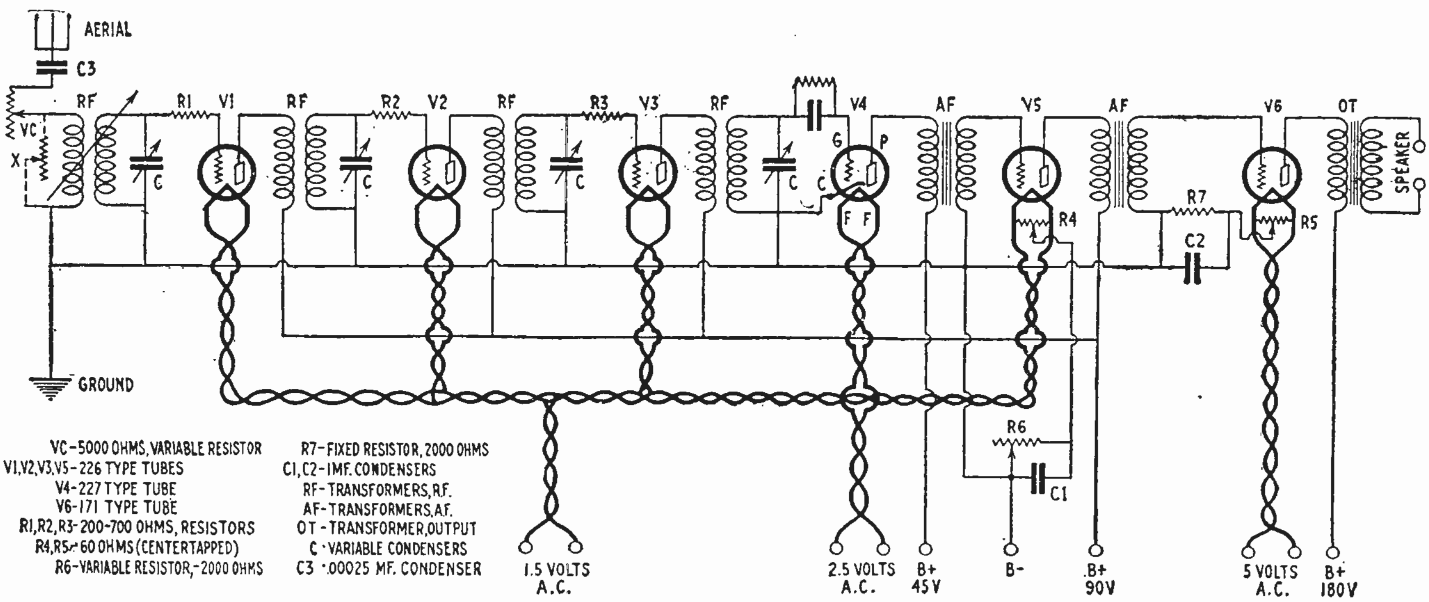
The reader should not, however, gather the impression that the 226- and 227-tubes are extremely critical on filament or heater current; as in fact a liberal percentage of voltage variation is allowed for in the tube design. Indeed, it will be seldom necessary to change the filament or heater resistances to compensate for temporary line-voltage fluctuation, once *your particular average voltage* is determined and adjusted for.

Another good reason for using a transformer with over-voltage output at the terminals is that, in various converted sets, some may have more voltage drop than others due to the resistance of the wiring. It is, therefore, considered the best practice to use a liberal over-voltage factor.

Plate-Power Supply

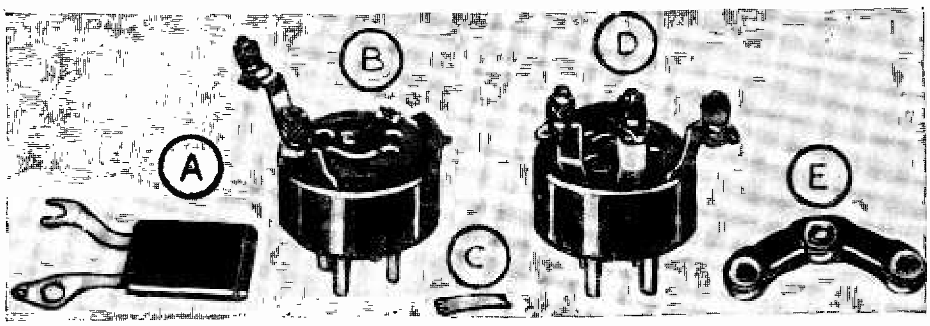
The "B" supply device may be any good unit available and does not differ from that used with the battery-operated sets. Complete "A B C" power packs designed to supply all power requirements for A.C. sets are making their appearance on the market, and will undoubtedly be widely sold. In considering the purchase of these units, care should be taken to see that they meet the conditions previously outlined.

The center-tapped resistors (R4 and R5) may be purchased in the market, or made by winding up with fine resistance wire a 60-ohm unit tapped in the



The schematic diagram shows the wiring connections of a receiver originally designed for D.C. tubes and converted into one operating with A.C. tubes.

X is an optional type of volume control; its range should be 0 to 5 megohms.



Parts used in connection with the new wiring harness: A, by-pass condenser; B, tube adapter for R.F. circuits; C, grid-suppressor; D, tube adapter for A.F. circuits; E, center-tapped resistance unit.

center. If a potentiometer is used, one with a resistance around 20 ohms will be satisfactory. A fixed 2,000-ohm resistor (R7), shunted by a 1-mf. condenser, is required for the last audio bias; and a similar combination (R6) is used for the amplifier bias except that the latter resistor should be variable or tapped, to meet varying conditions encountered in sets.

Needed Alterations

The actual rewiring and changes in sets to be converted follow in general certain standard practice. We discuss here the average six-tube set, consisting of three stages of R.F., a detector, and two stages of A.F. The accompanying schematic diagram shows the wiring for the conversion when using the 226-type tubes in the R.F. and first A.F. amplifiers, the 227-type in the detector and the 171-type in the last audio stage. Should the constructor wish to use 227-tubes in all except the last A.F. stages, the procedure is similar; except that the cathode lead of the R.F. and first A.F. tubes is to be substituted as a connecting point for the center tap of the 227-tubes. The use of center-tapped resistors at heater terminals of the 227s, with the center lead going to the cathode, is also advisable.

The fan who wishes to convert his battery-operated receiver into a set using A.C. tubes may easily do so, and he will find that there are two methods which he may follow. In one case it is necessary to remove all filament wiring in the receiving set, and then rewire the filament circuits for A.C. tubes. This is a simple operation, but requires some experience in set construction if best results are to be obtained.

For the radio fan who does not feel competent to rewire his set, or who wishes to convert it for A.C. tubes in the least possible time and with the slightest effort, several manufacturers have developed and placed on the market simple A.C.-tube adapters and harnesses. With these adapters it is possible to convert a D.C. set into one using A.C. tubes in a very few minutes, and without the necessity of changing any wires in the receiver except a few grid returns.

Use of A.C. Tube Adapters

As the adapters are of different types, it is difficult to write a general description which applies to all units. However, each kit is supplied with directions which explain exactly how the installation is best accomplished.

Usually each kit contains one adapter for each tube, and these adapters fit in the tube sockets of the set; while the tubes are inserted into the adapter. These adapters connect the grid and plate prongs of the tubes with the proper terminals of the socket, but insulate the filament prongs from the filament wiring of the set. On the adapters terminals are provided which connect with the filament prongs of the tubes, and the harness is connected with these posts; the harness, which is correctly arranged for A.C. tubes, replaces the filament wiring in the set. In order to light the tubes it is necessary only to connect the free ends of the harness with the proper terminals of a filament transformer.

Arrangements have also been made for installing the extra parts which are required; such as center-tapped resistors, by-pass condensers, grid resistors, and biasing resistors. The center-tapped resistors are designed so that they may be correctly connected in the circuit by fastening them to posts provided on the adapter, and the same is true of the by-pass condensers. The 500-ohm resistors (R1, R2 and R3), which are required in the grid circuit of A.C. sets, fit into slots in the adapters of one make; and provision is usually made for installing the grid-biasing resistors in the cable. The only change which is necessary in the wiring of the set is the installation of a new volume control (VC); this is required, as the rheostats in the filament circuits are made inoperative when the harness is installed.

Rewiring the Set

In converting the set without the aid of adapters and a harness, the first procedure is to cut away all previously-installed filament wiring and install the 5-prong sockets, for whatever number of 227-type tubes are to be used. The filament and heater wires should be twisted conductors; the average lamp cord has sufficient current capacity for this purpose. Many sets are equipped with battery switch on the panel; this cannot be used to control the A.C. current unless it happens to be one originally intended for use on 110-volt lighting supply. Should the power switch be installed on the panel, care must be taken to insulate the primary line with the same precautions usually adopted in all appliances connected directly to the house mains. Grid returns of all stages are brought directly to ground as shown in the diagram. Oscillation control is obtained by use of grid suppressors in the R.F. stages. The correct resistance values for these suppressors may run from 200 up to 700 ohms or over, because of varying circuit and R.F. transformer characteristics; the desired value is the lowest which will keep the R.F. circuits out of oscillations over the entire wavelength range. This method of oscillation control is the simplest for the constructor. Any control system affecting the 226-type tubes, whether it be for oscillations or volume, which in effect reduces the plate current below the minimum "ripple-voltage point" will not be satisfacotry; for, below this critical point the A.C. hum becomes suddenly apparent. Another procedure for controlling oscillation, which is highly efficient and easily adjusted, is to neutralize the R.F. stages by the conventional capacitive or neutrodyne method. If the set to be converted is a neutrodyne, reneutralization for A.C. tubes will probably be necessary. Should the set have a coil system depending upon a scarcity of primary turns on the R.F. transformer to make it non-oscillatory, the use of A.C. tubes will increase the tendency to oscillate; in average sets, however, this increase will not reach the spilling point. In general, any method to control oscillation is acceptable, *provided the plate current is not thereby reduced materially.* By-pass condensers in the R.F. stages are usually essential.

Voltage Regulation

In the previous discussion of suitable transformers, the filament- or heater-voltage situation was brought out. Our conclusions are that, in the first place, the *average* line voltage must be known. Should the transformer chosen deliver the correct voltage to the tubes no rheostats or resistances are necessary. In many cases this will not occur and therefore a rheostat for all 227-type tubes, or separate ones for the 226's and 227's, will be required. No rheostat control is necessary for the 5-volt last A.F. tube.

For the dealer or service man who expects to convert a number of sets, it is suggested that he prepare strips of resistance units consisting of bright michrome wire wound on fiber or similar material. When the set is converted and ready to install, the correct tube voltages may be determined by finding the proper point of resistance adjustment and permanently soldering or clamping the lead. This adjustment must be made on the *final set location.* Of course, the use of a *good* low-reading A.C. voltmeter, 0-3 volts, is essential for determining the proper tube voltages; do not use cheap meters, as they are apt to be inaccurate. The dealer or service man should always have a meter of this kind available for A.C.-set adjustment; for the individual who converts only one set it would be more economical to borrow a meter for the occasion, as the meter may never have to be used again. Should rheostats be used for the A.C. tubes, special types are necessary; as the rheostats ordinarily used in battery-operated sets are not wound heavy enough for the purpose. Suitable heavy-duty rheostats are already on the market.

We have previously referred to temporary line-voltage fluctuation; this usually occurs at the time when the heaviest load falls on the lighting company's mains. The voltage at the central station may be maintained constantly at a fixed standard, but the drop in various circuits causes this line fluctuation. If this condition prevails, the tube voltage will naturally follow the rise and fall in the main line. The operating characteristics of the A.C. tubes, however, are such that average fluctuation will not affect their operation or life; but, as we have said before, it is very necessary to know just what the average voltage is and adjust for it. In the re-wiring of the set keep the grid and plate leads away from the filament lines as much as possible.

A properly-converted set should not produce A.C. hum audible more than a few inches from the loud speaker.

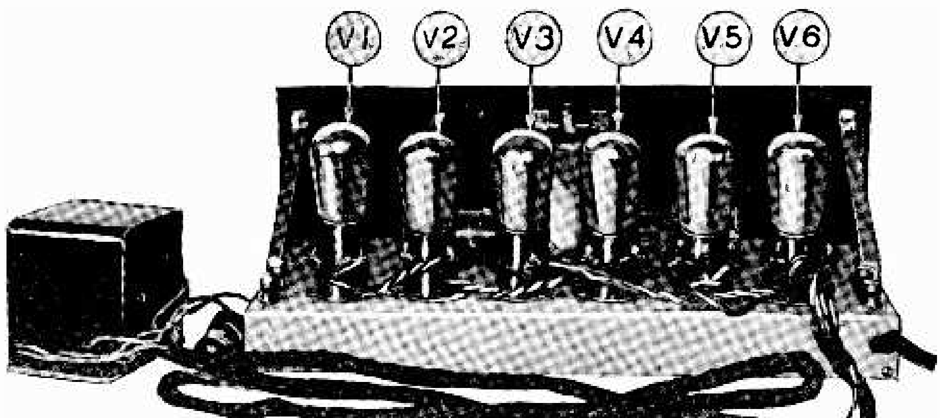
It is suggested that some means of identifying easily the last audio socket be adopted by constructors. The accidental insertion of the 226 tube in this position will result in an almost-immediate burn out.

Volume Control

Considerable difference of opinion exists regarding the best method to control volume in A.C. sets. The favorite method in battery-operated sets was to vary the filament temperature in one or more of the R.F. tubes. Although some manufacturers of A.C. sets use this method today on A.C. tubes of the 226 type, it is not considered ideal. The heating of the heavy filament is slow in following the rheostat adjustment, and this naturally introduces a very annoying time-lag. It is particularly noticeable when trying for distant reception.

We have previously discussed the necessity for keeping the plate current of the 226 tube at the minimum ripple-voltage point. If the bias on the R. F. tubes can be reduced simultaneously with the filament temperature, this will hold up the plate current and keep out the ripple. Some bias must be maintained at all times, however; as an uneven flow of grid current, and consequent modulation and distortion of the signal will result without it.

A high variable resistor across the secondary of the first audio transformer has been used by some; but this method is not recommended as it has a tendency to overload the detector. Varying the grid bias as a means of volume control is quite effective on circuits using 227 tubes as amplifiers, but is not recommended for 226's; as this method is apt to shorten the life of the tube. A high variable resistor (100,000 ohms) in the R.F. plate returns will do the job, in a way, but the disadvantages have already been mentioned. It would seem that the most logical procedure in controlling volume is to go to the heart of the matter and control the signal instead of trying to suppress it after it is amplified or rectified. Naturally this must be done in the antenna circuit. The most approved method is to couple variably a semi-aperiodic primary to the secondary of the antenna-coil unit. Unfortunately this is not always easily done in converting sets, as the antenna coil is usually of the fixed-coupling type. If it is at all possible to rotate the primary antenna winding, or secure a similar effect through taps, it is strongly recommended that this be done to obtain best results. A semi-aperiodic antenna coil of 8 or 10 turns of wire, wound on a bakelite tube and variable in its relation to the secondary, will work out very well.



A converted A.C. receiver with supply cable. Note twisted filament leads.

A variable resistor with a maximum of around 500,000 ohms, in shunt with the antenna coil, will control volume quite satisfactorily. It is suggested that for local or very strong signals the aerial be disconnected entirely from the set; this may be done by means of a snap switch conveniently placed.

A.C. sets give the very best reproduction when the circuits are tuned to exact resonance with the received signal. Any departure from this condition will detract from one of the most pleasing features of A.C. operation. Volume control is right *only when the strongest signal is not too loud when the set is tuned to exact resonance with the volume control at minimum.* Any attempt to control volume by detuning condensers will result in some distortion and an apparent lack of selectivity.

The Tubes

Due to the fact that the A.C. tubes of the 226 and 227 types are new on the market, many experimenters are inclined to be skeptical regarding their performance. The actual development of these tubes has been going on for some time, however, and their performance has been under observation over a long period. The characteristics of the 226 are approximately the same as those of the most familiar 201A type; long life may be expected, provided the tubes are operated under proper conditions. Maintaining the correct grid bias is quite essential for the successful use of the 226.

The characteristics of the 227 are such that by using this tube in all stages, except the last A.F., greater signal volume as compared with the 226 will result. There will be less tendency toward A.C. hum, although a properly designed or converted set using 226's should be practically free from this trouble. The 227 will probably have a longer useful life, due to the nature of the emitter. *The user of A.C. tubes is particularly cautioned to read thoroughly the instruction sheet accompanying such tubes.*

The 227 (separate-heater tube) requires about 30 seconds to come up to operating temperature. The momentary application of excess heater voltage to accelerate emission should never be tried. The A.C. tubes are operative at 25 cycles as well as at 60 cycles.

Troubles

Pronounced A.C. hum in the set may be due to several causes; the wiring of the filament lines if not twisted may cause hum. Frequently the "B" supply unit is at fault because of a defective rectifier tube. Should an internal leak develop between the cathode and the heater of the separate-heater tube, hum or noise will result; but this latter condition is of rare occurrence. Unshielded power transformers, if in close proximity to the set, will introduce line disturbances which sound very much like static. When separate-heater tubes have an excessive voltage on the filament, signals will gradually become weaker until, in some cases, they disappear. This is due principally to what is called *secondary emission;* namely, that caused when the grid gets sufficiently hot to emit (independently) electrons. This will, of course, disturb the stream of electrons and, consequently, the current between the cathode and the plate.

Reactivation of Tubes

(1) Mr. Henry Smith, Plainfield, N. J., asks:

(Q. 1.) Is there any method for rehabiliting UV-199 and UV-201A tubes which light but do not function satisfactorily?

(A. 1.) We are showing the correct circuit for the reconditioning of the tubes you mention. This equipment is in regular use at several places where these tubes are reconditioned. Any transformer having the output indicated will be satisfactory. The catalog number shown is that of the General Electric transformer particularly adaptable to the requirements. While it is possible to recondition only one or two tubes at a time, it is better practice to operate the circuit with four tubes in the sockets at one time, using the time-voltage formula shown.

For UV-201A tubes, the G. E. No. 236095, 100-watt step-down transformer will be satisfactory. Two transformers, two double pole double throw switches and four UV-199 sockets and four UV-201A sockets may be mounted on one board, making a complete reconditioning unit. Note that the 100-watt transformer will have the switch arm on point three, not on point one, as is necessary for the 50-watt transformer. However, these voltages should be checked with a voltmeter, as it may be necessary to move the switch arm one way or the other, depending upon the current supply voltage. Only connections B, C and D on both transformers are used, the A connection remaining open.

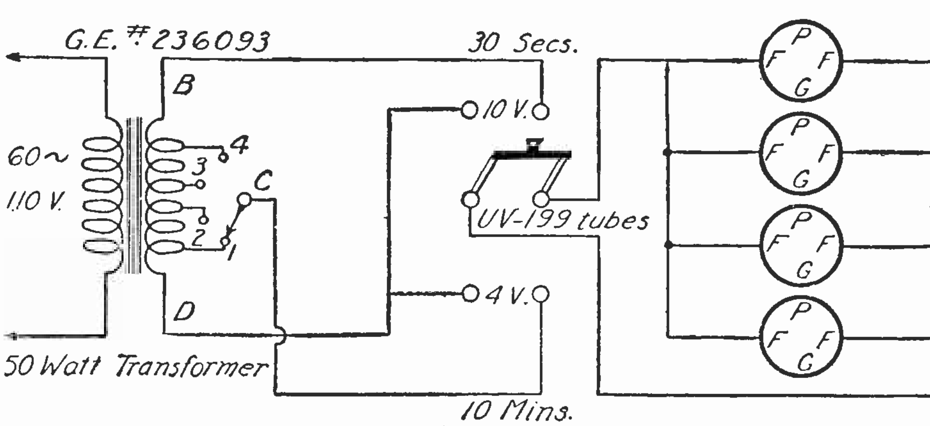


Fig. 1

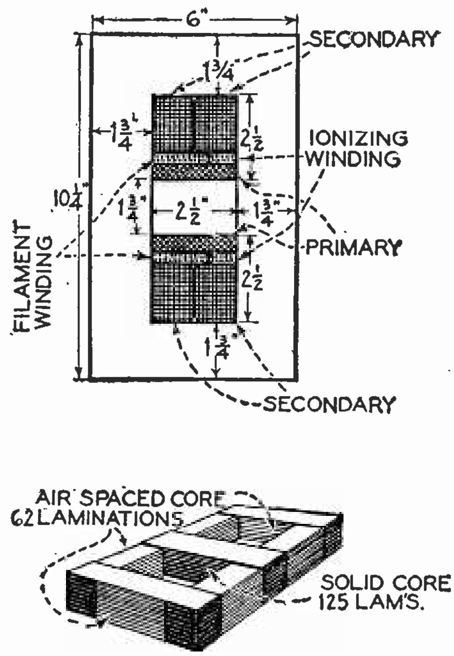
The 100-watt transformer, when connected in the manner of the 50-watt transformer, with the switch arm exception mentioned above, will deliver (closely) the voltages of eight and 16 volts. Putting the double-pole double-throw switch on one side should deliver 16 volts to the filaments of the UV-201A tubes for a period of only 30 seconds. Finish off with the switch in the opposite position, delivering eight volts for 10 minutes. For the UV-199 tubes, start with 10 volts for only 30 seconds and then immediately change over to four volts for a period of 10 minutes.

Power Transformer

(2) Jack Richman, Jackson, Mich., asks:

(Q.1) Will you kindly inform me through the Radio Oracle how to build a power transformer to supply A, B, and C voltages to be used with a 400 milliampere rectifying tube?

(A. 1.) On this page you will find an illustration showing the construction of the transformer core and also the placement of the filament, ionizer, and secondary windings. The core is made of No. 28 sheet silicon steel .014 inch thick. 62 laminations 2½"x1¾", 186 laminations 6"x1¾", and 125 laminations 10¼"x1¾", will be necessary for the core. The center leg of the core should be assembled from the 62 laminations. This should be placed in a vise and tightly bound together with tape. The primary winding which consists of 160 turns of No. 14 D. C. C. wire is wound on a wooden form, securely taped, and then slipped over the center leg of the core. Rice paper should be placed between each layer of the winding and a layer of empire cloth should be placed over the completed primary winding. The filament winding consists of 10 turns of No. 12 D. C. C. wire and is wound next to this and serve as the should be tapped at the center. Seven turns of the same number wire are wound next to this and serve as the ionizing winding. A layer of empire cloth should be placed over these windings. The filament and ionizing windings should be held in place with tape. The two secondary coils consist of 620 turns of No. 20 D. C. C. wire and should be wound upon a form, taped and then slipped over the filament and ionizer windings. The completed transformer will measure 6"x¼" and will have two windows, each 2½" square as shown in the illustration. The two secondary windings of 620 turns each should be connected in series. All the high voltage secondary leads should be well insulated with varnished cambric tubing or with rubber. This transformer can be used in an A, B and C eliminator employing the new 400 milliampere rectifier and will deliver 4 volts at 5 amperes to the ionizer and 5.5 volts at one ampere for filament operation. It will also supply 360 volts at 300 milliamperes and 375 volts under no load conditions for the plates of the tubes.



Above we have the details of the power transformer, showing assembly of core and windings.

Either double cotton covered wire, or single cotton covered enameled wire may be used. Except in the smaller sizes the use of plain enameled wire in transformers is not advisable. Enameled wire cannot be shellaced in place, which is a distinct disadvantage. The number of layers of wire is found by dividing the total number of turns by the number of turns per layer. From this the depth of the winding may be calculated, allowing for any insulation between the layers. When the transformer is put under load, the core and windings may become warm. Although it is possible to design transformers to operate at low temperatures, a certain amount of heating is permissible, and transformers that run warmer can be built somewhat cheaper and more compact. The temperature rise, however, should not be so great as to damage the insulation. When the transformer is put under a full load the voltage across the secondary terminals will drop a small amount.

Edison Battery

(3) Hal Coytes, Wichita, Kansas, asks:

(Q.1) What is the chemical action which takes place in the Edison storage battery?

(A.1) The fundamental action which occurs is the oxidation and reduction of metals in the electrodes. Neither the metals or their oxides dissolve or are combined. The water of the electrolyte is decomposed by charge and discharge, but it is again reformed in equal quantities and therefore its conductivity and density are the same over a long period of time. Since the active materials of the plates are insoluble in the electrolyte, no chemical deterioration takes place. In charging, the nickel in the positive plate is changed to a higher oxide and reduction takes place at the negative plate where the iron oxide is changed to metallic iron. The oxidation and reduction are accomplished by the oxygen and hydrogen set free by the electrolytic decomposition of the water, while the battery is on charge. During discharge a reversal of the above action takes place and the hydrogen reduces the higher oxide of nickel to a lower oxide and the oxygen oxidizes the iron to iron oxide.

The positive plate of the cell is made of perforated steel tubes filled with alternate layers of compressed nickel hydroxide and metallic nickel flakes. These tubes are rigidly clamped in a steel frame. The negative plate is built up of a large number of rectangular pockets filled with powdered iron oxide. The pockets are enclosed in a corrugated steel grid forming the negative plate. The electrolyte is an aqueous solution of potassium hydroxide, or caustic potash, having a specific gravity of 1,400. This hydroxide, if exposed to the air, combines with the carbon dioxide, forming potassium carbonate. For this reason the cells must be airtight. However, it has no effect on the steel containing jars which is an advantage over the lead acid cell.

"A" Eliminator

(4) Robert Shuter, Oklahoma City, Okla., asks:

(Q.1) I have a 5 ampere charger using a lamp as a rectifier. Can you advise me how I may convert the charger into an "A" eliminator?

(A.1) This type of charger can easily be converted into an "A" eliminator by filtering the output. An "A" choke and two "A" condensers of 2000 or more microfarads capacity, connected across the output on either side of the choke, form a suitable filter. An electrolytic filter could, of course, be used, as well as a dry "A" filter. The latter consists of two condeners and a choke coil, housed in a metal case. These are now available from several manufacturers.

Buckled Battery Plates

(5) J. Kafilides, Jersey City, N. J., writes:

(Q.1) The plates on my storage battery have become warped out of shape What is the cause of this?

(A.1) Buckled or warped plates may be caused by too high a temperature. Lead will, of course, expand upon the action of heat, and since it has a very low elastic limit when once expanded, it will stay in that condition. Most buckled plates are caused by continued overdischarge or lack of charge. An unequally distributed chemical action at the plates will result in unequal heat distribution and will cause irregular expansion at different parts of the plate. This results in bending and buckling. Prolonged discharge causes expansion, especially if the sulphate formed is crystalline in structure. On discharge, the active material which changes to the sulphate increases in volume, and this expansion may exert pressure on the grid, causing it to bend. Hard sulphate, formed in patches, will reduce the conductivity of the plates and cause the active material which is not covered up to be worked at excessive rates, even under normal conditions. This also results in high temperatures in certain spots and unequal expansion follows. Even at low rates of discharge or charge, a battery plate which is badly sulphated may become buckled. When acid is mixed with water, heat is liberated. On charge, the acid produced at the surface of the plates mixes with the water. At excessive rates of charge the heat may be so great and irregularly distributed that the plates become buckled or warped.

Reducing A. C. Filament Supply

(6) Mr. M. R. Smith, Flushing, N. Y., writes:

(Q.) I have a filament transformer designed for 7½-volt tubes, such as the 210 and the 250. I am using a 171 tube in the last stage in my set and I would like to use this transformer. I have tried to place a resistor in series with one side of the line to the filaments, but this produces an excessive amount of hum. "Can you help me?"

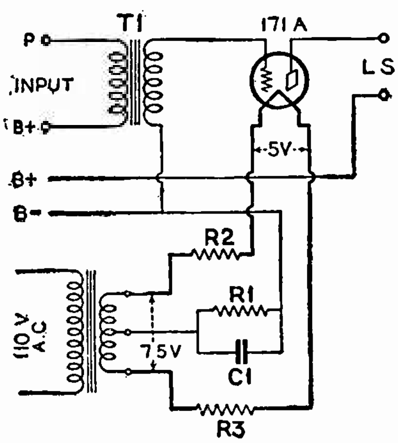


Fig. 2

(A.) In order to keep the filament current of the tube in a balanced condition (which is necessary to keep the hum at a minimum) the potential on each side of the center tap of the transformer must be the same. If resistance is added on one side, the voltage on that side of the filament is reduced and the filament is unbalanced.

If the center tap of the transformer is not used, and a variable voltage-divider or potentiometer is employed for the center tap of the filament circuit, the adjustable arm of the resistor may be used to counteract the unbalancing. A series resistor might also be connected directly to the filament terminal on the tube socket. In this way, the center arm of the tapped resistor would not need to be moved from the mechanical center, and a fixed tapped resistor could be employed.

When using a center-tapped transformer, however, this method of reducing the voltage is not practical; since it causes an unbalancing of the filament circuit. The obvious way of overcoming the difficulty is, of course, to place two resistors (R2, R3), in the circuit, one in each side of the filament supply. In this way, the voltage on each side of the center tap is kept the same and the hum is naturally reduced to a minimum. The actual value of the resistors depends on the filament current and the amount of voltage reduction required. Ohm's law is used for this calculation—that the resistance is equal to the voltage drop divided by the current in amperes. In this case, the voltage drop is equal to 7½ minus 5 volts or 2½ volts; the 171A tube draws ¼-ampere, so the resistance should have a value of 10 ohms. Each side would then need 5 ohms, in order to produce the required voltage-drop. The center tap of the filament transformer is connected to the negative "B" lead and grid return through the resistor R1 in order to supply the required "C" bias for the power tube. R1 is 2,000 ohms and C1 at least 0.5-mf.

Voltage-Regulator Tubes

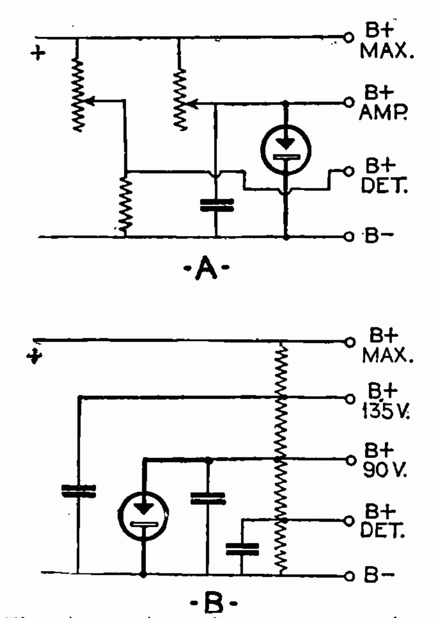
(7) Mr. N. B. Johnson, Cleveland, Ohio, writes:

(Q.) "I have a 'B' power unit in which I would like to use a voltage-regulator tube. The unit has two variable output taps and a maximum tap for the power tube; the last gives about 180 volts, and the variable taps supply voltages between 20 and 150 volts. I understand that a tube of this type can be incorporated without changing the internal wiring of the power unit. Can you help me to solve my problem?"

(A.) The use of voltage-regulator tubes in "B" power units should be of interest to a number of fans, as it is of great assistance in cases of variation in the voltage in the unit; whether they are due to line-voltage changes or to current changes in the load which cause corresponding changes in the voltage.

Such tubes operate by absorbing from the power unit all output current which is not being used by the receiver at any instant. Thus the output voltage is maintained at a constant value; the receiver, or load, receives exactly the power that it requires and the regulator tube takes the remainder.

The tubes are designed in such a way that their resistance is automatically decreased with any increase in the applied voltage. If, on the other hand, the voltage decreases, the resistance increases; so that whether more or less current is passed through the regulator tube depends on the voltage input and the amount of current consumed by the set. The commercially-available tubes are made so that their output voltage is kept at 90; in a power unit supplying



The voltage-regulator tube across a power-unit tap maintains its output at 90 volts.

a constant output in watts, the voltage-regulator tube will take sufficient current to keep the output voltage practically constant within the limits of the tube. Of course, if its input voltage is increased over the rated maximum-current value of the tube, since it will take only its maximum amount of current the terminal voltage will be accordingly increased.

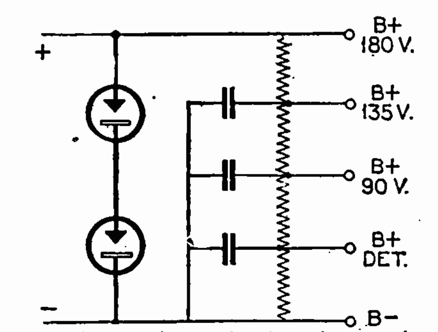
A voltage-regulator tube may be inserted between the negative terminal and the 90-volt tap of a power unit of almost any type, without disturbing the unit in any way. The necessary hookup for such a tube in a unit with two variable taps, is used in a number of commercial units. If the tap is provided with a by-pass condenser, the only additional connections are those from the tube to the "B plus Amp" tap and the negative terminal. Connections for a unit using the potentiometer, or series, output arrangement. The voltage at the terminal should be somewhat over 90 volts without the tubes; so that some current will flow through the tube and enable it to operate correctly.

Two voltage-regulator tubes may be connected in series for the output of a 180-volt supply as shown. In this case, the output voltage will be maintained at 180, even though the input from the rectifier and filter is increased above this value. By connecting the tubes in this way, the output of the complete unit will be maintained at a practically constant voltage. The maximum-variation voltage range also will be higher than with a single tube, so that greater voltage-variations can be accommodated.

Tube Operation

There is one drawback in the use of "glow" tube; that is, in order to have the tube operate correctly, it must be supplied with about 125 volts for an instant, in order to make it glow. This can be done by turning the power unit before switching on the receiver; as soon as the set is switched on, the voltage drops to 90 volts, which is the correct value. It is also necessary to connect the tube correctly; if the polarity is right, the glow will be noticed around the large circuit plate. If the tube is incorrectly connected, the glow will be around the small terminal; no damage will result from a temporary reversal of the connections, but the tube should not be left in this condition for any length of time. In some cases, it is advisable to connect a 1000-ohm resistor, in series between the 90-volt tap and the tube, to prevent an excess of current from flowing through the tube.

Another tube, called a "ballast" tube, is often used to keep the receiver's power supply constant; being connected in series with the primary of the power transformer. Its operation controls the current supplied to the power unit. After this tube it is necessary to use a special transformer with a primary designed for 65 volts, instead of 110 to 115. If the line-voltage averages 115 volts, the transformer should be designed to take, under load, 1.7 amperes



Two voltage-regulator tubes in series, as above, fix the "B plus Amp" value at 180 volts.

at 65 volts, the remaining 50 volts being dropped in the tube. If the line-voltage drops or rises 10 volts, the voltage across the tube will correspondingly change, but the transformer primary voltage will remain constant at 650.

The "ballast" tube requires about ten minutes to heat up fully, and the voltage drop increases rapidly for the first few minutes, after which it increases up to the final temperature; the "glow" tube mentioned previously functions instantaneously, as soon as the glow is seen. The "ballast" tube is equipped with a special screw base; while the voltage-regulator tube uses the standard four-prong UX base of the type used for receiving tubes.

Intermediate "B" Voltage from the Power Pack

The majority of 281-210 power amplifier units are constructed with transformers and choke coils of husky

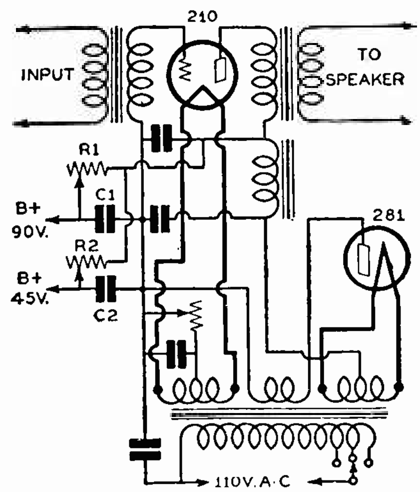


Fig. 3

enough design to supply the added current necessary for the "B" potentials of the average receiver. Fig 1 shows the circuit diagram of a typical power amplifier. The changeover, so as to dispense with "B" batteries, is extremely simple and very little extra equipment is required. Fig. shows the added voltage reducers R1 and R2.

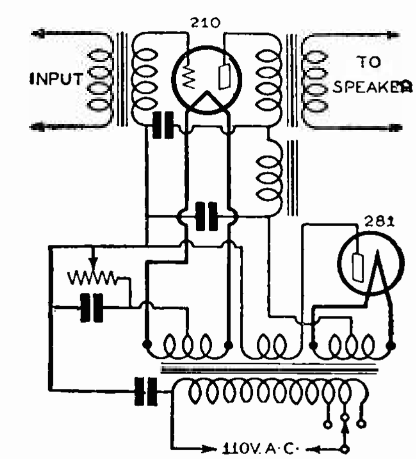


Fig 4

These variable resistors may be of the compression type, and have a range of 0 to 100,000 ohms. The cases of the resistors should by all means be connected to the low or reduced potential side. C1 and C2 are on the order of 1 mfd. 250 volt D.C. filter condensers.

With this arrangement as shown in Fig. 2 a wide variation of plate voltages can be obtained; a third voltage reducer may also be incorporated if, say 45, 90 and 135 volts are required. While "C" battery voltages may also be obtained, it is not advised, as radical changes to the unit will be necessary. Dry "C" batteries with this unit are by far the more convenient and need only to be replaced at the end of, say, nine months' use.

30-Henry Choke

(8) James Clarke, Wesfield, Mass., writes:

(Q.1) Will you please supply me with information about the construction of a "B" eliminator choke which has an inductance of about 30 henries while handling a current of approximately 85 milliamperes.

(A.1) The core of the choke coil should be made from silicon steel laminations, the thickness of each lamination approximately corresponding to Brown and Sharpe-gauge No. 26. The core is a single magnetic circuit with a square cross-section, 1¼"x1¼". The core is built up from laminations of four different sizes, 78 of each size being required if the laminations are gauge No. 26. The largest laminations are 5¾" long by 1¼" wide, the next 4" long, the next are 2⅜" long, and the smallest laminations are 1⅛" high by 2¾" wide. The core has four butt joints, a piece of ordinary writing paper is inserted at each of the joints to provide the necessary air gap.

The coil should have about 7,800 turns of No. 26 enameled wire, wound with 150 turns per layer. This coil should be wound on a wooden form, then bound with tape and slipped over the core leg which is built up with the 5¾" laminations. The direct current resistance of this choke will be about 240 ohms.

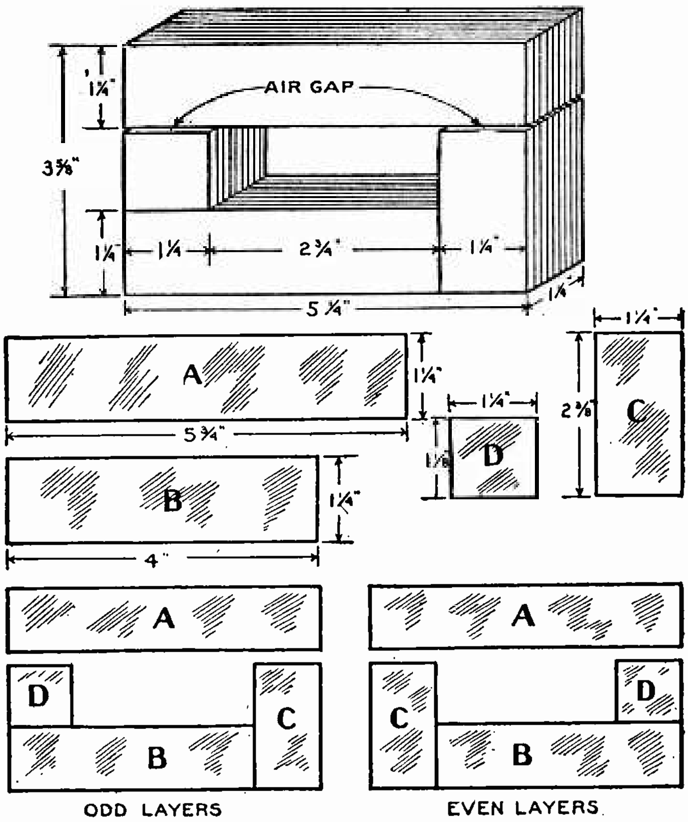


Fig. 5

Electrolytes

(9) J. McMann, Buffalo, New York, writes:

(Q.1) Will you give me some information concerning electrolytes used in electrolytic rectifiers. What are the advantages of using ammonium phosphate and ammonium borate, instead of the usual borax used in the aluminum-lead type rectifier?

(A.1) Usually a saturated solution of commercial borax is employed in the homemade rectifier. This electrolyte is suitable, but if it is not chemically pure trouble may arise. Ammonium phosphate or ammonium borate dissolved in distilled water will give better results. The former is prepared by making a saturated solution of acid ammonium phosphate. The ammonium borate electrolyte is prepared in the same manner.

The ammonium phosphate electrolyte may be permitted to stand for a long period without harm. The ammonium borate, during an idle period, will increase its internal resistance, which will cause a considerable drop in voltage. It may even be necessary to scrape the electrodes in order to have the rectifier function properly. The ammonium borate will react upon the lead, forming lead peroxide, which will fall to the bottom of the container. This trouble is not encountered with ammonium phosphate. Of course, the electrodes should be of the purest metal obtainable, so that no "local action" takes place.

Reducing Transformer Voltage

(10) Felix Simons, Houson, Texas, asks:

(Q.1) I have a transformer with a 7½ volt filament winding designed for operating a 210 tube. How can I cut this down to 5 volts, so that I may light the filaments of two 171-A tubes. A diagram of the method used will be appreciated.

(A.1) The problem of cutting down the voltage delivered by the 7½ volt transformer is an easy one, and it will simply be necessary to use a resistor in series with each leg of the winding.

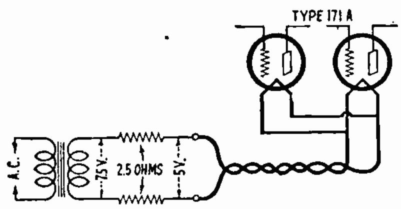


Fig. 6

This is done in order to preserve the electrical balance of the winding which would be destroyed if only one resistor were used in series with one of the leads. In order to operate two 171-A tubes which together draw a half ampere of current, the resistance required will be 2.5 ohms in each leg, since the voltage drop required is 2.5 volts. The resistors should be of sufficient capacity to carry the load.

Current-Carrying Capacity of Wires

(11) Mr. John Morrison, Havanna, Cuba, writes:

(Q.) "In making transformers and other apparatus such as choke coils, requiring windings, I am always bothered by the sizes of wire which I should use. In making the coils, I usually want to make them as small as possible and, for this reason, I like to use the smallest wire that is practical. I have never seen a table of the current-carrying capacities of small wires. Since this would be of interest to a great number of experimenters who make their own transformers and other coils which carry comparatively large currents, I would suggest that you publish one, even though the values are only approximate."

(A.) We give below the approximate maximum currents safely carried by wire of gauges which may be used in designing chokes, transformers, etc. The main consideration is the selection of a wire which will not overheat, when used for long periods of time. In audio-frequency chokes, the currents vary between the limits of a few milliamperes and a number of amperes and, naturally, the design of coils varies considerably with the maximum current to be passed.

The following table may be used in figuring the maximum allowable current in milliamperes which a wire of a certain gauge can handle:

TABLE A

Copper wire B & S Gauge	*Current in Milliamperes*
16	2,000 to 2,600
18	1,200 to 1,600
20	700 to 1,000
22	450 to 650
24	300 to 400
26	175 to 250
28	100 to 160
30	65 to 100
32	40 to 65
34	25 to 40
36	18 to 25
38	10 to 15
40	5 to 10

Since the resistance of the wire is an important point in the design of coils also, we print a list of the resistance values for the various gauges of wire, and also the number of turns per inch which can be wound with double-cotton-covered wire.

In figuring the space required for a multi-layer coil, the linear turns per inch can be squared to give the number of turns per square inch which can be wound into a slot; and simple proportion will then supply the figure for te required space.

TABLE B

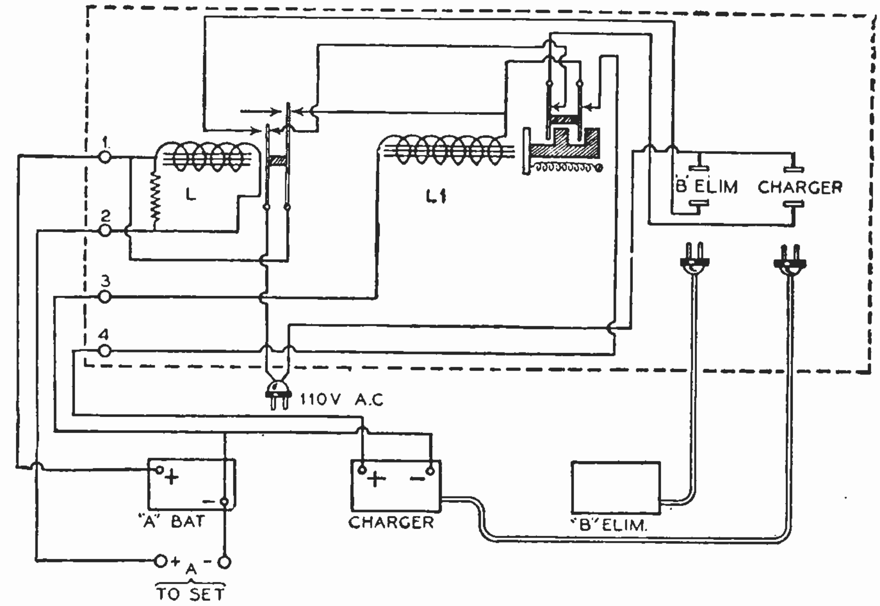
Copper Wire B & S Gauge	*Ohms per 1,000 Feet*	*Turns per Linear Inch (D.C.C.)*
16	4.09	16.7
18	6.51	20.4
20	10.4	24.4
22	16.5	30.0
24	26.2	35.6
26	41.6	41.8
28	66.2	48.6
30	105.	55.6
32	167.	62.9
34	266.	70.0
36	423.	77.0
38	673.	83.3
40	1,070.	90.9

Relay Diagram

(12) A. T. Wagnoll, Milwaukee, Wisc., asks:

(Q.1) If possible, please publish the circuit diagram of the Yaxley full automatic relay.

(A.1) The schematic hook-up of this relay is shown upon this page. Coil L is a low-resistance coil in series with the "A" battery and tube filaments. Coil L1 has a resistance of about 200 ohms. The numbers 1, 2, 3 and 4 correspond to the markings of binding posts on the front of the relay. A resistance is shunted across coil L, so that the voltage drop is always kept within 0.2 volt. This resistance is changed according to the current consumption of the receiver and consists of a strip of resistance wire. Two values of resistance wire are furnished with the relay. The action of the relay is such that when the filaments in the receiver are turned off, the charger is automatically cut in and the "B" eliminator is cut out of the circuit. Furthermore, when the battery is fully charged, the relay automatically cuts the charger out of the circuit.



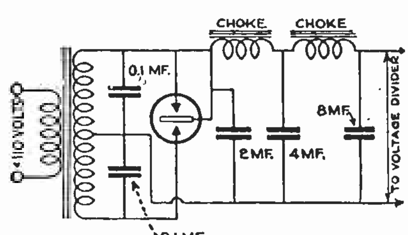
Above is the circuit diagram of the Yaxley full-automatic relay, for use with B eliminator, A battery and charger.

Improving Filter for "B" Power Unit

(13) Mr. R. Stenefield, Richmond, Va., writes:

(Q.) "I have heard about several changes that have been made in the filter circuit of the Raytheon type 'B' power unit, and before building one of these units I would like to know just what these improvements are so that I can incorporate them in my power unit. Can you help me in this matter?"

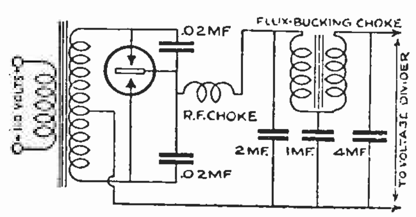
(A.) In a recent issue of the *Technical Bulletin*, published by the Raytheon Manufacturing Company, several changes in the usual design of the "B" power units employing the gaseous rectifier tubes were described. These changes consisted in the removal of the usual buffer condensers from the secondary of the power transformer, and the insertion of condensers at another point of the unit, to accomplish the same results. The advantage claimed for this change is in the use of a better position for these buffer condensers. The change in the position of the condensers is shown in the two diagrams, Figs. A and B. The condensers are placed as close to the terminals of the rectifier as possible.



The usual connection of "buffer" condensers

A radio frequency choke is also incorporated in the line from the rectifier to the filter. This choke tends to keep radio-frequency disturbances out of the filter, which results in better filtering and also reduces the noise level in the set itself. The condensers and choke are fastened directly to the terminals of the rectifier tube socket to provide extremely short leads; as the best results are obtained in this arrangement when the connections are short and direct.

The radio-frequency choke may be home constructed if desired, since it is very simple to make. It consists merely of a coil one-inch in diameter wound with 100 turns of No. 30 to 34 D.C.C. wire.



The new method of connecting condensers is more effective with smaller capacities.

Another change has been made in the unit, but the construction to the required apparatus is too difficult for amateur construction and unless commercial parts are available, it will not be practical to use this change. It is in the construction and design of the filter circuit. A choke coil arrangement called "a flux bucking choke" is used in place of the usual 30-henry chokes. The advantage of this choke is in the comparatively high saturation point. In other words, the choke is more efficient and economical than the older type. The economy is partly due to the lower capacity of the filter condensers required to give a constant output current.

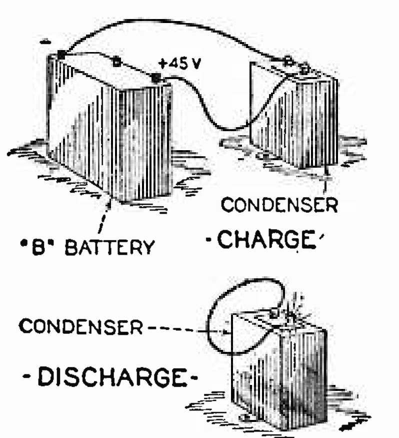
Although the choke sytem is not practical for amateur construction (unless manufactured chokes are available), the other changes can be made very easily and they will result in a more effective power unit.

A Test for Large Condensers

(14) Mr. I. V. Dinmore, Windsor, Ontario (Canada), writes:

(Q.) "I am using a 'B' power unit of the Raytheon type with a step-up transformer, rectifier, and filter circuit. The filter circuit contains several condensers and, some time ago, one of these condensers broke down. At that time, I replaced all the condensers with new ones. I am sure, however, that all these condensers are not injured and I would like to use some of them as by-pass condensers in my set. How can I tell which are good and which are not?"

(A.) There are several ways in which a filter condenser may be tested, but probably the simplest is the discharge test. The only apparatus necessary for testing condensers in this way is a "B" battery and two pieces of wire. The



A condenser which will spark when connected is shorted inside; one which will not spark when disconnected is open-circuited within.

battery is connected to the condenser for a minute, to charge it, and then one of the wires is connected from one side of the condenser to the other side (after the battery has been disconnected of course) in order to discharge the condenser. If the latter is in good condition, a spark will jump from it to the wire when that is brought close to the condenser terminal. If the condenser has been previously internally short-circuited, a spark will be seen when the battery is connected to the condenser; in this case, *the battery should be disconnected instantly*, so that it will not be injured. If no spark is obtained when the condenser terminals are shorted, connect the condenser again and repeat the experiment, to be sure that no spark can be obtained. If, at the second attempt no spark is obtained, it may be assumed that the condenser is defective. If a heavy spark is obtained when the battery is first connected, as mentioned above, the condenser is also defective. The method of connecting the condenser to the battery and discharging it as shown.

Small condensers, of less than ¼-mf. capacity or thereabouts, cannot be checked satisfactorily in this way; because of the comparatively small amount of current which can be stored in the condenser. The best way to check small condensers, without instruments for measuring the capacity, is to connect a pair of headphones and a "C" battery in series and try this unit across the condenser. In very small condensers, no click will be heard when the contact is made. If a click is heard, of about the same intensity as the click produced by touching the two wires from the phones and battery together, the condenser may be assumed to be defective.

Battery Terminal Replacements Quickly Made.

One contributor has found that a small ground-clamp, of the type equipped with a spring-clip binding post, makes an excellent substitute for the various components which make up the post of a storage battery.

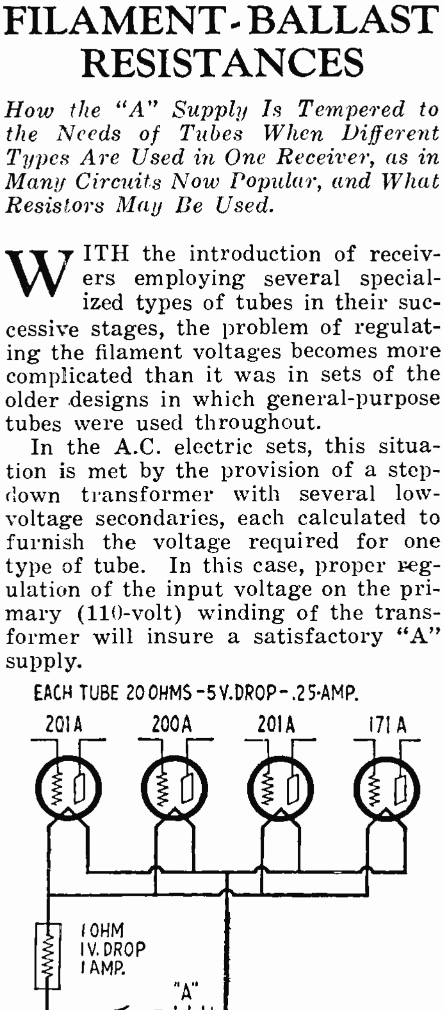
These parts, as a rule, suffer badly from corrosion and finally break off or wear off, leaving nothing but a short, rounded shank to which a ground-clamp may be fastened. It must be remembered that the clamp has a tendency to corrode rapidly unless liberal coats of heavy oil or vaseline are applied.

FILAMENT-BALLAST RESISTANCES

How the "A" Supply Is Tempered to the Needs of Tubes When Different Types Are Used in One Receiver, as in Many Circuits Now Popular, and What Resistors May Be Used.

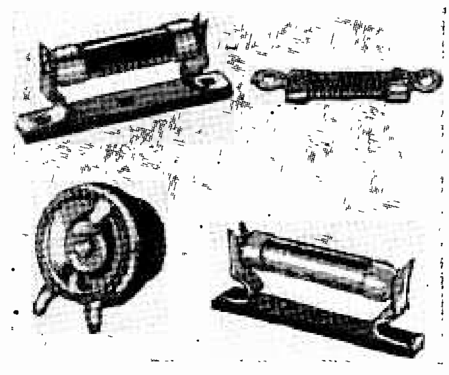
WITH the introduction of receivers employing several specialized types of tubes in their successive stages, the problem of regulating the filament voltages becomes more complicated than it was in sets of the older designs in which general-purpose tubes were used throughout.

In the A.C. electric sets, this situation is met by the provision of a step-down transformer with several low-voltage secondaries, each calculated to furnish the voltage required for one type of tube. In this case, proper regulation of the input voltage on the primary (110-volt) winding of the transformer will insure a satisfactory "A" supply.



The filaments of the tubes require the same supply. One fixed resistor is sufficient, though the voltage falls as the battery discharges itself.

On the other hand, if direct-current tubes are used, either the 3-volt ("dry-cell") or the new 3.3-volt ("screen-grid") filaments will require special protection if they draw their current from the same source as the 5-volt ("storage-battery") tubes. For this purpose, resistors, commonly called "ballasts," are used; either of a self-adjusting type, which automatically change their resistance with their temperature, and consequently permit the flow of a certain amount of current



Four types of filament resistors in common use.

only, or fixed resistors which properly divide the voltage existing within the circuit and leave only the correct amount across the tube filaments. Such resistors are commonly inserted in the "A—" return leads from the "F—" socket terminals of amplifier tubes, in order to secure a negative bias on the grids of the tubes. (Properly, this is a positive bias on the filament, but it amounts to the same thing; the filament is kept above ground potential by the amount of the drop through its series resistor.)

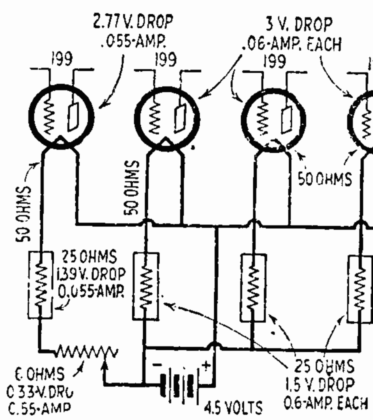
The most satisfactory method, perhaps, is to connect to each tube, or group of similar tubes, its own resistor; then a master rheostat between all the tubes and the battery permits all voltages to be varied proportionately, if it is so desired.

The filament resistance of the screen-grid (222-type) tube is a trifle more than that of the standard 5-volt tube (201A, 112A, 171A types); the former is 25 ohms and the latter 20. But if the 222 were put across the "A" leads, even after the rheostat had cut the voltage down to 5, it would draw one-fifth of an ampere, or 200 milliamperes, instead of the 132 for which it is designed. Consequently, an additional resistance of about 13 ohms in series with the filament of the 222 will be required. In all cases, it will be found better to use a resistor reducing the voltage of the tubes slightly below their rating, rather than one which will permit an excess of current. The 120-type semi-power tube operates similarly to the 222.

The filament resistance of the 199-type tube, we find, is much higher than that of the foregoing—50 ohms—but its current-carrying capacity is very much less. With the 199-type tube across a 5-volt supply, about 33 1/3 ohms in series will be required to safeguard its filament; and 50 ohms if it is exposed to the full 6 volts of a storage battery.

Figuring Resistances

A very easy way to calculate the value of the filament resistor required to reduce the voltage of a given current source to that required for one or more tubes is simply to take *the difference in voltage between the supplied voltage and the required voltage* and divide that by the current drain of the tubes with which it is to be used. For instance, the difference between the 6 volts supplied by a storage battery and the 5 volts required by quarter-ampere tubes such as the 201A-type, etc., is one volt. If only one tube is to be used, the current drain is 0.25-ampere and the resistance required will be 1.00 divided by 0.25 or 4 ohms. If three tubes are to be used, the total current



Here we have tubes requiring much greater voltage drop. When the rheostat is turned "down," as shown, it reduces the voltage across the first tube, and current, too.

drain will be 0.75-ampere and in this case 1.00 divided by 0.75 equals 1 1/3, the number of ohms required.

If several tubes of the same type of filament are connected *in parallel*, their combined resistance is equal to that of any of them, *divided by the number used;* and a single resistor in series with them must be divided in similar proportion to the value required to protect a single one of them.

For instance, two 222-type tubes in parallel have only *half the resistance of one*—12½ ohms instead of 25. Consequently, the resistor which ballasts them, and passes twice the current, should have one half the resistance of that used with one tube, or 6½ ohms, to maintain the proper voltage across their filaments.

In the case of a filament-ballast resistor designed especially for a given tube or tubes, whether it is of the fixed or the self-adjusting type, the manufacturer's instructions should be read carefully, and the user should make certain that he has the correct type for the tube or tubes which it is to protect, before inserting the resistor in the circuit. A resistor designed for two or more tubes in parallel would allow an unduly high flow of current through one of the same type; and it can be seen why it is undesirable to have any tubes out of their sockets when the battery switch is turned on. This risk is eliminated when each tube has its own resistor.

The use of a reliable voltmeter, it need not be said, is as desirable in skillful set operation as that of a steam gauge in the operation of a steam engine. For this purpose, the higher its resistance, the more reliable its readings, as a rule; for a low-resistance voltmeter is a load on the circuit it is testing and, by drawing additional current, makes its readings deceptively low.

The figures below indicate the resistances necessary to reduce the "A" supply to the specified working voltages, and consequent proper flow of current, through tubes of the type given.

Type of Tube	*Series Resistor Ohms*
6-volt "A" supply	
One 201A (or other ¼ amp., 5-volt tube)	4
One 199 (or other 60-milliamp., 3-volt tube)	50
One 199 (at 3.3 volts)	43
One 222 (at 3.3 volts)	21

(If the filament circuit of several tubes in parallel returns through one resistor divide the above resistance by the number of tubes.)

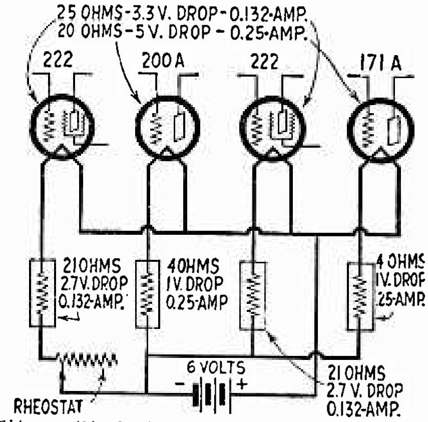
*One 201A, one 222	2 3/5
*Two 201As, one 222	1 3/5
*Three 201As, one 222	1 1/7
*Two 201As, three 222s	1 1/7
*Three 201As, three 222s	7/8
*Four 201As, three 222s	3/4
*One 201A, one 199	3 1/4
*Two 201As, one 199	1 4/5
*Three 201-As, one 199	1 1/4

(For purposes of calculating *current* drawn, two 222s equal one 201A, approximately, and two 199s equal one 222. A ½-ampere tube, 112 or 171, counts as two 201As.)

*As this resistor reduces the "A" voltage only to 5, additional resistors will be necessary in series with the low-voltage tubes.

5-volt "A" Supply (Behind Resistor)	
One 222 (at 3.3 volts)	13
One 199 (at 3.3 volts)	27
One 222 (at 3 volts)	15
One 199 (at 3 volts)	30
4½-volt "A" Supply	
One 222 (at 3.3 volts)	10
One 199 (at 3.3 volts)	19
One 222 (at 3 volts)	12½
One 199 (at 3 volts)	25
4-volt "A" Supply	
One 222 (3.3 volts)	6
One 199 (3.3 volts)	12
One 222 (3 volts)	8
One 199 (3 volts)	17

The figures above given are *minimum* resistance and, though fixed filament voltages need not be critical, a lesser value should not be employed—remembering always that resistors may



This possible hook-up is more complicated. Each tube has its own ballast, adding just enough resistance to regulate the amount of heating current from the battery. The rheostat here is turned "up," out of the circuit.

be slightly below their rating and that power units, in particular, may deliver slightly over their rating. The application of too much voltage across a tube filament, within reason, will not burn it out; but it tends to shorten greatly the effective life of the tube.

A diagram of a 32-volt filament supply which will usually operate satisfactorily from a farm-lighting plant is factorily from a farm-ligting plant. The current supplied by these units is, usually, sufficiently constant so that very little filtering is necessary. However, in order to keep noise level at a minimum, it is advisable to use a filter of some kind; and, for this purpose, you will find that a choke and two filter condensers are used. The choke will have to be made in such a manner that it will carry three amperes or more at 32 volts, without overheating. In case you cannot obtain a suitable coil, the choke may be omitted and a single 4-mf. filter condenser or larger size may be used for the filter. This method is not as efficient as the first; but it will often operate satisfactorily, especially in the larger installations.

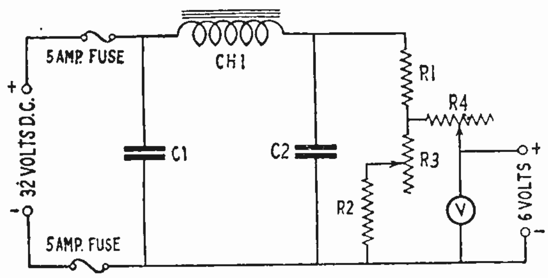
The remainder of the unit consists of the voltage-reducing device, made up of resistors. The first resistor R1 and the second R2 are fixed resistors, the values of which are determined by the type and number of tubes used in the set. If 5-volt tubes are employed, a resistor of 12.5 ohms and a current-capacity of about 60 watts will be suitable for sets using up to 1 ampere. Between 1 and 1.5 amperes, the resistor should have a value of 10 ohms and a capacity of 60 watts; while sets drawing up to 3 amperes should use a resistor with a higher current rating such as 125 watts. The Ward-Leonard type PEB-6.4 resistor is suitable in this case. The resistance value is 6.4 ohms.

For resistor R2, the value is also

dependent on the number of tubes used. A current rating of 60 watts will be sufficient for all purposes. A table of resistances follows:

Current drain amperes	*R1 Resistance ohms*	*Rating watts*	*R2 Resistance ohms*	*Rating watts*
.75	12.5	60	5	60
1.00	12.5	60	7	60
1.25	10.	60	5	60
1.50	10.	60	7	60
1.75	6.4	120	3	60
2.00	6.4	120	3.5	60
2.25	6.4	120	4.25	60
2.50	6.4	120	5	60
2.75	6.4	120	6	60
3.00	6.4	120	7	60

The current drain of the set should be figured from the number and the



Many homes in rural and suburban districts have 32-volt light plants. The current, properly filtered, may be used with D.C. tubes and suitable resistors.

type of the tubes used, and the corresponding resistors for R1 and R2 should be used.

R3 and R4 are rheostats of about 6 ohms. They should be made with wire sufficiently heavy to carry 3 amperes without overheating. If 199-type tubes are used, resistors R1 should have a value of 45 ohms and R2 one of 7 ohms. R3 and R4 in this case should have a value of about 20 ohms. In constructing the unit, the two resistors R1 and R2 should be mounted in such a way that they will be well ventilated, so that there will be no danger of overheating. R3 and R4 are adjusted with the set in operation and a voltmeter is used to determine the correct setting. Two 5-ampere fuses should be connected in the circuit, and, in some cases, it is advisable to place a one-microfarad condenser in the ground lead of the receiver, to prevent a short circuit in the power-supply unit. The condenser is merely connected between the set and the ground. Its use will not affect the operation of the set.

Tungar tubes may be easily made as good as new when they are only suffering from scale which forms on the graphite button. While the battery chargers are being replaced by all-electric sets, there are yet thousands using batteries and the tungar chargers, to whom this may be of help.

The small trickle charger tubes seem to suffer from this trouble most, the larger tubes either burning out or the filament sags away from the anode, making the tube useless. The smaller tubes do not seem to pass enough current to keep the graphite in a working condition, a sort of scale forming which insulates the button and causes the tube to become inoperative.

To remove this scale, procure a spark coil such as Ford spark coil and connect one of the high-tension terminals to the filament of the tube and the other high-tension terminal to the anode or graphite button. The high-tension terminals of a Ford coil are the two on the side of the box. The primary terminals are the bottom one on the side and the one on the bottom of the box.

Connect the primary terminals to a six-volt battery and a spark will pass between the filament and the graphite button. The spark punctures the scale and removes it. This treatment should be continued intermittently for a couple of minutes and then if the tube does not function normally it should be repeated. When the tube is working properly a blue glow will be seen around the filament. With the large tubes, in charging a six-volt battery, if they fail to start when first turned on, they may sometimes be started by short-circuiting the charging terminals for an instant.

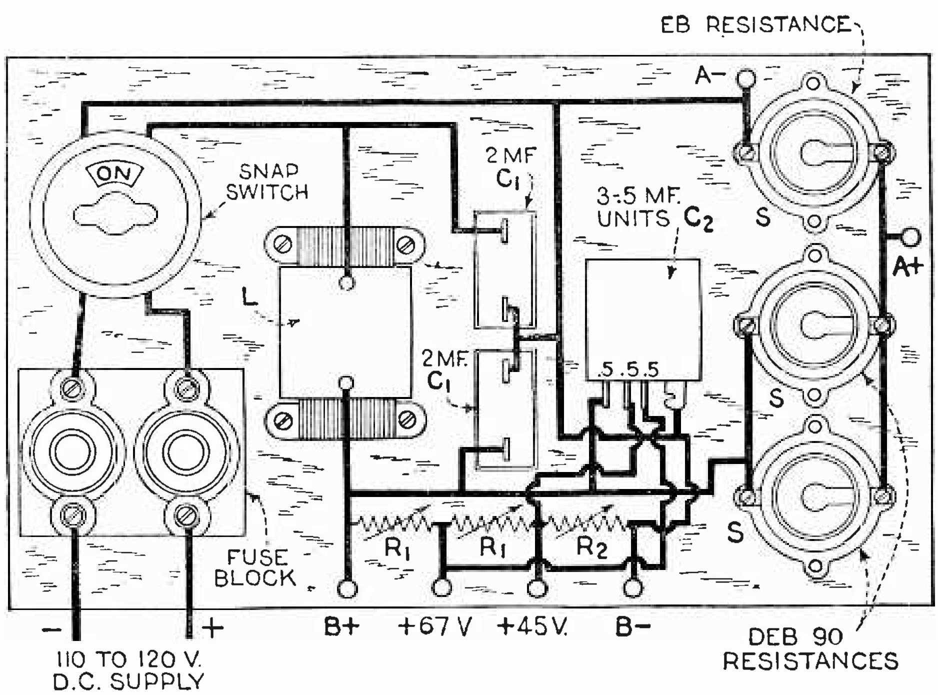
"A" and "B" ELIMINATOR for D.C.

(15) Mr. Schwartz, Boston, Mass., asks:

(Q. 1.) The current supply in my particular vicinity is of the "direct" type. I have been informed that it is exceedingly simple to construct an "A" and "B" battery eliminator to operate with that type of current; and that a power unit having the requisite characteristics has been designed by F. C. Logan and is called the "Varion" D.C. Eliminator. Can you furnish me with the necessary details?

(A. 1.) Mr. Logan has described the Varion D.C. eliminator in the radio section of the *New York Telegram*. Because of numerous requests for a device of this type, we reprint the complete description of the unit.

"Until recently little attention has been given to the requirements of the radio owner with direct current in his home. Many a man has walked hopefully from one radio store to another in search of data on the construction of a good "A" and "B" eliminator for direct current. But he has met with disappointment on every hand. "We don't know of any such thing," was the unsatisfactory answer he received in every store.



An "A" and "B" battery eliminator, operating from a Direct Current source only. The "B" battery voltage out-put is approximately 100 volts at maximum. By varying the amount of DEB resistances employed, any number of tubes up to 10 (201-A type) will be supplied with filament current (see the table, "Figuring the Resistances.")

"True, direct-current eliminators have been put on the market, but we have seen none which supplies both 'A' and 'B' current and which has voltage variation over the wide range necessary to take care satisfactorily of detector, radio-frequency and ocsillator tubes, many of which operate at their best only if just the right voltage for the particular tube is applied.

"Why there has been a lack of attention to the design of an all-around, efficient eliminator for direct current is hard to understand. Certainly not because of lack of demand, for in Manhattan and Brooklyn alone there must be several hundred thousand installations with direct current. As far as the difficulties in design and building go, there is, of course, much less trouble and expense involved in the construction of a good eliminator for direct current than in one for alternating current. The necessity of rectifying is done away with, and with it the use of a number of expensive chokes and condensers to smooth out the rectified (and often very interrupted) direct current. The cost of a D.C. eliminator is naturally much lower, since less apparatus is required. So, if you are one of those fortunate individuals with direct current in your home, prepare to eliminate 'A' and 'B' batteries at small cost and without sacrifice in operating efficiency.

"The D.C. eliminator described in this article replaces both 'A' and 'B' batteries at a cost of approximately $33.00 for the complete equipment required, a little less than the investment necessary to purchase a good 100-ampere-hour storage battery and a charger. The expense of a set of 'B' batteries would bring the cost considerably higher. With this cost in mind it can be seen that building for oneself a D.C. eliminator is decidedly an economy.

Simplicity of the Varion

"In designing the Varion every effort was made to keep assembly and construction as simple and safe as possible. That this effort succeeded quite well is attested by the fact that the eliminator has been constructed and placed in successful operation on a receiver by a non-technical builder in an hour and three-quarters time. There is really nothing difficult or complicated about it, as there are only fourteen soldered connections and there are no special coils or chokes to wind. All the parts required can be purchased at any well-stocked radio store.

"The second, and probably the more important point is that there is nothing to deteriorate or wear out in this particular eliminator. The resistances, of course, are good for a lifetime; and as they practically constitute the eliminator one is fixed for many years when he builds this unit.

"If the eliminator is constructed with the apparatus, and following the layout shown here, no difficulty will be had in conformity to all the specifications of the Underwriters' Laboratory. Both legs of the incoming D.C. line are equipped with fuses, and in case of an overload, even a very slight one, they will blow and protect your equipment and accessories.

Details of the Varion

"The Varion does away with both 'A' and 'B' batteries in the following manner: The direct-current line is shunted by a current-carrying resistance or resistances, as shown in the wiring diagram. The filament supply is taken off from the negative side of the line at a point between resistances AR-1 and AR-2. By variations of the resistances AR-1 and AR-2 the unit will accommodate any filament-current drain from ¾ amperes to 2½ amperes. This takes in sets ranging from 3 to 10 tubes. If a heavier current drain is imposed upon the unit it is possible to obtain extra current by means of a suitable resistance. To figure the correct resistances to use, let us assume you have a 5-tube Neutrodyne set, with one power tube in the last stage. Four 201-A tubes draw ¼ ampere each at 5 volts, or a total of 1 ampere; the power tube will draw ½ ampere at 5 volts. This gives us a total of 1½ amperes for the filament consumption.

Figuring the Resistances

Filament Consumption Amperes	Resistance	Resistance
.75	1 DEB 90	1 EB 12.5
1.	2 DEB 90	1 EB 5
1.25	2 DEB 90	1 EB 6
1.5	2 DEB 90	1 EB 7
1.75	2 DEB 90	1 EB 10
2.	3 DEB 90	1 EB 3.5
2.25	3 DEB 90	1 EB 4.25
2.5	3 DEB 90	1 EB 5

"Looking at the table above, it will be seen that resistance 'DEB' should consist of two Vitrohm units (DEB 90) and 'EB', of one Vitrohm resistance (EB-7). This is simple and should offer no difficulties to any one applying this current-supply to any type of set. Almost any combination of voltages up to 110 can be obtained without difficulty. If necessary you may have three different voltages for your receiver. This feature makes the eliminator particularly desirable for use with the superheterodyne and some types of tuned-radio-frequency sets where a number of different 'B' battery voltages are desired.

Determining 'B' Battery Voltages

"A total of 200,000 ohms is placed across the 115-volt D. C. line, as shown in the wiring diagram. There are three units used and two possible voltage variations. The 'B' voltage outputs shown in the diagrams are those commonly used; but the experimenter may vary the resistances to produce almost any voltage value from 10 to 110 volts. If more than three 'B' taps are brought out from the resistance line, however, be sure that an 0.5-uf. tap condenser is shunted from the extra tap of the negative 'B' battery line. This precaution is taken to eliminate the resistance as far as possible from the radio circuit.

Assembling the Varion

"The assembly of the unit is simple and the wiring self-explanatory from the accompanying diagram. Make all leads of No. 14 wire and be sure that they are as short and direct as possible. Solder each connection thoroughly and be sure that contacts in the bottom of the tube receptacles are clean. There are very few precautions to take in placing the Varion in operation on your receiver. The first and most important is to connect a fairly heavy condenser, such as an 0.5-uf., in series with your ground lead. This is to prevent burning out your tubes in case the polarity of the plug is incorrect when the unit is first put in operation.

"It is not necessary while using this unit to connect up the 'B—' post on your set, as this is automatically a common connection through the eliminator. While the voltage from the eliminator at the filament supply tap is six, when all the tubes are in your set and lighted it is very decidedly not 6 volts with only one tube in your set. When no load is placed on the circuit *the voltage jumps up to nearly* 20, and you are very likely to mourn the loss of a tube if you place it in the set without all its mates being in position. These simple precautions are really the only things you will need to give attention to while placing the eliminator in working order."

List of Parts

One Choke Coil (L), large current-carrying capacity (Amertran);

Two By-Pass Condensers (C1), 2.0-uf.;

Three By-Pass Condensers (C2), 0.5-uf.;

One Snap Switch and three Porcelain Sockets (S), 110-volt type;

One Porcelain Fuse Block, with two holders, and two fuses, 110-volt 10-ampere type;

Three Variable Resistance; two (R1), 0-50,000 ohms, and one (R2), 0-100,000 ohms ("B"-eliminator type);

One Resistor, type "EB" and two Resistors, type "DEB" (Ward-Leonard). (See table above for computing the number of these required for various sets.)

Battery Charger

(16) 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) 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 and ask for a junked pole transformer of about 1-kva. capacity. These transformers can usually be obtained for a small sum. Both

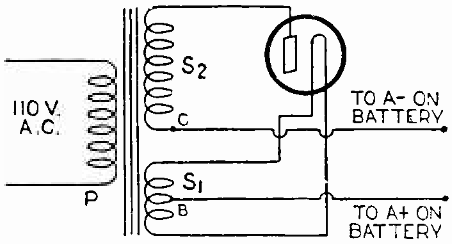


Fig. 7

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.

(17) Mr. Arthur F. Clark, San Antonia, Texas, writes:

(Q.) "I am a constant reader of your magazine and I have been looking for some time for instructions for making a transformer for lighting the filaments of A. C. tubes. I have been disappointed, however, since I have never seen the details for making a transformer of this type. I have also looked in your latest edition of "1001 Radio Questions and Answers" but I do not find the instructions in this book, either. Will you give me these?"

(A.) The diagram shows the core of a suitable transformed for 60-cycle current. The core is made of strips of silicon steel .014-inch thick and 1¼ inches wide, which are cut to two lengths; the longer are 4¼ inches, and the shorter pieces 2¾ inches long. The strips are cut from sheet metal and the corners are filed to prevent any rough edges from protruding; after the laminations have been cut they are shellaced or varnished on at least one side to insulate them. About 170 of each size will be required; the insulating coat should be thin and evenly spread.

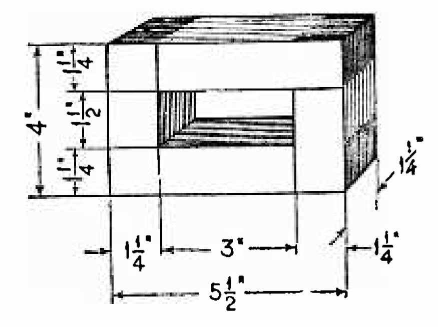
The coils are made by preparing a block of wood 1 5/16 inches square and about 5 inches long; this is wrapped with several layers of heavy paper and a piece of fiber 2¾ inches wide over the paper. Two pieces of fiber 3¾ inches square are also prepared and a hole 1 5/16 inches square is cut in the center of each; the two washers thus formed are placed over the ends of the fiber strip which has been wound on the wooden block. This will provide a spool made of the pieces of fiber, into which the transformer windings are to be placed; the washers are glued firmly in place to make it secure. The spool is 2¾ inches wide and may readily be slipped over one of the long segments of the core.

One section of the core should be assembled with the long laminations, (offsetting every other one, 1¼ inches, so that the core will fit together correctly; using enough to make a pile 1¼ inches high; the pieces are then bound firmly together with friction tape. The spool containing the windings is next slipped over tc core and fastened tightly by forcing several wooden wedges between the coil and the core. Finally, the rest of the core is assembled around the coil and the complete core is firmly bound with friction tape to prevent the laminations from vibrating.

It might be well also to clamp the laminations tightly between wooden blocks, although this is not essential. Such blocks are 5 inches long, with holes cut in the ends to carry bolts. Four are required, and placed at the opposite ends of the core; one at each side with a bolt at each corner.

Next, the primary winding is placed in the spool; it contains 528 turns of No. 22 D. C. C. wire, layer-wound. (The easiest way to wind this is to fasten the block in some manner to the chuck of a hand drill, or of a lathe if one is available.) A layer of varnished cambric, or several layers of heavy paper, is placed over this winding, after the two ends of the wire have been brought out through holes in the end of the spool; and the first of the secondary windings is placed over the primary. Between each successive pair of windings, a layer of varnished cambric or paper must be placed, to insulate the windings more thoroughly.

A winding to give 15 volts across its ends will need 72 turns, and one for 7½ volts 36 turns, of No. 14 D. C. C. wire. A 5-volt winding contains 24 turns of the same wire; a 3-volt winding contains 15 turns and a 2½-volt winding 12 turns. For a 1½-volt winding, 8 turns of wire are sufficient, and, in this case, No. 12 D. C. C. wire should be used to carry sufficient current for a number of 226-type tubes. Center-tappings of the windings which require it should be done as the winding progresses, and the ends of the wires should be brought out through holes in the end of the spool. To design a transformer for 25-cycle current, the cross-sectional area of the core should be twice the given value, or 1¾ inches square; the same number of windings will be used in each case.



Four laminations are used for each layer of th core; they are "staggered" to make it firm. I should be bound firmly together.

Reducing the Hum in A. C. Sets

(18) Mr. B. Brown, Miami, Florida, writes:

(Q.) "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?"

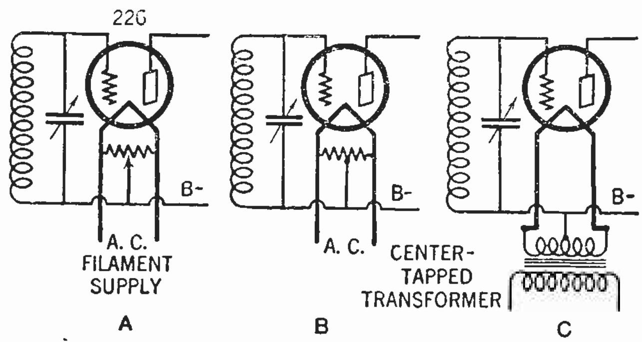
(A.) The method of balancing out the audio-frequency noises in an A. C. receiver is a rather puzzling problem for the average radio fan. The usual method of connecting the grid return directly to one side of the filament supply circuit is not satisfactory with A. C. sets, since it unbalances the filament 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 A, B and C; hese 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 teh 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 actual center of the filament circuit is slightly to one side of the theoretical center.

Fig. B is similar to Fig. A except that a fixed center tapped resistor is used. This method is not guite 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 kept as far away from the grid circuits as posible. This wire must be quite heavy (No. 14 at least), to pass a considerable current.

The voltage on the filament alternates, except at its center, which is a "node" or point of uniform potential. On the "Wheatstone bridge" principle, a resistance shunted across this must contain a point of identical voltage, located by the sliding arm.

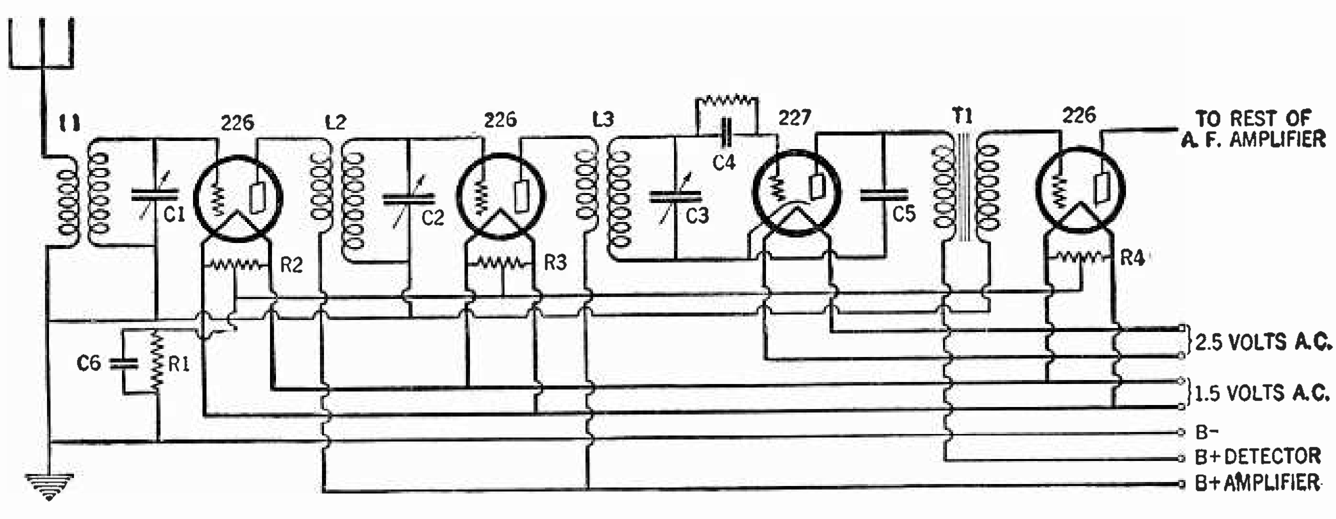


The use of resistors for the grid returns of tubes in a radio-frequency amplifier sometimes results in instability or oscillation in the amplifier. However, this difficulty can easily be overcome by connecting fixed condensers between the center tap of the resistor and each side. These condensers should 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 is 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. It will be noticed that the center filament terminals of these amplifier tubes are connected to one side of resistor R1, while the other side and the grid returns connect 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



A typical A.C. Hook-up.

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 equal 9 divided by .009, or 1,000 ohms, which is the correct value for the resistor R1. The condenser C6 in the diagram is used to by-pass the radio-frequency currents around resistor R1. This condenser should have a value of about 1-mf.

Repairing "B" Power Units

(19) Mr. J. R. Cliffman, Rochester, N. Y., writes:

(Q.) "I am a custom builder and repair man. In repairing sets I often encounter trouble in "B" power units and, up to the present, I have never seen any information for locating trouble in these units. This is especially true of the units using the gaseous rectifiers; since there is no filament to tell when the tube is operating correctly."

"I am also at a loss when one tap of the unit will not supply any current, while the rest of the power unit works satisfactorily. I would appreciate any information that you can give me in this matter."

(A.) Although there are few causes for trouble in the standard "B" power units, trouble does occur sometimes; and a few simple tests will enable the experimenter to locate and correct it.

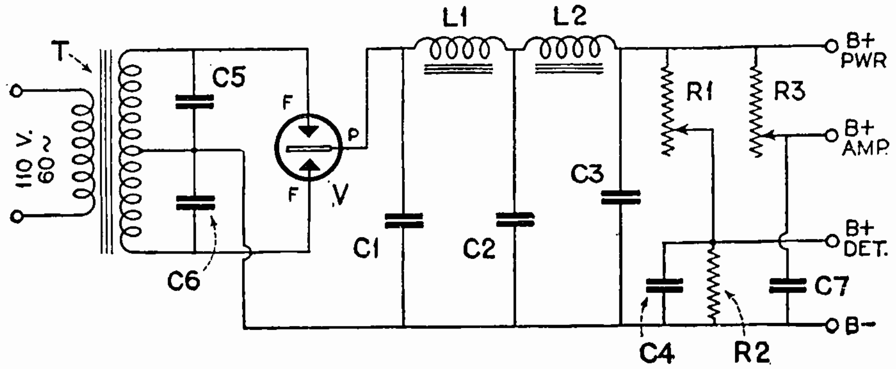
The diagram of the most common type of unit, employing the gaseous-conduction type of rectifier tube, is shown. This diagram will be followed in making suggestions, although other types of units can also be tested by the same methods. Test with set connected:

No Voltage at a Given Tap

If no voltage can be read *With a high-resistance voltmeter* from *one* of the taps of the unit, the logical point to look for trouble is in the resistor bank. Then, if the trouble is not located, the parts should be tested back from this point until the defective part is found. When making the tests, first look at the rectifier tube to make sure that it does not appear to be damaged. Then make sure that current is flowing through the primary of the transformer.

An open-circuited or burnt-out resistor will result in no current flow at the tap that it controls; for instance, if the resistor R1 becomes open-circuited there will be of course no voltage at the "B plus tap. On the other hand, if R2 is broken the detector voltage will immediately increase. In receivers of some types this would result in a decrease of the volume; while sets with regenerative detectors would get out of control.

The simplest method of locating a defective resistor is to connect a high-resistance voltmeter to each tap in turn. A meter of this type is almost essential when a unit of this type is used; both for measuring the output, in order to get the best results from a set, and for testing defective units. In the absence of a voltmeter, a 15-watt 220-volt electic-light bulb may be employed; it should be connected like the voltmeter, between the negative terminal and each of the positive terminals in turn. It should glow a dull red on the high and intermediate taps and, with the detector resistor turned all the way in, a dull glow should be obtained on this tap also. If the detector lights the bulb with brightness equal to that obtained from the other taps, the 10,000-ohm resistor (R2) is open or defective.



The circuit of a typical "B" power unit employing a gaseous rectifier tube.

No Voltage from any Terminal

This trouble may be due to an open circuit in the windings of the power transformer or in one of the choke coils; or it may be due to a broken-down condenser in one of the filter circuits, or to a broken wire.

If the tap voltages are found correct and the set does not operate well, the trouble may be due to the development of a defect in a by-pass condenser, or to a faulty construction of the unit, omitting a condenser where it is needed.

In testing for these brakes the following method may be used. Disconnect the power supply from the unit; then connect a pair of phones, with a battery in series, between the plate terminal of the rectifier tube and the *positive* output terminal. (Remove the rectifier tube before testing these circuits.) You should hear a click on making contact; and also, on testing, between either of the filament terminals on the rectifier socket and the *negative* terminal of the unit. The clicks from both of these binding posts should be of equal strength; if one is stronger than the other, the trouble is generally due to a defect in one of the buffer condensers (C5 and C6 in the diagram). If no click is heard from one terminal, either the secondary winding of the transformer is open or the center tap does not connect to the negative terminal.

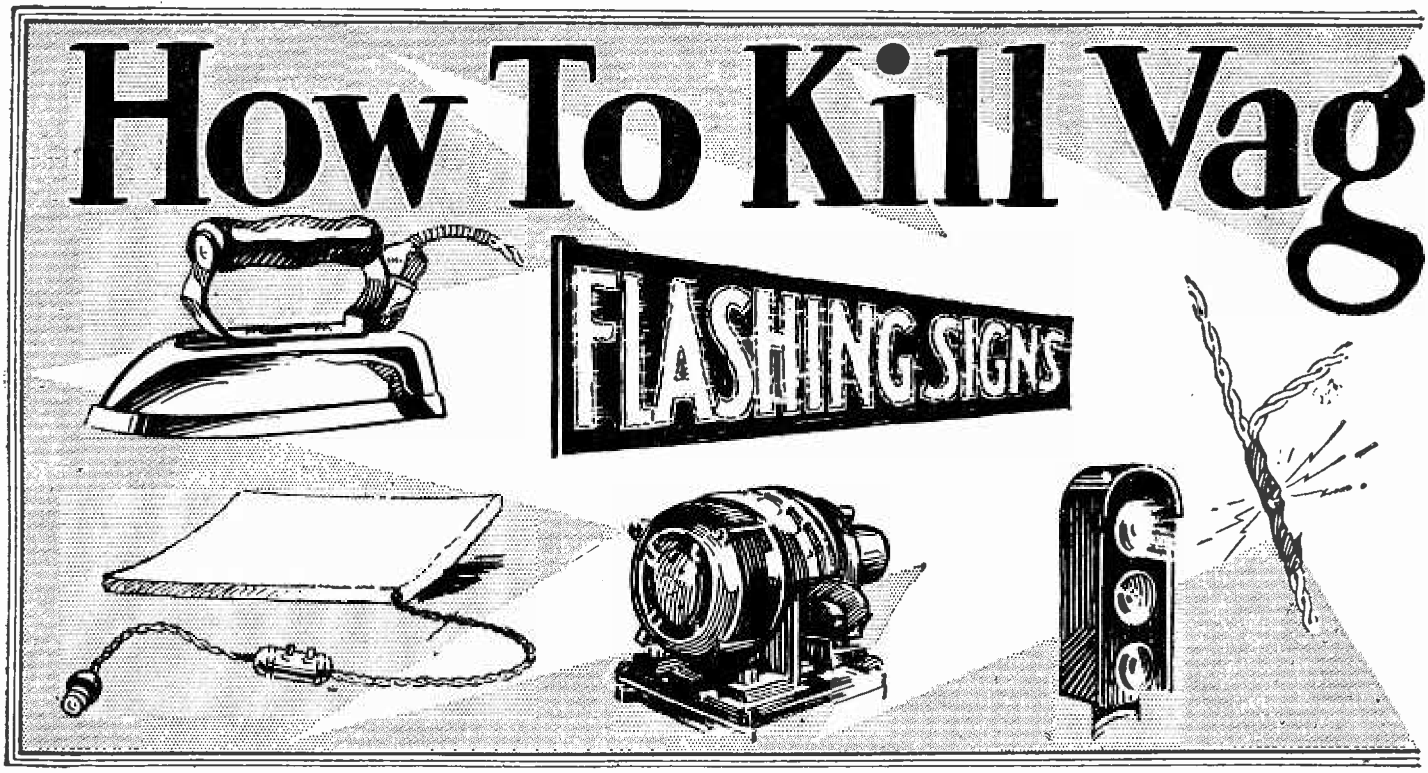
The secondary winding of the transformer can be checked by first removing the tube from the socket and then connecting the primary of the power transformer to the line through a 25-watt 110-volt lamp, in series with one of the leads. If the secondary is in good order, the lamp will not glow at all, or a very dull glow may be seen. If the lamp glows brightly, either the secondary is broken down or one of the buffer condensers is short-circuited. On replacing the rectifier tube in its socket, the lamp in the primary lead will glow brighter. The buffer condensers should be disconnected in order to test them separately. The test described above will also serve to gauge the operation of the gaseous tube since a poor tube will not show an increase in the light of the lamp.

A gaseous-conduction rectifier tube will usually give about 1,000 hours of service before trouble is encountered. When the tube becomes old, the output voltage gradually falls off and it is necessary to keep turning up the resistors to maintain the correct voltages. When the resistors can no longer be adjusted to give the required voltage, a new tube must be used. The gaseous tube becomes quite warm when operating correctly and this fact often serves to indicate whether or not the tube is in good condition.

Excessive Hum

This may be caused by a filter condenser's becoming open-circuited, or by an open lead to one of the condensers; it might also be due to a short-circuited choke coil or to the usual causes of hum *in the receiver itself*. The action of the choke coils may be tested by short-circuiting each of them in turn.

If both chokes are functioning correctly, the hum will be increased when either is short-circuited. If no difference is noted when one of the chokes is shorted, the connections should be checked and, if they are found correct, a new choke should be inserted. In some installations, although the power unit is in apparently good working order, the hum will be objectionable. In such case, it may usually be reduced by increasing the size of the filter condensers, C2 and C3.



Some of the radio noise-makers. Top row: electric flat iron ith poor contact or defective resistance; flashing signs or flashers in window displays. Bottom row; electric heating pad, sparking motor, railroad signals, faulty connections in lamp leads.

WE would be willing to wager a goodly portion of the munificent weekly sipend that, if you were ot inquire the funny little noises in his set, he would make one of the two answers; *viz*:

Answer No. One: "Static."

The Other: "A leak in that doggone transformer on the post in the alley."

Such a simple disposition of a difficult problem! Surely no other solutions could appeal so strongly to such a variety of minds. Somebody or other gave these simple explanations to the first radio fan; and that great love of truth which characteries all receiving-set owners has fostered them and the radio fraternity has clasped them to its bosoms. They are magnificent in their broad generality; and, like so many other beautiful but broad generalities, they are far from being true.

After a great deal of intensive research on the part of a great deal of engineering brains, it was discovered that Grandpapa Static is innocent of a lot of crimes for which he had been blamed. After a lot more research, these same engineers ascertained that, in most cases, the people who made complaints were in the same class with the dog who sat on his own tail and howled, but was too lazy to move.

It was the consensus of expert opinion that, with the home-brew-noise industry getting along so nicely, natural static might as well be put on a sled and started on the well-known road to oblivion. A man with the hives, you know, doesn't do much kicking over a mosquito bite.

Interference and Interference

As this sub-title indicates, and as those of us who get more or less enjoyment from listening ot radio programs should be fully aware, there exist two kinds of interference. A type which is, happily, confined to the vicinity of large cities is the spirited interference of one broadcast station with another and makes itself known to the listener by a beautiful whistle in the background of the music, instead of the more conventional bass. The only remedy that comes to mind at this moment is either several sticks of well-placed dynamite or aggressive activity on the part of the Federal Radio Commission.

On the other hand, if the sounds that float gently out from your loud speaker seem to be a cross-section of a kitchen working overtime frying eggs, with attendant crackles, hums, moans, roars, sputters and waht you will—then this is something else again and there is a good chance that the noises can be chased down to their lair and killed. Of course, it would not be right to assume that *all* the noises come from within the home—for that above-mentioned transformer in the alley *might* be to blame; but the chances are that, if a little intelligent thought and work is put on the problem, the source of the noises can be tracked down and will be found within your own four walls or those of a neighbor.

Making Interference at Home

The list of noise-makers that are in the equipment of the average modern electrically equipped home is far too long to be here included. However, take heart, radio fan, and read on; for, although these noisemakers are numerous yet it is a simple matter generally to find out where the trouble is and then to kill it. And all this does not necessarily mean that the searcher need have a wide knowledge of the mysteries of electricity, or possess a thick pocketbook; for the most part it is a relatively simple matter.

It should be stated again that "the doggone transformer out in the alley" is usually about as much of a source of radio noises as the mummy of one King Tut recently found in his old family cemetery, west of the waterworks in his home town. To the radio public in general it may seem logical that power companies should burn coal in the power house, at its present prices, just for the fun of pumping current through holes in the lines to ground. But they don't. They would much rather sell electricity than broadcast it.

Some of the real offenders have been classified by the National Electric Light Association, as follows:

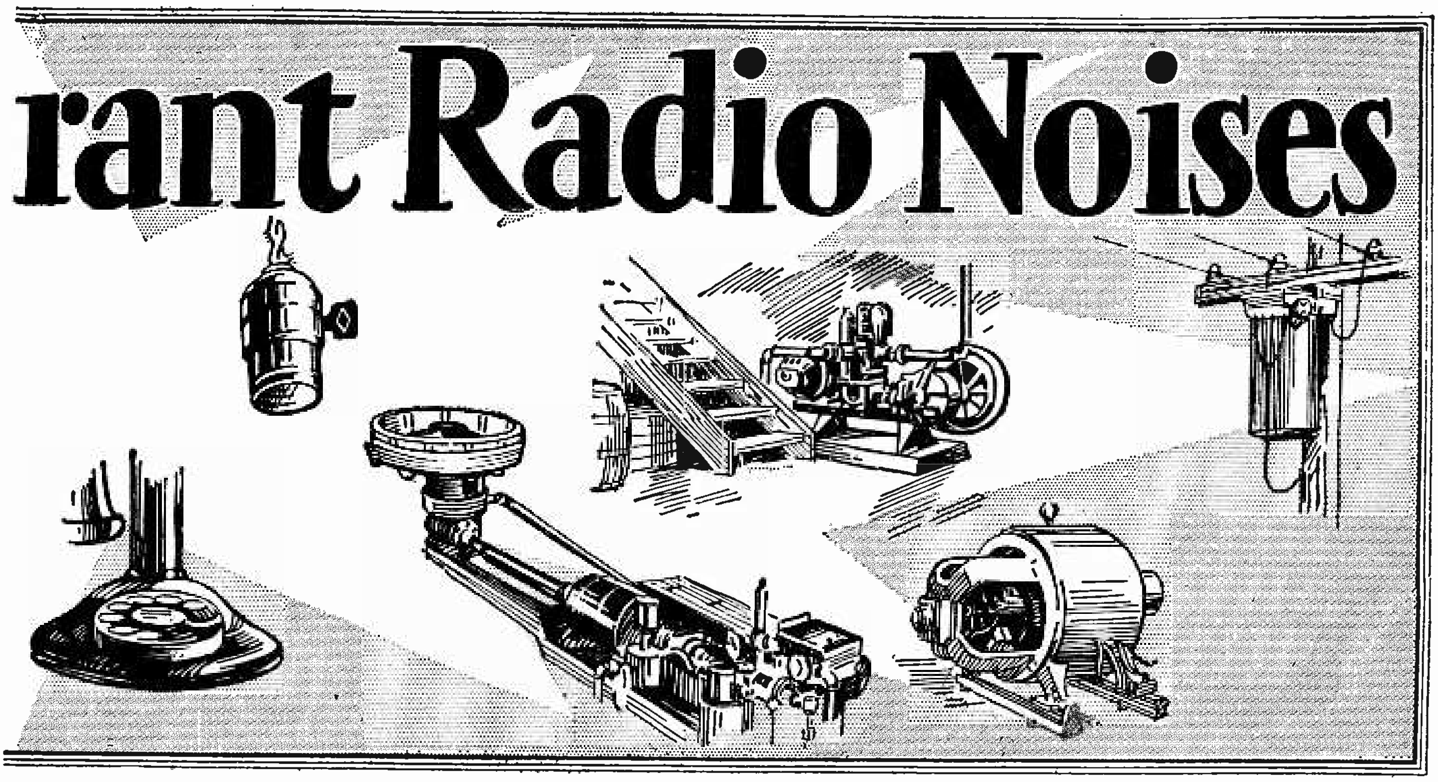
Power Circuits: (1) lines;; (2) insulators; (3) lightning arresters; (4) transformers; (5) generators and motors; (6) induction voltage-regulators.

Industrial Appliances: (1) arc-light circuits; (2) telephone and telegraph lines; (3) pole changers and converters; (4) street cars and electric railroads; (5) smoke and dust precipitators; (6) motors; (7) sign flashers.

Household Appliances: (1) electric pads; (2) violet-ray machines; (3) flatirons; (4) doorbells, light-switches, various small motors.

Miscellaneous: (1) X-ray machines; (2) storage-battery chargers; (3) annunciator systems; (4) stock tickers; (5) ignition systems; (6) electric elevators and electric furnaces; (7) moving-picture equipment; (8) high-voltage testing equipment.

This list covers in a general way most of the field of household and industrial noise makers; but, if it were not for the lack of space, further class-



Automatic telephone dials; bad contacts in light sockets, thermostat controls on oil burners, contactors on farm-lighting equipment, dirty commutators on motors, leaky transformers, are among the sources of interference.

ifications might be made; for example, under the heading of heating pads might be included all those devices, which are operated by some sort of an electrical thermostatic control; with flatirons might be included those articles which use resistance-wire heaters, such as curling irons, percolators, waffle-griddles, etc.

Now, as has been suggested, much work has been done on reducing the output of these non-licensed broadcast stations and in due time the secrets will be unfolded to a panting world and illustrated by rare old Sargents will crosses marking the spot where the body was found. We have intimated that the method of bomb-tossing is a bit too crude for this advanced day and age and should be left to those nephews of our National Uncle who get their thirty bucks a month for doing just such little odd jobs. We shall try to shunt to Oblivion, Gehenna and other way stations the hums, crackles and other noises that were given to the radio fan for his sins.

Recognizing the Noises

Some bright student of the class might at this moment get up on his hind legs and pipe, "But how the—pardon me, how on earth are we going to tell where a hum comes from and where a crackle has its home?" Sit down, Oscar, and incline your ear this way and you will get an idea (if possible).

Suppose you hear romping through your loud speaker, a nice, low, deep hum sounding like a note pulled cut of a bull fiddle by the long-haired gentleman in the orchestra pit. Such hums, which are sometimes induced in an aerial which runs parallel to a line carrying 60-cycle alternating current, may also be among those present through the medium of power-supply units with defective rectifier tubes or bad filters. A little thoughtful search by the operator will usually bring such a hum to nought.

The unwanted voices of the violet ray and X-ray machines are pitched deeper and have the added characteristic of sounding like a neighbor's winter supply of coal going down the chute into his cellar. Similar to these sounds are those of a wild and undomesticated battery charger.

Another type of grating sound is caused by spark interference, although this has sometimes a high-pitched note accompanying it. It is generally intermittent. Also intermittent is the noise from a thermostatic control, like those of some types of electric irons.

Crackling noises can generally be traced to defective contractors, loose wiring connections and bad sockets. A crackle with a steady hum indicates a dirty commutator on a nearby motor.

Of course, it is mighty difficult to differentiate between the fine graduations of tones which might mean an entirely different source of interference; but each annoyance has, and sticks to the bitter end to, its own pet note which we shall soon attempt to describe. The experienced trouble-shooter should know his notes, as well as the piano tuner knows the difference between middle C and G sharp; but this is small consolation to Mr. Average Listener, whose affronted ears only tell him that his loud speaker is snarling at him. However, one need not be a grand-opera singer or a performer on the fiddle to track down the elusive interference.

The mthods are simple for the most part.

On Trouble's Trail

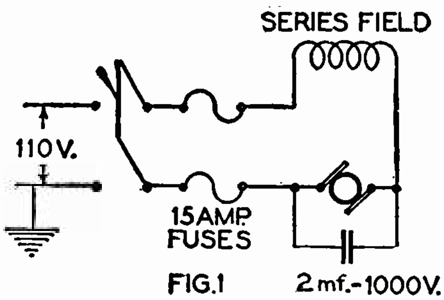
One of the first thinks that the trouble shooter should implant firmly, away in the back of his skull, is that the power company has not concocted a plot to annoy him every time he hears a queer noise in his loud speaker. Many a time and oft an investigating first thrust rudely in the "innards" of a receiver is the cause for bent condenser plates; and plates that touch and therefore sometimes spark are every bit as potent a source of noise as any trolley car that ever wandered up a street.

And then batteries can play a little tune all their own. Corroded terminals in jacks and battery clips, corroded socket contacts and tube prongs do their stuff nicely. An excellent imitation of a 60-cycle hum is caused by an open circuit in the audio amplifier. Did you ever hear a defective grid leak fry and sputter? Well, they do. And above all, loose connections will let loose as nice an assortment of noises as has ever been your lot to listen to.

There has been much published on the subject of trouble-shooting in the mazes of a receiver and we will skip blithely over that with this admonition: look carefully over your various batteries and socket-power units, connections fore and aft, test your tubes, for contacts and microphonic noises, your switch and jack springs, and the loud-speaker cords.

Cadgets Arond the House

If sister is getting all dolled-up to go to a party and the curling iron, the violet-ray machine, and the flatiron are all working overtime to aid her, and if these various objects are doing their level best to drown out whatever music —if any—is trickling through the loud speaker, don't spoil your sister's evening by crashing a storage battery over her head. She didn't invent the noise-makers. Attack the problem in a more scientific way, look for the source of the trouble.



One way to stop a motor interference is by placing across the brushes a 2-mf. condenser of suitably high-voltage rating.

After sister has succeeded in waking up her boy friend, who has been waiting "just five minutes"— has it ever happened to you?—turn off all the trouble makers and then turn them on one by one and see which one is making all the fuss. If one kicks up a rumpus, first inspect the light socket from which the appliance is getting its power. The contact in there may be bad.

Of course, some cases may not be so simple to trace and it may be necessary to resort to a small portable set using a loop antenna so that its directional properties can be used. But let this word of caution sink in: be sure that the trouble is not in your own house before you go snooping around some neighbor's domicile.

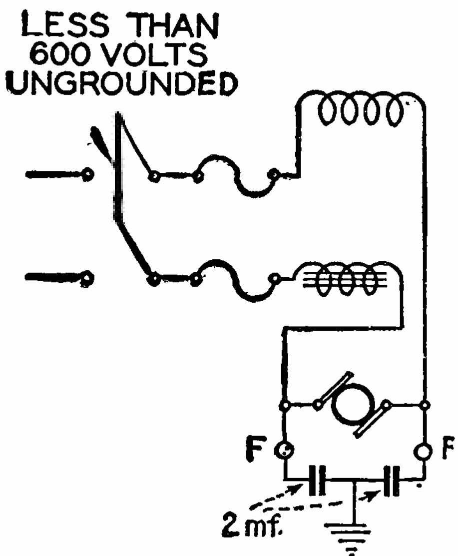
Suppose that you have traced the trouble to a motor which is merrily sparking; in most cases this is due to dirt on the commutator, causing the brushes to make bad contact and resulting in a spark jumping to them. This will in time pit the commutator, and this result will not help to reduce noise. First clean the motor, and if the iron frame of the motor is not connected to ground, make this connection. The last of the interference may be killed by connecting a 2-mf. condenser (tested to stand 1,000 volts D.C.) across the brushes. Place the condenser as near as possible to the place where the sparking occurs.

If the line is over 110 volts and ungrounded the design of the filter should be changed. Two condensers of the same size mentioned above are connected *in series*, with their common point grounded. This system is then shunted across the commutator, as will be seen in Fig. 2. For very small motors, such as are used in hair driers, vacuum cleaners, soda-mixers, etc., a high-test condenser of ¼-mf. will do the trick.

In the case of a refrigerator control, furnace control, heating pad, or like device, giving trouble, more than likely sparking is taking place at the thermostat contacts. Hook a ¼-mf. condenser across the input. The result should be silence.

Then we have the case of bad contacts. Of course, the best remedy that we can advise is to fix the contact. But then we just know that someone is going to yelp, "Suppose you can't fix it. What then?" If you find, for instance, that the delicatessen man over the way is using his sign to put your radio reception on the blink, tell him about it and we will bet another nickel that he will gladly let you hook a 1-mf. condenser across the terminals. Business is business.

Now, suppose that you are located far away from sign-flashers, street cars and the other noise-makers of the city and that, when you want to get your telephone operator to put through a call to Mary's house, you have to turn a funny crank on the side of the box. That, being attached to a magneto, can do plenty in the way of noise making. In order to have radio reception such as you read about, make a filter of two condensers grounded at their common point and put them in series with two choke coils, one in each side of the line.



The choke coil consists of 100 turns of No. 18 D.C.C. wire wound in a single layer on a 3-inc tube form, ⅛-inch thick and 8 inches long. It is wrapped with insulating tape after winding.

As we have said, somewhere in the first portion of this advice, there are many sources of interference, which we have no room to treat of here. We respectfully suggest that, if you are bothered with some ill to which radio is heir, you should consult the "Manual on Interference prepared by R. J. Casey for the Radio Manufacturers Association. We are indebted to this excellent booklet for some of the suggestions herein given.

Soldering

(20) Mr. LeRoy Jonson, Aberdeen, N. C., asks:

(Q. 1.) Can the use of acid-core solder be the cause of a set not functioning properly?

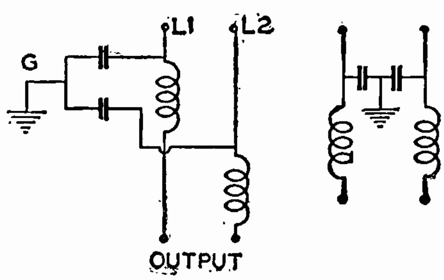
(A. 1.) Possibly. It depends somewhat upon what is being soldered and the way in which the soldering is done. In general, it is very inadvisable to use acidflux for any kind of soldering in connection with radio apparatus.

(Q. 2.) What would be a satisfactory method for soldering radio instruments and wiring?

(A. 2.) First have a real hot soldering copper (called a soldering "iron"). This "iron" should not be allowed to turn red, as this causes the "tin" to burn off. To make a satisfactory connection the hot iron should be applied to the work, so as to heat the work before the solder is applied. When the solder on the iron seems to be taking hold of the surface to be soldered, the solder can be applied. If a resin core flux is used, no other flux is usually necessary to make the solder stick.

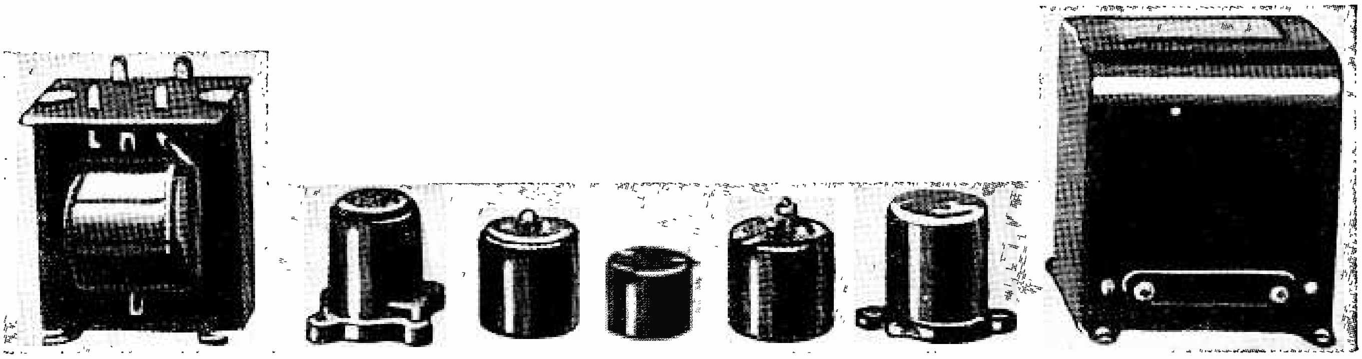
In order for the iron to work properly, it is necessary that it be well "tinned." The simplest way to make sure of this is to have a large sheet of tin handy, also a jelly glass of muriatic acid which has been "killed" by the addition of sufficient scrapings of zinc to prevent the further formation of bubbles when zinc is added. By heating the iron to almost a red heat, then quickly dipping it into the acid, the iron will readily become coated with a film of solder, when the iron is rubbed around on the sheet of tin, on which are pieces of solder. A file sometimes assists the process. No flux is used in this operation, the acid treatment being sufficient for the purpose. When all sides of the iron have become coated with a film of bright solder wil not stick to thesoldering ready for use; without the tinning, solder will not stick to the soldering copper, and the soldering copper will not heat the work.

Beware of soldering "pastes." They sometimes cause more harm than good. There are several good soldering pastes on the market, but they must be used judiciously. An excess may form a leakage path just where it is not wanted. A little care and thought will be all that is necessary. Capillary attraction sometimes causes conducting fluxes to creep into undesirable places. Sometimes, too, it will spatter into the wrong spot.



A compound filter that silences bell-ringers, so far as the radio set is concerned.

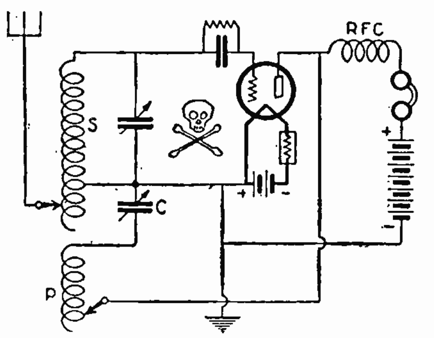
The How and Why of Radio Filters



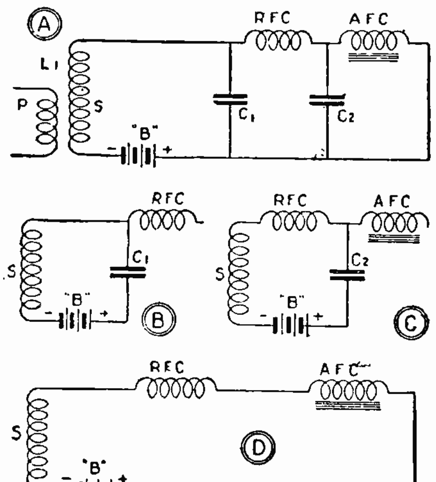
The two large cases contains chokes for use in audio-frequency filters, and the five small ones radio-frequency chokes.

MANY set builders are of the opinion that radio engineers insert choke coils and by-pass condensers i nthEir circuit designs for radio receivers either for their own amusement or for the sole purpose of causing the public to purchase additional equipment when building sets. Among radio constructors, there has circulated the rumor that these instruments may be removed from most circuits without affecting the operation of the receivers in any way, and some experimenters have proved this "fact," to their own satisfaction, at least. However, when poor results are experienced with such a set, most fans think they have selected a poor circuit; and it seldom occurs to them that the trouble might be corrected to some extent, at least, by the use of choke coils and condensers.

Because of the general misunderstanding which seems to exist on the subject of choke coils and by-pass condensers, the writer will endeavor to show the purpose of these instruments in electrical circuits, and, at the same time, to explain how they may be used most intelligently in radio receivers.



In order to return as much as possible of R.F. energy to coil P for regeneration, the choke RFC is inserted, keeping this current from the phones and battery.



A is the complete circuit; B the path taken by the R.F. current; C, path of the A.F. current, and D that followed by the battery's direct current.

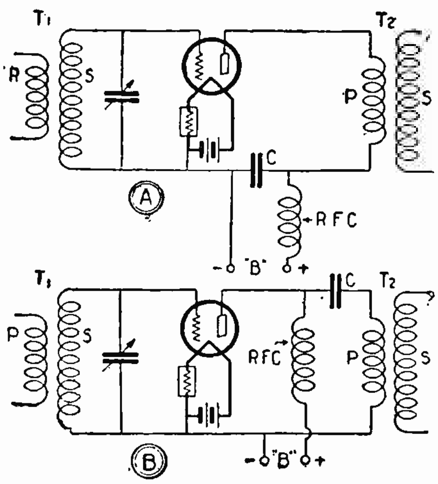
It is, of course, ridiculous to assume that engineers specify apparatus which is not necessary in receiver designs. Therefore, the set builder who considers a part unnecessary should attempt to find the reason why it is used before eliminating it from the receiver. If this plan were followed by everyone, the average home-built receiver would give much better performance.

A choke coil may be described as a device which, when connected in an electrical circuit, hinders alternating currents of a certain frequency or frequencies from passing and, at the same time, readily allows direct current and alternating current of lower frequencies to pass; it consists of a number of turns of wire. Choke coils for use in radio-frequency circuits are usually of the air-core type, while audio-frequency choke coils almost always have iron cores.

"By-passing" Action of Condensers

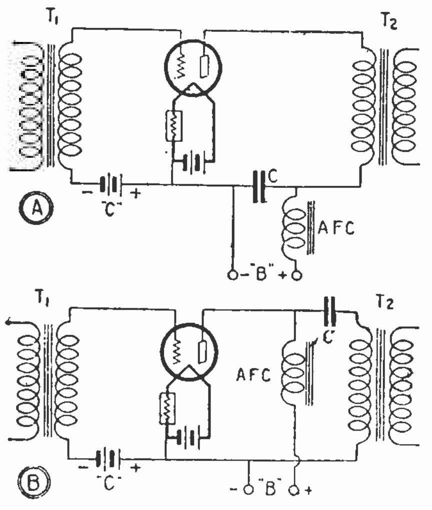
By-pass condensers perform an exactly opposite function in a radio receiver. These may be described as fixed condensers of standard type, which are connected in a circuit in such a way that currents of one frequency or band of frequencies are forced to pass through them; but D.C. and A.C. of lower frequencies are practically unable to pass. The capacity of the by-pass condenser determines the frequency of the current which it will pass efficiently. For example, a small condenser (say .001mf.) will by-pass only high- or radio-frequency currents; while a large condenser (1.0 mf.) is needed for audio-frequency circuits. However, large by-pass condensers will allow high- (radio-) frequency as well as audio-frequency currents to pass through them.

In radio circuits, choke coils and by-pass condensers are commonly used together; *i. e.*, the choke coil is employed to prevent currents of a certain frequency from entering a circuit and the by-pass condenser is used to provide a



Two methods of using R.F. chokes and condensers in the plate circuit of a receiver, for the prevention of interstage coupling.

new path for the excluded current. In this way it is possible to separate the alternating- and direct-current components which are present at the same time in one circuit; and it is possible also to separate the radio-frequency and audio-frequency components by the same method. That portion of a circuit which consists of a choke coil and by-pass condenser is known as a "filter."

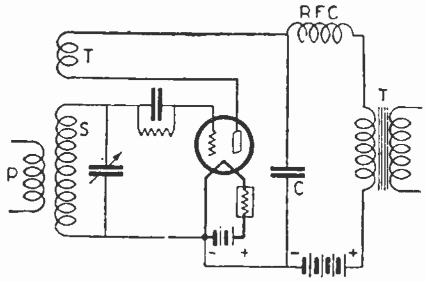


Two methods of using A.F. choke coils and condensers. A is the more usual, and B one used when the plate-supply current is heavy, to keep the plate current from the transformer's primary.

A DOUBLE-FILTER SYSTEM

A hypothetical diagram gives an example of how currents of different frequencies may be separated by means of choke coils and by-pass condensers in combination (filters). In the complete circuit (A), of tis illustration, L1 is a transformer with a primary winding P and a secondary winding S; B is a battery; RF C a radio-frequency coke coil; AFC an audio-frequency choke coil; and C1 and C2 are by-pass condensers, small and large respectively. In this circuit a current composed of two different frequencies is induced in the secondary winding of the transformer by the primary winding which, we will say, is connected to an audio-radio-frequency oscillator. Also, the battery B introduces direct current into the circuit.

The problem is to separate the three different components of the current. This is accomplished by the action of the choke coils and the by-pass condensers. A glance at the diagram will show that the R.F. component of the current cannot pass the R.F. choke coil (RFC) and, therefore, is forced to go through the by-pass condenser C1. However, direct current cannot pass through a condenser and the capacity of C1 is so small that very little A.F. current is able to follow this path. Therefore, the direct current and the A.F.-current components continue through the circuit until the A.F. component is impeded by the A.F. choke coil (AFC). This current is then forced to pass through the by-pass condenser C2. As the direct current is not stopped by the choke coils, it passes through the coils and makes its return



The choke coil RFC and condenser C are connected as shown, in order to keep R.F. currents out of the A.F. amplifier, where they would tend to overload the tubes.

to the battery via the only available path.

The circuit action is further analyzed in detail at B, C and D, which show more clearly how the three different currents were separated. B is the path of the R.F. current, which is unable to pass the R.F. choke coil; C is the path of the A.F. current, which is unable to pass the A.F. choke coil; and D is the path of the direct current, which is unable to pass through the by-pass condensers C1 and C2.

USE OF R.F. CHOKES

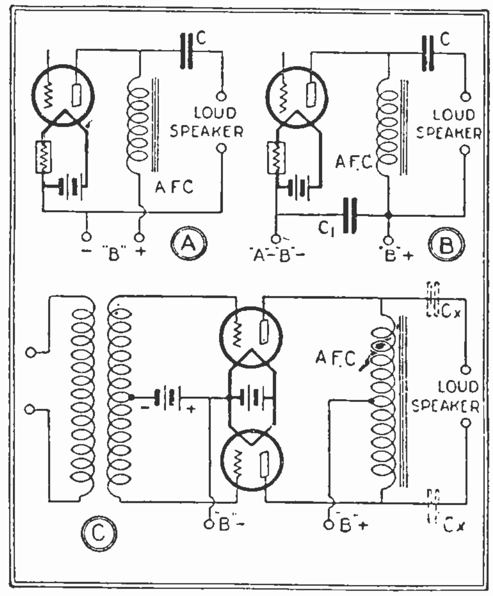
Now that the purpose of by-pass condensers has been explained, we are ready to consider the various ways in which choke coils of various sizes may be used to advantage with them in radio circuits. As R.F. and A.F. choke coils are used in different parts of the circuit, the use of the R.F. choke and by-pass will be explained first.

In last month's issue of *Radio News*, it was pointed out that regeneration, when correctly used, is a great aid in increasing the sensitivity and selectivity of receivers. On the other hand, in circuits where regeneration is not required, and where it cannot be controlled properly, its presence is sufficient to ruin reception. The same is true of resistance in a radio receiver; in tuned circuits its existence causes poor results; whereas, in other parts of the set, it is needed to produce a voltage drop for biasing purposes, to reduce filament current, etc.

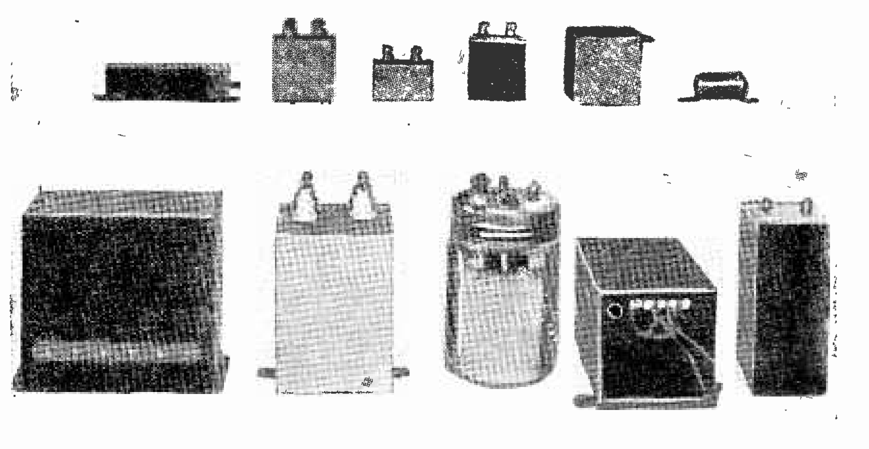
Coupling is a consideration equally as important as regeneration and resistance. It is essential to the operation of every receiver that the various circuits be coupled together; however, the way in which this is done is often responsible for either the success or failure of the set. In certain parts of the circuit the coupling must be highly efficient, while in others any trace of coupling causes poor or undesirable results. This applies not only to radio-frequency circuits, but also to audio-frequency and power circuits. In many cases undesired coupling may be prevented by a system of choke coils and condensers.

CONTROL OF REGENERATION

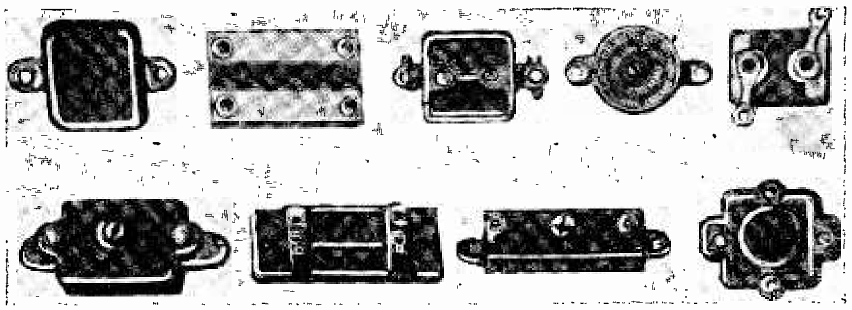
In order to explain one of the most frequent causes of undesired coupling, and its effect upon the operation of a radio receiver, the writer will refer again to his article, "Regeneration—What it is and What it Does," which



appeared in a past issue of *Radio News*. In this article it is explained that regeneration is caused by coupling between the plate and grid circuits of a vacuum tube; as such coupling makes it possible for plate-circuit energy to be returned to the grid circuit and to be re-amplified excessively. This coupling may be effected by the use of either condenser, induc-



Above are two groups of condensers of high capacity. Those in the upper row are suitable for use as A.F. by-passes. Those in the lower row are of types suitable for power filters.



In the above illustration are shown various types of fixed condensers which may be used in filter circuit as R.F. by-passer.

tors or resistors; but in all cases the effects upon the receiver are similar.

A limited amount of regeneration in a receiver is beneficial; for it tends to reduce the "effective resistance" of the circuit, and also improves the selectivity and sensitivity of the receiver. However, if the regeneration is not properly controlled, the results are unsatisfactory. Where too much regeneration is present, the set is unstable in operation and is apt to enter a state of sustained oscillation, on the least provocation. This ruins the utility of a set for the reception of broadcast programs; as speech or music becomes badly distorted.

In designing receivers, engineers have provided many ways for controlling and limiting regeneration. In some systems, energy is fed from the plate circuit to the grid circuit *with the phase of the current reversed,* so that it neutralizes any normal feed-back current which may exist. In other systems, resistors are connected in the grid circuit of each tube to overcome regeneration, or other means are employed to reduce the efficiency of the circuit. Shielding, automatic coupling-variation and grid-bias control are still other processes which are employed for limiting regeneration.

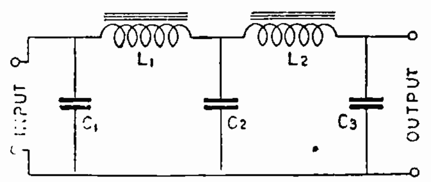
A fact which puzzles many experimenters is that a radio receiver may perform excellently in one location, but give very poor results when it is connected to other batteries or a socket-power unit in another location. Some persons are inclined to blame the new location for the trouble but, in a majority of cases, it will be found that the new batteries or the power unit are responsible. An examination of the circuits of most receivers will show that the same source of power is used to provide potential to the plates of all the tubes. As there is a certain amount of resistance in the batteries or power unit, the various circuits of the set are *linked together by a form of resistance coupling;* and, as a result, feed-back takes place and regeneration and sometimes strong oscillation is produced.

Chokes in the Plate Leads

One of the most important uses of R.F. choke coils is to prevent inter-stage coupling which might take place through the "B" power-supply device. These choke coils not only tend to make the operation of the receiver more stable by preventing feed-back, but they often improve the selectivity of the set by preventing the long "B" supply wires from acting in the capacity of aerials. When the "B' batteries are new the advantage of the choke coils may not be very apparent; but, where socket-power units or old batteries are used for the "B" supply, the judicious use of choke coils and by-pass condensers will often greatly improve results.

Below shows how the coils and condensers should be connected with the "B" supply wires of an R.F. stage. Diagram A shows the usual method; with the choke coil RFC connected in series with the "B+" supply wire to the primary of the R.F. transformer; and the by-pass condenser C connected between the filament circuit and the "B+" side of the R.F. transformer primary . Diagram B shows the use of the choke coil in a *shunt-feed* circuit; by this arrangement the "B" power is delivered directly to the plate of the tube through the choke coil and the R.F. energy is transferred from the plate to the following transformer primary through the by-pass condenser. Both circuits give approximately the same results and, in each case, the choke coil prevents the R.F. current from entering the "B" supply wires; while the by-pass condenser provides a path for the R.F. signal to go directly from the plate of the tube, through the transformer and thus reach the filament of the next tube.

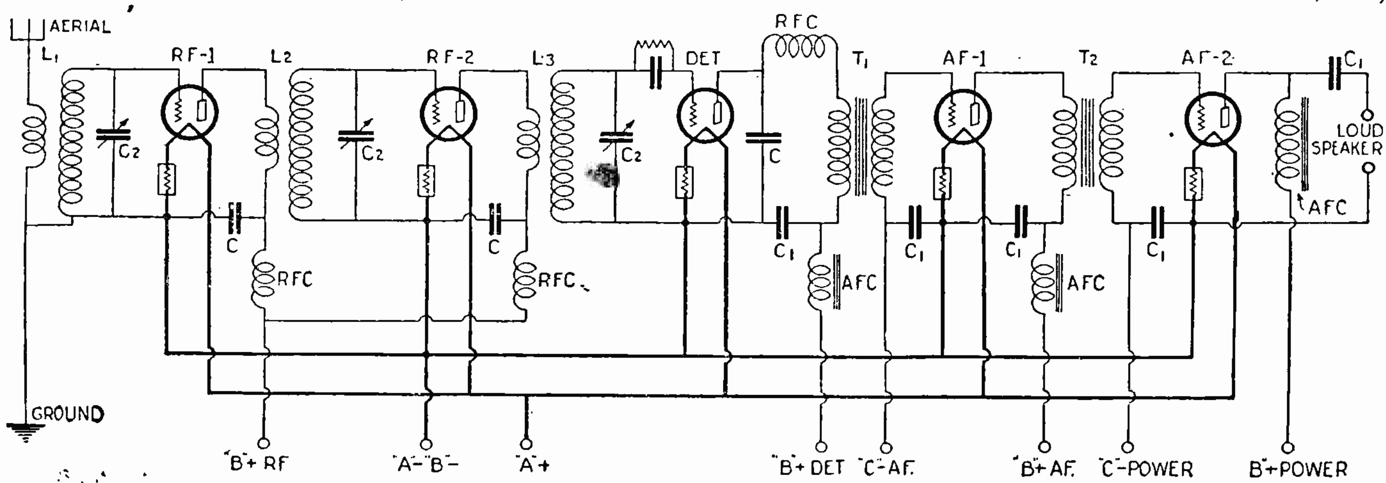
In this illustration, the choke coil and condenser are used to *prevent* coupling. However, there are other circuits which require choke coils to *create* coupling. An excellent example of this is in the Reinartz circuit, shown in Fig. 3. In this circuit, in order to obtain regeneration, it is necessary that the R.F. energy in the plate circuit of the detector should be fed back to the grid circuit through the plate coil P of the coupler and the regeneration condenser C; therefore, the purpose of the choke coil RFC is to prevent the energy from going through the headphones and "B" battery. In this case the by-pass condenser (C) is variable, as it is used to control the amount of feed-back.



How chokes and condensers are used in a power-supply unit to smooth out the "ripples" in the rectified current.

Before the A.F. Amplifier

A third important use of the R.F. choke coil is to prevent R.F. currents from entering A.F. circuits. There are many types of audio-frequency amplifiers which will amplify R.F. currents as well as A.F. currents; and,



In a tuned-radio-frequency receiver of the type shown here, both R.F. and A.F. filters can be used to great advantage. Three of each will be seen in the schematic diagram above, one after each of the tubes.

if the former were allowed to enter the audia amplifier, the utility of that device would be greatly reduced because the R.F. currents would overload the tubes, and thus prevent the efficient amplification of the A.F. impulses. All A.F. amplifiers will amplify R.F. currents, to some extent; but this is true particularly of resistance- and impedance-coupled amplifiers.

R.F. currents are most apt to enter the audio amplifier through the primary of the first A.F. transformer or the first coupling device, which is connected in the plate circuit of the detector tube; because a detector always transmits some R.F. impulses. Therefore, a choke coil and by-pass condenser should always be connected in the detector circuit, in such a way that the R.F. currents cannot pass through the primary winding of the transformer. The way in which this is accomplished is illustrated clearly in Fig. 4. The R.F. choke coil is connected in series with the lead to the A.F. transformer from the tickler coil or plate of the detector; and the by-pass condenser is connected between the *plate* side of the R.F. choke coil and the filament. Consequently, the D.C. and the A.F. components of the current in the plate circuit of the tube pass from the plate through the primary of the A.F. transformer; while the R.F. component is blocked by the choke coil and is forced to return to the filament through the by-pass condenser. The same circuit is used, whether or not a tickler coil is employed.

The use of a choke coil in the position shown in Fig. 4 has an especial advantage when the amplifier is connected externally to the receiver cabinet. With an R.F. choke coil in the plate circuit the R.F. current is shunted directly to the filament, and only audio current is fed to the amplifier. The wires connecting the set with the amplifier may then be as long as required without affecting the results obtained.

The more important uses of R.F. chokes and R.F. by-pass condensers have now been considered; but there are many other places in which these parts are always required in radio circuits. For example, by-pass condensers are always connected in shunt with any instrument which introduces straight *ohmic* or pure resistance into a tuned circuit, as in this way it is possible to reduce the total resistance (the *impedance*) of the unit to R.F. currents. In reflex circuits, condensers are connected across the windings of A.F. transformers; and in other circuits, similar condensers are connected across potentiometers, grid-bias resistors and other apparatus which is sometimes connected in the grid circuit, to protect them from R.F. currents.

Use of A.F. Chokes

In audio-frequency circuits choke coils are used just as much as in R.F. circuits, and are employed in much the same way. In "impedance"- (capacity-) coupled amplifiers, chokes are required actually to *prevent* coupling; in socket-power units they are employed to smooth out or to filter out the "ripples" of the rectified alternating current. In other places they serve to separate the D.C. from the audio-frequency component of the current in a circuit as in output filters.

A very important use of the A.F. choke coil is in the plate-supply wires of an audio-frequency amplifier. When connected in this position it prevents the interstage coupling, which might take place as a result of the *resistance* in the output circuit of the power-supply devices. Frequently, this is the only way in which howling and "motorboating" may be prevented; particularly when "resistance-coupled" or "impedance-coupled" amplifiers are operated from "B" socket-power units. With these amplifiers, an audio choke and a by-pass condenser, connected in the plate lead of the detector stage, and also in that of each detector stage, will usually obviate the troublesome effects altogether.

Fig. 5 shows the method of connecting an A.F. choke and an A.F. by-pass condenser in the plate circuit of a detector or an audio amplifier tube. Diagram A shows the usual method, with the choke coil connected in the "B" supply wire to the transformer T2, and the by-pass condenser C between the "B+" side of the transformer and the filament ("B—"). With this circuit the A.F. current must return directly to the filament through the by-pass condenser because, after the current passes through the primary of the transformer, the choke coil pevents it from entering the "B" supply circuit.

Diagram B shows another method, which is sometimes used when the plate current of the tube is heavy, and in any case where the core of the transformer might be saturated by the plate current. The advantage of the system ("shunt-feed") is that the direct plate current does not pass through the transformer winding, but is delivered directly to the plate through the choke coil connected in series with the "B+" wire. Also, by this method, the insulation of the transformer is not subjected to high voltages. In this circuit the by-pass condenser is connected in series with the wire to the primary of the A.F. transformer from the plate of the tube and the A.F. choke coil. This condenser makes it possible for the A.F. current to pass from the plate, through the A.F. transformer, and to the filament circuit.

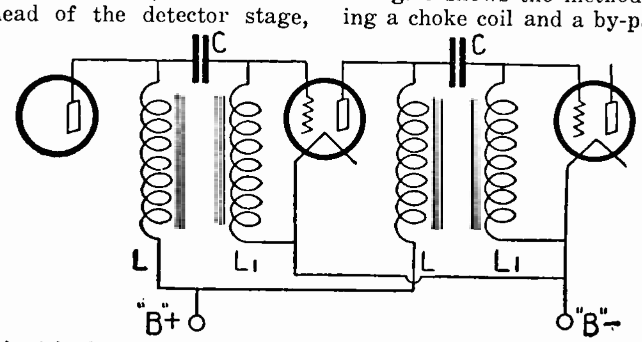
Protecting the Speaker

Since power tubes have become generally used in the last audio-frequency stage of receivers, the use of an A.F. choke coil and a by-pass condenser in the output circuit of a receiver is almost universal practice. The purpose of this choke-and-condenser combination is to allow the A.F. current to pass through the loud speaker and, at the same time make it impossible for the plate current of the tube to flow through the windings of the loud-speaker unit. This is absolutely necessary in many cases; as the heavy plate current required by the power tube would be sufficient to burn out the fine wire in the loud-speaker unit or, at least, it might "saturate" the winding, and the results would be almost equally unsatisfactory.

Fig. 6 shows the method of connecting a choke coil and a by-pass condenser ("tone filter") in the plate circuit of the last A.F. stage. Diagram A and B are for the usual amplifier arrangement, and diagram C is for the push-pull" amplifier. At A is indicated the arrangement followed when the choke coil and condenser are a part of the receiver proper; and the chief advantage of this circuit is that the loud speaker is at ground potential. When the choke coil and condenser are connected externally to the receiver, however, the circuit shown at B is usually used because of its greater simplicity Both circuits give identical results; but in the use of the latter the loud speaker is kept at a high potential, which is sometimes considered unwise. When a push-pull circuit is used, a special choke coil is required; this coil is twice as large as the usual choke and has a center tap for connecting the plate supply wire. As both ends of the choke coil are at the same D.C. potential, it is not necessary to use by-pass condensers in the wires to the loud speaker; but, if it is desired to keep the loud speaker at ground potential, two condensers may be connected in the positions indicated in dotted lines.

"Impedance" A.F. Coupling

An "impedance"- (capacity-) coupled audio-frequency amplifier circuit is another place where A.F. choke coils are required in numbers. In these circuits choke coils are used for two different purposes; so that two choke coils as well as one by-pass condenser are required in each stage. Fig. 7 shows the circuit arrangement usually employed; in this the by-pass condensers C are used to transfer the audio-fre-



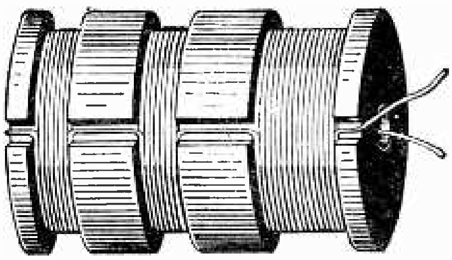
In Fig. 7, at the right the coils marked L and L1 are audio-frequency choke coils, which are employed instead of transformers in an impedance-capacity-coupled audio-frequency amplifier. The condenser C transfers the energy from the plate of one tube to the grid of the following one; the chokes being in the circuit to retain the A.F. impulses, yet supply the needed voltages to the grids and plates.

quency energy from the plate (output) circuit of one stage tothe grid (input circuit of the next stage. The choke coils L provide a path for the direct ("B") current to the plate of the tube and, at the same time, prevent the A.F. component of the current from returning to the filament without going through the condenser C. The choke coils L1 allow the charges on the grids of the A.F. amplifier tubes to leak back to the filament.

In the first part of this article it is stated that choke coils and by-pass condensers may often be removed from a receiver without affecting the results. The fact is that, under certaia receiving conditions, if a choke coil were short-circuited the music would not be affected; but under other conditions the choke would greatly improve the results. The fact is, that a receiver fully protected with chokes is more stable in operation and is capable of giving superior performance under most conditions. The number of choke coils required varies with the circuit used, but Fig. 8 shows the positions in which choke coils may be used to advantage, in practically every receiver. Of course, special circuits often require many additional chokes and by-pass condensers.

The uses of audio chokes, which have been considered thus far in this article, are those of the choke coils which are used in the receiving set proper. However, probably more choke coils are used in power-supply units for radio receivers, than for any other purpose. When used in this way they are part of a filter circuit consisting of two or more choke coils and a condenser "bank." (Filter circuits are provided to smooth out the ripple in the interrupted direct current which is delivered by the rectifier—*i.e.*, to remove the 60-cycle hum from the direct-current output of the rectifier tube.) The action of a filter circuit requires a rather lengthy explanation, and, therefore, it will not be fully covered in this article. However, it may be said that the choke coils retard the pulsating component of the current and the condensers act as reservoirs, which become charged at "peak" voltages and discharge smoothly between "peaks." By use of combinations of chokes and condensers, in a circuit similar to that illustrated in Fig. 9, it is possible to change a pulsating direct current into direct current pure enough to operate the plate circuits of radio tubes.

In their construction, both R.F. and A.F. choke coils offer more complications than one might think. In the case of the R.F. choke coil it is necessary only to wind a coil of wire possessing sufficient *inductance* (and therefore *impedance*) to offer an effective barrier to the radio-frequency current which it is desired to block. However, in winding the coil the maker must take care to see that the *distributed capacity* is as low as possible. If the distributed capacity of a coil is high, this capacity tends to short-circuit the coil, thus destroying its utility. Several methods have been developed for winding coils having a very low distributed capacity, and one of them is illustrated in the picture shown on this page. In this system, the coil is wound on a small wooden bobbin, in three or more sections of various widths. In most cases, the end of the wire leading from the smallest-winding section is connected to the high-potential side of the circuit.



Typical example of the construction of R.F. choke coils; the windings are separated to reduce self-capacity.

In winding A.F. choke coils, the problem is to produce a coil which will have sufficient inductance when a comparatively high current is passing through the winding. This is a problem which concerns the manufacturer more than the eperimenter; because it is rather impractical for the latter to attempt to build a home-made A.F. choke coil. However, it is important for the constructor to select an instrument which possesses the proper inductance and suitable current-carrying rating for the particular circuit in which it is to be used.

(21) Mr. Metherell E. Pearce, Anderson, Indiana, asks:

(Q.1) In building a three stage audio frequency amplifier for a Radiola III, what ratio transformers should be used? Should they be arranged at right angles?

(A.1) Transformers of about 4:1 ratio will probably be satisfactory. It may be advisable, however, to use a 3:1 or even a 2:1 ratio for the last audio frequency transformer. Best results will be had from a push-pull, resistance coupled, or choke coil, third stage amplifier.

Hints on Operation for the Short-Wave Beginner

WHEN the receiver goes in and out of oscillation with a squawk, or a loud cluck, experiment with various grid-leaks until you find the proper value which will allow the receiver to go into oscillation smoothly. Obstinate cases can be cured, generally, by reducing the detector plate voltage.

When wiring the receiver always connect the rotor (movable) plates of the tuning and regeneration condensers to the *filament return* of the stage.

Power units, of both the "A" and "B" types, are not recommended for use with short-wave receivers. A good "B" power unit is entirely satisfactory when used with a broadcast receiver; for the simple reason that, should a slight A.C. ripple be present in the speaker, it will not be noticed because of the volume of the reproduced signal. However, listening to a very weak signal with headphones is another matter; in this case A. C. ripples which would be inaudible in a broadcast receiver become literally roars in the phones. It should be remembered, also, that the broadcast receiver is, or should be, operated below the point of oscillation; this is quite a factor in keeping the A.C. ripple down to a minimum. In using a short-wave receiver, as the regeneration control is advanced, the ripple is amplified in direct proportion to the signal.

An efficient vernier dial must be used on the tuning condenser of a short-wave receiver. This refinement is not essential on the regeneration condenser; but tuning on the high frequencies is so critical that often signals are passed over without the operator being aware of their presence. This statement also, emphasizes the necessity of slow and deliberate tuning, when a mere slight pressure on the knob of the dial may bring in a station.

It should be remembered that short-wave receivers can be logged — not quite as easily as the stabilized broadcast-wave receiver; but with a fair degree of reliability. After a station has been tuned in to the point where it is loudest, turn the regeneration dial to as low a point as it can be brought without losing the signal; when this has been reached, adjust the tuning condenser until the signal is loudest. At this dial reading the station may be logged; with some assurance of returning to it, when desired, with a minimum of "juggling."

Skip Distances

Chas. McCormick, Proctor, Utah, writes:

(Q.1.) Will you kindly explain the meaning of "sunset effect" and short-wave skip distances?

(A. 1.) It has been demonstrated a number of times that short waves are decreased in strength as the distance from the transmitter is increased, until a certain point is reached. At greater distances beyond this point, the signals gradually increase in strength to a maximum. Beyond this point, the strength usually decreases. The distance between the transmitter at the beginning of the rise in signal strength is called a skip distance. This zone is not sharply defined and is found to be longer at night than in the day, and is usually longer in winter than in the summer. In most cases, the skip zone is a region where signals are entirely absent. The shorter the wave-length, the greater the skip zone distances will be. Long waves do not have such skip zones as true attenuation begins at the transmitting antenna. This accounts for the greater distances covered by short waves even during daylight.

During the period of transition from daylight to darkness, "sunset effect" is often observed. About an hour before sunset there will be a noticeable rise in signal intensity, which will drop just about as the sun sets, after which, it will rise until a maximum strength is reached about an hour later. During the night a further gradual rise in signal strength will go forward, until several hours before sunrise. A "sunrise effect" similar to the "sunset effect" will then be noticed, but the phenomenon will be reversed.

Amateur Licenses

Mr. C. D. Nelson, Caldwell, N. J., asks:

(Q.) "Is it possible for you to supply me with information for obtaining an amateur license? What are the requirements for such a license and where is application made? Any information that you can give me will be greatly appreciated."

(A.) The prospective amateur should forward an application for a license to the Supervisor of Radio for the district in which he resides, as shown below. This application will bring a letter of instructions; from which the applicant will learn that he must be able to read the International Morse code at a speed of ten words or more per minute and also that he must pass a written examination covering the theory and practical operation of the transmitter and receiver to be used. He will also learn that he must obtain a copy of the Radio Communciation Laws and Regulations of the United States, and study carefully the regulations relating to amateur operators. A copy of these regulations may be obtained at a cost of 15 cents (not in stamps) from the Superintendent of Public Documents, Government Printing Office, Washington, D. C.

The regulations mentioned contain a copy of the code; and a considerable amount of time must be devoted to learning the code before further steps are taken to obtain the license. An article explaining several methods of learning the code will be found in the August, 1928, issue of *Radio News*. In order to obtain the necessary information on the theory of radio and the operation of transmitters and receivers, it will be necessary to refer to textbooks and periodicals. The Signal Corps handbook entitled "The Principles Underlying Radio Communication" is a very good textbook on the theory of transmission; this book can be obtained from the Government Printing Office and is priced at $1.00.

The vacuum tube is used in all amateur transmitters now, and this point should be particularly stressed. As soon as the applicant is sufficiently confident that he is capable of passing the code test and the theory test, he should make an appointment for personal examination at the office of the Supervisor of Radio for his district. These districts are as follows:

First District: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut. Address Supervisor of Radio, Custom House, Boston, Mass.

Second District: New York (New York City, Long Island, and the counties on the Hudson River up to and including Schenectady, Albany and Rensselaer) and New Jersey (counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson and Ocean). Address Supervisor of Radio, Sub-Treasury Building, Pine and Wall Streets, New York City.

Third District: New Jersey (all counties not included in second district), Pennsylvania (counties of Philadelphia, Delaware, all counties south of the Blue Mountains and Franklin County), Delaware, Maryland, Virginia and the District of Columbia. Address Supervisor of Radio, Custom House, Baltimore, Maryland.

Fourth District: Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, and the Territory of Porto Rico. Address Supervisor of Radio, Room 524, Post Office Building, Atlanta, Georgia.

Fifth District: Mississippi, Louisiana, Texas, Arkansas, Oklahoma and New Mexico. Address Supervisor of Radio, Custom House, New Orleans, Louisiana.

Sixth District: California, Nevada, Utah, Arizona and the Territory of Hawaii. Address Supervisor of Radio, Custom House, San Francisco, Cal.

Seventh District: Oregon, Washington, Idaho, Montana, Wyoming and the Territory of Alaska. Address Supervisor of Radio, Room 2301, L. C. Smith Building, Seattle, Washington.

Eighth District: New York (allcounties not included in the Second District), Pennsylvania (all counties not included in the Third District), West Virginia, Ohio and the Lower Peninsula of Michigan. Address Supervisor of Radio, Room 405, Federal Building, Detroit, Mich.

Ninth District: Indiana, Illinois, Wisconsin, Michigan (Upper Peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, South Dakota and North Dakota. Address Supervisor of Radio, Federal Building, Chicago, Ill.

If successful in the examination, the applicant is granted an amateur first-grade license; if unsuccessful, he must wait three months before he is eligible for re-examination. If the applicant lives in a point remote from the district headquarters, he may submit evidence of his qualifications to the supervisor by mail; and, if the evidence is accepted, he may be granted an amateur second-grade license. To secure the license, the amateur must take an oath to preserve the secrecy of all radio messages which he may hear.

Describing the Transmitter

Before an amateur can construct a station, he must also obtain a station license. The transmitter must be described in detail and a very complete diagram of the transmitting equipment and aerial system must be shown. The type of transmitter must agree with the requirements of the radio laws in the matter of the type of wave emitted and the wavelength used.

Spark transmitters are now banned, because of the serious interference caused by their operation; and the use of conductive coupling in amateur transmitters is no longer permitted with any type of transmitter, except where loop aerials are used. The maximum power input which may be used is limited to 1,000 watts and, where a station is located within five nautical miles of a naval or military radio station, to 500 watts.

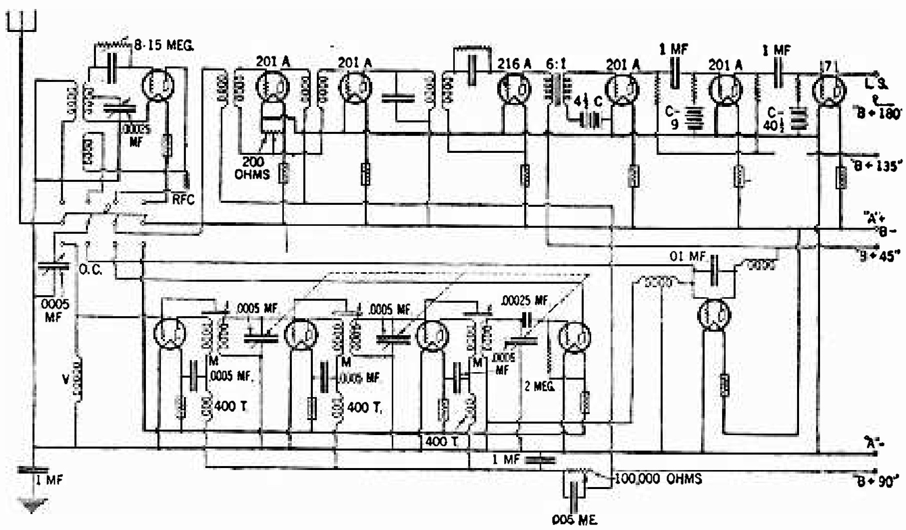
The required licenses having been obtained, the amateur may proceed with the operation of his station in accordance with the regulations governing such stations and under the conditions set forth on the license itself. The station cannot be used betwen the hours of 8.00 and 10.30 p. m., or during the broadcasting of church services on Sundays, on wavelengths between 150 and 200 meters; although on wavelengths below 87.5 meters the station may be operated at any time, provided it does not interfer with radio reception. If the amateur should cause interference on the broadcast band, the radio inspector will withdraw the privilege of operating during the hours mentioned until the amateur can prove that he has eliminated the cause of the interference.

The amateurs in the United States enjoy many privileges not given to amateurs in other countries. That these are appreciated, in most cases, is shown by their efforts to be of public service and by the number of amateurs holding responsible positions in the radio industry. It is also proven by the many developments credited to them.

The information given here for obtaining a license has been put into general form so that it may be of service to anyone because of the great number of letters which we have received on this subject.

An Elaborate Combination

Some time ago I was flooded with requests from other readers for particulars of my short-wave set. Unfortunately, circumstances did not allow me the time to answer, and in the meantime I have developed a set that will be of great interest to the *advanced* amateur and, more especially, the owner of a superheterodyne. With this I listen regularly to Chelmsford and the Dutch, French and German short-wave broadcast stations.



Mr. Van Koolbergen's combination ingeniouslp uses the same condenser for both long- and short-wave superhets. We can conscientiously recommend any constructor to steer clear of it unless he is used to finding his way out of the woods alone on a dark night.

The long-wave side is exceedingly efficient, and one wonders why some sets cannot bring in stations clearly on the lower end of the broadcast band; as when tuning with this set we get a great number of stations below WPG, and distance well around 11 p. m. Pacific Coast reception is quite frequent.

The combination comprises (a) a short-wave single-circuit regenerative unit with plug-in coils; (b) a one-dial R. F. amplifier and detector unit; (c) an oscillator unit; (d) two I. F. stages with filter; (e) an A.F. amplifier, one stage transformer-coupled, two stages resistance-coupled, and an output stage of two 210 tubes in push-pull with 300 volts on the plates.

Now, there are two controls for the long-wave set, one for the short-wave set, and a D.P.D.T. Yaxley jack switch. The oscillator condenser for short-wave work becomes the oscillator condenser for the long-wave super by throwing the switch. There is one combination rheostat and potentiometer, and one master battery control. I used a former Freed-Eiseman panel.

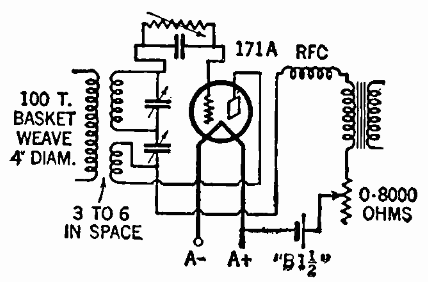
This set, with its interchangeable coils, will tune from 17 to 24,000 meters; it is a real DX getter, is very selective and gives assembly-hall volume. What I consider very important is that the 23-control set, with its battery troubles, has been reduced to not more than three controls at one time and operated from the house-current supply. When changing from one waveband to another, the filaments of the side which is not in use are automatically cut out.

On account of the great distance from broadcast stations here in the Far North (120 miles north of Quebec) shielding was not necessary; but it was provided to see what the difference would be. A slight gain in selectivity was observed, and when it was operated with the battery in a shielded container and cabled underground antenna, static was reduced to practically nil.

For my intermediate and R.F., I used "peanut" tubes to save space. The R.F. coils are placed under the three-gang variable condenser and the peanut tubes between the different sections; so that the two sets, one with nine tubes available for short waves, the other with twelve for long waves, are contained in a cabinet 7x9x30, and are so simple to control that a child can operate them.

The short-wave super has been designed for broadcast reception only, and is a combination of the sets described in *Radio News* for July, 1927, and October, 1927, and the short-wave superheterodyne described in the February, 1927, issue of the same magazine, where all data as to coils, etc., can be found. I have eliminated the regenerative detector for code reception. For the broadcast band (200-600 meters) I have found that a very selective single-control receiver loses its selectivity on account of the difficulty of tuning the first stage. So I added one tube ahead of the three tuned circuits; its amplification peaks between 400 and 600 meters. This permits the three following stages to tune very sharply, and adds also somewhat to amplification at the higher wavelengts. I find the 100,000-ohm resistor indispensable in this circuit; because, even without an aerial, powerful stations like WGY, KDKA, WJZ and others come in with such termendous force as to be too loud even for a big hall. The Peridyne principle of stabilizing has been added, as well. The set permits the reception of code on the short-wave set by using the potentiometer on the intermediate stages and permitting the set to oscillate.

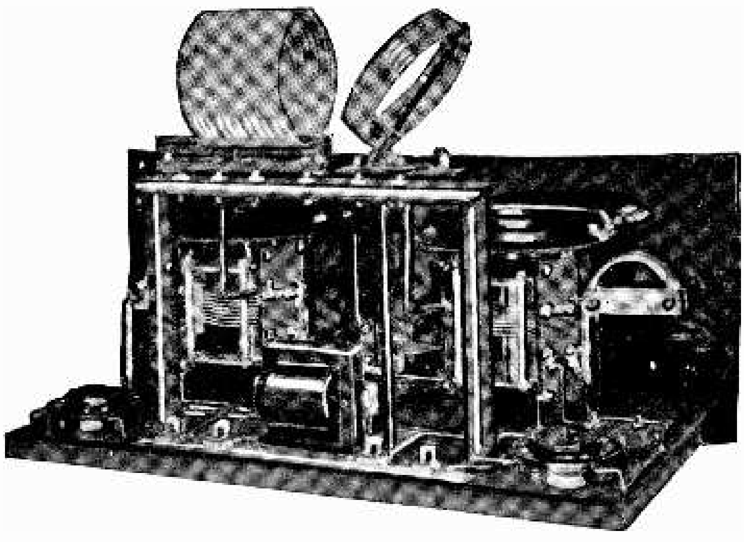
The condenser C, which serves as the short-wave condenser or oscillator condenser, depending upon how the switch is turned, is .0005-mf., and might be as high as .001-mf., improbable as this might seem, provided its minimum is low enough. I use a Remler for the purpose and can go as low as 13 meters. By putting a .0005-mf. fixed condenser in series with the "short-wave" set's secondary, that set can be made to oscillate up to 24,000 meters using



Mr. Van Koolbergen uses 1½ volts on the plate—plus, of course, half the "A" voltage, as compared with the center of the filament.

a 1,200-turn duo-lateral coil. Although the circuit seems terribly complicated, if properly placed it is simplicity itself and can be enclosed in a cabinet 24x12x8 without undue crowding. Of course, in this out-of-the-way part of the world, where radio is our only amusement, distance-getters are welcomed and I have so far changed three standard sets for friends of mine. With this set we have music, speech or lectures during all hours of the day and cover both continents as well. I am enclosing a letter of verfication from the British Broadcasting Company, London, on 5SW.

Coil data can be found by those desirous of building this set in any good radio hook-up. However, to help those who have no time to look it up, here goes:



Rear view of the Grebe CR18 short wave receiver

Coils V, 50 turns Advance resistance wire on a half-inch spool. Coils M ("binoculars" 1⅞ inches in diameter each section) have 50 turns on each of good No. 22 enameled wire—wound in the same direction. The primaries have each 40 turns of No. 38 S.S.C. wire inside the binoculars close to the filament terminals. These coils with their 400-turn chokes and .0005-mf. condensers are enclosed in a copper box; the tubes are mounted on top of this box and the triple condenser at the side. No leads are longer than half an inch. On the other side of this condenser are the I.F. section and three tubes: the Yaxley switch and the oscillator condenser are at the right of these, and finally the A.F. amplifier is at the end of the baseboard. The three dials are thus in a row on the panel, which carries also the two resistor controls, and the jack switch above the oscillator condenser. This is all except for the filament switch at the right.

I have also found a pronounced improvement in short-wave reception which may be of interest to readers in the use of a 171A as the detector; not with the usual 45 volts upward, which caused the signals to be mushed, but by using a 1½-volt "C" battery on the plate, with a 0-8000 ohm resistor in series (Fig. 2). With this, instead of aerial and ground, I use a basket-weave coil of 4 inches in diameter and having 100 turns. With this three inches from the grid coil, and the circuit led into the intermediate and R.F. amplifier and a dynamic speaker, we had a band concert all day, to the surprise of the villagers—at least, to the owners of $500 sets.

J. H. Van Koolbergen,
Port Alfred, Quebec, Canada.

GREBE SHORT-WAVE RECEIVER

(22) Mr. B. P. Deverest, Ottawa, Can., asks as follows:

(Q. 1.) I am informed that A. H. Grebe has developed a new short-wave receiver, "CR-18" I think. Can you furnish me with any constructional information concerning same, as I am very much interested in short-wave sets?

(A. 1.) All the available information on the Grebe CR-18 short-wave receiver is obtained from their booklet "Instruction and Operating Manual." All the necessary data which we think you might need, contained in that booklet, are herewith reprinted.

Short-Wave Receiver Design

"In designing a receiver for short-wave reception, many problems are encountered which are not met with when dealing with the higher wave-lengths. Radio frequency amplification does not seem to offer any particular advantages, and more complex circuits using multi-stage amplifiers are either unstable or have too many operating controls to be of any practical use.

"The adjustable-tickler-coil circuit, for example, is inferior at very short wave-lengths, because a change in regeneration produces so great a change in wave length that the transmitting station cannot be received with any degree of certainty. On the other hand, the capacity feed-back coupling method generally used results in stray-capacity effect so great that tuning is destroyed and the receiver becomes difficult to operate. While few receivers have been designed, using the above mentioned circuits, generally the wave-length range of such sets is small and they can only be used to cover a limited band.

"In order to receive continuous-wave stations to the best advantage, the circuit should be such that the point of oscillation is practically constant over the entire tuning range. For reception of broadcoasting on the high frequencies, however, the regeneration control should operate in such a manner that the change from oscillating to non-oscillating condition is gradual rather than sudden.

"The CR-18 receiver has been designed with all these points in mind, and a study of the circuit will reveal that variable electro-magnetic coupling between the antenna and secondary circuit is employed, contrary to the usual practice of using a small coupling condenser. This coupling coil permits a greater transfer of energy without affecting the wave-length calibration, and affords greater selectivity, reduces interference and induction noise and makes possible the use of harmonic tuning when using a large antenna.

Interchangeable Coils

"In order that tuning shall not be too critical the receiver is provided with five different coils which cover wave-length ranges, as shown above. The winding indicated as 'L' may be approximately 8 turns. Coupling is varied by changing its position of proximity to the other windings.

"These coils are fitted with plugs and are mounted outside of the cabinet, in order to reduce all losses and permit the coils to be interchanged without delay or difficulty. (No. 16 or 18 DCC wire will be satisfactory for winding these coils. Although each coil covers only a small wave-length range, the frequency-range is very large; and for this reason the beat-frequency control, consisting of a small variable air condenser, is incorporated in the receiver. This condenser permits one to discriminate between stations separated by only a fraction of a kilocycle and makes it possible to hold a station which is swinging or changing its frequency.

"In place of a choke-coil in the plate circuit, the CR-18 employs a resistance. This resistance eliminates non-oscillating points in the tuning range which frequently occur when a choke-coil is used. Cushion sockets are used to eliminate all vibration and microphonic disturbances, which seriously affect the operation of a short-wave

Coil No.	Wave-length range-Meters	L1 turns	Space	L2 turns	Frequency range Mega-cycles
1	8.5- 18	1	1	2	16.6 -35
2	15.8- 31	3	1	2	9.7 -19
3	29 - 62	8	1	4	4.85-10.3
4	56 -112	18	2	6	2.68- 5.35
5	107 -216	49	1	18	1.38- 2.8

Operating Instructions

"The CR-18 is designated to operate with 201-A, 5-volt, ¼-ampere, X-type-base vacuum tubes. It is sometimes advisable to reverse the tubes in order to obtain the most desirable results. A storage battery should be used for filament supply.

"At least 90 volts of 'B' battery is necessary. A clip should be provided on the detector lead, so that variation of detector plate-voltage may be easily secured, as certain coils require more voltage than others.

"The antenna should consist of a single wire, aproximately 75 or 100 feet in length including the lead-in, and should be well insulated. Good results may be obtained with an antenna as short as 25 feet, or even an indoor antenna may be resorted to. Connection to the ground should be made securely by means of a ground clamp fastened to a water pipe or radiator system. Care should be exercised in making all connections, as loose connections are more detrimental on short waves than on the higher wave-lengths.

"Set the wave-length dial on '0,' and starting at '0' on the regeneration dial slowly increase the reading to 35 or as far as necessary to cause indications of oscillation to be heard in the telephones. This point is usually 40 but will be subject to slight variations. When the point on the regeneration dial at which oscillations occur has been determined, move the dial 5 points higher. The receiver should now be in an oscillating condition over the entire wave-length range covered by the wave-length dial. A simple test to determine whether the receiver is oscillating or not is to touch the left-hand screw on the secondary coil; if a click is heard in the telephones the receiver is oscillating.

"Insert the antenna coupling coil and connect the antenna to the binding post provided. Adjust the antenna coil so that there is a separation of two inches between the top of this coil and the top of the secondary. Note again whether oscillations take place; if they have stopped, increase the regeneration dial 10 degrees and if this is not sufficient to cause oscillations, further separate the antenna coil from the secondary coil. Starting at '0', move the wave-length dial to 100; and if points are found where the receiver stops oscillating, it indicates that the antenna circuit or a harmonic of it is in tune with the secondary circuit.

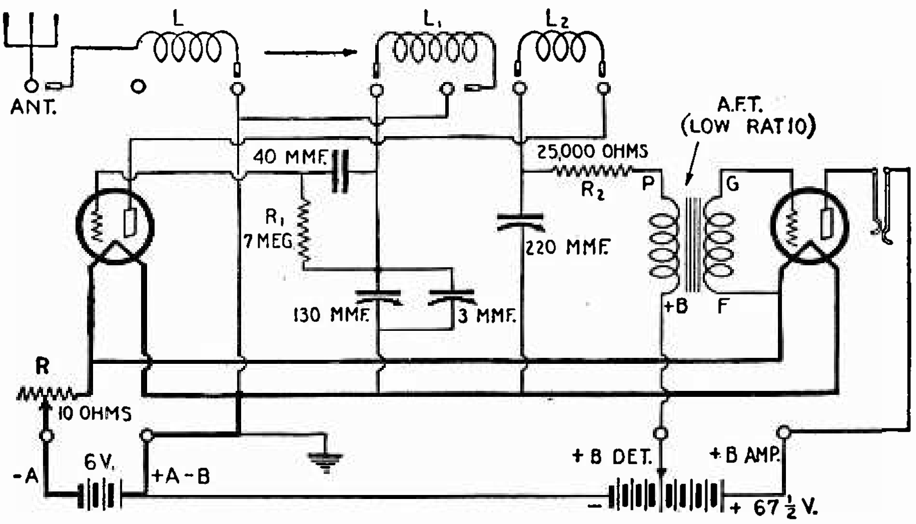
"If in later experience it is found that these non-oscillating points fall directly in the most generally used wave-length ranges, the points may be shifted by either lengthening or shortening the aerial. It will be impossible under certain conditions to eliminate all these points, regardless of the treatment of the antenna; but when these points appear, moving the antenna coil further away from the secondary coil will again permit oscillation to be maintained. Moving the regeneration dial to a higher point will also accomplish this, but it is preferable to utilize the antenna coupling coil for this purpose.

Use of Antenna Condenser

"With further reference to the occurrence of non-oscillating points on the wave-length dial, some may prefer to use a third method of shifting or eliminating such points. It may be accomplished by connecting a small variable condenser with a capacity of .00035- or .0005-*uf*. between the aerial and the antenna binding post on the receiver. By tuning this external condenser, a point will be found where the receiver stops oscillating; and by adjusting the condenser, above or below this point, stable operation will again be restored.

"It is important for the operator to appreciate fully the advantages that may be gained by harmonic tuning. This can be accomplished by using a small variable condenser connected in series with the antenna and the coupling coil. The effects are most noted on wave-lengths in which the fundamental period of the antenna is some multiple of the received wave-length.

"For example, if the length of the antenna is such that, when it is connected to the antenna coupling coil, it has a natural period of 300 meters, the following harmonics would occur; second harmonic at 150 meters; third at 100 meters; fourth at 75 meters; fifth at 60 meters, etc. If the antenna coil is close to the secondary coil, the receiver will stop oscillating at these wave-lengths. However, if oscillations are again restored by any of the previously-mentioned methods, stronger



Super-regeneration, or regeneration, at short wave-lengths? By a slight change, the experimenter has either available, a will. We will welcome reports, on reception conditions in various parts of the world, at short wave-lengths.

signals will be obtained at these points than on other wave-lengths in the tuning range. It is therefore possible to adjust any antenna so that some harmonic falls on approximately the wavelengths one desires to receive. The advantage of this method is that a long quency control wheel. With this in will have better pick-up qualities.

"It is important for the operator to realize at the outset that the frequency band included in a single wavelength dial division is sufficient to accommodate as many as fifteen stations; and while very fine tuning can be secured with the tangent wheel, many of the stations will be passed over unless use is made of the beat-frequency control. The tuning values of the main wave-length condenser and the beat-frequency control are so proportioned that, whereas approximately fifteen stations will be found in one degree of the wave-length dial (one notch of the tangent wheel) each station may be separated by approximately one notch of the beat-frepoint. A final critical adjustment rheomind, the operator will soon become familiar with the tuning capabilities of this receiver.

Reception of Code

"When receiving C.W. or I.C.W. code signals, the regeneration dial should be reduced to the lowest reading possible, where oscillations are just maintained. This will result in weak signals being received with greater intensity. In other words, the weaker the signal, the weaker the oscillations in the receiver should be for maximum intensity in the telephones. However, where signals are easily readable, stronger oscillations may be used and are helpful in reducing noises and low-frequency interference.

"In order to receive broadcasting or speech it is necessary to keep the receiver in a non-oscillating condition. Maximum strength of reception will be obtained when the regeneration dial is set just below the oscillating

Grid Leaks

be made by using the filament rheostat."

(23) D. B. Leibman, Salem, Illinois, writes:

(Q. 1.) What is the function of a grid leak in a detector circuit?

(A. 1.) A grid leak is a higher resistor which is connected between the grid terminal of the detector tube and some portion of the filament circuit. The purpose of the grid leak is to assist in controlling the grid bias and also to allow the excess of the negative electrons that accumulate on the grid to leak away. By correctly biasing the detector tube, it is possible to obtain rectification without using a leak, but this method is not as sensitive as the grid leak detector. The value of the grid leak used depends upon the type of tube employed and on the strength of the receiver signal. To some extent, it is also dependent upon the tendency of the receiver to oscillate. When weak signals are being received, it is necessary to employ a high resistance leak for good volume, and when loud signals are being received a low resistance, in order to maintain fidelity. A compromise value must therefore be chosen to give both quality and sensitivity. If the leak has too high a value, the set will block and howl. If the resistance is too low, distant stations will be weak or entirely absent and it may also be found difficult to make the set regenerate. Further, when the regeneration point is reached, the receiver will suddenly fall into oscillation.

Grid leaks are also used in amplifiers of certain types. In choke coil and resistance coupled amplifiers the grid must be supplied with the correct bias. A choke coil or resistor of the correct value will keep the signal in the right channel, but will also allow the D.C. potential of the "C" battery to be impressed upon the tube grid and yet will not short-circuit the signal current.

Kilocycles-Meters Conversion Chart

(24) Mr. H. Parkhurst, Denver, Colo., writes:

(Q.) "I have just bought a new receiver, but I am having some difficulty because the dials are calibrated in kilocycles and I do not know what the corresponding wavelengths are for the kilocycle readings. If I knew these wavelengths, I am sure that I could tune in more stations than I can get at present. Can you supply me with a list of kilocycles and the corresponding wavelengths?"

(A.) We are printing a chart for the conversion of wavelengths to kilocycles, since this should interest many of our readers. The frequency scale is being used more, at present, than it has been in the past and several manufacturers have put out sets with the dials calibrated in kilocycles. It is quite easy to convert wavelengths to kilocycles by merely dividing the wavelengths into 300,000. The wavelength in meters can also be figured in the same manner. The number 300,000 is obtained from the speed of radio waves. In miles per second, this is 186,000 and when this is converted to the metric scale, it is approximately 3,000,000 meters. Dividing the length of one wave into the speed would give the frequency in cycles. Since Kilocycles (which means "thousand cycles") is more popular than cycles, we divide the 3,000,000 by 1,000 which gives the 300,000 originally used. The figure 3,000,000 meters for the velocity of radio waves is only approximate, but the error is very slight and it can be disregarded.

Frequency Kilocycles	*Wavelength Meters*	*Frequency Kilocycles*	*Wavelength Meters*
1500	199.9	990	302.8
1490	201.2	980	305.9
1480	202.6	970	209.1
1470	204.0	960	312.3
1460	205.4	950	315.6
1450	206.8	940	319.0
1440	208.2	930	322.4
1430	209.7	920	325.9
1420	211.1	910	329 5
1410	212.6	900	333.1
1400	214.2		
		890	336.9
1390	215.7	880	340.7
1380	217.3	870	344.6
1370	218.8	860	348.6
1360	220.4	850	352.7
1350	221.1	840	356.9
1340	223.7	830	361.2
1330	225.4	820	365.6
1320	227.1	810	370.2
1310	228.9	800	374.8
1300	230.6		
		790	379.5
1290	232.4	780	384.4
1280	234.2	770	389.4
1270	236.1	760	394.5
1260	238.0	750	399.8
1250	239.9	740	405.2
1240	241.8	730	410.7
1230	243.8	720	416.4
1220	245.8	710	422.3
1210	247.8	700	428.3
1200	249.9		
		690	434.5
1190	252.0	680	440.9
1180	254.1	670	447.5
1170	256.3	660	454.3
1160	258.5	650	461.3
1150	260.7	640	468.5
1140	263.0	630	475.9
1130	265.3	620	483.6
1120	267.7	610	481.5
1110	270.1	600	499.7
1100	272.6		
		590	508.2
1090	275.1	580	516.9
1080	277.6	570	526.0
1070	280.2	560	535.4
1060	282.8	550	545.1
1050	285.5		
1040	288.3		
1030	291.1		
1020	293.9		
1010	296.9		
1000	299.8		

Battery Life

(25) H. B. Wentworth, Trenton, Tenn., asks:

(Q.1) Can you supply me with a service curve showing the service hours at various currents obtained with a medium sized 45-volt "B" mattery?

(A.1) On this page you will find the curve requested which shows the service record of a 45-volt "B" battery known commercially as a 5 lb. battery. The results shown were determined by one of the large battery manufacturers in a series of laboratory tests. This gives the service hour capacity at various currents to an end voltage of 34 volts with the discharge based on an intermittent service of 2 hours per day. The current from a "B" battery to a tube does not remain constant but drops off as the battery voltage decreases. To estimate the service hours of batteries, it is necessary to know the average working voltage of these batteries. The average working voltage of a 45-volt battery between 45 volts and an end voltage of 34 volts is 39.5 volts.

Laminated Bakelite

(26) John Kerney, Watertown, Mass., writes:

(Q. 1.) Will you outline briefly the process used in making laminated bakelite and if possible give some of its outstanding properties?

(A. 1.) For the manufacture of laminated bakelite, the initial or primary resinoid, which is obtained from the interaction of formaldehyde and phenol, is dissolved in solvents to produce a varnish. This is then used to impregnate the fabric or cloth. Impregnation is caried out with special machines which coat the paper or cloth with a uniform layer of varnish. These are then dried and cut into sheets of convenient size. A number of these sheets are then stacked up and placed in a hydraulic press where, under the action of heat and pressure, a hard plate is produced. The final product cannot be resoftened by heat and is non-hygroscopic. The variety of properties available in laminated bakelite is determined by the amount of resinoid and by the type of laminating sheet used. Physically speaking, laminated bakelite is a dense uniform solid with a smooth and even surface and is obtained in a number of colors. Mechanically, it is sufficiently strong so that it can be substituted for wood or metal in many cases. It is free from variation in structure and is stronger in some respects than cast iron. It has 90 per cent of the tensile strength of aluminum and only one-half the specific gravity. It is the most generally effective organic insulating substance, is more heat-resisting than shellac and more water-resistant than fiber. Its application in the electrical field and in radio work are familiar to all and are too numerous to mention here. Chemically, it is quite inert and is not attacked by most reagents. It is unaffected by most organic acids and by most dilute mineral acids. It is, however, attacked by hot alkaline solutions. For more information concerning laminated bakelite, we would suggest that you obtain a copy of *Bakelite Laminated* from the Bakelite Corp.

Forming Rectifiers

(27) Albert Nesbit, Hamilotn, Ontario, Canada, writes:

(Q. 1.) How may aluminum-lead electrolytic rectifiers for a battery charger be formed and what indication shows when they are ready for use?

(A. 1.) The aluminum electrode in a rectifier of this sort must be covered with a film of hydroxide of aluminum and the process by which this film is obtained is known as "forming." This can be done by connecting the rectifier to the output of a toy or bell ringing transformer delivering about 10 volts. After the aluminum plate turns a light grey color, the rectifier is ready for use. When an electrolytic charger is not in use for a long time, the film on the aluminum electrode will gradually disappear and the rectifier must then be reformed. The loss of the film can be prevented by removing the electrodes from the solution and wiping them dry if the charger is to remain inoperative for any length of time.

Noise Level

(28) Herbert McKellar, Euclid, Ohio, writes:

(Q. 1.) What is the meaning of the term "noise level"?

(A. 1.) The combination of all noises coming into a radio receiver is usually taken to be the noise level. These noises are caused by true static, electrical interference, by reradiating receivers or by any apparatus or device which forms electrical impulses which may be picked up by the receivers. The limit of radio reception is governed by the distance and power of the transmitter and also by electrical disturbances which drown out signals as soon as their intensity falls to a certain degree. A point is reached where the signal from the station has less strength than the impulses forming the noise level. It is then impossible to receive the station because the receiver will amplify the noises equally as well as it amplifies the true signal.

Scratch Filter

(29) R. Lindsay Wickes, New Haven, Conn., asks:

(Q. 1.) Will you please give data for constructing a scratch filter to be used with a phonograph pick-up.

(A. 1.) A satisfactory scratch filter consists of a 1,500 turn honeycomb coil connected in series with a .008-mf. condenser. This series combination is placed across the first audio frequency transformer primary, or across the pick-up. If a honeycomb coil of this size is not available, 1,800 turns of No. 28 D.C.C. wire may be wound on a form 2 inches in diameter and 1 inch wide, or an 85 millihenry choke may be used in place of the honeycomb coil.

Tone Control in Amplifiers

(30) Mr. E. B. Hamilton, Pasadena, California, asks:

(Q.) "Can you help me to solve a problem which has been bothering me recently? I have seen in a magazine some time ago a method of controlling the tone of a radio set by connecting condensers of different sizes across the audio frequency transformers. I have looked through all of my old copies of *Radio News* but I have not been able to find the article in question. As I remember the arrangement, a number of fixed condensers were connected with a switch so that any one of the condensers could be connected across the transformer. I do not remember whether the condensers were connected to the primary or the secondary."

(A.) We are printing two diagrams of tone control arrangements, which you can use to improve the quality of your receiver. It is well known that the tastes of people do not agree as to the quality of receivers, some owners desiring soft low type of tone, in which the low frequencies are comparatively loud, while others desire a sharper type of tone in which the middle frequencies are more predominant than either the high or lower tones.

The use of a condenser of the correct size across the secondary of the first audio frequency transformer will

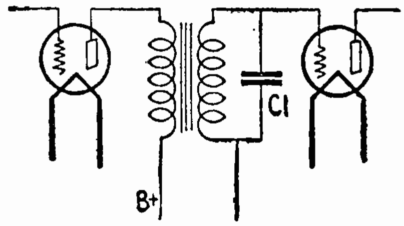


Fig. 8

help to change the characteristics of this transformer in such a way that the tones on the correct part of the band are brought out more strongly than the others. This may be done in two ways. The first of these is to try different condensers across the transformer until the best one is found, and the other is to arrange a number of condensers of different sizes with a switch, so that the different capacities may be used by merely shifting the position of the switch. An arrangement of this kind is shown. An extra contact should be added with no condenser attached so that the amplifier can be operated without the shunt condenser if desired.
above.

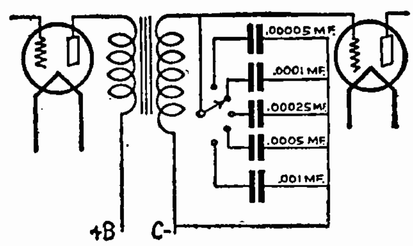


Fig. 9

The use of the switch method will allow a convenient variation of the tone for different types of programs. In other words, if an orchestra is being received, one type of tone may be desired, while if a lecture is being received, an entirely different type of tone may be preferred.

The capacities needed to supply these different characteristics in the audio amplifier vary between a very small value, about .00005 and a large value. The maximum capacity rarely exceeds .001-mf. and this is the value showns on the accompanying diagram. A fixed condenser can be used in many cases o improve the characteristic of a poor audio transformer, by bringing out the section of the band which is weak, usually the lower frequencies. In using a condenser for this purpose, it is not necessary to use the bank of condensers, unless a change in the tone is desired, as explained above. Fig. Q2345A shows how this is done.

Underground and Underwater Aerials

(30) Mr. C. Williams, Union, N. J., writes:

(Q.) "I would like to obtain information in reference to the operation and construction of underground and underwater "aerials." I have seen a number of advertisements in recent issues of the radio periodicals advertising antenna devices of this type to reduce static and increase the selectivity of a receiving set. There have been so many "static eliminators" advertised and exploited from time to time, all of which were failures, that I am rather skeptical about the results obtained with an aerial of this type.

(A.) The underground aerial is well known in radio circles and its advantages were proved quite conclusively by tests made during the war by the U. S. Navy Department and several individual experimenters, led by Dr. James Harris Rogers, whose laboratory is located at Hyattsville, Maryland. The tests made by these experimenters showed that the ratio of static and noise to the signal strength was much less than with the ordinary elevated type of aerial. Dr. Rogers arranged aerials of various lengths and depths in all directions around his laboratory, so that by means of switching systems combinations or individual aerials could be used at will. It was found that the underground aerial, when buried in a straight line, is more or less directional, in the plane of its length. It was found that the best wire for use with underground aerial experiments is one with heavy rubber insulation covered by a coating of lead. Seventy-five feet is usually considered about the correct length for an aerial to be used on wavelengths between 150 and 500 meters. Under average conditions, stranded or solid copper wire, about No. 14 gauge, with a good rubber insulation and coated with lead, will be found most suitable for this purpose. The wire should be buried in a shallow trench between 12 and 24 inches below the surface of the ground. An aerial of this type is shown.

Another type of underground aerial which has been used extensively is one consisting of a number of spirals of lead-sheathed wire buried in a pit about four feet deep and three in diameter. An aerial of this type is meter. An aerial of this type is shown. The end of the wire should be insulated very carefully by pouring meled paraffin or sealing wax over it and then winding upon it rubber or friction tape to prevent the wax from breaking away. In this way, the end of the wire is made completely waterproof and there is no chance of moisture short-circuiting the wire to the sheath. The spirals should be made with the turns of wire 3 to 4 inches apart, and the smallest diameter should be about 6 inches. The lowest spiral should be placed about 3 feet below the surface of the ground and a space of 6 to 8 inches should be left between each of the spirals.

The advantages of such an aerial over the first type mentioned are that it is not directional and is much easier to lay. The disadvantages are that the pick-up is much smaller and naturally it is necessary to use a more sensitive receiver in order to obtain equally satisfactory results.

Underwater Aerials

In constructing underwater aerials, the same specifications should be followed for the type of wire, insulation of the end, and length. When the wire is placed in fresh water, it has been

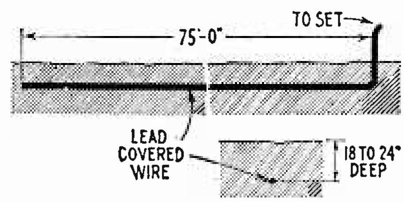


Fig. 10

found that it can be submerged as deep as 60 feet without an appreciable decrease in signal strength. In salt water, however, it has been found that the signal strength drops off very rapidly when the wire is submerged to any great depth. In making an underwater aerial for operation in salt water, buoys should be fastened to the wire at intervals in order to keep it close to the surface. The underwater aerial is quite satisfactory for portable use, since camps are usually located near a lake or other water supply. If desired, a number of wires may be sunk in a fan-shaped area, and connected together at the lead-in, in order to increase the pick-up. In underwater aerials, it is extremely important that the end of the wire be made watertight; since, if water enters through the insulation, the wire will be grounded and results obtained will be very poor.

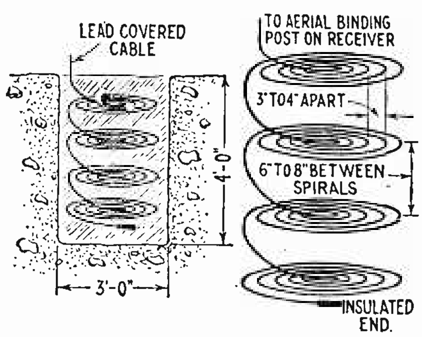


Fig. 11

The amount of signal energy received by the ground system is less than that obtained with the average elevated aerial, depending upon the type used, and for this reason it is necessary to use a set with several R.F. amplifier tubes in order to obtain satisfactory volume. The use of an aerial buried in a large circle or semi-circle will overcome the directional effects to some extent; while it has been found that the use of the ground aerial in combination with a "coil" (loop) aerial is of assistance in eliminating interference and strays, since under proper conditions this combination forms a unidirectional aerial.

The official naval tests from time to time during the war showed some very interesting comparisons between the degree of signal strength as compared to the static when using underground aerials. At New Orleans, for example, it was found possible to carry on steady radio reception from a distant station, with the underground aerial, while a heavy electric storm was directly overhead. It is practically impossible to accomplish anything like this when using a regular elevated aerial, and it would be sometimes rather dangerous to attempt it.

Types of Receivers

One of the most important points to remember is that you will not reap the full benefits of static reduction with an aerial of this type, *unless you are using a shielded set.* If your

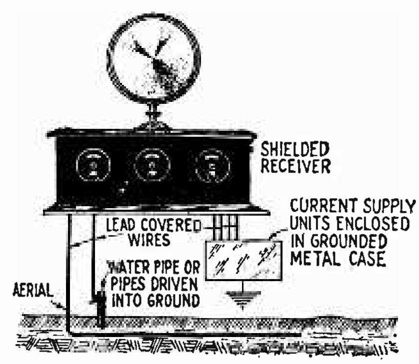


Fig. 12

receiving set does not already have shielded condensers and coils, the set can be shielded by placing aluminum or copper plates all around the inside of the cabinet and then grounding the metal lining. It is important to remember that the lead-sheathed cable must extend up to the set, and also that the ground wire must be a piece of lead-sheathed wire. It will be of advantage, in some cases, also to place the filament and plate supply in a metal-lined box with the lining well grounded. The wires between the power supply and the set, unless they are very short, should be lead-covered and, in any case, all lead sheathing on the wires must be connected to ground. In order to obtain the greatest ratio of signal strength to static, it is best to use batteries to supply the current to the filaments and plates, and to place them in a metal-lined box as mentioned before.

If a "B" power unit-operating from the 110-volt line is used, there is liable to be a feed-back of "strays" through the power unit. This is especially true in country districts where elevated electric-light feed wires branch off from the poles and then proceed to the house. In the city, where most of the electric-light wires are shielded and buried in the street, this effect is much less noticeable, and the "B" power unit can be used quite sucessfully.

Shelf-Shielded Coil

(31) Can you give me any information concerning the design of a solenoid which will be self-shielded both electrostatically and magnetically?

(A. 1.) Certain forms of coils have been designed which have a small external field and are uncoupled both magnetically and electrostatically. Among the forms employed are "D" windings, binocular coils and oroid windings. Even with these types, coupling between coils and the other apparatus is frequently experienced. A cross-sectional view of a self-shielded solenoid appears on this page. The coil comprises an inner and an outer form arranged in coaxial relation. The outer coil forms a magnetic and electrostatic shield for the inner coil. The two coil sections are connected together as shown, so that instantaneous currents traversing tne coil sections are in opposite directions, or, in other words, so that opposite fluxes of different magnitudes are produced in the core of the inner coil. The outer coil and inner coil are

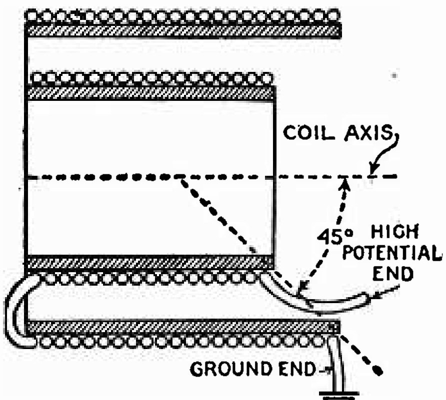


Fig. 13

joined at the same axial end, so that they may be wound in the same direction. The free end of the inner coil is the high potential end, and the free end of the outer coil is the ground end. The outer coil should preferably overlap the inner coil, so that a line joining their ends makes an angle of approximately 45 degrees with the axis of the coils. To produce the magnetic decoupling of the coil system, the ratio of the number of turns of the two coil sections must bear a definite relation to the ratio of the areas of the two coils. The product of the area and the number of turns of one section should equal the product of the area and the number of turns of the other coil section. If this coil system is placed in a uniform magnetic field of variable intensity directed along the axis of the coils, the emf. (electro-motive-force or voltage) induced in the inner coil section is equal to the emf. induced in the outer coil section, because the induced emf. in a coil is a linear function of the number of turns and the total flux threading the coil. The resultant field at a distance is negligible, since the field produced by one coil neutralizes the field produced by the other coil. If the magnetic field is not parallel to the axis, the same condition exists. To produce the static shielding, the coil system is so constructed that the self-inductance of the outer coil section is made equal to the mutual inductance between the two coils. When this condition exists, there is no potential drop along the outer coil, due to the high frequency currents flowing and the whole surface of this coil is substantially at one potential. Now, if this potential be made the ground potential, it will be seen that the coil system is electrostatically shielded. The outer coil may overhang the inner coil at each end, which slightly impairs the electrostatic shielding of the high potential end of the inner coil, but slightly improves the magnetic shielding. Generally, the ratio of areas of the outer to the inner coil may be from 5 to 1 to 1½ to 1, and for producing the greatest efficiency, this ratio should be about 2.1 and 2.2 for coils having ratios of 1.26, 1.58 and 2.1 respectively, of outer coil diameter to length. The inductance of the coil system is obtained mainly because the inner coil has in its core a relatively intense magnetic field, which is only partly neutralized by the flux of the outer coil. A detailed description of the self-shielded coil will be found in U. S. Patent No. 1,608,560.

Reducing Antenna Effect of Eliminator

(32) A. Rampelli, San Francisco, Calif., writes:

(Q. 1.) Is there any method which can be used for reducing the antenna effect of a "B" eliminator.

(A. 1.) A fixed condenser placed in series with the ground will prove effective. In some cases it may even be necessary to reduce the length of the regular aerial or disconnect it entirely. The provision of a counterpoise may sometimes be necessary. Disconnect the regular aerial and ground and connect the counterpoise to the ground binding post. This will give a slight condenser effect between the lighting circuit and counterpoise, thereby increasing the selectivity. Sometimes it will simply be necessary to move the eliminator away from the receiver as the signal may be transferred by induction. Sometimes it will be helpful to provide a radio frequency choke coil in series with each output line of the eliminator with by-pass condensers placed between each output terminal and the B negative. This will isolate the R.F. currents and prevent them from getting into the plate circuits of the tubes.

Coil-Winding Information

(33) Mr. M. Galane, Brooklyn, N. Y., writes:

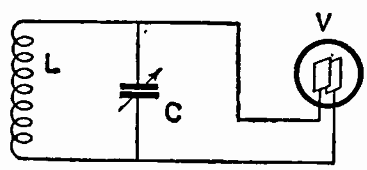
(Q.) "I would be obliged to you if you could tell me how many turns to place on a 2-inch tube for the primary and secondary, using litz wire (equivalent to No. 25 B. & S. gauge, containing 20 strands of No. 38 wire) when a 199 tube is to be used with a .00035-mf. condenser.

"Also please give me the constants for No. 22 D.S.C. wire for the same tubes and tubing. I've walked all over New York City and can't find coils for the 199s, as they don't make them any more."

(A.1) A coil to be incorporated in a set using 199-type tubes, and covering the broadcast band, may be wound with a secondary of 98 turns of the litz wire you describe, on a 2-inch tube. The primary size depends on the type of stabilizing and the type of circuit in which the coil is to be used. If a "losser" control is used, such as a resistor in the plate lead, the primary should contain about 15 turns or in some cases, more. In sets of the neutrodyne or similar types, a primary of about 20 turns may be used safely, without making the set unstable. If a *tapped* primary is used for neutralizing, the complete primary should contain 40 turns with a tap at the 20th turn.

In the aerial circuit, it may be advisable to use a somewhat smaller primary in order to make the set sufficiently selective.

(A.2) If No. 22 double-silk covered wire is used in place of the litz wire, the secondary should contain 108 turns. The primary is wound according to the instructions given above and depends on the type of balancing used.



A neon lamp connected to a resonant circuit indicates, by lighting, the flow of current which creates voltage across the plates of the condenser and the ends of the coil.

A.3) Tuned radio-frequency coils designed for the 201A-type tubes are quite satisfactory for the 199s in most cases. The 201As oscillate more easily than the smaller tubes and, if losser methods of oscillation control are used, the efficiency of the amplifier might be poor when using the 199s. However, if the primary is increased slightly in size, this trouble will be overcome.

If the set is a neutrodyne or uses a similar method of oscillation control, no changes are necessary; the same coils will be quite suitable.

Using Small Neon Lamps

(34) Mr. D. Stanton, Superior, Wis., writes:

(Q.) "I have recently purchased several small neon tubes with small semi-cylindrical plates. These tubes are not very satisfactory for television receivers because of the small size of the plates. I wonder if they have any other practical purpose? Can you help me to put these tubes to some use?"

(A.) The radio experimenter will

find a number of uses for the small neon tubes which were placed on the market recently. A circuit using one of these tubes with a coil and a variable condenser for use in testing a set for oscillation; it may be used also for testing the oscillation in a superheterodyne set. If the tube lights when the condenser and coil are in tune with the oscillator, the oscillator may also be considered to be operating correctly. By calibrating the condenser with a regenerative receiver when tuning in various signals and then making the detector oscillate, the unit may be used as a wavemeter. When calibrating the unit, the regenerative receiver should be tuned to different stations and the wavelength of each noted on the scale of the condenser of the neon unit.

Another use for the neon lamps is in testing "B" power units. If the power unit is working, the tube will glow when connected across the maximum terminals. In this case the tube replaces the usual high-resistance voltmeter required to test these units. By connecting one of the lamps across the terminals of a "B" power unit, a constant indicator that the unit is connected to the power lines will be available. The neon lamp can then be mounted in a prominent place to show when the set is "on" or "off."

Audio-frequency transformers can be tested, by connecting a neon tube, in series with the winding, across the terminals of a "B" power unit or other source of high potential. These small lamps will not glow with less than 150 volts of direct current or 100 volts of alternating current.

The neon lamp makes also a very handy polarity-indicator for high-voltage direct-current supplies. When the lamp is connected to a source of sufficient D.C. potential, the electrode connected to the *negative* terminal will glow; while the positive side will remain dark. When it is connected to an A.C. supply, both sides will glow, so that this phenomenom can also be used when there is doubt as to the type of current supplied to a certain house.

By connecting the lamp with 150 to 200 volts of direct current, it may be made to flash periodically by placing a condenser across and a resistor in series with the line. A change in either the capacity or resistance will change the period of the flash. When either the capacity or the resistance is constant, the value of the other can be determined by comparing its "flash period" with that of a resistor or condenser of known value. There are also a number of other uses for these lamps which will occur to the individual experimenter. These lamps may be used wherever a high-resistance indicator is needed for testing purposes, because of the extremely small amount of current consumed by the lamp. This value is about 4 milliamperes at 110 volts A.C.

In using the tube for testing the capacity of condensers, use a variable resistor of about 0-500,000 ohms and connect it in one of the leads to the neon tube. Then adjust it until the tube flickers in and out at a slow, steady rate with a condenser of known capacity connected across the two terminals of the tube. Replace the condenser with the one of unknown value and note the difference in the flickering speed.

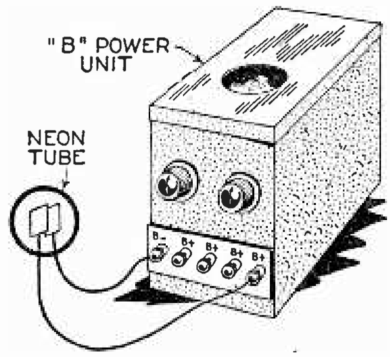


Fig. 17

These small neon tubes can be used for experimental television reception by mounting several of the tubes in a line so that the entire space between the inner and outer holes of the spiral is covered. In this way a much larger image can be obtained than by using only one. The tubes should be all connected in parallel and the two wires connected in the usual manner to the set.

Choice of Speaker

Wm. Pitt, Brooklyn, New York, asks:

(Q. 1.) I would like to know whether it would be better to use an electrodynamic speaker or the more common magnetic speaker?

(A. 1.) The electrodynamic speaker will give considerably better quality, especially when great volume is delivered. The volume produced by either type with a given input is about the same. One of the reasons why better quality is obtainable with the moving coil type speaker (as the electrodynamic speaker is often called) is that it is capable of producing pure low notes at frequencies below 100 cycles, which speakers with iron armatures cannot do. Furthermore, the iron armature speaker delivers a considerable part of the input energy at harmonics of the input frequency, especially with large volume. The mass and the elasticity of the iron armature mechanism also causes resonant distortion.

High-Frequency Filament Supply

(35) Mr. A. H. Murray, Rochester, N. Y., writes:

(Q.) "Can you give me some data as to how I may step up a 6-volt 60-cycle current of four or five amperes to radio frequency? I believe that the Fansteel Company uses such an arrangement in their new radio receiver. If details cannot be given, I will be satisfied with an idea of how to proceed, so that I will be able to do some experimenting along this line?"

(A.) Most A.C. receivers produce a small amount of hum, even though care is taken to prevent this. The 226-type tubes cause a considerable amount of hum unless they are carefully balanced, and even the 227s with isolated heater-filaments are not absolutely free from hum. The "A" power units used to electrify battery-type sets are practically hum-free, if properly constructed, but they are affected by changes in the supply voltage. Series-filament arrangements have been used with some success, but radical changes must be made in the wiring of the set for such a method of supply. Other complications, such as audio feed-backs, are also encountered and are often hard to eliminate in sets of this type.

One method of overcoming these difficulties has been utilized by a radio manfacturer, to change the rate of alternations in the supply voltage from 25 cycles or 60 cycles to a *frequency above the audible range*. In this way, ordinary battery-type tubes can be operated from an alternating-current supply without noticeable hum. A frequency is chosen above the audible band but not high enough to cause interference in the radio frequencies. Such high-frequency currents are produced by a 250-type tube, which is supplied with current from an ordinary high-voltage "B" power unit, using 281-type rectifiers.

The 250 tube is connected as an oscillator with a suitable coil arrangement, using either very thin laminated iron, iron filings or air only, even, in the cores. An ordinary oscillator circuit, such as the Hartley, is used and suitable coils are coupled to the oscillator inductor to light the filament of the tubes in the set. The tubes are connected in the usual parallel manner.

Offhand, one would not suppose that a 250 tube can supply sufficient current to light the filaments of the tubes used in a radio set; but it must be remembered that the plate current of this tube is almost 25 watts at maximum value and the current required for the filaments of an average 5- or 6-tube set, rarely exceeds 12 watts. The frequency of the current does not affect its ability to light the filaments as long as there is sufficient current, and a suitable oscillator arrangement can be made to supply current.

The power tube or tubes in the receiver can be operated from the usual 110-volt-primary, step-down transformers; since very little hum is noticed when these tubes are operated on the 60-cycle supply, and this lightens the load on the oscillator even more. The transformer must be specially constructed, as mentioned above, and no information is available as to the construction of a filament transformer of this type. If the system is to be tried out, the experimenter will have to try different core arrangements, etc. No one except an amateur familiar with transmitting work and R.F. currents of some magnitude should attempt it.

Another point which must be considered is the control of the filament supply. This may be accomplished by controlling either the filament voltage or the plate voltage in the oscillator tube; it might be varied also by adjusting the value of the grid leak on the oscillator. The filament current for the 250 oscillator tube in manufactured power units is supplied from a special filament winding on the power transformer; which supplies also the plate current for this tube and the other tubes in the receiver.

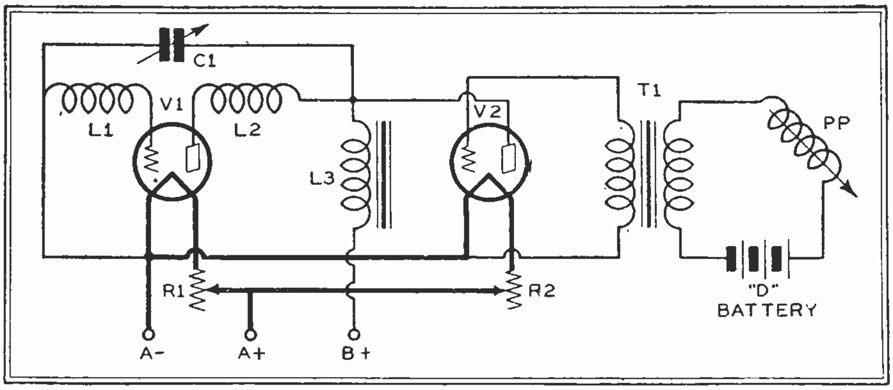


Fig. 14

Set Tester

With the universal use of gang condensers comes the need for an easy method for balancing. Being able to tune in a few high-powered broadcast transmitters helps materially in such work, but the majority of experimenters are not so fortunate as to have this class of station on a number of wavelengths in the immediate community. So the need arises for some simple piece of apparatus that will produce a strong carrier wave on any desired wavelength. The apparatus required for the set tester may be found in all experimenters' junk boxes. Now, referring to Fig. 14, we will run through the parts. The most important piece of apparatus is the condenser C1, of a capacity of .00035 mfd. This condenser should be well constructed, as the plate potential is across it and a breakdown or shorted plate will ruin the "B' battery. The inductance L1 and L2 are wound on a 3-inch form with No. 22 d.c.c. wire. L1 consists of 32 turns, while 34 turns are wound on L2. Both these wirings should be in the same direction. The audio choke, L3, may, on account of the small plate current, be the secondary of an audio transformer. No matter if the primary is burnt out, so much the better, as we will not be tempted to remove it for some other experiment. The two tubes are of the 199 variety, with 30 ohms each in R1 and R2. Either a modulation transformer or a good low-ratio audio transformer is needed for T1. The phonograph pick-up, PP, is used to obtain a source of tone in the shape of phonograph reproduction to modulate our test oscillator. Battery D will have to be experimented with, as its correct value will depend on the type of pick-up used at PP. Three dry cells will do nicely for the "A" battery, and from 60 to 90 volts for the "B" is plenty. Now that we have the set tester built and all ready for operation, let us make sure that V1 does actually oscillate. Tune a broadcast receiver on any station near the middle of the dial. Light up V1 and V2 and tune C1 slowly from its minimum to its maximum setting. As the tester passes through the frequency band that the receiver is operating on, a loud squeal will result, providing V1 is oscillating. Imagine that the squeal has not developed; all right, that is simple; reverse the winding leads on L2 as shown in Fig. 15. This time the squeal will be heard.

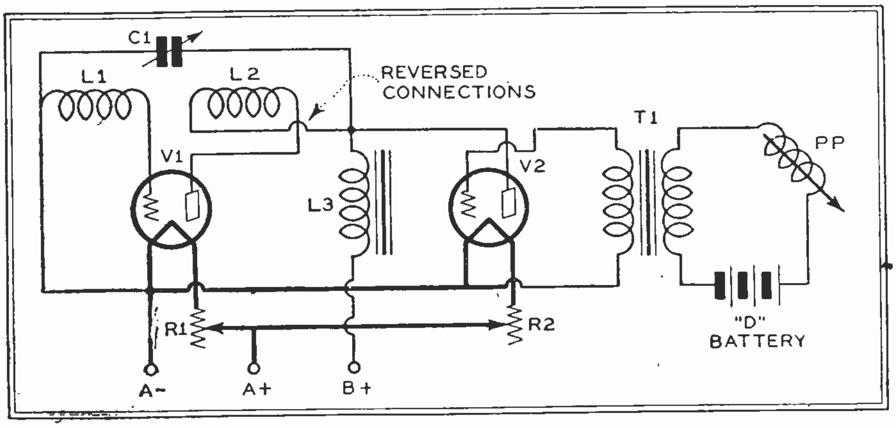


Fig. 15

So now the tester is ready for calibration. Mr. Brennan has explained thoroughly how this is accomplished in his construction article of the modulated oscillator. For those who have not the February issue of *Radio News*, we will repeat what he said on this subject. "Calibration of an oscillator is not as difficult as it sounds. The procedure to be followed for the broadcast band of frequencies will be explained. A simple one-tube regenerative detector is all the accessory needed. Insert the broadcast coil in its mounting, place the 'tester' near the regenerative detector and then turn on both the detector and the 'tester.' Begin at the high end of the dial. When a station is tuned in, determine its identity and wavelength. Usually this is possible by listening for the station's call letters; by referring to a newspaper or current call book, for the wavelength, the frequency equivalent may be obtained. Now, without moving the dial of the detector tuning condenser, rotate the dial of the oscillator. As resonance is approached a high-pitched squeal (referred to above) will start gradually coming to a beat note and then back to the high pitch. The beat note or the point midway between the two high-pitched squeals is the point to be noted and this is the wavelength, on our 'tester,' that the broadcast station is using. Mark down the

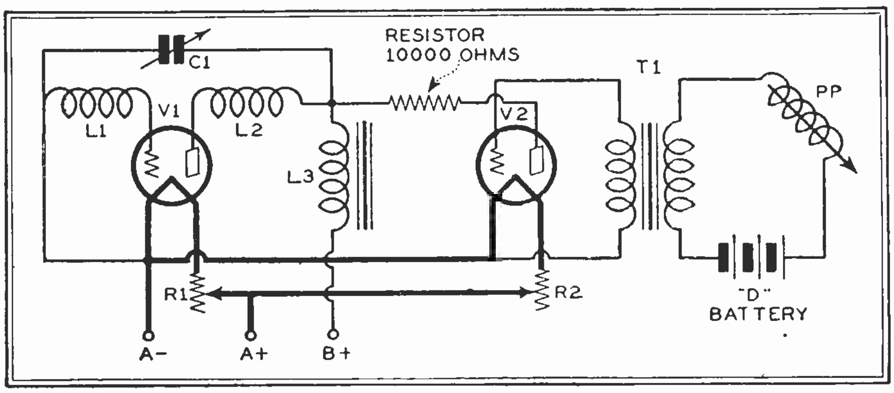


Fig. 16

dial reading of the 'tester' tuning condenser carefully, continuing the calibrations on as many broadcast stations as possible. Having a number of wavelengths for our tester, it is now ready for the pick-up, PP, to be used. This pick-up may ordinarily be of the phonograph type. Adjust the tuning condenser C1 to a wavelength on which there is no broadcast operating, set the phonograph going and enjoy the thrill. The plate voltage of the tube V2 may be too high, which will result in distorted transmission. This can be rectified by inserting a 10,000-ohm grid resistor as shown in Fig. 16. A unit of this type will prove its worth for neutralizing receivers, testing sets for over-all amplification at the high, medium and low wavelengths. As experience is gained with the operation of the set "tester," various tests will suggest themselves to the experimenter."

Simple Screen-Grid Shielding

Constructors who, in their experiments with the screen-grid tube, have found shielding absolutely essential for best results, will appreciate this wrinkle, which is extremely simple and yet makes as good a shielding job as can be done with more elaborate material.

It is simply a matter of wrapping the tube to be shielded with heavy tinfoil or leadfoil. This is held in place with shellac or a similar preparation. When curving the foil about the top of the tube a much neater effect may be obtained by slitting the foil to avoid wrinkling. A lug is left at the bottom to fit over the "F—" prong of the tube, thus grounding the shield. Care should be taken to cut out sufficient foil about the cap of the control-grid to avoid grounding it.—*Contributed by Charles E. Hammer.*

Reduction Trolley Line Interference

(36) Mr. P. Van Doorn, Newark, N. J., writes:

(Q.) "My home is located on a street which has a trolley line on it. For several years I have been bothered by interference from these trolleys and I have spent a lot of time erecting aerials of all types and in all available locations, without being able to overcome the trouble. To be more specific, whenever a car approaches within several blocks of my home, a terrible crackling noise is heard. This continues until the car has passed to a point of several blocks on the other side, when it gradually fades out.

The reception is then very clear until another trolley car approaches. The trouble cannot be due to my set, as I have used several receivers during the time that I have been in the present location and the interference was encountered on each. It has occurred to me that the noise might be reduced by using a ground connection separate from the water pipe. Since the use of aerials placed at right angles to and as far away from the street as possible have only reduced the noise slightly. I believed that the ground may be partly at fault. My reason for believing this is that the water main runs under the tracks and the water pipe from my house runs directly to this main. I wonder if a ground

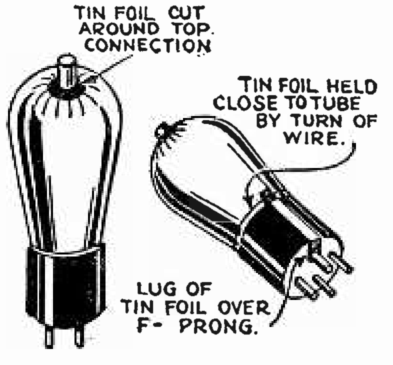
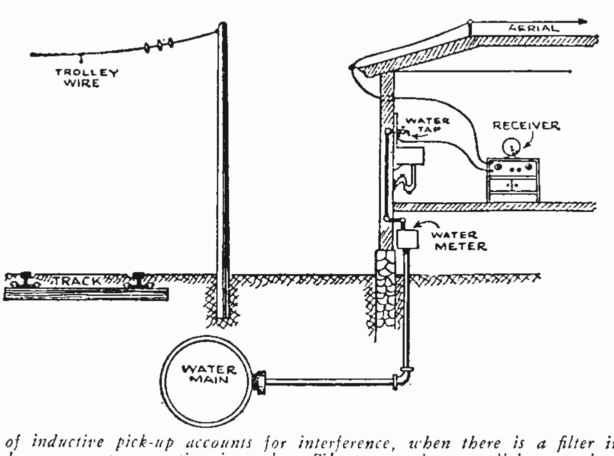


Fig. 18

made by driving pipes into the ground in the back of my house would reduce this interference?"

(A.) It would not be possible to say exactly just what effect the new ground connection would have on the volume of the interference. However, we believe from your description that the use of the ground that you mention would cause a considerable reduction in the volume of the noise. We base this statement on the fact that the usual ground connection is not really at ground potential. If a ground connection is not at zero potential, a potential difference may exist between the two circuits connected to ground.

In this way, a voltage might be set up in the receiver from the trolley and this would be heard in the set as a crackling noise similar to static. By placing the ground connection as far away from the source of this interference as possible and making the connection as perfect as possible, the interference may be either cut out or reduced very much. In making the connection, we would suggest that you drive pipes in the ground as deeply as possible in order to reach the moist earth. The various pipes should be connected together and be used as the



The phenomenon of inductive pick-up accounts for interference, when there is a filter in the light-line; or even when no house-current connection is made. The water pipe, parallel to track and trolley wire, may cause this disturbance to become very strong. A separate ground should be devised in this case.

Grid Leaks

(37) Mr. J. M. Johnson, Andover, Mass., writes:

(Q.) "What is a 'grid leak,' and why is it used in the grid circuit of the detector tube of my set? I should think that a resistance in the grid circuit of the tube would have a tendency to reduce the volume of the music. Will you please explain the reason for its use?"

(A.) A grid leak is a high resistor, connected between the grid terminal of a detector tube (or an amplifying tube) and some part of the filament circuit of the tube. Grid leaks are usually rated according to their resistance in megohms or in fractions of that unit; the megohm is equal to 1,000,000 ohms. One of the chief difficulties with grid leaks has been the uncertainty of their resistance.

Many kinds of grid leaks have been used; the original type consisted of pencil marks on a piece of paper between two contacts. Naturally this type of grid leak was affected by moisture in the air and changes of temperature. A more recent type is made of a piece of fibre impregnated or coated with some form of carbon, mounted in a short length of glass tubing, and fitted with metal ends, which make contacts with two spring clips. Leaks of this type are quite satisfactory, if they are air-tight so that moisture cannot enter.

The most recent type of grid leak consists of a piece of glass tubing, on the inside of which has been deposited a layer of resistant metal, which acts as the conducting medium. Another variation of this metallic type has the coating on a piece of insulating compound inside the tube. The resistance of these grid leaks is much more constant than that of other types and, by carefully watching the amount of metal deposited, the resistance values can be made much more accurate.

Grid Leaks and Detectors

The purpose of the detector's grid leak is to assist in the control of the "grid bias" of the detector tube, and also to allow dissipation of the excess negative charges (electrons) that accumulate on the grid of the tube. Although detection can be obtained without a grid leak, by correctly biasing the detector tube, this method is not nearly as sensitive as the grid-leak method and, for this reason, has not gained much favor.

The proper value of the grid leak depends both on the type of tube employed and on the strength of signal being received. It also depends, to some extent, on the tendency of the receiver to oscillate. When very weak signals are being received, a very high-resistance leak should be used, in order to get the greatest amount of volume. However, when loud signals are received, a rather low resistance must be used to maintain good tone quality. From this explanation, it can be seen that a compromise value must be chosen, to give good quality and sufficient sensitivity. A variable grid leak may be used; but most of them are unsuitable because of their tendency to make the set noisy, and set owners usually try to avoid adding another adjustment. If the grid leak has too high a resistance, the receiver will howl and block without much provocation. The blocking is indicated by a series of popping noises either fast or slow, depending on the value of the leak and the other constants of the circuit.

If the resistance of the grid leak is too low, the distant stations will be weak, or entirely absent. It may also be found difficult to make the set regenerate and, when the regeneration point is reached, the set will suddenly drop into oscillation.

With the "hard" tubes (such as the 201A, 199, and 112A) a grid leak with a value of between 2 and 5 megohms will usually be found satisfactory, at wavelengths in the broadcast range. The gaseous tubes (of the 200A type) will also use a value within this range; while the old-style soft tube (similar to the UV-200) required a value of about ½ megohm. However, the best value for the grid leak in a particular receiver can only be found by experiment.

Grid Leaks in Amplifiers

Grid leaks, or grid resistors, are used also in amplifiers of certain types. In the choke-coil- and resistance-coupled amplifiers, in which the stages are coupled through transformers, the grid must be supplied with the correct bias. In order to keep the "signal" (A.F. or, sometimes, R.F.) in the correct channel, it is necessary to use an arrangement which will allow the direct-current potential of the "C" battery to be placed on the grid, but will not short circuit the signal current. This may be accomplished by the use of either a choke coil or a resistor of the correct value. Since the latter is much simpler and cheaper, it is used more frequently.

The bias applied to the grid is determined by the value of the leak and method in which the resistor is connected to the filament circuit. If it is connected to a "C" battery, the biasing voltage depends on the potential of this battery, of course, as well as on the resistance of the grid leak. When the grid return is connected to the negative terminal of the filament circuit, the bias is derived from the "A" battery, and it is necessary to use the correct resistance in the grid leak in order to have the tube correctly biased. The latter method is often employed in the first stages of an amplifier where the grid voltage does not have to be very high.

Measuring Resistances

Every radio experimenter, at some time in his experience, finds it necessary to measure the values of fixed and variable resistors. A certain resistance may be required for a circuit, and although any number of variable and fixed resistors may be found in the "Junk Box" they cannot be used unless the exact resistance value is known; or unless some means is devised to find the correct point on the scale (in the case of a variable resistor). Mr. J. F. Goldman, Boston, Mass., raises the question again, in a letter addressed to this department. Mr. Goldman is building a new power-operated receiver, and intends to use resistors for the "C" bias. He has a number of variable resistors on hand, but does not know the point on the scale at which the correct resistance will be found. He inquires as to a method of determining this point.

Very few of us possess a resistance bridge, and although it is possible to make one of these units at home, it is a rather difficult task to calibrate it. Also, it would take considerable time, and for this reason it is impractical for our purpose. However, there is a simple way of measuring resistance values which uses the equipment found in almost every radio experimenters' kit. This system makes use of a voltmeter and a milliammeter in conjunction with a battery of the correct size. The voltmeter should be one of the high-resistance meters employed for testing "B" power units. The milliammeter should have a scale of about 0 to 100 milliamperes.

One of the three well-known versions of Ohm's Law states that the resistance in ohms is equal to the voltage divided by the current in amperes. If we connect our voltmeter and milliammeter to a resistor and "B" battery of about 20 volts, as shown in Fig. 1, we can use Ohm's Law to show the resistance value. Suppose we take a particular case such as required by Mr. Goldman. If the voltmeter shows that the "B" battery has a voltage of 20, and the current flowing through the milliammeter is 10 milliamperes (.01 amperes), then the resistance value is 2,000 ohms. This conclusion is reached by dividing 20 by .01. Since the current flowing through the current meter in our circuit registers thousandths of an ampere, we can change the original equation slightly and simplify the calculation. This is done by multiplying the voltage by 1,000 and dividing this figure by the current in milliamperes. In the above example, we would multiply the voltage, which is 20, by 1,000 (which equals 20,000) and then divide by 10 milliamperes, giving the same result—2,000 ohms.

Almost any value of resistance can be measured in this way by using the correct size of battery. The question may arise as to what would be done if the resistance that we are testing had such a low value that the pointer on the milliammeter moved beyond the scale. It is merely necessary, in this case, to reduce the voltage of the battery or use a smaller battery, so that the meter will remain on the scale.

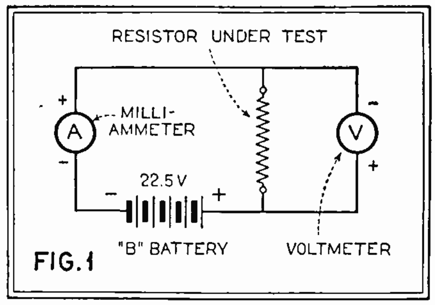
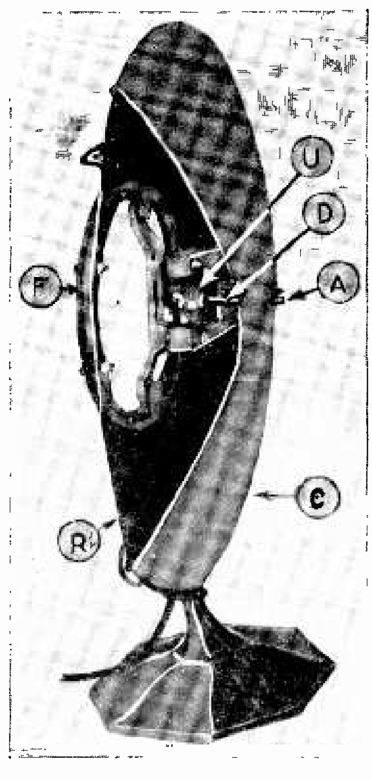


Fig. 19

In connecting the meters to the resistor and battery, as shown in Fig. 1, the connection between the milliammeter and the resistor should be left off, until we are ready to make the test. Then it should be touched lightly to the resistor, to be sure that the milliammeter is not injured because of too much current passing through it. We can also tell, from this test, if the resistor is short-circuited.



The interior construction of a modern cone loud speaker.

Methods of Obtaining Suitable Screen-Grid Voltage

THE theory of the screen-grid tube is now fairly well understood and many manufacturers and experimenters are engaged in a race to see what heights of amplification can be reached. Various circuits and shielding plans have been evolved, but one arrangement has remained unchanged, *i.e.*, the method of obtaining the positive bias on the screen-element.

The standard method has been to take off a tap, somewhere along the plate battery. This plan is very good, so long as the various batteries maintain constant terminal voltage; but consider what will happen after the set has been in use for some time and one or more of the battery units deteriorates. A set of screen-current and plate-current curves (plotted with fixed plate voltage and variable screen voltage, or with fixed screen voltage and variable plate voltage) will serve to show the difficulties which are sure to result if the ratio between the plate and shield voltages is not maintained within certain limits. It is true that this ratio is not extremely critical; but any service man can assure you that it is not at all unusual to find two identical batteries, connected in series for the same length of time, whose voltages differ as much as *ninety per cent.*

In addition, this method requires an extra lead, which must be brought out of the set through the already-crowded filter system and cable.

Why not, then, make some arrangement whereby we can obtain this screen voltage *inside* the receiver and, at the same time, maintain a fixed ratio between screen and plate voltages?

Use of Series Resistor

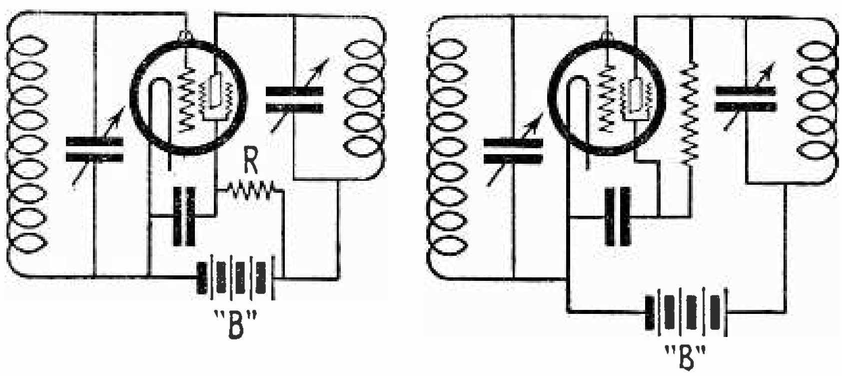
Such a system is shown in Fig. 1. Here we are using a simple series resistor, R, to reduce the full plate voltage to the value required for the screen. Now, if the plate voltage varies for any reason, the screen voltage will also vary *in almost direct proportion.* In addition, we no longer require the extra screen-voltage lead to our batteries.

Since the ratio between plate and screen voltages is not extremely critical, it is evident that the size of the series resistor will not be critical and our work is simplified; since we can use a resistor of the standard size nearest to the indicated value.

For example: Curves of screen current and plate current show that the screen current will be approximately 0.18-milliampere, with a plate voltage of 135 and a screen voltage of 45. Assuming that these are the values we are to use in the circuit, it is evident that the series resistor must be of such size that the voltage drop across it, due to the screen current, will be sufficient to reduce 135 volts to 45 volts. In other words, the drop across this resistor must be 135 minus 45, or 90 volts.

Then, applying Ohm's law:

$$R = \frac{E}{I} = \frac{90}{.00018} = 500{,}000 \text{ ohms.}$$



Figs. 1 and 2 show alternative methods of insuring automatically a proper voltage between screen-grid and plate. The latter is somewhat easier mechanically.

Since this can be supplied by a standard size of metallized resistor, capable of carrying safely far more than .018-milliampere, see how simple our problem has become. It is possible in most cases simply to connect this resistor between the plate and screen-grid posts of the tube socket, as shown in Figs. 2 and 3; although, theoretically, it would appear that the arrangement of Fig. 1 is better. This, perhaps, is a question whose answer depends on the remainder of the circuit and the voltages used.

The shielding system of the receiver, usually, forms the negative filament return and, where this is the case, it is customary to simply ground the screen-grid by-pass condenser to this shielding system. However, care must be taken to *make all ground connections at the same point on the shield.* If this is not done, circulating currents will be set up in the shield and undesired coupling effects will almost certainly result.

It will, of course, be evident that this same arrangement may be used to obtain the *positive bias for the inner grid,* in any space-charge-grid A. F. amplifiers.

Coil Construction

(38) Mr. W. E. Wilson, Pelham Bay, New York, writes:

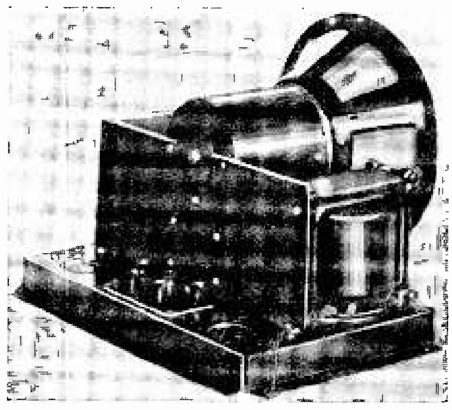
(Q.) "As a constant reader of your radio magazine for the past five years I would be very much obliged if you could tell me how many turns I should put on a 2-inch tube for the primary and secondary using Litz wire, 20 strands of number 38 wire which is equivalent to number 35 D.S.C. B & S gauge, for UX199 tubes. A .00035 tuning condenser will be used.

I have tried in all the local stores, but I can't find coils for 199s as they do not make them anymore, so I would appreciate if you would send me the above data. If there are any special precautions to be taken when using 199s I would also like you to tell me, so that I can get the best results with my set."

(A.) In winding a coil with Litz wire, the equivalent solid wire may be used as a base for figuring the number of turns required to cover a certain wave band. In the case mentioned above the secondary would be wound with 90 turns in order to cover the wavelengths between 200 and 550 meters. The size of the primary depends on the method of balancing or stabilizing the circuit. In using UX-199 tubes, a larger primary can be used than with the UX201A type. This is due to the latter type of tube oscillating more freely than the smaller type. With a tube that does not oscillate very freely, a greater amount of coupling can be used without difficulty.

In a set using resistors for suppressing the oscillation, a primary of about 18 turns can be used. In sets of the neutrodyne and similar balancing methods, a primary of up to about 22 turns can be employed with no difficulty, while if no balancing or suppression is used, the primary must be smaller; about 12 to 15 turns. It is advisable to bunch or slot wind the primary in order to keep the capacity between the two coils at a minimum.

In making a set with the UX199 tubes, no special precautions need be taken, except the usual need for short leads in the grid and plate circuits and the placing of the coils in such a way that there is a minimum of coupling between the succeeding stages. The apparatus used in the set should, of course, be the best obtainable, in order to get the best satisfaction.



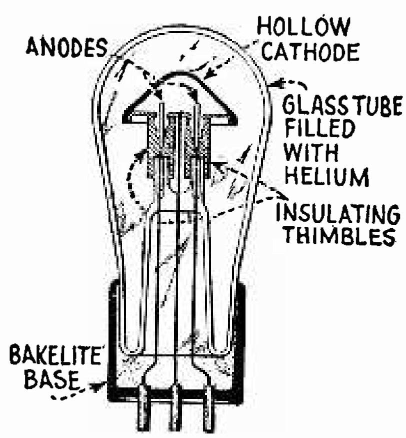
A typical commercial Dynamic Loud Speaker

Gaseous Rectifier

(39) Howard Clyman, White Haven, Pa., asks:

(Q.1) If possible would you kindly give me some information regarding the construction of a gaseous rectifier tube such as made by Raytheon and publish an ilustration of this tube?

(A.1) On this page you will find an illustration of a gaseous rectifier. This type of rectifier employs a glass envelope, a hollow cathode of tantalum, an anode, insulating thimbles and a base of insulating material. The tube or glass envelope is filled with helium, which serves as a carrier for the space current. The cathode is formed in two parts, the upper part comprising a conically shaped element, and the lower part a cover which fits the open end of the cone. A portion of each insulating thimble is spaced from the anodes a distance materialy less than the mean free path of the electron present and serves to prevent the passage of current between either anode and the outer surface of the cathode. Ionization is thus confined to the space enclosed by the

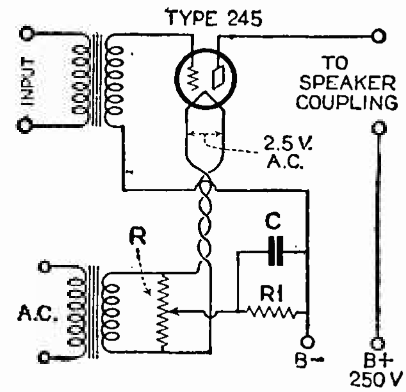


Above is a cross-sectional view of a gaseous rectifier such as that made by Raytheon and others. The glass envelope is filled with helium gas.

cone. In order to minimize the internal losses, the active portion of the cathode is coated with an alkaline substance. The cylindrical insulating thimbles contain circular recesses adjacent to the openings, which reduce the tendency of current to flow between the cathode and anode. In order to conserve the tantalum which is expensive, nickel pins are used coated with a thin band of the metal at the end and act as the anodes. Additional information concerning this rectifier will be found in the following United States patents: Numbers 1,679,449, 1,420,824, 1,617,171, 1,617,180, 1,499,-078, 1,617,172, 1,617,178, 1,617,181, 1,545,207, 1,617,174, 1,617,179.

(Q.1) What is the action which takes place in a gaseous rectifier. How is it possible to prevent the current from flowing equally in both directions?

(A.1) When potential is applied to the gaseous rectifier the gas atoms become ionized. Each atom now positively charged is attracted to the cathode or negative element from which it picks up another electron and returns to its original state, only to be re-ionized by collision with other atoms, and again to pick up an electron from the cathode. The electrons which are lost seek the positive terminal of the tube and hence a flow of electrons occurs from the cathode



C bias for the new 245-type power tube may be obtained from the "B" eliminator by using the drop across a resistor R1, as illustrated above.

to anode through the external circuit. If the anode and cathode are of the same dimensions, the current will flow equally well in both directions. However, by making one electrode small in comparison with the other, the positively charged atoms may readily strike one electrode and pick up electrons, while with the potential in the opposite direction their ability to strike the small electrode and secure the necessary electron is greatly diminished. The atoms in their attempt to do this collect around the small electrode and build up a positive charge which tends to repel the other atoms. A few, however, do strike the small electrode and cause a back or reverse current to flow. This back current, however, is now reduced to a negligible factor. In the full-wave rectifiers of this type, the two anodes are in the form of pins or points with one large cathode. The two anodes are so constructed that alternately one and then the other passes current, resulting in full-wave rectification.

(Q.2) What determines the life of a gaseous rectifier?

(A.2) The life of a gaseous rectifier depends upon several things. The purity of the gas employed, the amount of gas introduced into the tube or gas pressure, the removal of impurities from the materials of the rectifier, all play an important part in the tube's life. The surface of the electrodes are also guarded against being ripped apart by the bombardment of the gas atoms. The applied voltages and the current passed also help to determine the life of the tube.

C Bias for Type 245 Tube

(40) R. H. Bowker, Greenwich, Connecticut, writes:

(Q.1) I intend to use one of the new 245 power tubes in the last stage of my power amplifier, lighting the filament from an A.C. source. I will use the maximum plate voltage of 250 and would like to know how I may secure the proper C bias.

(A.1) Doubtlessly this query will interest a large number of radio fans, as there are many who will desire to change their present equipment and substitute the new power tube for the 171 or 171-A, which is now employed in the last audio stage. The schematic diagram reproduced here shows the correct manner in which to use the new 245 type power tube. The resistor, R, which is placed across the secondary of 2.5 volt filament transformer should have a variable center tap and preferably a resistance of 40 to 60 ohms. The C bias can be secured by connecting a 1,500-ohm resistor between the grid return and the center tap of the filament transformer resistor. This is designated in the diagram as R1 and is by-passed by a condenser, C, having a capacity of 2 to 4 mfs. The grid return is connected to the B— and thus the bias is secured by the plate current drop through the resistor R1. It must be remembered that when using this method for obtaining C bias, the plate voltage available will have to be 300 volts, in order to allow 250 volts for the plate potential and 50 volts negative bias for the grid of the tube. If the plate voltage available is less than 300 volts, the bias is probably best secured by means of a C battery.

If the C bias is secured by using the drop across a resistor, it will necessarily be subtracted from the plate voltage available. The center tap of the resistor can be adjusted until A.C. hum is eliminated, and the grid and plate voltage can be correctly adjusted with a 50 milliampere milliammeter in the plate circuit, if there is any doubt as to their value. If the needle is deflected downward, the C bias should be raised or the plate voltage lowered. If the needle kicks upwards, the plate voltage should be increased or the grid bias reduced.

Tube Brilliancy

(41) L. T. Gerschwin, Cedar Rapids, Iowa, asks:

(Q.1) I noticed that my 227 detector tube varies in brilliancy even when the voltage remains constant. Is this an indication of a defective tube?

(A.1) Occasionally it happens that the 227 tube does not always glow with the same brightness, even though there is no flucuation in the operating voltage. The filament of the 227 is pure tungsten which is threaded through an insulating material. At the top of the structure, the filament is exposed and may be seen through the top of the bulb. A slight difference in contact at this point results in the increase in the operating temperature, which in turn changes the brilliancy of the filament. As the filament is operated below the melting point of tungsten, this temperature variation does not affect the performance of the tube. The fact that a tube may glow brilliantly is not necessarily an indication that it is overloaded.

New Power Tubes

(42) Mr. A. H. Horlick, Cleveland, Ohio, writes:

(Q.) Some time ago in one of the local paper there appeared a description of a new power tube, that used a plate voltage of 250 as a maximum and had an undistorted output much greater than the usual 171 tube. I would like to build a power unit and amplifier with these tubes and there is some information that I would like to have before thinking further about such a power pack. In the first place, the description mentioned that the filament was different than the other power tubes in that a filament voltage of 2.5 is used. Is this correct and how much current is required to operate this filament? In using A.C. current for the filament supply as the article mentioned, what value of resistance would be required for the grid bias, using the common method of employing a resistor in the grid return for the bias. What grid bias is required when a plate voltage of 250 is used? What bias with 180 volts? Will it be necessary to use a special transformer to supply the 250 volts for the plate of this tube?

(A.) The new UX245 power tube is designed to operate with a plate voltage of 250 and supplied and undistorted output of 1600 milliwatts at this plate potential. This output is the same as the UX210 with a plate potential of 425 volts. The filament of the new tube is designed to operate from a 2.5-volt supply, either from a step-down transformer connected to the A.C. power supply or from a suitable battery. The filament current is 1.5 amperes.

The grid bias for the tube is—50 volts when a 250-volt plate potential is used. With 180 volts on the plate, the grid bias is—30 volts. This grid bias can be obtained through the voltage drop in a resistor connected in the grid return of the tube, in the usual way. A resistance of 1,500 ohms is required to give the correct grid potential.

In order to obtain the best results with the new tube, a plate voltage of 250 is required. The usual type of "B" power unit, using the Raytheon BH or the UX280 tube will not supply more than 180 or 200 volts when it is used to supply current to the rest of the set, or in other words, under load, and for this reason a number of new transformers are being designed by transformer manufacturers in order to supply the required 250 volts under load.

Radio Tubes

BACK in the forgotten years that we date B.B. (Before Broadcasting) when a radio tube was merely that and nothing more, the purchase of this important device comprised numerous steps, or stages, which eventually led up to the actual transaction. Mr. Experimenter, after many months of more or less satisfactory crystal reception, decided to obtain a vacuum-tube detector; the very thought of possessing this awesome instrument so thrilled him that he started saving for it at once. (Incidentally, radio apparatus, in those days, was not merely purchased; it was "saved for.") Through weeks of absence from the movies, and by the simple expedient of staying home on Wednesday nights, the ransom necessary to extricate the treasure from the clutches of the radio dealer was finally amassed. Then, on the long-awaited day, the prospective tube owner entrained for the city with imaginary bands seeing him off and spring very much in the air. His feelings as he got off the train and entered the store may readily be imagined; but the conversation which took place between him and the dealer is worthy of note. This conversation, it might be added, invariably followed fixed lines.

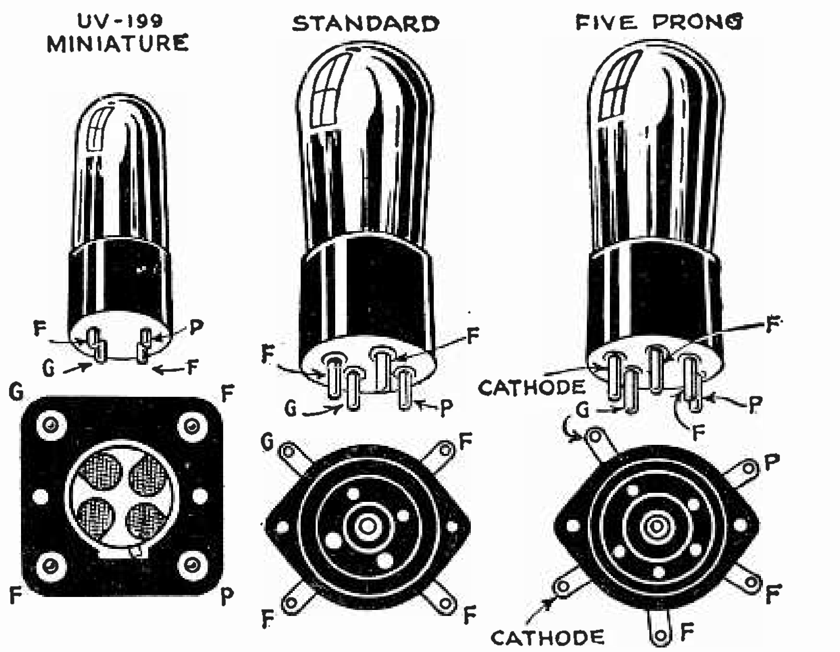
"Give me a tube," said the buyer, after he had been asked his wants. Doubtless, he was nervous and there was a touch of excitement in his voice.

"Right" was the terse reply of the dealer, as he reached back for the mysterious box, tested the contents, then wrapped it up and handed the precious burden to the thrilled radio fan.

And that was that! How times—and tubes—have changed!

New Tubes Galore

At the present time the customer may make his selection from nearly forty types, the most commonly used of which are produced in similar design under more than one trademark and type-number. The "general-purpose" tubes—that is to say, those which may be used both to amplify either R.F. or A.F. frequencies and as detectors—were until recently the only ones with which the set builder was familiar; even today tubes designed solely for the purpose of detection are comparatively little used. The increasing demand for volume and quality of amplification, however, compels the use of "power tubes"; which are adapted for use solely in the final stages of an audio amplifier where very high voltages and currents must be handled.



The UV base and socket (left) are now little used; the UX (center) is practically universal but for certain A.C. tubes which require the UY (right).

The introduction, however, of circuits in which "raw" or unrectified alternating current is used, to heat the filaments of tubes, has doubled the number of the tube types on the market. There were about a dozen "storage-battery" types with filaments designed to be operated from direct current only, in addition to the power tubes; which, by reason of their final-stage position, may be lighted by alternating current, when desired, without introducing undue hum. There are now over a dozen different types of A.C. tubes, which will be found listed in this article, with descriptions of their characteristics. The rectifier tubes swell the list with seven more types; and three tubes devoted to automatic regulation purposes have been produced to meet the condition of fluctuating line-voltage which made electric-set operation inconvenient in some localities.

Television has introduced two new families to the radio public; the television lamps (neon-gas glow-lamps) and the photoelectric cells. The latter, however, had been known for some time to scentists and engineers, though television interest has stimulated the demand for them and is working toward the improvement and mass production of these, as well as the television lamps. The latter, particularly, will be in great demand as television broadcasts are more generally undertaken. There are other tubes, such as the "grid-glow-relay" type and the oscillograph, which are of scientific and industrial use; but, as they are not suited to the requirements of the radio builder, they will not be described here.

In the description below of the "vacuum" tubes (including a few of the "gas-filled" (types) which are adapted to use in a radio receiving set or its power unit, the attempt has been made to present them in logical order, with a concise statement of the most important characteristics of each, its functions, its socket connections, its voltage and current requirements its plate resistance (impedance), amplification factor, and (in the case of the power tubes) its maximum undistorted output. The reader will find it to his advantage to keep this article at hand for reference when undertaking experimental or new constructional work.

General-Purpose Tubes

Under this head, as stated above, may be included most of the tubes of older design and those used in receiving sets of earlier models. With the specified voltages applied to their elements, tubes of any of these types might be used in all stages of a receiver.

Among the earliest tubes to find favor are four types generally known as "dry-cell" tubes, because of the low voltage and small current consumption of their filaments. The first two of these, the WD-11 and WX-12, are still in use, though seldom if ever specified in new construction. The table of their characteristics should be sufficient comment.

WD-11 and WX-12 Types

Use, detector-amplifier (not power amplifier);

Socket, WD-11, special; WX-12, UX-type;

Filament voltage 1.1; current 0.25 ampere;

Plate voltage 22½ to 45 as detector, 90 to 135 as amplifier; current 1.5 mla. at 45 volts, 2.5 mla. at 90, 3.5 mla. at 135;

Grid bias 4½ volts at 90 plate, 10½ at 135 plate;

A.C. plate resistance 15,500 ohms at 90 volts, 15,000 at 135;

Amplification factor 6.6.

The second pair of dry-cell tubes, the UV-199 and UX-199 types, have found more favor and more widely used, especially to obtain compact light construction. The two differ only in their bases; the first being designed to fit a special miniature socket, and the second adapted to the UX socket which is now standard. Both tubes are electrically alike; they function equally well in all receiver sockets, up to the limit of their current-carrying capacity; they have a companion, the UX-120 type, which is a true power tube, suited for the operation of a loud speaker. These tubes require three dry cells or a 4-volt storage battery for lighting their filaments (a 6 volt battery may be used with a suitable resistor) and draw but little current; as their filaments need be heated but moderately to give a heavy *electronic emission* and maintain a suitable path for the plate current.

X-199 and V-99 Types

Use, detector-amplifier (not power amplifier);

Socket, V-199, miniature; X-199, UX-type;

Filament voltage 3.3; current .063 ampere;

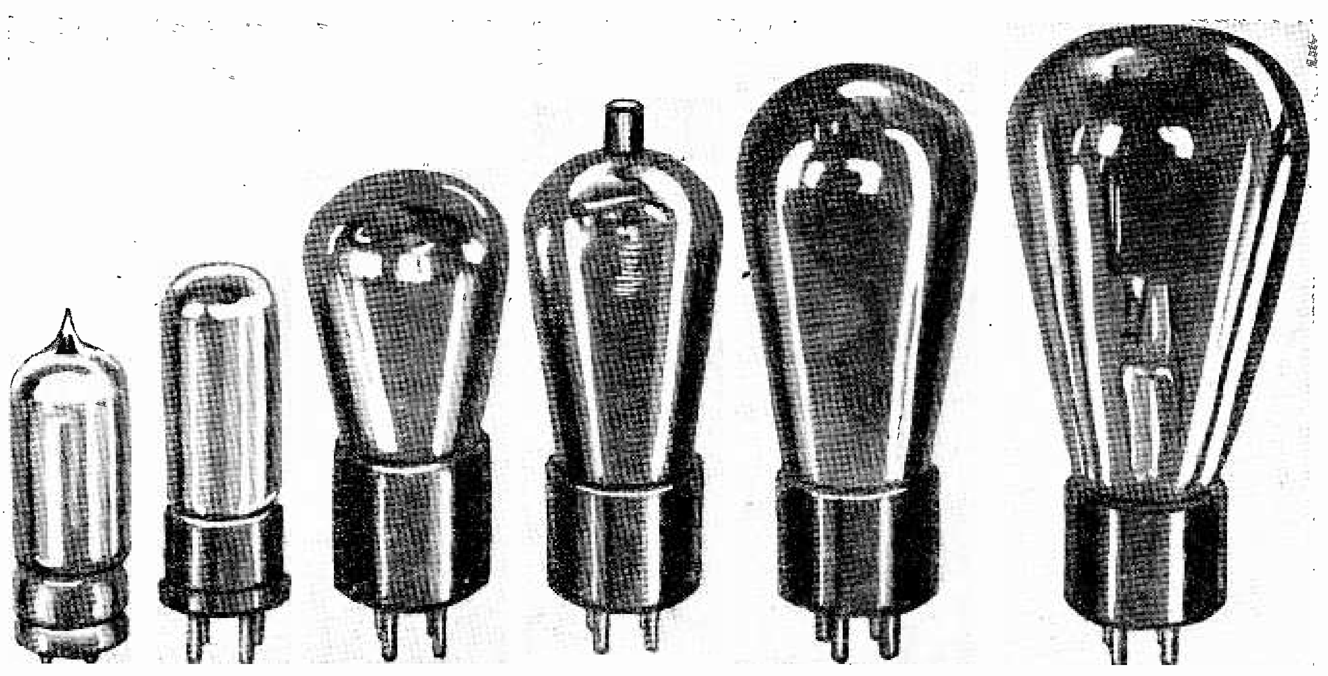
Plate voltage 45 as detector, 90 as amplifier; current 1.5 mla. as detector, 2.5 mla. as amplifier;

Grid bias, 4½ volts as amplifier;

A.C. plate resistor 15,500 ohms;

Amplification factor 6.6.

The 120-type, the earliest power tube, is a companion of the 199-type but is designed only for the last stage of audio amplification in a battery-operated receiver. It may be operated from either three dry cells wired in series or (provided a suitable resistor is in the filament circuit) a storage battery. A large grid-



Older members of the radio vacuum-tube family and their big younger brothers: the types are, from left to right, UV-199, UX-199, UX-201A, UX-222 (with control-grid cap), UX-210 and, last, but surely not least, UX-250, the giant of receiving tubes.

biasing voltage is absolutely necessary with this tube—22½ with 135 volts plate.

120-Type

Use, power amplifier (last A.F. stage);
Socket, UX-type;
Filament volts 3.3; current 0.132-ampere;
Plate volts 135; current 6.5 mla.;
Grid bias, 22½ volts;
A.C. plate resistance 6,600 ohms;
Amplification factor 3; undistorted output 110 milliwatts.

"Storage-Battery" Tubes

The 201A-type tube has been the favorite for all purposes for some years; it is the standard, all-around, flexible "storage-battery" tube of radio functioning with high efficiency in radio-frequency, detector and audio-frequency circuits. More tubes of this design, undoubtedly, have been made than all others combined. Though it can be used as a last-stage audio amplifier, with 135 volts on the plate and the proper grid bias, the 201A is not a power tube; its maximum undistorted output is but 55 milliwatts. It is listed, also, under manufacturers' type numbers, as "301A" and "AX." (Type numbers of other manufacturers were not obtainable at time of writing.)

201A and 201B-Types

Use, detector-amplifier (not power amplifier;
Socket, UX-type;
Filament voltage 5; current 0.25-ampere for 201A, 0.125-ampere for 201B;
Plate voltage 45 as detector, 90 to 135 as amplifier; current 1.5 mla. as detector, 2.5 mla. at 90 volts, 3.0 mla. at 135 volts, as amplifier;
Grid bias 4½ volts at 90 plate, 9 at 135;
A.C. plate resistance 11,000 ohms at 90 volts, 10,000 at 135;
Amplification factor 8; undistorted output 15 milliwatts at 90 volts, 55 at 135.

The 01B-type tube is identical with the 201A-type except that its filament at 5 volts draws 125 milliamperes (one-eighth ampere) instead of the customary quarter-ampere of the 201A-type. It was designed to answer the demand for a tube which may be used in series operation with rectified A.C. on the filaments. Because of the slight current drain of the 01B-type filament, it is possible to obtain from a rectifier of the 280 or 281 type sufficient current for a receiver using these tubes, provided they are wired in *series*. It is very essential that the proper grid bias be used with this tube whenever the plate voltage exceeds 40.

The characteristics of the K-type tube show it to be well adapted for radio-frequency amplification with the usual R.F. transformers employed today in T.R.F. sets. The use of this tube is recommended only in sets having adequate provision for re-adjustment of neutralization. Its plate resistance is almost twice that of the 201A type; its electrical characteristic differ from the latter principally in this matter.

Power Tubes

The 112-type tube, though engineered before the development of the A.C. receiver for storage-battery operation, may also be used with alternating current; though, as with all other tubes of D.C.-filament design, only when used as a power amplifier. This tube, however, though not classified by manufacturers as a general-purpose tube, functions with remarkable efficiency in any socket of the receiver. The present type, 112A, has a filament consumption reduced to a quarter-ampere at 5 volts; this type is manufactured, also, as F-12A.

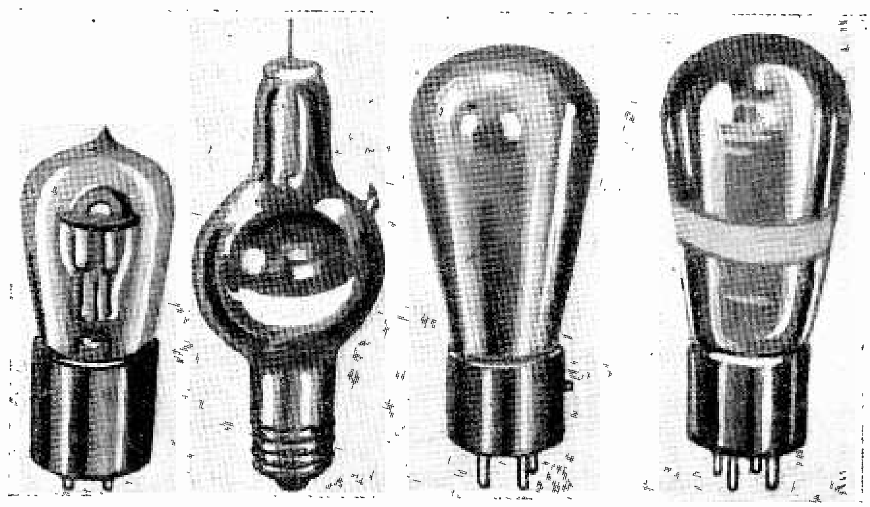
The 171A tube, perhaps, is the most popular power amplifier at the present time. It has an extremely low output impedance and is suitable for use in the last stage only. Since the plate current of this tube is exceptionally high at maximum voltage, some form of loud-speaker coupling, such as an output transformer or a choke coil and a by-pass condenser, should be used to prevent the heavy direct-current component from passing through the windings of the loud speaker. Alternating current may be applied directly to the filament of the 171A, only when it is used in the last audio stage. It replaces the old 171-type, which drew half an ampere of filament current.

112A-Type

Use, amplifier, power amplifier or detector;
Socket, UX-type;
Filament voltage 5; current 0.25 ampere.
Plate voltage 90 as amplifier, 135 to 180 as power amplifier, 45 as detector; current 5.5 mla. at 90 volts, as amplifier, 7 mla. at 135 volts, 10 mla, at 180 volts as power amplifier, 15 mla. as detector;
Grid bias 4½ volts at 90 plate, 9 at 135; 13½ at 180;
A.C. plate resistance 5,300 ohms at 90 volts, 5,000 at 135, 4.700 at 180;
Amplification factor 8; undistorted output 120 milliwatts at 135 volts, 300 milliwatts at 180.

171A-Type

Use power amplifier (last stage only);
Socket, UX-type;
Filament voltage 5; current 0.25-ampere (may be A.C.);
Plate voltage 135 to 180; current 16 mla. at 135 volts, 20 mla. at 180;
Grid bias 27 volts at 135 plate, 40½ at 180 (Note; When a power tube has A.C. filament supply, it is necessary to increase the grid bias by one-half the filament voltage, or 2½ volts here);
A.C. plate resistance 2,200 ohms at 135 volts, 2,000 ohms at 180;
Amplification factor 3; undistorted output 330 milliwatts at 135 volts, 700 milliwatts at 180.



Well-known rectifying tubes; left to right, gas-filled filamentless, gas-filled filament, half-wave (one-plate), and full-wave (two-plate) filament types.

Larger Power Tubes

The 210-type especially, because of its heavy filament-current requirement, is usually operated with alternating current from a special transformer secondary, direct to its filament, and is used in the last audio stage only. It is capable of handling far greater volume without distortion than any other receiving tube except the recently introduced 250-type. The high plate current of this tube makes a loud-speaker coupling device, such as those recommended for use with the 171A-type, a necessity. The filame of this tube is normally operated from the 7.5-volt winding of a step-down transformer, and draws 1¼ amperes.

The 250-type is the largest and most powerful power amplifier manufactured for radio reception, and capable of handling more than three times as much undistorted energy as the 210-

type. Obviously, while the new tube is capable of enormous output, it should be employed at but a fraction of its full capacity, thus securing undistorted output at all times with ample reserve power. The output of this tube must lead into a protective coupling device.

210-Type

Use, power amplifier only;
Socket, UX-type;
Filament voltage 7.5; current 1.25 amperes (usually A.C. from special winding);
Plate voltage 250 to 425; current. 12 mla. at 250 volts, 16 mla. at 350; 20 mla. at 425;
Grid bias 18 volts at 250 plate, 27 at 350, 35 at 425;
A.C. plate resistance 5,600 ohms at 250 volts, 5,000 at 425;
Amplification factor 8; undistorted output 340 williwatts at 250 volts, 925 at 350 volts; 1,540 at 425 volts.

250-Type

Use, power amplifier only;
Socket, UX-type;
Filament voltage 7.5; current 1.25 amperes (usually A.C. from special winding);
Plate voltage 250 to 450; current 28 mla. at 250 volts, 35 at 300, 45 at 350, 55 at 400, or 450;
Grid bias 45 volts at 250 plate, 54 at 300, 63 at 350, 70 at 400, 84 at 450;
A.C. plate resistance 2,100 ohms at 250 volts, 2,000 at 300; 1,900 at 350; 1,800 at 500 and 450;
Amplification factor 3.8; undistorted output 900 milliwatts at 250 volts; 1,500 at 300; 2,350 at 350; 3,250 at 400; 4,650 at 450.

Screen-Grid Tubes

The 222-type is a four-electrode screen-grid tube, designed particularly for radio-frequency amplification, but adaptable as a "space-charge" tube to A.F. amplification. With proper shielding of the radio-frequency circuit, neutralizing and stabilizing devices are unnecessary because of the extremely small capacity between control-grid and plate. The shielding "screen-grid" between the usual third-element (or "control-grid") and the plate thus eliminates the effect of plate-to-grid feed-back capacity; and it also increases the "mutual conductance"; that is, the current output-signal input ration of the tube. Special coupling circuits are therefore required. The filament of this tube operates at 3.3 volts and draws 0.132 amperes; but, with a series resistor of 15 ohms, it may be connected in parallel with the 5-volt filaments of other tubes.

222-Type (Screen-Grid)

Use, amplifier (not power amplifier);
Socket, UX-type (control-grid terminal at top of tube);
Filament voltage 3.3; current 0.132-ampere;
Plate voltage 135 as R.F. amplifier; current 1.5 mla. with 1½ volts on control-grid 1 mla. with 3 volts. (See below.)
Plate voltage 180 as A.F. amplifier, "space-charge" connection; current 0.3-mla. with 1½ volts on screen-grid.
Special voltage 45 on screen-grid as R.F. amplifier; 22½ on inner ("control") grid with "space-charge" connection as A.F. amplifier.
A.C. plate resistance with 135 volts, 850,000 to 1,100,000 ohms, depending on grid voltage; with 180 volts, "space-charge" hook-up, 150,000 ohms;
Amplification factor as R.F. amplifier 300 (theoretical; reduced by circuit limitations); as space-charge A.F. amplifier 60.

"High-Mu" and Special-Detector Tubes

The "high-mu" 240-type tubes (classified, also, as types "340," and "G") were designed especially for use with resistance- or impedance-coupled audio amplifiers. It is important that the plate voltages, on the 240-340-types, be applied through a plate-coupling resistor of 250,000 ohms; and coupling resistors of 50,000 to 75,000 ohms and a plate voltage of 135 should be used with the "G" type.

240-Type ("High-Mu")

Use, resistance-, or impedance-coupled amplifier or detector;
Socket, UX-type;
Filament voltage 5; current 0.25-ampere;
Plate voltage 135 to 180, as amplifier or detector; current 0.2-mla. as amplifier, 0.3- to 0.4-mla. as detector;
Grid bias 3 volts at 135 plate, 4½ at 180. With 250,000-ohm plate resistor, bias 1.5 volts at 135 plate, 3 at 180.
A.C. plate resistance 150,000 ohms;
Amplification factor, 30.

The "special-detector" 200A-type tube is designed for this purpose only and is available, also, under the designations of type 300A, and type H. It is not at all critical to voltage adjustments, and may be substituted for a 201A-type in the detector socket without circuit or voltage changes. (Ex-

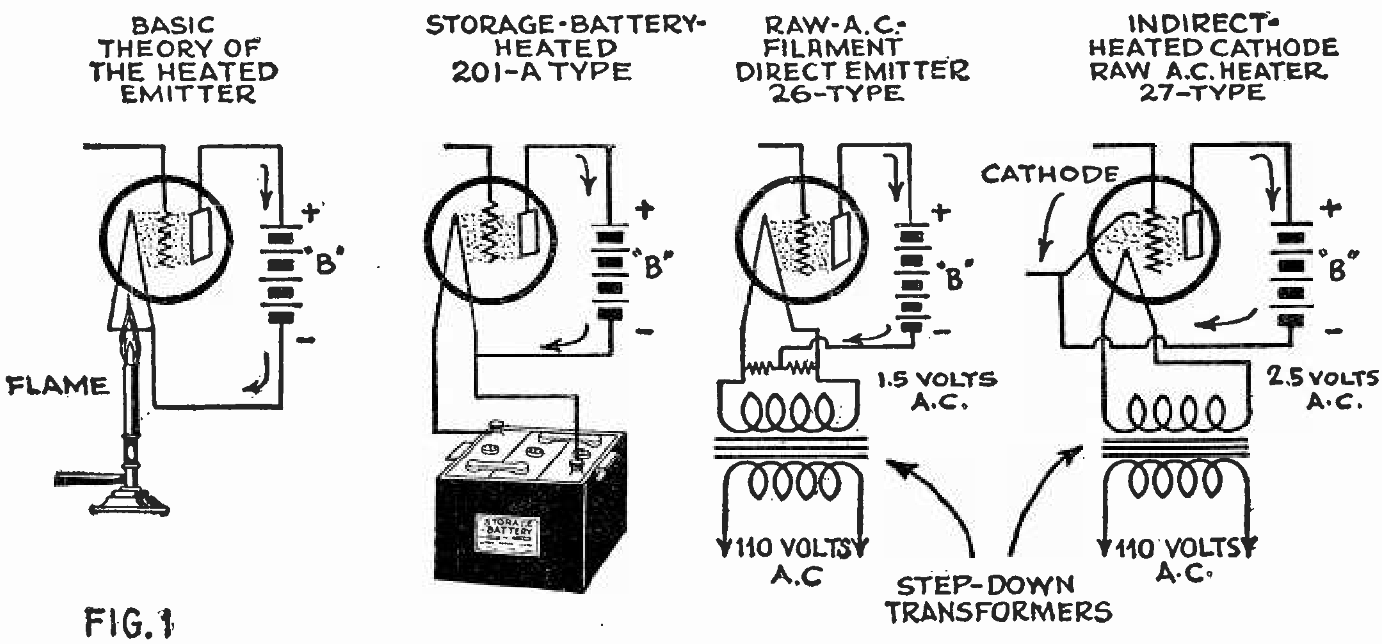


FIG. 1

The filament or "A" current takes no part in the operation of a tube, except as it is used incidentally to give bias. A tube may theoretically be operated with a gas flame to heat its filament, as at the left. A storage-battery tube (even if operaed from an "A" unit) has only direct current in its filament; so has the No. 27-type tube at the right, in which the alternating current does not enter the cathode, which acts as a filament. The 26-type, however, has slight A.C. coupling in its filament circuit.

cept that type H requires a minimum plate voltage of 67.) The use in this stage of a specially-designed tube of this type, it is claimed, produces additional sensitivity and volume nearly equal to that which would be obtained by the addition of one stage of radio-frequency amplification; it is particularly helpful when receiving distant stations. The tube's mechanical and electrical characteristics are identical with those of the 201A-type, except that its A.C. plate resistance is 30,000 ohms, and its amplification factor 20.

200A-Type

Use, special detector;
Socket, UX-type;
Filament voltage 5; current 0.25-ampere;
Plate voltage 45; current 1.5 mla.
A.C. plate resistance, 30,000 ohms;
Amplification factor, 20.

Alternating-Current Tube

The question has often been asked, "How can alternating current be applied to the filament of a tube without the accompanying 60-cycle hum becoming a pronounced factor in the output?" It can readily be seen that this problem becomes somewhat hazy to the uninitiated, when they know how that raw alternating current is used to light the filament of the 226-type tube, and, to all appearances, the 227-type tube as well.

The "Diode"

In order to gain a clearer understanding of the functions of an A.C.-operated tube, it is first necessary to review the *electronic action* which adapts a vacuum tube for use in radio reception and transmission. Without entering too lengthy a discussion of this subject, it may be stated briefly that the electrical characteristics of the vacuum tube depend on the *electron-emitting* property of a heated metal; this action was first discovered by Thomas E. Edison and is known as the "Edison Effect." Edison found that, by heating a piece of metal to a high temperature, he obtained conditions permitting the flow of electricity in a vacuum; now known to be due to the emission of electrons.

Some time after Marconi had obtained his first patents, J. A. Fleming made use of this effect and constructed the first vaccum tube to be used in radio circuits. This tube was a crude affair containing a filament which, when heated by a battery, served as the electron-emitter, and a plate which was kept positive by connecting it to the "+" side of a high-potential generator (the "B" battery). When the filament was heated it emitted a constant stream of electrons which were directed toward the plate, by its attraction for the electrons, which are negative. (The half-wave rectifiers described in this article are actually "Fleming Valves" in operation, though greatly improved electrically and mechanically.)

As long as the filament remained incandescent there was an electrified region between filament and plate, providing what is known as a "path of unilateral conductivity"; that is, permitting a current in one direction only. This "one-way" characteristic provided a sensitive rectifier (or what was then considered sensitive) necessary to "detect" radio waves and reduce them to audio frequencies.

The "Triode"

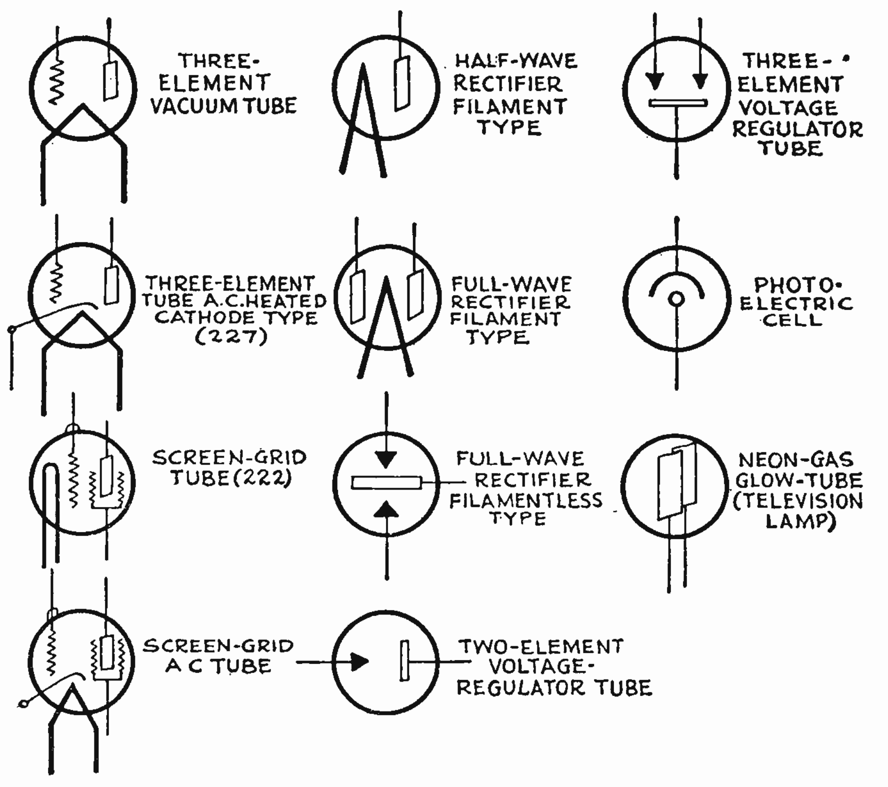
This development was the forerunner of the modern three-element vacuum tube, which was invented by Dr. Lee de Forest and by him styled the "audion." He found that, on inserting a third element (the grid) between the filament and the plate, he obtained a sensitivity of detection heretofore unknown. This resulted from the grid's action in responding to the feeble flow of energy collected by the antenna and so affecting the current of electrons from filament to plate. The introduction of the grid made possible also audio-frequency amplification, radio-frequency amplification and the adaptation of the vacuum tube to radio-telephone and telegraph transmission, where it is employed as a generator of high frequency currents. There is no doubt that, without the triode or three-element vacuum tube, radio telephony could never have even neared the perfection it enjoys today.

While the battery-operated three-element vacuum tubes gave excellent results, and for that matter still do, the public's demand for increased simplicity of operation brought forth A.C. tubes, designed for operation from the light socket. Incidentally, it may be mentioned here that (contrary to a general belief) there is a theoretical difference only in efficiency between the two classes of vacuum tubes; the phactical differences are found merely in the convenience of maintenance and operation. Where the 201A-type requires a storage battery or an "A" power unit with rectifier and filter, the 226- and 227-type tubes require for filament excitation only a step-down transformer; which in turn is connected to the house-lighting line, thus doing away with the routine of charging and watering a battery.

However, for the benefit of those who lack a source of alternating current it should be repeated that, other things being equal, they are equaling the results of the A.C. tube users except in the previously mentioned matter of convenience.

What the A.C. Tube Does

In the first diagram a three-element vacuum tube, the filament of which is brought to incandescence through the medium of a flame, is shown at the left. This, of course, is merely to illustrate the "Edison effect" in its basic form and has no practical counterpart in the commercial or present-day experimental field; though Dr de Forest is said to have used a flame in his early experiments in order to obtain electronic emission from a filament. It will be noticed that the plate current, carrying the sngal heard in the loud speaker, travels from filament to plate and "return" and is entirely independent of the heating method used on the filament.



The symbols used in schematic diagrams to indicate the types of tubes here described. The first, and commonest, symbol is the same for a direct-current tube or for one working with raw alternating current on its filament.

The second sketch in the same illustration shows the conventional direct-current tube with its battery-heated filament. Of course, this may as well represent any of the dry-cell tubes; the principle is the same with the exception of the voltage and current demands of the respective filaments. Here, as in the first sketch, the filament-plate current follows the same path.

Before proceeding with a description of the A.C. tube, it should be emphasized that the only difference between the latter and the D.C.-filament types lies in the construction of the filament. This is, of necessity, much heavier in construction in the A.C. tubes. Necessarily, there is a difference between the filament circuits of both types; the grid and plate circuits, however, are similar and require no changes in the event that a D.C. receiver is rewired to use A.C. tubes; except that the return is made to the "midpoint" of the filament circuit. This refers to the 226-type tubes, which can be used only in radio-frequency and audio-frequency amplification circuits, and not as a detector.

ELIMINATING A.C. HUM

The schematic structure of the 227-type A.C. detector is illustrated in Fig. 1; this tube employs a "heater" which is entirely independent of the grid, plate and filament-return circuits and, for this reason, produces less hum than the 226-type. Many commercial receivers employ these tubes throughout the amplifying stages to guard against any possibility of hum. Unlike the 226, this tube employs for its electron-emitter a fourth element known as the "cathode" (this accounts for the fifth prong on the UY socket), which is nothing but a cylinder built about the filament or "heater." It is the sole function of this heater to heat the cathode until it has reached the temperature where it will emit electrons. (See the sketch at the right of Fig. 1.) This explains the slight delay which takes place between the switching-on of an A.C. receiver and the moment its detector begins to function; this interval averages about 30 seconds and has always been somewhat of a mystery to the layman.

Another hazy subject, to the beginner, is the center-tapped resistor which is placed across the secondary of the step-down 1½-volt filament transformer used in lighting the filament of the 226-type tubes. Briefly, the reason for the use of this component is the necessity of providing an electrical balance in the filament circuit, in order to allow as little "ripple-voltage" or hum as possible. Such a resistor must be connected as shown in Fig. 1, where it is balancing the filament of the 226-type tube; as the alternating current flows back and forth in the filament, voltage at its center is practically uniform. This resistor is absolutely essential when using 226-, 171-, 210- or 250-type tubes in A.C. circuits.

The filament of the 226-type tube is operated on raw alternating current; so that it cannot be used in place of the 201-A-type unless suitable circuit changes are made. Through this tube is fitted for use as an R.F. or A.F. amplifier, with an amplification factor equal to the 201A-type, *it cannot be used as a detector* because of the hum which it would intrdduce; and, as an amplifier, it must be used with a grid bias. Though its filament is rated at 1.5 volts, the recommended voltage is 1.35; to avert the rapid deterioration of the oxide coating of the filament, which sets in when excessive voltage is applied. As an audio amplifier the 226-type is capable of an undistorted output of 160 milliwatts at 180 volts, and of 70 at 135 volts, compared with 55 for the 201A. Other type numbers are 326 and M-26.

226-TYPE (A.C. DIRECT-TO-FILAMENT)

Uuse, R.F. or A.F. amplifier (*not* detector);
Socket, UX-type;
Filament voltage 1.5 "raw" (unsectified) A.C.; current 1.05 amperes;
Plate voltage 90 to 180; current 3.5 mla. at 90 volts, 6 at 135, 7.5 at 135.
Grid bias 6 volts at 90 plate, 9 at 135, 13½ at 180; A.C. plate resistance 9,400 ohms at 90 volts, 7,400 at 135, 7,000 at 180;
Amplification factor 8.2; undistorted output 160 milliwatts at 180 volts.

The 227-type is of the "indirectly-heated-cathode" type. That is to say, although raw alternating current is applied to the "heater" (a tungsten filament which passes through the center of the "cathode," from which it is insulated), the function of this current is merely to heat the cathode. The latter element takes upon it the duty of the filament in a D.C. tube as the actual electro-emitter and furnishes the neutral point on which both plate voltage and grid bias are based. The 227 was designed for use as a detector employing a grid leak and condenser, and requires no bias when so used; but it may also be used as either a radio- or an audio-frequency amplifier with considerable similarity, in characteristics, to the 201A-type. It has been found that the use of 227-type tubes in a set throughout, except in the last audio stage, results in excellent performance. An operating characteristic of this tube is that an interval of about 30 seconds, after it is turned on, is required for the cathode to heat to its functioning point. Other type numbers are 327 and N-27.

227-TYPE (A.C. "HEATED-CATHODE")

Use, detector-amplifier (not power amplifier);
Socket, five-prong UY-type;
Filament voltage 2.5 raw A.C.; current 1.75 amperes;
Plate voltage 45 to 90 as detector, 90 to 180 as amplifier; current 2 mla. at 45 volts, 7 at 90 volts as detector, 3 mla. at 90 volts, 5 at 136, 6 at 180 as amplifier;
Grid bias 6 volts at 90 plate, 9 at 135, 13½ at 180;
A.C. plate resistance 9,000 ohms;
Amplification factor 9.

"HIGH-MU" AND SCREEN-GRID A.C. TUBES

The Hi-Mu 26-type tube has "static" characteristics similar to the 240-type but is operated from a raw-A.C. 1.5-volt filament source, taking 1.05 amperes, like the 226-type. It is particularly adapted for use with resistance and impedance audio amplification, from which it was designed; this tube should not be used without a grid bias.

HI-MU 26-TYPE (A.C. DIRECT-TO-FILAMENT)

Use, amplifier (not power amplifier);
Socket, UX-type;
Filament voltage 1.5 raw A.C.; current 1.05 amperes;
Plate voltage 135 and up, depending on plate resistor; current 2.6 mla.
Grid bias 4 volts;
Amplification factor 20.

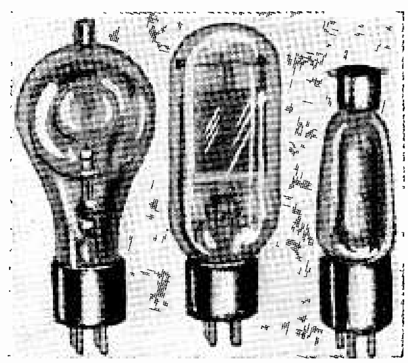


Fig. 21

The A.C. 22-type tube is similar in
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characteristics to the 222-type, except that it is designed for operation on alternating current; as the cathode is similar to that found in the 227-type. The control-grid lead comes out through the top of the tube and the base has five prongs. The outer or screen-grid is connected to the base prong used in the 227-type for the control-grid. When a metallic shield with a closed top is used over this tube, it is advisable to drill a few holes in the top and bottom of the shield to allow dissipation of heat. The tube may be used as a screen-grid amplifier or as a space-charge-grid tube.

A.C. 22-TYPE (SREEN-GRID HEATER CATHODE)

Use, amplifier (not power amplifier);
Socket, five-prong UY (connection to control-grid through top of tube);
Filament voltage 2.5 raw A.C.; current 1.75 amperes;
Plate voltage 135; control-grid bias 1½ volts; screen-grid voltage 45 positive. When used as space-charge amplifier, the screen-grid and control-grid interchange functions, as with the D.C. 22-type.
Amplification factor 300 (theoretical,

limited by circuit conditions) as R.F. amplifier, or 75 as space-charge amplifier.

15-Volt A.C. Tubes

The first part of this article, in last month's *Radio News*, described the 1½- and 2½-volt alternating current tubes, which include the 226-, 227-, Hi-Mu 26- and A.C. 22-types.

Another class of alternating-current tubes makes use of the separate heater-filament for all types, instead of A.C. current led directly to the filaments as in some of the A.C. tubes listed above. These tubes require a step-down transformer with a single fifteen-volt secondary; whereas the others require transformer secondary voltages of 1.5 and 2.5, in addition to a separate supply for an accompanying power tube.

15-Volt 26-Type (A.C.)

Use, detector; socket, UX-type;
Filament voltage 15 raw A.C.; current 0.35-ampere;
Plate voltage 22½ to 45; current 1 to 2.5 mla.
Grid bias 4½ to 9 volts positive.

28-Type

Use, amplifier (not power); socket, UX-type;
Filament voltage 15 raw A.C.; current 0.35-ampere;
Plate voltage 90; current 7.5 mla;
Grid bias 1.5 volts;
A.C. plate resistance 9,000 ohms;
Amplification factor 10.5.

30-Type

Use, power amplifier; socket, UX-type;
Filament voltage 15 raw A.C.; current 0.35-ampere;
Plate voltage 180; current 22 mla.;
Grid bias, 27 volts; A.C. plate resistance 3,500 ohms;
Amplification factor 3.8.

32-Type (High-mu)

Use, amplifier (not power); socket, UX-type;
Filament voltage 15 raw A.C.; current 0.35-ampere;
Plate voltage 135; current 1.5 mla.;
Grid bias 3 volts; A.C. plate resistance, 32,000 ohms;
Amplification factor 30.

40-Type

Use, power amplifier; socket, UX-type;
Filament voltage 15 raw A.C.; current 0.4-ampere;
Plate voltage 180; current 21 mla.;
Grid bias 40½ volts;
A.C. plate resistance 2,000 ohms;
Amplification factor 3.

48-Type (A.C.)

Use, amplifier; socket, UX-type;
Filament voltage 15 raw A.C.; current 0.35-ampere;
Plate voltage 90; current 4.5 mla.;
Grid bias 4½ volts;
A.C. plate resistance, 9,200 ohms;
Amplification factor 11.

22-Type (15-Volt A.C.)

Use, voltage amplifier (not power);
Socket, UX-type;
Filament voltage 15 raw A.C.; current 0.35-ampere;
Plate voltage 135; current 1 mla.;
Grid bias, control-grid 1 volt, screen-grid 30;
A.C. plate resistance 700,000 ohms;
Amplification factor 400 (theoretical).

"Overhead-Filament" A.C. Tubes

Still another type of A.C. tube is familiar to many because of its distinctive "overhead" construction; the terminals of its cathode heater are brought out from the tube through a bakelite top; while, though four prongs are in the base of the tube, only three of these are employed electrically. One is connected to the grid, a second to the plate, and the third, which provides the grid return for the circuit, to the heater-filament. These tubes differ from the others which have been described in that they require a three-volt A.C. supply for the filament.

401-Type (Overhead Filament)

Use, detector-amplifier (not power amplifier);
Socket, UX-type (filament connection through special cable);
Filament voltage 3 raw A.C.; current 1 ampere;
Plate voltage 150;
Grid bias 4½ to 9 volts.

403-Type (Overhead Filament)

Use, power amplifier;
Socket, UX-type (filament connection through cable);
Filament voltage 3 raw A.C.; current 1.5 amperes;
Plate voltage 180;
Grid bias 40 volts.

Rectifier Tubes

Rectifier tubes are divided into three classes; the first, gas-filled, filamentless, full-wave rectifiers; the second, high-vacuum, electron-emitting-filament rectifiers, comprising two half-wave and two full-wave rectifiers. With the latter, it is necessary to provide a supply of current (usually from a low-voltage secondary on the power transformer) to heat the filaments; this is unnecessary with the first type. The third comprises gas-filled tubes with filaments.

Three types are offered in the first (gaseous) classification, all using UX sockets; the first is a moderate-power full-wave filamentless, rectifier designed to supply plate voltage for a standard radio receiver using no tube of heavier duty than the 112A-type. This is known as the "B" type and has an output rating of 60 milliamperes at 150 volts, with a maximum allowable input A.C. voltage of 275 per "anode' (positive electrode).

The next in this class is the "BH" type, a heavy-duty full-wave rectifier having an output of 125 milliamperes at 300 volts. This tube will rectify sufficient current to supply the plate requirements of a standard receiver using the 171A-type amplifier in the last audio stage. The transformer-secondary A.C. voltage may be as high as 325 per anode.

The third rectifier in this series was designed to supply "A," "B" and "C" voltages to series-filament receivers using quarter-ampere tubes; its rating is 350 milliamperes at 200 volts. Known as type "BA," this tube has a maximum allowable input A.C. voltage of 350 per anode.

Filament Type Vacuum Rectifiers

In this class, the high-vacuum, filament rectifiers, are found four types, the 280-type, a full-wave rectifier, the 281-type, a half-wave rectifier; the 213-type, a full-wave rectifier for a full-wave circuit; and the 216B-type, a half-wave rectifier for a half- or a full-wave circuit.

213-Type (Full Wave Rectifier

Socket, UX-type;
Filament voltage 5, current 2 amperes;
Plate voltage 220 A.C. maximum (per plate);
D.C. output (both plates) 65 milliamperes maximum; 170 volts at maximum current, as applied to average filter.

216B-Type (Half-Wave Rectifier)

Socket, UX-type;
Filament voltage 7.5; current 1.25 amperes.
Plate voltage 550 A.C. (maximum);
D.C. output 65 milliamperes (maximum); D.C. output 470 volts at maximum current as applied to average filter.

280-Type (Full-Wave Rectifier)

Socket, UX-type;
Filament voltage 5; current amperes;
Plate voltage 300 A.C. maximum (per plate);
D.C. output 125 milliamperes maximum both plates); 260 volts at maximum current, as applied to average filter.

281-Type (Hull-Wave Rectifier)

Socket, UX-type;
Filament voltage 5; current 2 amperes; 1.25 amperes;
Plate voltage 700 A.C. (maximum);
D.C. output, 65 milliamperes recommended; 85 milliamperes maximum; voltage maximum 620, as applied to filter or average circuit.

Filament Gaseous Rectifier Tubes

These are of the hot-cathode gas-filled rectifier type containing, at low pressure, the inert gas *argon* (found in small quantities in the atmosphere) which is *ionized* by the electrons emitted from the incandescent filament. This ionized gas acts as the principal current-carrier, with the result that the bulb operates with a very low voltage-drop (3 to 8 volts) and is capable of passing a current of several amperes; the current limit depending on the design and size of the tube. Two elements make up in the internal construction of the tube; the cathode (lower electrode) consists of a filament of small tungsten wire coiled into a closely-wound spiral, and the anode (upper electrode) is graphite of relatively large cross section.

The tube rectifies because, on the half-cycle when the graphite anode is positive, the emitted electrons from the heated filament are being pulled toward the anode by the voltage across the tube. They collide with the gas molecules and ionize them; that is, make them conductive in the direction from anode to cathode. During the other half of the cycle, when the anode is negative, any electrons that are emitted are driven back to the filament; so that the gas in the bulb is non-conductive during that half-cycle.

These tubes have been designed primarily for heavy-duty work such as storage-battery chargers, rectifiers for "A" power units and commercial needs. They are available in both half-wave and full-wave types; the former, which has been described above, is in most common use and is produced in three current ratings; the smallest is a 0.6-ampere type designed for trickle chargers using a half-wave rectifier circuit. It requires a filament current of 6 amperes, and a transformer-secondary "pick-up," or "starting" voltage of 8 to 12; it requires a transformer the secondary of which must deliver at least 25 volts for a 6-volt storage-battery load.

The 2-ampere type requires a filament current of 12 amperes, a "pick-up" voltage of 9.5 to 15, and a transformer-secondary minimum of 30 volts at 6-volt storage-battery load. The 5-ampere type requires a filament current of 18 amperes, a "pick-up" voltage of 11 to 16, and a transformer-secondary minimum of 30 volts at 6-volt storage-battery load. Both 2- and 5-ampere tubes are of the half-wave type.

The full-wave-rectifier tube differs from the half-wave type only in the addition of another graphite anode; thus giving an internal construction consisting of a heavy tungsten-wire filament and two graphite anodes. However, this tube is used on rare occasions and so may be difficult to obtain. All the above-mentioned tubes make use of the standard 110-volt screw-lamp socket for the base through which the filament leads are brought out. The anode is brought out through the top of the glass bulb in the form of a projection of heavy wires, to which connection is made by means of a spring-clip binding post, which is in turn connected to a flexible lead.

Regular Tubes

The 874-type tube is a voltage-regulator tube designed to maintain constant voltages supplied by "B" power units at different current drains. The tube has two elements, an anode and a cathode, and contains a low-presure mixture of gas. It maintains a constant potential of 90 volts to the radio receiver.

The 876- and 886-type tubes, on the other hand, are designed for maintaining constant the current to radio sets operated from A.C. house lighting circuits; the former 1.7 amperes and the latter 2.05 amperes. The useful property of these tubes is that, within their rated voltage range, the current through them remains approximately constant. Such a tube should be used only in a circuit especialy designed for it, and *must never be placed in a lamp-socket on the house-lighting line.*

876- and 886-Types (Current-Regulator)

Socket, UX;
D.C. rated voltage, 90;
Starting voltage, 125;
Maximum current (direct) 50 milliamperes.

874-Type (Voltage Regulator) lator)

Socket, large ("Mogul") screw type;
Operating amperes, 876-type, 1.7; 886-type, 2.05;
Voltage range, 40 to 60.

Television Lamps

Under this head come the tubes used in reproducing televised images at the receiver; they were formerly knows as "neon-gas glow-lamps," but the new designation was decided upon by the Television Committee of the Radio Manufacturers Association. These tubes should be used in the plate circuits of 171- or 210-type tubes, in order to obtain best results; also, they require a series resistor to prevent excessive current from reaching them, and a minimum direct-current voltage of 180, independent of the plate voltage applied to the last tube in the audio amplifier. Gradual blackening of the bulb indicates an excess of direct current passing through the lamp.

Television Lamp

Socket, UX-type;
Plate 180 volts; maximum current 20 mla., while 10 is recommended. (Current is generated by output of amplifier, not by television lamp.)

Photoelectric Cells

These tubes may be considered the "eyes" of the television transmitter; for it is their function to convert into electricity the fluctuations of light reflected from the subject being televised and send them on to the transmitter, where they are converted into radio waves and sent out like voice or music. These impulses, by now familar to many listeners, when received on the loud speaker sound very much like dot-and-dash code signals with very rough notes, except that they are all dashes. In mechanical form the cell usually comprises a light-sensitive coating on the inside surface of the glass, and a metal electrode facing this coating. While no light is shining on the cell, no current will pass between the coating and the metal; but, as soon as the cell is excited by light, an electron-stream, the intensity of which depends upon that of the light, will pass from the coating to the metal element, thus closing the circuit.

This description of the action of the photoelectric cell explains its use in light-recording apparatus, fire-alarm systems and other commercial applications where light is required to operate a mechanism. These cells are manufactured in two types; those of the high-vaccuum type require a high voltage, about 600 volts D.C. for best results. The proper voltage for the gas-filled type is found exposing the cell to the maximum light to be used and gradually increasing the applied voltage until "ionization" occurs. This voltage is noted, and a potential about ten lower is selected as the optimum to be applied. One stage of audio-frequency amplification is required for experimental operation of the cell; the requirements for commercial application depend upon the duty of the photoelectric apparatus. As the manufacture of these cells is not yet standardized, characteristics are not given here.

A new vaccuum tube has been announced. It is the power 45 and is of particular interest, because it provides a very satisfactory power output with a relatively low plate voltage. It will find ready application as a replacement tube, to be used in place of the 210; unfortunately, however, its amplification constant value is less than that of the 210. The accompanying figures speak for themselves.

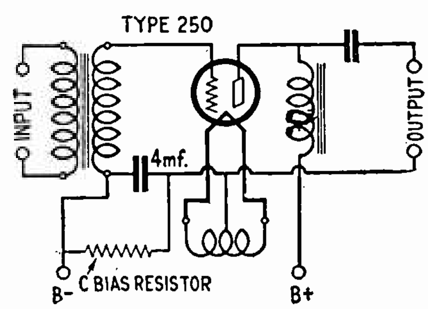
	45 Power Tube	
Filament volts (A.C.)	2.5	2.5
Plate volts	180	250
Bias volts	33	50
Amplification	3.5	3.5
Plate resistance, ohms	6,000	6,000
Mutual conductance	1,800	1,850
Plate current, milliamps	26	32
Output impedance, ohms	1,950	1,900
Max. undisturbed output, milliwatts	750	1,600

"C" Bias for the 250

(649) M. Chiante, Fairchild, Wis., asks:

(Q. 1.) Will you please publish a diagram showing how I may obtain the necessary "C" bias for my 250 power tube from the "B" supply.

(A. 1.) On this page you will find a diagram showing how this may be done. It will be seen that part of the



A straight audio stage.

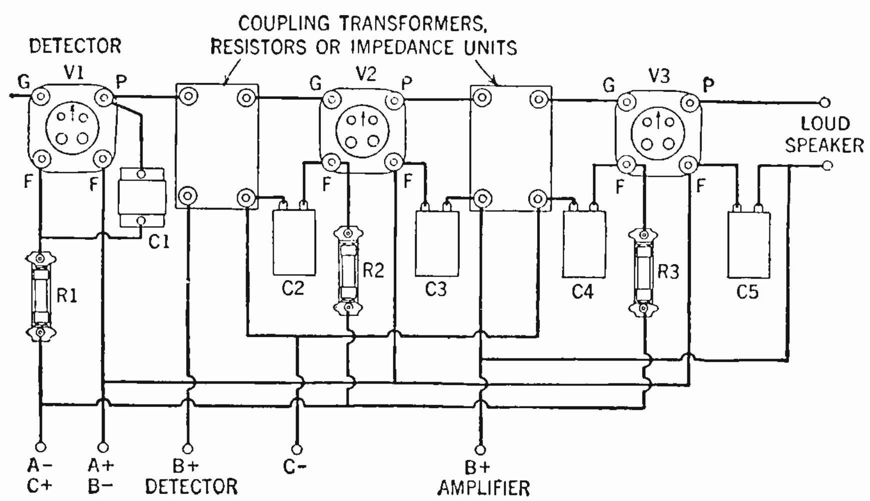
"B" voltage is used to obtain the necessary "C" bias, therefore the voltage between the B+ and B— terminals will have to be raised. For instance, when using 450 volts on the plate, a negative grid bias of minus 84 volts is required. The voltage between the B+ and B— terminals in this case should be raised to 584 volts to compensate for the 84 volts being used on the grid. When using 250 volts on the plate, the "C" bias resistor should be rated at 1,600 ohms, with 300 volts the resistor should be 1,550 ohms, with 350 volts 1,400 ohms, with 400 volts 1,250 ohms, and with 450 volts 1,545 ohms. It will be noted that with 450 volts on the plate the "C" bias resistor is rated at 1,545 ohms, while with only 400 volts on the plate the resistor is rated at 1,250 ohms, obtaining a bias of minus 70½ volts when using 400 volts on the plate. With 450 volts on the plate a negative grid bias of minus 84 volts is used. It will be seen, therefore, that the increase in grid bias is disproportionate, so that the plate current does not exceed 55 milliamperes when using 450 volts on the plate. The resistor used, as shown in the diagram, is inserted between the filament winding center tap and the "B" negative. A by-pass condenser of nearly 4 mfds. is inserted across the two resistor connections. The resistor should be of the heavy duty type, as it must handle up to 55 milliamperes at 84 volts for a single 250 tube, and 110 milliamperes at the same voltage when two such tubes are used. For any intermediate voltage not given here, the value of the resistor can be calculated by using Ohm's Law. It must be borne in mind, however, that the voltage between the B+ and B— terminals should be equal to the plate voltage plus the grid voltage.

By-Passing Audio Amplifier

(43) Mr. R. W. Wilson, Portland, Maine, writes:

(Q.) "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?

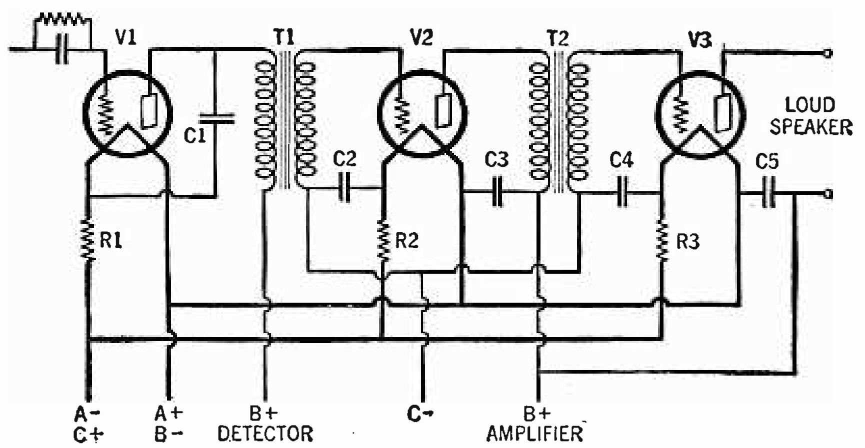
(A.) Audio-frequency amplifiers are often constructed in such a way that a common coupling is unavoidably formed by the power unit or common "B" battery. This coupling provides an excellent path for feed-backs, from which a large amount of distortion may result. This trouble may be reduced very easily by the proper use of 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 currents by placing by-pass condensers of ¼-mf. or more capacity between the transformer secondaries and the filament terminals.



Alternating impulses are kept out of the "B" battery, which is common to all circuits, by the use of suitable condensers which divert them to the grounded filament. C1 is an R.F. by-pass; C2 and C4 block the "C" voltage, and C3 and C5 the "B" voltage from the filament while completing the A.F. circuits.

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 the illustrations below. The first represents any audio-frequency amplifier with transformer coupling, These condensers are represented at C2 and C4.

The diagram in Fig. Q2307 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 unit.



Schematic circuit of the arrangement when transformers are used. C1 may be from .001-mf. up; C2 and C4 are usually 0.25-mf., C3 and C5, 1 mf., though such values are not critical.

Resistance-Coupled Amplifiers

(44) Mr. I. N. Jefferson, Peoria, Illinois, writes:

(Q.) "I am building a resistance-coupled amplifier with two high-mu tubes and a power tube. The high-mu tubes are of the 240 type, while the power tube is a 210. I do not know the correct values for the plate and grid resistors in the amplifier. Can you supply the data? I am also undecided whether it would be better to use an impedance in place of the grid leak in the last tube circuit. The coupling condensers in my amplifier have a capacity of .01-mf. Is this correct?"

(A.) In building a three-stage resistance-coupled amplifier with high-mu tubes of the type you mention, the plate resistors in each case should be given a value of approximately 0.25 megohm. The grid resistors for the first two stages should have values of 1 megohm; that for the power tube, if a resistor is used, should have a value also of approximately 1 megohm. Better results are, however, usually obtained with a suitable choke coil in this circuit; especially if power units are used to supply the plate current to the tubes, because of the tendency of the amplifier to "motorboat." The values of the grid resistors given here are slightly lower than those usually specified; their use will tend to reduce the volume to some extent; but it will overcome the possibility of blocking and, when a grid choke of very high inductance (say 100 henries) is used in the power-tube circuit, there will be very little chance of "motorboating."

The coupling condensers you are using will be quite suitable.

When using a resistance-coupled amplifier with a radio receiver, it is very important that a by-pass condenser be connected between the plate of the detector tube and the "B—" terminal, to keep R.F. currents out of the audio circuits. The omission of this condenser will often prevent the correct operation of the amplifier and, in some cases, the latter will refuse to work at all until the condenser is inserted. Most sets have a .001-mf. fixed condenser at this point and this value is quite suitable; but it is advisable to be sure that the condenser is incorporated in the set before trying to operate it.

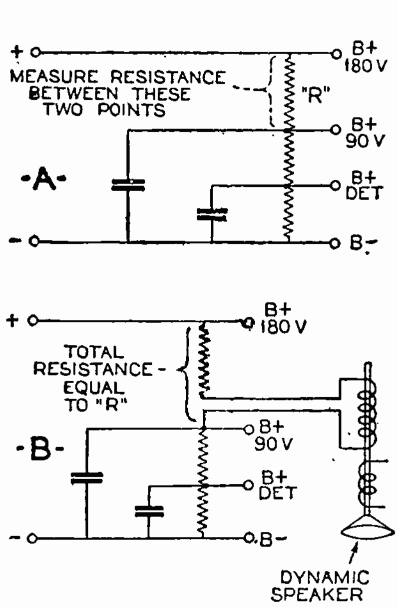
A Dynamic Speaker with "B" Unit

(45) Mr. Arthur M. Russell, El Paso, Texas, writes:

(Q.) "Having purchased a dynamic speaker to operate from a 'B' power unit, I am at a loss to know how to connect it. No instructions were given with the speaker and my power unit is not arranged to be used with a speaker of this type. The field winding of the speaker is designed to operate on 80 to 90 volts at about 80 milliamperes. The 'B' power unit supplies 180 volts at a current of 125 milliamperes, and it has two other output taps for the detector and amplifier. The amplifier supplies 90 volts and the detector 45 volts.

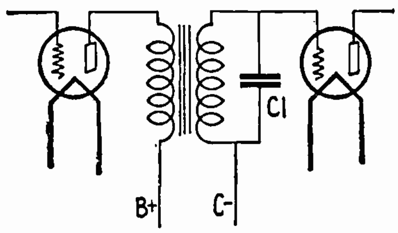
"I believe that the field minding can be actuated from my power unit, but I do not know how to connect it. Will you show me how?"

(A.) The field winding of your speaker can be connected to the "B" power unit, if it is used to replace one of the resistors in the voltage-divider. The most suitable point is between the



A speaker's field windings may replace one resistor in a power unit, if the latter will supply sufficient current for its operation.

maximum "B+" terminal and the amplifier tap. In order to insert the winding properly, the resistance between the two points must be known or a variable resistor substituted in place of the regular resistor. The correct connections are shown. The actual resistance value between the ends of the resistor in question must be the same as the original value, or somewhat less, in order to maintain the taps at the rated values.



A condenser of suitable capacity (determined by the owner's ear) will improve audio tone.

Because of the large increase in the current drawn from the unit, it may be advisable to readjust all the resistance values in the voltage divider; and for this purpose, a wire-wound resistor with variable output taps is the most convenient. A power unit supplying more than 80 milliamperes must be used, since there would not otherwise be sufficient current for the tubes in the set. Many of the common "B" power units using full-wave rectifier tubes are designed to supply about 125 milliamperes, and this is sufficient for most receivers.

If, as usual, the dynamic unit requires more current than the tubes of the set, this may be compensated by reducing the two lower-tap resistors; the voltages must be very carefully checked with a high-resistance voltmeter.

Audibility Meter

(46) William Laher, Ferndale, Michigan, asks:

(Q. 1.) How may the comparative strength of received signals be obtained?

(A. 1.) The comparative strength of a receiver signal may be indicated by an audibility meter. The careful comparison of two or more signals requires delicate instruments. Although the current received may be measured by sensitive galvanometers, the method requires careful manipulation and is not satisfactory. A simple method of obtaining good results is roughly to compare the signal strength when the phones are shunted with a known resistance. By reducing the resistance of this shunt until the signal is just audible, it is possible to calibrate the variable resistance so that comparisons with other signals may be made. If properly calibrated the ratio of impedance of the head set and the impedance of the shunt resistance may be expressed in units of current, and can be taken as the degree of audibility of the signal. Another method of determining signal strength is to compare the one signal intensity with another signal of known intensity produced by an oscillator using a high-pitched buzzer or a vacuum tube.

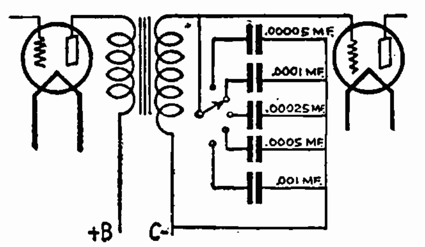
If the signal is just audible when 99 per cent of the detector current flows through the shunt resistance and one per cent through the phones, the signal is said to have an audibility of 100. For use in connection with an oscillating detector circuit, a simple series resistance is not sufficient to give an accurate reading. Changes in the constants of the oscillating circuit often cause variations in the phones which are out of proportion to the changes introduced. A series resistance must be added in the plate circuit to compensate for the reduction in resistance caused by the shunt resistance at the phones.

One simple method of comparing signal intensities consists in using a crystal detector and a galvanometer by means of which currents as small as 10 microamperes can be measured. This experiment requires careful manipulation, and information regarding it will be found in circular No. 74 of the U. S. Bureau of Standards. Careful comparison of two signals is a measurement which require apparatus available only in large laboratories. However, where accuracy is not of prime importance, any one of the approximate methods are satisfactory.

Tone Control in Amplifiers

(47) Mr. E. B. Hamilton, Pasadena, California, asks:

(Q.) "Can you help me to solve a problem which has been bothering me recently? I have seen in a magazine



A unit of this type, such as used at one time in a receiver of a well-known make, permits the set operator to make adjustments on the tone quality of a program to his own taste.

some time ago a method of controlling the tone of a radio set, by connecting condensers of different sizes across the audio frequency transformers. I have looked through all of my old copies of *Radio News* but I have not been able to find the article in question. As I remember the arrangement, a number of fixed condensers were connected with a switch so that any one of the condensers could be connected across the transformer. I do not remember whether the condensers were connected to the primary or the secondary."

(A.) We are printing two diagrams of tone control arrangements, which you can use to improve the quality of your receiver. It is well known that the tastes of people do not agree as to the quality of receivers, some owners desiring soft low type of tone, in which the low frequencies are comparatively loud, while others desire a sharper type of tone in which the middle frequencies are more predominant than either the high or lower tones.

The use of a condenser of the correct size across the secondary of the first audio frequency transformer will help to change the characteristics of this transformer in such a way that the tones on the correct part of the band are brought out more strongly than the others. This may be done in two ways. The first of these is to try different condensers across the transformer until the best one is found, and the other is to arrange a number of condensers of different sizes with a switch, so that the different capacities may be used by merely shifting the position of the switch. An arrangement of this kind is shown. An extra contact should be added with no condenser attached so that the amplifier can be operated without the shunt condenser if desired.

The use of the switch method will allow a convenient variation of the tone for different types of programs. In other words, if an orchestra is being received, one type of tone may be desired, while if a lecture is being received, an entirely different type of tone may be preferred.

The capacity needed to supply these different characteristics in the audio amplifier vary between a very small value, about .00005 and a large value. The maximum capacity rarely exceeds .001-mf. and this is the value shown on the accompanying diagram. A fixed condenser can be used in many cases to improve the characteristic of a poor audio transformer, by bringing out the section of the band which is weak, usually the lower frequencies. In using a condenser for this purpose, it is not necessary to use the bank of condensers, unless a change in the tone is desired, as explained above.

Rules for Radio Installations

(48) Mr. D. S. Spiegel, Batavia, N. Y., asks as follows:

(Q.1) Will you please state the requirements (fire insurance companies, or Bureau of Standards, etc.), for the correct installation of an antenna and ground system? I am in the radio retail end of this game and do a lot of set installing. Installations of antenna are quite numerous and I desire to keep up-to-date with the new legal requirements.

(A.1) The following are among the safety rules for radio installations issued by the Bureau of Standards, which are given in full in its new Handbook No. 9, "Safety Rules for Radio Installations."

In erecting antennae and guy wires for your radio sets, see that you do not attach them to telegraph or electric light poles, do not carry your wires over streets or tracks and avoid crossing electrical conductors of all kinds. Antenna supports must be sufficiently rigid and of such size as to withstand any load which may come on them. Attachments to chimneys should be avoided. Metal poles, or masts extending more than ten feet above the supporting building, must be permanently and effectively grounded.

The bureau recommends that locations involving crossings over railroads, supply lines, etc., be avoided; but where no other location is possible, special rules are given for the installation.

In case of receiving sets, lead-in conductors shall be not less than No. 14 wire (0.064-inch in diameter) if of copper, nor less than No. 17 (0.045-inch) if made of bronze or copper-covered steel. Clearances are given between lead-in wires and other conductors on the building, and it is recommended that lead-in conductors be "securely fastened in a workmanlike manner." The code also requires that the lead-in wire shall enter the building "through a rigid non-combustible, non-absorptive, insulating tube or bushing, or through a drilled window-pane."

For receiving sets, grounds must be made to gas pipes, but should be made to cold-water pipes, if these are connected to a street main. An outlet pipe from a water tank fed by a street main or a well may be used, provided this outlet pipe is adequately bonded to the inlet pipe connected to the street main or well. Where the wire is attached suitable clamps must be used, and the entire surface of the pipe covered by the clamp must be scraped clean.

Rules for the application of protective devices, such as lightning arresters and antenna-grounding switches, are also given. Each lead-in conductor for a receiving set must be provided with a lightning arrester, whether or not an antenna-grounding switch is used. The arrester may be either outside the building or inside if away from combustible materials.

If your set is connected to a power supply-line, the device used and methods of wiring must be in accordance with the rules covering permanent or portable fixtures, devices and appliances, as given in Section 37 of the National Electrical Safety Code. The wiring of storage batteries must also confor mthese rules and such batteries must be placed where there is adequate ventilation.

Copies of this handbook may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents each.

Definitions

(49) J. Berger, Alotona, Pa., writes:

(Q. 1.) What are the definitions of the following terms: acoustic impedance, acoustic reactance, acoustic resistance, acoustic ohm? I recently came across these terms when reading a report of electric acoustic devices used with radio receivers.

(A. 1.) The Handbook of Radio Standards of the National Electrical Manufacturers' Association gives the following definitions for the terms mentioned:

Acoustic impedance—acoustic impedance of a sound medium on a given surface is the vector ratio of the pressure (force per unit area) on that surface to the flux (volume velocity or linear velocity multiplied by the area) through that surface. The acoustic impedance may be expressed in terms of mechanical impedance, the acoustic impedance being equal to the mechanical impedance divided by the square of the area of the surface considered.

Acoustic resistance—the acoustic resistance of a sound medium is the real component of the acoustic impedance. This is the component of the acoustic impedance resulting from the dissipation of energy.

Acoustic reactance—the acoustic reactance of a sound medium is the imaginary part of the acoustic impedance. It is the component of the acoustic impedance resulting from the effective mass or compliance of the medium.

Acoustic ohm—an acoustic resistance, reactance or impedance is said to have a magnitude of one unit when a pressure of one bar produces a volume of one cubic centimeter per second. This is an acoustic ohm.

A pressure of one dyne per square centimeter is called a bar. The above definitions are from a preliminary report of the Institute of Radio Engineers.

(50) J. B. McKngiht, San Diego,

(6) J. B. McKnight, San Diego, Calif., asks:

(Q. 1.) Kindly give me the correct technical definitions of the following radio terms: sensitivity, selectivity and fidelity.

(A. 1.) The Institute of Radio engineers has compiled the following definitions: Sensitivity is the degree in which a radio receiving set responds to signals of the frequency to which it is tuned. Selectivity is the degree to which a radio receiving set is capable of differentiating between signals of different wave frequencies. Fidelity is the characteristic of a system or a portion of a system, by virtue of which it accurately reproduces at its output, the modulation of the signal which is impressed upon it. As applied to a radio receiving set, fidelity is measured by the accuracy of reproduction of the modulation of the received wave at the output terminals. The term fidelity is therefore used to describe the faithfulness of the reproduction of a sound.

Fixing "Sticky" Radio Tubes

The solder on the ends of the contact pins of some radio tubes is slightly lumped, and prevents the tubes from sliding easily in and out of their sockets. To remedy this trouble, simply pare off the lumps with a sharp knife, or file the pins smooth with a fine file.

Why Batteries are Still in Fashion for Short-Wave Receivers

MANY of us have probably wondered why, in the numerous diagrams appearing in the various radio publications of short-wave broadcast or code reception, "B" batteries, rather than socket-power devices, are always designated as a source of plate supply. That there is a good reason for this, however, in indicated by some interesting tests recently made.

In the first place, a short-wave receiver is almost invariably of the regenerative type, consisting of a detector and one or two stages of audio amplification. It is designed on the low-loss principle (which in short-wave reception really means something) and consequently is extremely sensitive and must be capable of maintaining the most critical adjustments. When it is used in connection with a power unit, the remaining unsuppressed A.C. hum, which may be entirely unnoticed in the ordinary broadcast receiver, becomes pronounced and grows in intensity as the regenerative coupling is tightened. In addition to this residual A.C. hum, the alternating-current variations may also be picked up through the antenna system. Many radio fans, who possessed in the old days broadcast receivers of the regenerative type, will probably recall how easily the 60-cycle hum was picked up when the aerial lead-in paralleled the house wiring, even though it might be separated by many feet, and how the proximity of an electric light was sufficient to also cause this effect.

Furthermore, a stable plate current is vital to success in short-wave reception. The tickler is almost always in a state of micrometrically-critical adjustment; consequently, if the plate current is not stablized and varies ever so slightly, it will cause the tube to spill over, thus necessitating readjustment. As the A.C. input to the power unit is varying constantly and this variation, on a smaller scale, is reflected in the output of the device, the impossibility of maintaining a state of critical adjustment is obvious.

This varying voltage is a factor also in broadcast reception on the higher waves, and has caused a few manufacturers of "B" power units to incorporate a regulator or glow tube in their outfits. This glow tube has as its function the preservation of a uniform current flow, but, unfortunately, its current consumption is so heavy that it can be used only in eleminators especishort-wave receivers to all forms of drags down the over-all voltage, causes choke-coil core saturation, and intensifies the A.C. hum.

Because of the sensitivity of the short-wave receivers to al forms of electrical disturbance, background noise must be eliminated whenever it rests within the power of the set operator to accomplish this. Power units, when used on short-wave receivers and highly-sensitive broadcast sets, are inherently noisy, owing to line fluctuations. If some kind of vibrating household device, which operates on the make-and-break principle from the house current, is in use, it will generate strong waves, which will probably be picked up by the receiver through its antenna even when "B" batteries are used. However, when the receiver's plate supply is obtained from the same power source as that operating the interfering device, the interference will be greatly magnified. In neighborhoods supplied with direct current for lighting, because of the fact that connections are *direct* rather than through *transformers*, interference of this character may attain astonishing volume.

For this reason, additional importance is to be attached to the increasing vogue of constructing the power unit and amplifier as a separate instrument from the receiver proper—R.F. and detector. Not only is there greater flexibility in the use of a phonograph combination with the amplifier; but a small, highly-sensitive short-wave receiver may be used with the amplifier for the purpose of receiving the programs now available from great distances. Even with a stage of R.F. ahead of the regenerative detector, as in the short-wave broadcast receiver rescribed in this issue of RADIO NEWS, the amount of current consumed by the two tubes required would be but a small drain on batteries and entail little trouble.

Circuit Changes on the Neutroheterodyne

SINCE publishing a series of three articles describing the theory, construction and operation of the Reich Neutroheterodyne receiver and its power unit (in the May, June and July numbers), Radio News has received a considerable number of letters from readers who desire further information on the circuit. Many of these contained simple questions about the construction of the set, but others suggested changes and improvements and requested our opinion on revised arrangements. Therefore, this article will consider the most popular queries received, for the benefit of those who are interested in the set but did not write in. Also, it will describe a circuit improvement perfected by Mr. Reich since the publication of his article.

Screen-Grid Tubes Not Advised

Probably the question most frequently asked us regarding the Neutroheterodyne receiver is this: "Is it advisable to redesign the set to permit the use of 222-type (screen-grid) tubes in the intermediate-frequency amplifier stages?" In this connection it may be explained that the use of screen-grid tubes in place of 201-A type tubes in the intermediate stages of a receiver may result in one of two possible advantages: either an increase of amplification, or a decrease in the number of tubes. On the other hand, when used with 201A-type tubes, the Neutroheterodyne, as now designed, at all times gives more than ample sensitivity and volume. Gaining additional sensitivity per stage, by use of 222-type tubes, in order to make possible the elimination of one intermediate stage without reducing the range of the receiver, is not entirely satisfactory; as the selectivity of the receiver would be impaired to an undesirable point. There would, therefore, be no real advantage in the use of 222-type tubes, and their use would introduce a number of needless complications. These tubes also tend to be very micophonic.

199-Type Oscillator

The type of the tube used in the oscillator stage also attracted some attention. In the text and list of parts in the second instalment of the article, it was stated that either the 201A- or 199-type tube may be used satisfactorily in this position; and several experimenters have found that better results are obtained with the 201A-type. It is true that the coils of the set were designed especially for a circuit using a 201A-type tube and, when a 199-type tube is used in the oscillator stage, there is some reduction in signal strength on long-wave stations. Also, the dials do not remain perfectly synchronized on all waves.

If it is desired to use a tube of the 199-type permanently in the oscillator stage, it will be best to reconstruct the oscillator coupler. Adding five turns of wire to each winding of the coupler will make it possible to obtain the same efficiency with a 199-type tube as from a 201A-type with the original coil. Also, the use of a 199-type tube in this position effects a reduction in the filament current required for the receiver.

When building the power unit for the receiver, it may be found necessary to reduce its size slightly in order to fit it into a console cabinet. It is possible to make the power unit somewhat smaller by removing two of the parts and placing them in the receiver. The first-detector "B" choke may be mounted above the first audio transformer in the receiver, instead of in the power unit, and this arrangement will not affect the efficiency of the circuit in any way. In addition, if preferred, the output choke coil may be mounted in the receiver, over the second audio transformer. Because of the limited space, it will be necessary, however, to use a choke coil having smaller mechanical dimensions. A choke of the type used in the first-detector "B" circuit may be employed for the purpose.

In operating the receiver, with the first-detector "B" choke mounted in the power unit, if a fairly loud 60-cycle hum in heard at all times in the loud speaker, it probably is caused by stray fields from the power transformer, which are picked up by the choke coil. In order to eliminate this hum the choke coil should be turned about until best results are secured. If it is found impossible to eliminate the hum entirely, it may be necessary to place the choke coil in the receiver as described in the preceding paragraph. Also, the power unit should be placed at least three feet from the receiver wherever possible.

Adjustment of I.F. Tuning

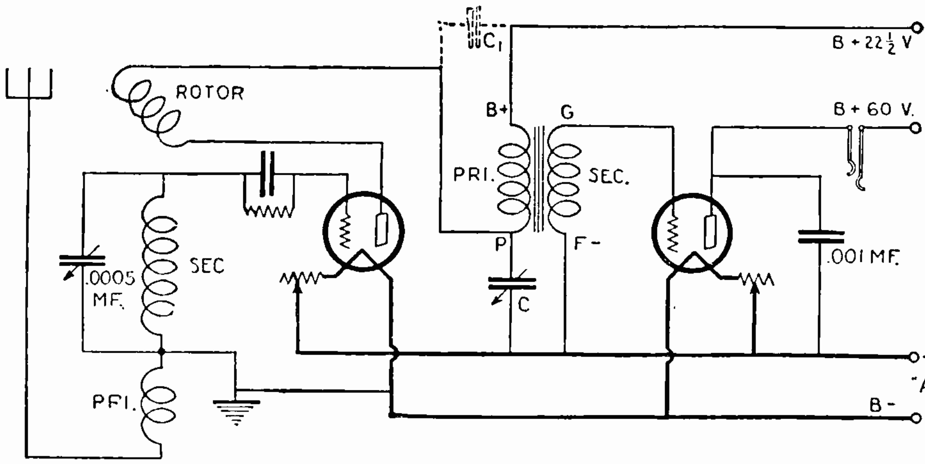
An important operating kink has to do with the connections to the adjustable condensers which are used to tune the intermediate-frequency transformers of the receiver. One terminal of each condenser makes electrical contact with the adjusting screw; to prevent detuning during adjustment, it is essential that this terminal be connected to the transformer terminal R, and not to G. Also, it will be noticed that these condensers change slightly in capacity with their temperature. It is, therefore, best to adjust the receiver carefully after the set has been in operation for several hours, and has warmed up completely. Also, it is well to check this tuning occosionaly.

A Recommended Change

Since the publication of this article on the neutroheterodyne in the June issue of Radio News, the designer of the set found that a considerable improvement can be made by a slight alteration of the circuit. In the original circuit, the oscillator pick-up coil, which is in the secondary circuit of the first detector, is not included in the tuned portion of that circuit, and therefore responds to its own natural frequency. It may happen very readily that this frequency corresponds to that of a short-wave transmitter; and in this case a small amount of energy from an undesired station will be superimposed upon the carrier of the desired station. Harmonics from the oscillator may heterodyne an undesired station to the intermediate frequency, resulting in an audio-frequency heterodyne whistle. This trouble may be prevented entirely by *including the coupling coil in the tuned portion of the detector secondary circuit;* so that it will respond only to the frequency of the desired station, and not to its own natural frequency.

It is a very simple matter to make this change, as only one connection is altered in the actual wiring. The frame (rotor plates) of the first-detector tuning condenser is connected to the shielding instead of to the terminal R of the first-detector transformer; while R connects to the O terminal of the oscillator coil, as before. See page 1339 o fthe June issue of Radio News.

With this arrangement, it is obviously unnecessary to insulate the variable condenser from the panel shield or to substitute a bakelite shaft for the regular brass condenser shaft. It is necessary, however, to reduce the number of secondary turns from 70 to 60.



A regenerative circuit employing the use of inductive and capacitative feed-back, termed "throttle control."

Throttle Control of Regeneration

(51) Mr. V. Sia, Shanghai, China, asks:

(Q. 1.) What is "Throttle" control of regeneration?

(A. 1.) This is control of regeneration by means of a variable by-pass condenser connected across the primary of the audio frequency transformer connected in the plate circuit or, from the plate binding post of this winding to the "A" battery. This is made clear in the circuit diagram, No. Q.-2160.

Regeneration is controlled by means of variable condenser "C", which we may call the "throttle condenser." It may have a value of .0005 to .001 uf., the exact value being governed by the natural capacities of the instruments used. The distributed capacity, as it is called, of the audio frequency transformer, is represented as "C-1." If its value is large, only a small capacity variation will be necessary in "C," to start and stop circuit oscillation; and if small, the value of the other may be made larger.

The three-coil coupler is of standand type and may, for example, have the values stated below:

Primary, 6 to 15 turns at the filament end of the secondary. Secondary, about 50 turns of No. 24 D.C.C. wire wound on a 3-inch tube, at the end of the primary winding. It is not necessary to space the primary and the secondary more than ⅛-inch. Rotor, 20 turns of the same size wire on a 2½-inch tube or ball, placed at the grid end of the secondary, and rotably arranged. If dry cell tubes having lower internal capacities are used, it will probably be necessary to increase the number of tickler, or rotor turns to about 35 to 40, in which case it may be more convenient to use a smaller size of wire. The exact number of turns for the tickler must be such that the rotor can be left in one position, almost full coupling, and not changed thereafter. The number of tickler turns must be so proportioned that throttle condenser "C" will fully control circuit oscillation at all wave-lengths, without recourse to an adjustment of "rotor."

It is advisable to operate this circuit with at least one stage of audio frequency amplification, as otherwise the capacity of the phone cords would become part of the "throttle" capacity and capacity effects would be very noticeable and annoying; every movement of one's head would vary the phone cord capacity and, thereby the regenerative balance of the circuit.

(Q. 2.) What can I use to fill the unwanted holes in a panel used for experimental work?

(A. 2.) Black sealing wax may be used for black panels and the proper shade of brown sealing wax for brown panels. The proper degree of "mottling" may be obtained by the addition of a very slight amount of black sealing wax.

(Q. 3.) How are panels given a dull finish?

(A. 3.) The original polish of bakelite, formica or hard rubber panels is easily removed with No. 00 emery cloth. The graining is usually done with a left-and-right motion. If a somewhat finer finish is desired, the panel may be rubbed with very fine emery powder. For bakelite, a light machine oil lubricant may be used with the powder; on hard rubber, oil should not be used, plain water being much better.

Latest Harkness Reflex Circuit

(52) Mr. Stanley R. Hart, Philadelphia, Pa., asks:

(Q. 1.) Please show the latest Harkness reflex circuit.

(A. 1.) The latest Harkness reflex is being shown in these columns.

Radio frequency transformers R.F.-T.2 may be made by winding about 50 turns of No. 24 D.C.C. wire on a three inch tube. One end of this secondary coil connects to the grid. The other end connects to "A" plus. About one-quarter inch from this end of the secondary is wound the primary, which may consist of about 15 turns of the same size wire.

In the earlier Harkness receivers the tuned radio frequency transformer marked R.T.F.1 consisted of two coils which we have designated "P" and "S." In the newer circuit it has been found possible to eliminate the 15 turn primary, the aerial being connected directly to the grid end of the 50 turn secondary (wound with No. 24 D.C.C. wire on a three inch tube), through a very small variable condenser instead of to the 10 turn tap or the end of the primary. The capacity of this condenser is higher than the maximum capacity of the average condenser of the "neutrodon" type. It is of such small size that changes in its capacity change the wave-length very little, but an excellent control of selectivity is afforded by its use. This method of inducing antenna current to the control grid of an amplifier tube will probably come into more general use.

The neutralizing condenser marked N.C. may be of the usual "neutrodon" type.

Resistances R-1, which may be variable grid leaks, will probably be required if the General Radio No. 285 audio frequency transformers are used. The .0001 mfd. fixed by-pass condenser may not be required with these transformers if the metal shell is connected to "A" minus.

Before the neutralizing condenser is adjusted a loud howl should be heard when both tuning condensers tune their respective circuits to the same wave-length.

The variable condenser rotor plates are indicated by the arrowheads.

If a three to six and one-half volt "C" battery is placed at "X", it will be possible to use high as 135 volts in the amplifier "B" battery.

(Q. 2.) Why are the amateurs permitted to send "CQ" in code a dozen or more times, at a wave-length of 80 meters, when the Government has requested that these letters be sent only a few times?

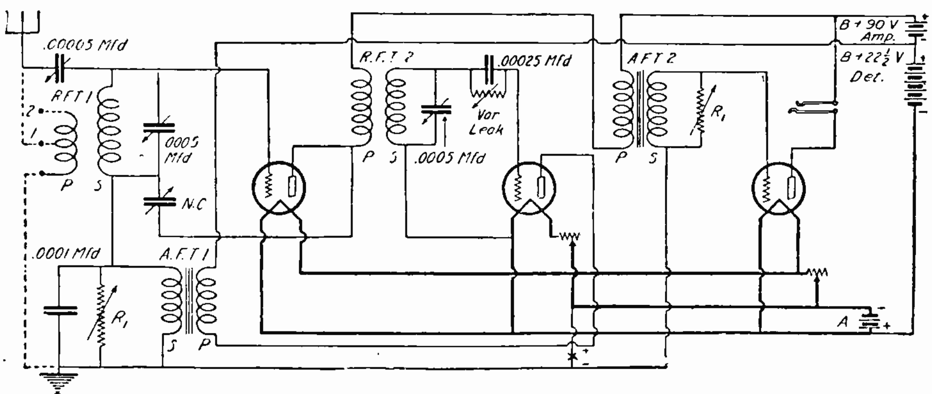


Fig. 22

(A. 2.) Th regulation was intended to apply to spark transmission, not C.W. (continuous wave) transmission, with inductively coupled antenna systems. Due to the extremely sharp tuning at such short wave-lengths, it is necessary that the receiving set be adjusted very slowly. For this reason the amateurs have been permitted to repeat this general call many times before signing the letters assigned to the sending station. This gives the receiver a chance to properly tune in the calling station, an operation requiring much more time on the short wave-lengths than at the longer wave lengths or when the continuous waves are interrupted. Such interrupted or modulated signals are more readily tuned in, but this type of transmission is not permitted on the wave-length band you refer to.

O'Connor Frequency Changer

(53) Mr. W. T. Lambert, W. Palm Beach., Fla., asks:

(Q.1) Please give full construction details for making the O'Connor Frequency Changer. I wish to use it in conjunction with a Neutrodyne receiver.

(A.1) Full details for the arrangement you mention appeared in the June and August, 1925, issues of *Radio Broadcast Magazine.* The important details are contained in the text below:

"Pri. 1" is the primary winding of the first neutroformer, and *it is absolutely necessary that this primary connect ONLY to the two posts indicated as "output."*

The Neutrodyne is adjusted for the maximum wave-length, which will be in the neighborhood of 600 meters. After once being adjusted, there is no further adjustment of this receiver required. The tuning controls are now reduced to two, the two tuning condensers in the frequency changer.

The object of the O'Conner Frequency Changer is to transfer incoming received signals to the wave-length for which the regular receiving set has been tuned to respond.

This effect is obtained by means of the usual "Heterodyne" method.

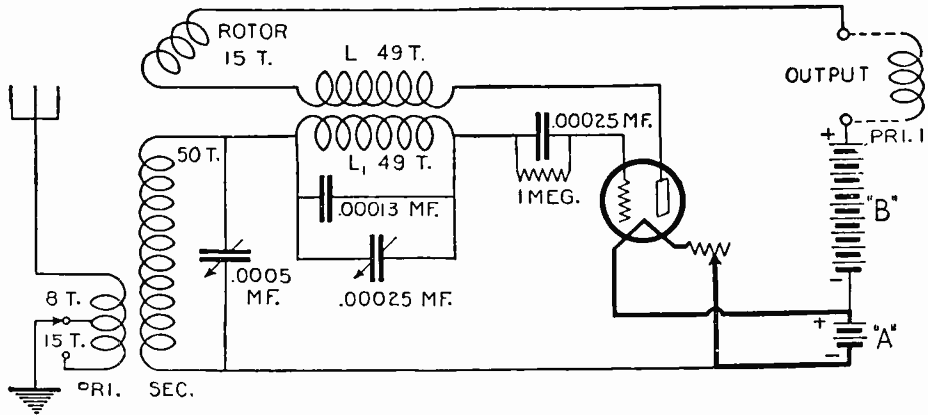


Fig. 23

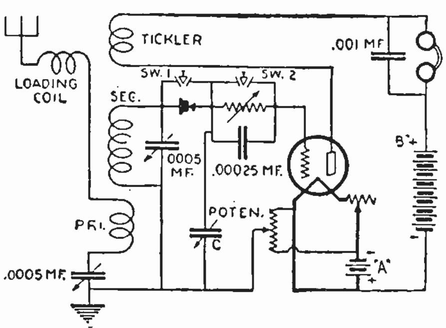
In "heterodyning" a signal from one wave-length (frequency) to another, a second, or "beat" frequency is used. The difference between the beat frequency and the incoming signal is called the "intermediate" frequency. In regular Super-heterodyne the "intermediate" frequency is of a wave-length between 1,000 and 10,000 meters. In the arrangement shown in this month's "I want to Know" department the intermediate frequency is about 600 meters, the exact wave-length being determined only by the adjustment of the standard receiver being used, in this case one of the Neutrodyne type.

There is one big advantage in the use of the combination shown which will appeal to any one having had previous experience in operating a standard Super-heterodyne. It will be recalled that stations in the middle of the tuning band were heard at two different points on the oscillator dial. Those unfortunates having sets that tune in stations from three to eight times are probably wishing their sets would work in such a way as to bring in stations at *not over* two points on the oscillator dial; but such receiving sets have other afflictions than an intermediate frequency amplifier—signal response to wave-lengths between 1,000 and 10,000 meters, the cause for receptions of stations at two points on the oscillator dial.

By using the extremely low intermediate frequency of 600 meters, it is not possible to hear twice any broadcast stations that operate on the present American wave-length band of 200 to 545 meters, so far as intermediate frequency amplifier design, the main governing factor, is concerned.

The oscillator design has a wave-length range of approximately 161 to 287 meters, in order to heterodyne stations in the regular broadcast range so as to produce the 600-meter intermediate frequency.

The oscillator design is as follows: "L" and "L-1," 49 turns of No. 24 D. C. C. wire, wound double-"spider-web" or "Lorenz" fashion. The coils are ⅛-inch thick, with a ⅝-inch core, and are slidably arranged on a 3- or 4-inch insulating rod, the best coupling of the two coils being determined by test.



A crystal-tube combination.

The exact number of turns required for "L" is readily determined experimentally, by varying the number of turns in this grid coil until a 545-meter signal station is heard with the oscillator dial at about 95.

The use of the .00013 *uf.* condenser results in obtaining tuning over exactly the wave band desired, with a half-circle variation of the capacity of the .00025 *uf.* condenser.

The "B" and "A" battery shown may be the regular current supply to the radio set. Be sure "B" minus connects to the same "A" battery terminal of both the oscillator and the regular set. Probably not more than 10 turns will be required in "Pri.1," depending upon the particular tube used as the detector-oscillator.

(Q.2) Please show a circuit using the regular three-circuit coupler, but with provision for:

(a) Grid leak rectification.
(b) Grid bias rectification.
(c) Crystal detector rectification.

I would like to have any one of the three arranged to be had optionally.

(A.2) The circuit requested is shown.

Switches Sw. 1 and Sw. 2 may be of the push-pull type, in which event the crystal shorted by Sw. 1 should preferably be of the fixed type.

The grid leak shorted by Sw. 2 is variable, and must be of the very finest quality, otherwise noisy operation is sure to result.

Variable condenser "C" is a Chelton Midget, or the equivalent thereof.

A 400-ohm potentiometer is to be preferred.

The writer is of the opinon that this is the first time this composite diagram has ever been shown. It affords complete mastery of the major rectification means.

The "B" potential should be varied to determine the best value. It will probably be found that 22½ volts is the required potential.

Try reversing tickler leads.

Crystal rectification and grid-bias rectification are best for quality; grid leak rectification is best for sensitivity.

Condenser rotor plates are indicated by the arrowhead.

(Q.3) I would wish to be advised as to how my 2-variometer circuit can be arranged so that there is regeneration control by means of a potentiometer. I have a 400-ohm potentiometer I can use. The two variometers are in inductive relation, resulting in strong circuit oscillation at the shorter wavelengths.

(A.3) We have modified your circuit in the manner requested. It is shown in diagram Q.2161-B.

We are inclined to believe it would be better to transpose the aerial and ground connections, although it is stated that results are exceptional with the arrangement shown.

Filter and Testing Circuit

(54) Mr. Herbert Chamberlain, Plainfield, N. J., writes:

(Q.1) I understand there is a special filter circuit for sharp tuning. Kindly show this diagram.

(A.1) The filter circuit you mention will be found in these columns. Vernier condensers or attachments will probably be found necessary with this arrangement. The amount of energy transferred is controlled by the variable resistance. The inductive relation must be as shown in the diagram. One is assured of an exceptionally selective regenerative receiver, if this construction is followed.

(Q.2) What are wiring diagram connections of the Jewell Radio Test Set?

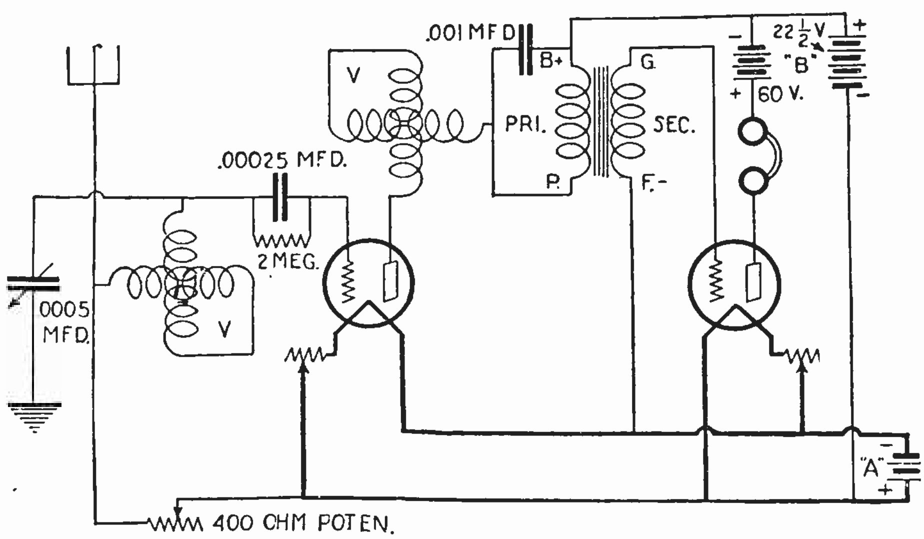
(A.2) This diagram is shown in these columns. This unit has been specially designed for tube testing, and a complete set of curves may be made showing every D.C. characteristic of any vacuum tube, by the use of this instrument. In addition, the individual instruments may be arranged for innumerable other tests. See the January, 1924, issue of *Science and Invention* magazine, which contains an excellent article on modern testing sets, including one for the determination of the A.C. characteristic of vacuum tubes.

It will be noticed that the rheostat is in the positive lead. This is for the purpose of securing a zero grid potential when the potentiometer arm is placed half way between the two ends. Were the rheostat in the negative lead with the grid return to "A" minus, a negative grid bias would be placed on the grid, and this grid bias would not be indicated by the grid voltmeter, unless the grid return connected directly to the filament, when the applied plate voltage would be lowered, due to the rheostat resistance. This drop in voltage will not be shown by the plate voltmeter, in either case.

(Q.3) Why does my potentiometer smoke (two of them have burned out) when connected up?

(A.3) You may have an imperfect instrument. Usually, though, it is an entirely different cause. If the potentiometer arm and one end of the potentiometer winding are connected across the "A" battery and the switch arm placed so that only a few turns are included in the circuit, the fine wire, unable to carry the current, will fuse (burn out). Only the two outside ends of the potentiometer winding should be connected across the battery (switch arm going only to the grid return lead). The total resistance of the entire winding is so high that it cannot fuse or melt under this, the correct, connection.

Variometers are used in this circuit



OBTAINING CURRENT SUPPLY FOR AN ELECTRODYNAMIC SPEAKER

MANY owners of electric receivers, who have purchased new electrodynamic loud speakers in an effort to obtain the utmost in radio reproduction, have found themselves confronted with a very perplexing problem. Unlike others, an electrodynamic unit requires an external source of direct current to excite its special field winding, and the speakers will not operate unless this power is supplied. The amount of current consumed by the field coil varies in different speakers, but most units need aproximately ½-ampere D.C. at 6 volts. However, this potential is not available in circuits where the tube filaments are heated with alternating current.

Nevertheless, this current may be obtained very easily from a standard trickle charger; as the current used by the field coil need not be pure D.C. and any rectified A.C. of the proper voltage will give satisfactory results.

An Ingenious Method

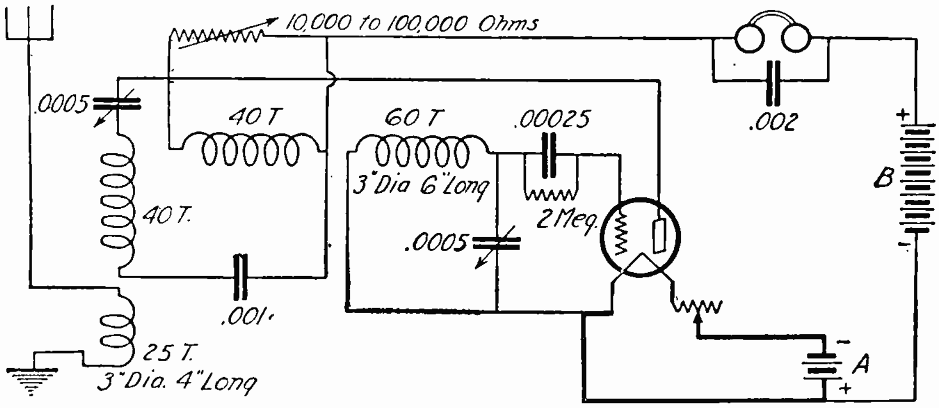
In addition to the electrodynamic speakers which operate at low voltages there are other types which require a potential of 100 volts or more at a current of approximately 50 milliamperes. When using a speaker of this type in connection with an electrified receiver the power may often be obtained by using the field coil of the loud speaker in place of the filter-choke coil in the "B"-power unit.

Use of Separate Amplifier

THERE is no unanswerable reason why the audio-frequency amplifier of a receiving installation should be built as part of the radio set; while on the other hand, it is often more satisfactory to construct it as a separate unit. The practice of combining the audio amplifier with the "B" socket-power unit is now becoming very common, and has received the endorsement of a large number of radio engineers.

With the amplifier and "B" supply device in one unit, the installation is much more flexible; as it may be connected quickly and easily with any type of either radio set, phonograph pick-up unit, or microphone. In addition, this prevents the necessity of rebuilding the audio amplifier every time one builds a new set, and eliminates the danger involved in having exposed high-tension wires between the "B"-supply unit and the power tube.

The reproduction obtained will be no less satisfactory when an external amplifier is used, provided one simple precaution is taken in the design of the receiver; *i.e.*, an R.F. choke coil and a by-pass condenser must be connected in the plate circuit of the detector tube. The by-pass condenser should have a capacity of approximately .001-mf. and be connected between the detector plate and the "A—" lead. The R.F. choke coil should be mounted near the detector tube and connected directly in series with the lead to the A.F. amplifier.



The increasingly opular Filter Circuit to be that of an exceptionally sharp-tuning, complete receiver, Careful instrument layout, careful construction and good apparatus will be required for best results.

Reflex with Regenerative Detector

(55) Mr. M. Gayman, Beamsville, Ontario, Can., asks:

(Q.) "Will you supply me with the diagram of a receiver using a stage of reflexed amplification and a regenerative detector? I have a one-tube set using a capacity-controlled regenerative detector and I would like to improve it. I believe that the reflex system would be the most suitable, as it is not practical to use many tubes here on account of the necesity of using dry batteries. I am an old reader of *Radio News*, and I am certainly pleased with the 'new' magazine. It is a great improvement over the old system."

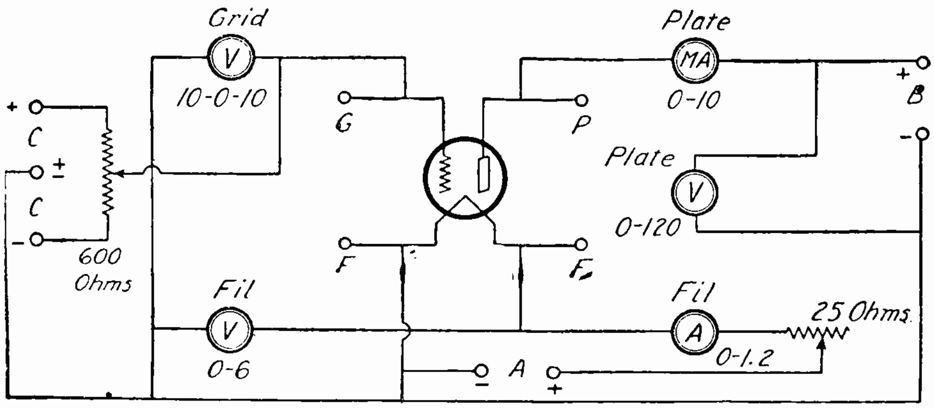
(A.) We are printing, as Fig. Q2330, the diagram of a set of the type that you desire. In order to obtain the best service, the radio-frequency amplifier must be neutralized or stabilized and, for this reason, a double primary coil is employed. The coil L2 which you are using in your present set will be satisfactory as a R.F. coupler if you remove the primary winding and replace it with a double winding. This is done by taking two pieces of wire of the same length and gauge and winding them together on the coil; the correct length in this case is the same that is used in the primary at present.

The aerial coil L1 is wound on a tube of the same size as the detector coupler and similar to it, with the same size of wire, etc. The primary is placed on the same tube, about ¼-inch away from the secondary, and contains 8 to 10 turns of wire.

The other apparatus, needed for the double-purpose amplifier, is as follows:

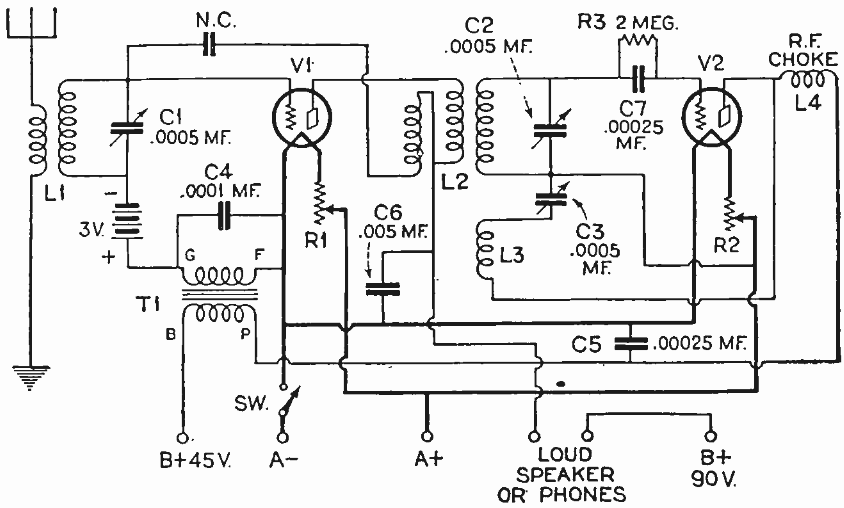
One .0005-mf. variable condenser C1;
One audio - frequency transformer (about 3:1 or 4:1 ratio) T1;
One 3-volt "C" battery (or two flashlight cells in series);
One neutralizing condenser (about 20-mmf. capacity) NC;
One dry-cell tube V1 and socket;
One .005-mf. fixed condenser C6;
One .00025-mf. fixed condenser C5;
One .0001-mf. fixed condenser C4;
One 30-ohm rheostat R1;
One radio-frequency choke (about 85 millihenries) RFC;
Binding posts, wire, etc.

Place the two coils at right angles and as far apart as possible to prevent any interaction, and keep all the grid and plate wires away from each other. If the set does not operate correctly when first tried, reverse the connections to the primary of the A.F. transformer to obtain the correct rela-



Direct current tube characteristics are indicated with test sets connected as shown. A different circuit arrangement is required for determining the exact characteristics under alternating current conditions.

tion between the various circuits. The neutralizing condenser is adjusted until the amplifier does not oscillate; first connecting a pair of phones in the plate lead of the detector tube and turning off the rheostat in the radio-frequency amplifier. Then adjust the neutralizing condenser until the signals fade out or are at minimum volume. The regeneration in the detector



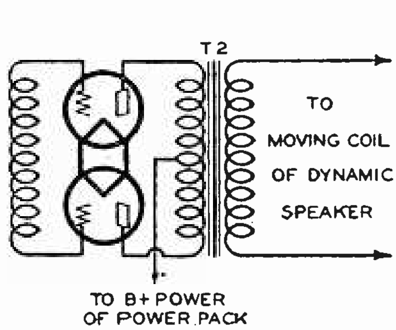
The reflex two-tube receiver shown here (see preceding page for description) adds one tube to a single-circuit regenerator and makes a "bloopless" circuit with R.F. and A.F. stages.

should be suppressed, so that the detector will not oscillate while adjusting the amplifier. Then remove the phones from the detector plate lead and the set is ready for operation. During the neutralizing of the amplifier the two phone or loud-speaker binding posts should be connected together, so that the plate circuit will be complete; or the loud speaker should be left connected to these binding posts.

Diagram appears on the following page.

Using Two Speakers

The experimenter who, for peace in the family, uses a commercial receiver with a built-in dynamic speaker may wish to equip this receiver with an additional speaker of the magnetic type. Having speakers at various locations throughout the home is by no means new. But a number of us have been



For built-in speaker

a little timid at the idea of tinkering with the family receiver. In Fig. 7 is shown the average push-pull commercial hook-up. Here T2, the output transformer of the push-pull stage, is of the step-down variety. This transformer has in some cases a step-down of as much as 8 to 1. A ratio of this kind is, of course, necessary for the dynamic speaker where large current changes, and not voltage changes, are required. With the magnetic speaker somewhat more different is the case; that is, voltage changes as well as current changes produce the greatest armature variations.

Fig. 8 shows the method employed in connecting the additional parts to the circuit. C1 and C2 are 2 mfd. 400-volt filter condensers. AC1 is an audio choke of 30 henries. C2 is connected in the grounded metal portion of the receiver chassis and gives added protection if, as in some receivers, the chassis ground is at a "C" potential instead of a "B—." A neat arrangement may be worked out to suit the experimenter's fancy by wiring outlets in the various rooms where "local speakers" are desired.

Dry Cell Tube Set

(56) Mr. James Hardwick, South Dartmouth, Mass., asks:

(Q.1) Will you kindly furnish me with a schematic diagram of a set incorporating the following items I now have? A variocoupler, a fixed radio frequency transformer, a variometer, two audio frequency transformers, five WD-11 tubes and a variable grid leak.

(A.1) We are herein showing a circuit incorporating the parts you name and a few other necessary items.

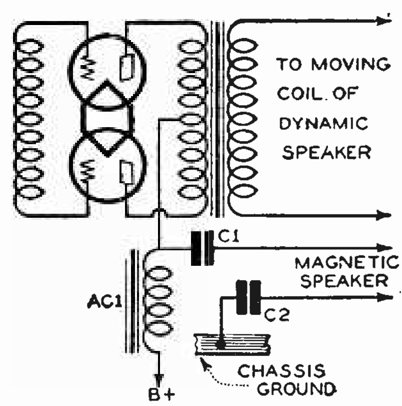
You do not state whether your coils are of the two-coil or of the three-coil type. If of the latter form of construction, it may be a good plan to connect the tickler coil as indicated by the dotted lines, resulting in a Superdyne effect that will enable you to move the potentiometer arm more toward the negative end, resulting in greater amplification. Since turning the tickler coil through a full circle will be the equivalent to reversing the connections on the tickler, it is not necessary to take especial pains as to which way the rotor is connected in the circuit.

(Q.2) Will the UV-712 audio-frequency transformer work with the UV-199 tube?

(A.2) This transformer is quite suitable for amplification of code signals due to the high ratio of 9:1. It may also be used in the reflexed stage of a reflex set intended for broadcast reception. A lower ratio transformer is more suitable for an amplifier of broadcast programs.

(Q.3) Is there any difference between the grid lead and the grid return lead?

(A.3) Peculiarities of certain circuits modify the usual understanding of these two terms, which is that the grid return lead is wire connecting the grid to the tuning inductance; a grid condenser is sometimes connected in series with this lead. The grid return lead is considered as that wire connecting the tuning inductance to the filament circuit.



Revamped circuit

Five-Stage Neutrodyne

(57) Mr. Jerome Fennimore, Basking Ridge, N. J., asks:

(Q.1) What is the tube tester diagram using an oscillating circuit?

(A.1) This is standard. It will be found in these columns.

The inductance may be made by winding 50 turns of No. 22 D.C.C. wire on a tube about 1¼ inches in diameter. There is a tap at the middle of this collodion coated coil.

A Weston thermo-galvanometer ("G") model 425, is used, having a range of 0 to 115 milliamperes.

The D.C. ammeter ("A") is a Weston model 301, 0 to 1 amp, range, instrument. The D.C. voltmeter ("V") is also a model 301 Weston with a range of 0 to 7 volts.

The voltages shown must be used. Tubes having 0.06, 0.25 and 1.0 amp. filaments at the respective voltages of four and one-half, six and six volts, may be tested. Different tubes known to operate satisfactorily should be put into the tester and the readings noted. An average reading may thus be determined, by which unknown tubes may be checked.

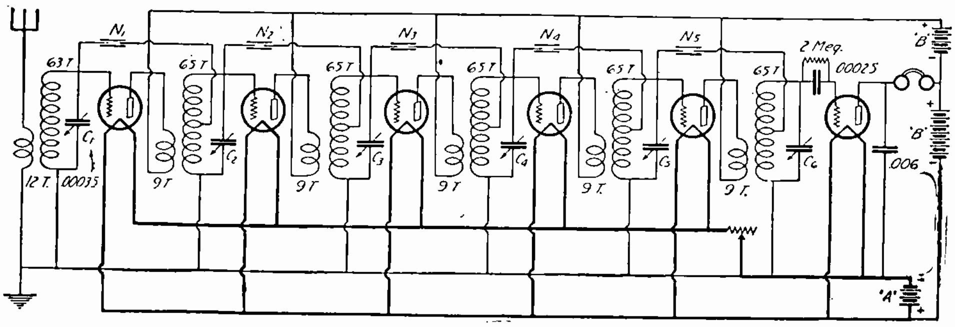
(Q.2) I would like very much to have you publish a picture diagram showing how to use a three-slide tuner in a regenerative circuit.

(A.2) We are showing you two ways of using your tuner in a regenerative circuit.

Circuit A shows the Weagant system of producing regeneration oscillation.

The radio frequency choke may be made by winding about 250 turns of No. 36 B. & S. gauge S.C.C. wire on a tube about two inches in diameter.

Circuit B shows the negative filament as connecting to a middle tap on the coil. Instead of tapping here, however, connection may be made to one end of the coil, as shown by the dotted line. Mark X denotes a break if the filament is connected as per the dotted line.



This is an experimental Neutrodyne diagram. A detector rheostat, not shown, is required in the positive lead of this tube. Reception reports should be addressed to the "I-Want-To-Know" department.

(Q. 3.) Since it is possible to make a satisfactory Neutrodyne having three dials, why would it not be possible to make one having five or six dials?

(A. 3.) It is possible, but not easily done. If care is taken in the construction of the set, it would be interesting to construct one along the lines of the Neutrodyne circuit illustrated in this issue..

Probably the best way to go at this unit is to first make up the set with only the usual two stages of neutralized radio frequency. Then, one-by-one, build additional stages, carefully neutralizing and balancing each successive one. As soon as a stage is balanced, the aerial and ground are removed and that coil to which the aerial and ground were connected now becomes the plate circuit primary winding for the next stage.

All neutroformers and condensers should be of the one make and type selected. N-1, etc., are the usual neutralizing capacities. C-1, etc., are the usual tuning variable condensers, all of the same capacity.

The combination shown is one of extreme sensitivity and selectivity. Audio frequency amplification may be added in the usual manner, if desired. One stage, using a transformer of about 3:1 ratio, is sufficient.

It may be quite difficult to neutralize some of the stages unless the neutroformers are counted in such a way as to be rotatable through an arc of perhaps five degrees to the right or left of the calculated angle.

This set will not function if the parts are crowded.

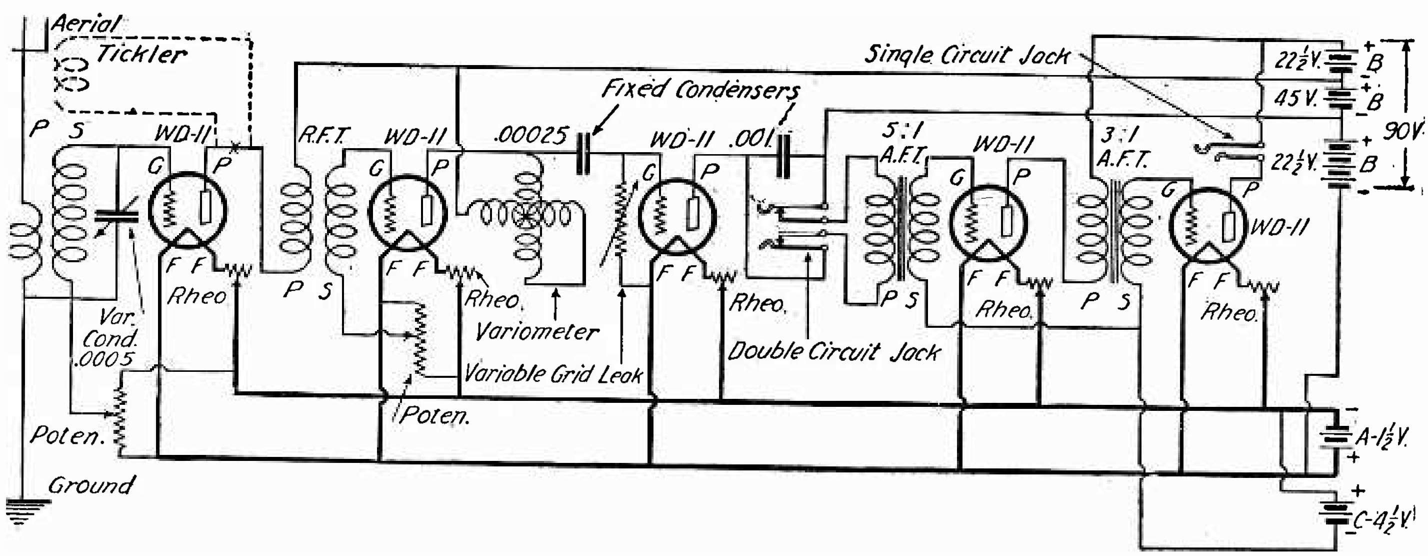
The neutroformer windings are on tubes 2¾ inches in diameter. No. 26 S.S.C. wire is used. The neutrodon taps are taken 15 turns from the grid end of the secondary.

To prevent oscillation, it may be necessary to use only four to six turns in the radio frequency tube plate primaries.

A Portable Receiver

Quite a number of our readers appear to be interested in the construction of a portable set to be used in a car. A set which will operate efficiently in this position must have considerable amplification because of the comparatively poor pick-up which will be obtained. In Fig. 5 we are showing a schematic diagram of a 5-tube set, using two screen-grid tubes and three UX-199 tubes. Although the apparatus in this set seems to take a considerable amount of space, it can actually be arranged in a small enough cabinet which can be conveniently used in a car. Individual shields are used for the coils and tubes instead of the usual method of using complete "stage shields." This conserves space and also allows more flexibility in the construction of the set.

The coils L1 and L2 are wound on 2" tubes and contain 70 turns of No. 26 D.C.C. wire. The shields for these coils should be either box-shaped or cylindrical, and they should be 3½" across or in diameter. The filament resistors R1 and R2 have a value of 15 ohms with a tap at 5 ohms. This tap provides the C bias for each of the tubes. Resistor R3 is a 2 megohm resistor which completes the grid circuit of the screen grid tube. Resistor R4 is also a 2 megohm resistor and is used as the grid leak. Resistors R5, R6 and R7 are filament ballast resistors designed for use with the 199 type tubes. Condensers C1, C2, and C3 are variable condensers; C2 and C3 may be ganged together. C4 and C5 are coupling condensers, while C6, C7, C8 and C9 are by-pass condensers. C6 has a value of .002 mfd. and the other three by-pass condensers have a value of 1 mfd. The transformers T1 and T2 are ordinary audio frequency transformers with a ratio of 2 or 3 to 1. The choke coils CH1,



One of the many variations possible wherein a variocoupler, fixed-tune radio frequency transformer, and continuously variable inductance (variometer) are used. Only two dials are required for this set. The R.F. transformer should not have a sharp peak at one wave-length.

CH2 and CH3 radio frequency chokes with an inductance of 80 or 85 millihenries.

In laying out the parts for the set, care must be taken to prevent any feed-backs occurring between the various stages. In order to do this, the grid and plate leads should be kept as short as possible, and if practical, they should be enclosed in copper tubing with the tubing grounded to the negative filament. The loop aerial is one of the ordinary types and a suitable one may be made at home if desired. A wooden frame, 18" square and wound with 15 turns of No. 18 or 20 wire around the frame with a spacing of ¼" between the turns will be suitable.

After we have assembled the set, the next thing to do is to connect the batteries. The filament supply consists of a group of dry cells with the spark plug and the wire from the distributor. The choke coil should be shielded in a metal can to prevent inductive reaction between choke and the receiver.

The portable set which we have described above is only portable from the standpoint of being transported in a car or other suitable conveyance. The batteries and apparatus in the set would make it too bulky and heavy to be carried by hand, and it could not be made lighter without reducing its efficiency.

"Microphonic" Noises

Very often in amplifying circuits where "hig-mu" tubes are used, a howl is noticed in the loud speaker, which is not changed by adjustments of the receiver. If this happens the tubes are said to be "microphonic."

How to Drill Holes Exactly as Laid out on the Panel

No one knows better than the amateur radio constructor the difficulty of drilling a panel so that it comes out perfectly true. A panel may be laid out correctly and the center punch used for locating the start of the drill; and yet, due to the travel of the drill point, the drill holes will be off center.

A simple method for overcoming this trouble follows: The panel is laid out in the usual way with the center punch. Then with a rose countersink drill out a "bed" which will just take the slope of the drill point, as shown in the illustration. This scheme is a sure way of starting the drill point on true center and never fails of getting a hole drilled where it is wanted.

—*Contributed by Lester P. Young*

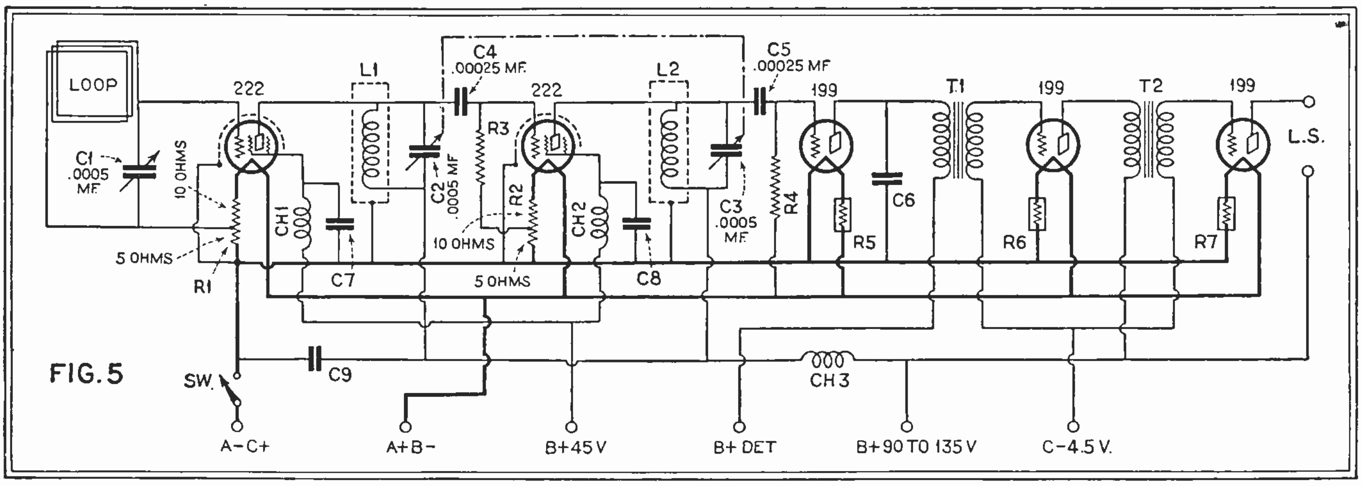


FIG. 5

three cells in series for each section. If two of these sections are made and the positive and negative terminals of these sections are connected together, the battery will last much longer than if a single section were employed. In connecting the three cells in series, the positive terminal of the first cell should be connected to the negative terminal of the second; the positive of the second should be connected to the negative of the third and the remaining positive and negative terminals should be connected to the filament circuit of the receiver. If possible, a "B" supply of 135 volts should be used, although satisfactory results can be obtained with 90 volts on the plates of the screen grid tubes.

The construction of the set for use in an automobile brings another point to mind. If the set is to be used while the car is in operation, trouble might be encountered with interference from the ignition system. The most practical way to overcome this interference is to place resistors or choke coils in series with the leads from the spark gaps. If resistors are employed, they should have a value of 20,000 ohms and should be of the carbon type. If choke coils are used, they should be wound with heavy wire. A suitable choke may be wound by winding 8 to 10 turns of No. 16 D.C.C. wire on a tube 1½" in diameter. This choke coil is merely placed between

This condition can usually be corrected by moving the reproducer away from the receiver; although it may be necessary to mount the tubes on sponge rubber to dampen the vibrations. There are on the market at present several types of shock-proof sockets which are helpful in preventing this microphonic ringing. Exchanging tubes in the sockets is also helpful in some cases.

Pepping Up the Veteran Radio Tubes

A simple and efficient method of rejuvenating tubes which have "gone dead" is to turn their filaments up to normal brilliancy and then to reverse the polarity of the "B" battery, connecting its positive terminal to "A+" and its negative to the lead which is normally connected to the "B+." The tubes should be left connected in this manner for a full hour; the filament current should then be turned down to the lowest point and left this way for another half hour.

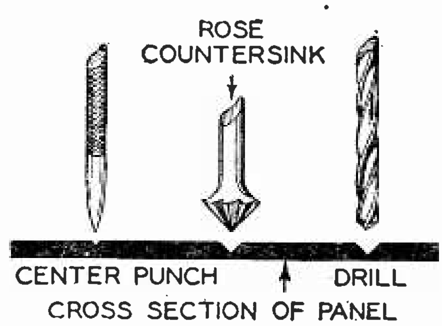
In cases where the tubes are unusually poor, the treatment may have to be repeated. After the tubes have been allowed to cool off, the batteries should be connected in their correct manner. It should be borne in mind that some types of tubes are not suitable for rejuvenation; such are the 200A, and certain power tubes.

A Well Designed Super-Regenerator

(58) Mr. S. K. Walker, North Bergen, N. J., asks:

(Q. 1.) Will you please furnish me with the circuit diagram of an efficient and well-designed Super-Regenerative circuit, one that you think would give satisfactory results?

(A. 1.) The accompanying diagram of the wiring connections, with detailed data, of super-regenerative receiver are self-explanatory.



The loop aerial used in conjunction with this set is wound with 7-strand No. 22 twisted wire, 12 turns, separated ½-inch on a 42-inch square. An aerial, 150 feet long, of No. 14 wire, which is connected to the top binding post of the loop, effects reception over a radius of about 1,000 miles. This distance increases by 150 miles as the operator learns to handle the set. One stage of audio frequency is added, to enable the use of a loud speaker.

These are the necessary parts of the set:

One variocoupler of special design, consisting of tubing 4 inches high and 4 inches in diameter, with a regenerator inductance coil at the bottom, consisting of 35 turns of No. 22 DCC wire, and at the top a stator winding of 26 turns of No. 30 DCC wire on each half. The rotor, which is 8 inches in diameter and 1½ inches long, is wound with 26 turns of No. 30 DCC wire. All this is mounted on a 4½"x4½"x⅞-inch wood block and shellaced.

One Air-choke Coil wound with 400 turns of No. 28 enameled wire on a 5-inch tube 8 inches long, supported by blocks cut to fit under each end and shellacked.

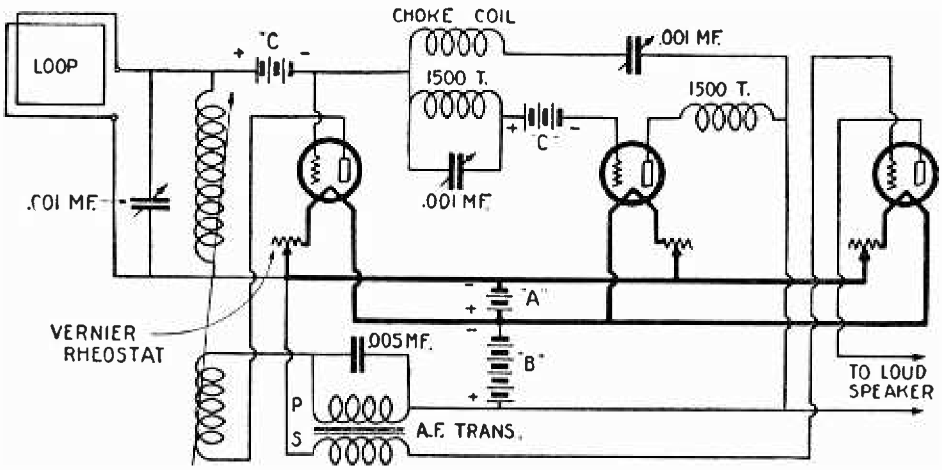
3 Variable Condensers, .001-uf.;
1 Fixed Condenser, .005-uf.;
3 Filament Rheostats, one with vernier;
1 A.F. Transformer;
3 Power-Tube Sockets;
3 UV-202 or UX-210 Tubes;
1 Bakelite Panel, 12x21x3/16 inches;
2 "C" Batteries, 0-12 volts;
1 "B" Battery, 100-200 volts;
4 3-inch Dials;
2 Contact Arms, 1½" radius;
30 Contact Points;
6 Terminals for loop and battery connections;
2 Honeycomb Coils, 1,500-turn.

Super-Pliodyne 9-Tube Receiver

(59) Mr. D. Stanley, Tuxedo, N. Y., asks as follows:

(Q. 1.) Please furnish me with the schematic wiring diagram of the Super-Pliodyne 9-tube receiver, which incorporates a special means of controlling oscillations in the R.F. stages, six stages of tuned-radio-frequency amplification, detector and two stages of audio. Also any constructional data or constants.

(A. 1.) This receiver is manufactured by their courtesy. All the variable condensers (C1, C2, C3, C4, C5 C6 and C7), are .0005-mfd. capacity. These condensers are all geared together, thus giving you one dial for control. The transformers employed allow broad tuning. This is the reason for the use of so many stages tuned, simultaneously.



A three-tube Super-Regenerative Circuit which the average constructor can build with the assurance that the troublesome defects, usually encountered in this type of circuit, are eliminated or minimized to a great extent. Very satisfactory loop reception may be expected, if this circuit is constructed properly.

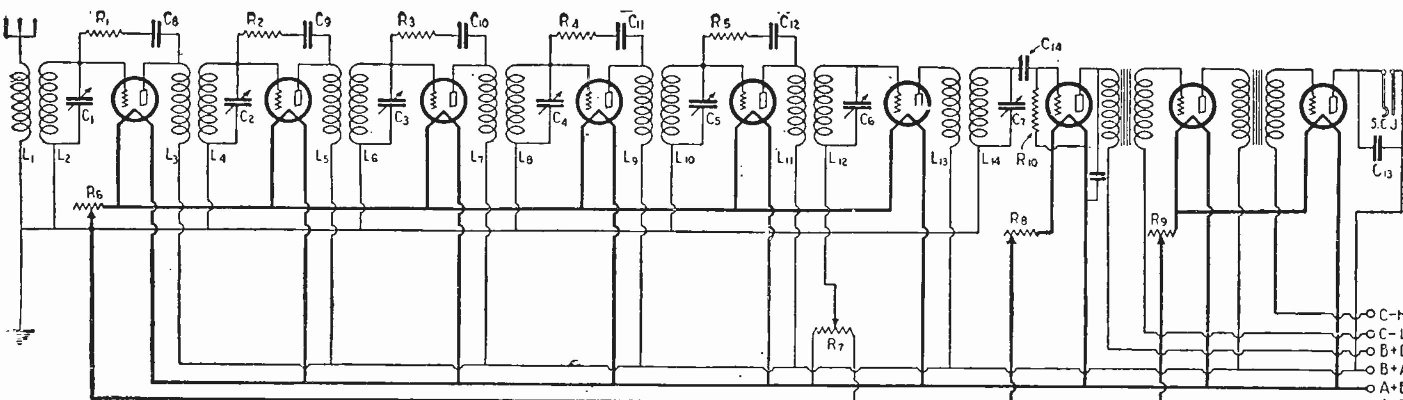
The primaries (L1, L3, L5, L7, L9, L11, L13) consist of 25 turns, wound on 1¾-inch tubing. The secondaries (L2, L4, L6, L8, L10, L12, L14) consist of 100 turns wound on 2-inch tubing. No. 26 D.C.C. wire is used. The primary tubing is placed inside of the secondary tubing. The primary winding is spaced. Between every primary turn, allow a space equal to three turns, or about 1/8-inch.

The resistors (R1, R2, R3, R4, R5) in the neutralized stages are variable, although not indicated as such. They vary from 20,000 to 120,000 ohms. The condensers in these stages are also variable, being of the regular midget type. C14 is the grid condenser, having a capacity of .00025-mf. R10 is the grid leak, having a resistance of from 1 to 3 megohms.

The filaments of all the R.F. tubes are controlled by a single rheostat, R6, which has a resistance of 6 ohms, and should pass 1½ amperes. The filament of the detector tube is controlled by a 20-ohm rheostat, R8. The filaments of the A.F. tubes are controlled by a single 10-ohm rheostat, able to pass ½-ampere. Tubes of 201-A or 301-A type are used throughout, with a 6-volt "A" battery. C13 is a .003-mf. fixed condenser. R7 is a 400-ohm potentiometer, used to control the oscillatory action of the tube.

Wiring the Receiver

The beginning of the primary winding is brought to the antenna post, and the other end to the ground post and to the beginning of the secondary winding L2. This same lead is extended to the arm of the rheostat, R6, and to the "A—C+" post. The rotor plates of all the variable condensers and the beginnings of the secondary windings of all the coils, except L12, are connected to this same lead. This gives all the tubes in these circuits a negative grid return. The beginning of the secondary winding, L12, is



Wiring diagram of the Super-Pliodyne 9-tube receiver, which employs six stages of tuned radio-frequency amplification, and incorporates a novel means of suppressing oscillations. The amount of radio-frequency amplification obtained is tremendous, resulting in a very sensitive and selective receiver.

brought to the arm of the potentiometer, R7, and the resistance terminals of this potentiometer are brought to the "A+" and "A—". Altnough the grid return through the secondary winding, L14, is to "minus," a positive bias is obtained on this detector tube by connecting the grid leak in shunt to the grid and "A+."

The beginning of these secondaries (L2, L4, L6, L8, L10, and L12) are brought to the grid posts of their respective sockets, and the beginning of L14 to one terminal of C14. The other terminal of this condenser is brought to the grid post. The beginnings of the secondary windings (L2, L4, L6, L8, and L10,) are also connected to the resistors in their stages, while the other terminals of these resistors are connected to the fixed condensers. The other terminals of these condensers are brought to the plates of the respective tubes. No such resistor and condenser are connected to the sixth R. F. tube, the potentiometer taking its place. The rheostats are all connected in the negative legs of the respective filament circuits which they control. The variable condensers are connected in shunt to the secondaries, the rotor leads going to the filament side and the stators to the grid side.

Batteries Required

The plates of the R.F. and the A.F. tubes should receive about 90 volts ("B+Amp."); that of the detector tube about 45 volts ("B+Det."). A 4.5-volt "C" battery ("low") should be used as a grid bias in the first stage of A.F. coupling, and a 9-volt "C" battery "High" in the last stage.

The first variable condenser can be controlled independently of the other six, which may be ganged. This may lead to easier synchronization of dials and louder signals.

The complete set is housed in a totally-shielded cabinet, with the coils placed so that practically no field exists between them; this is to prevent interstage coupling and consequent uncontrollable oscillations of the tubes in these circuits.

If a power tube is desired in the last stage, it would be best to isolate the "B" and "C" voltages that connect to this stage. A voltage not exceeding 135 should be used for the UX112 tube, and about 175 for the 171 tube; 9 volts "C" battery for grid bias with the first tube and approximately 22½ volts "C" battery for the latter.

The amount of amplification obtained from this receiver is tremendous, which permits loop reception. The loop connections are made to the grid of the first tube and to the "A—" terminal instead of to L2.

The Arkay Receiver

(60) Mr. L. K. Riley, Geneva, N. Y., asks as follows:

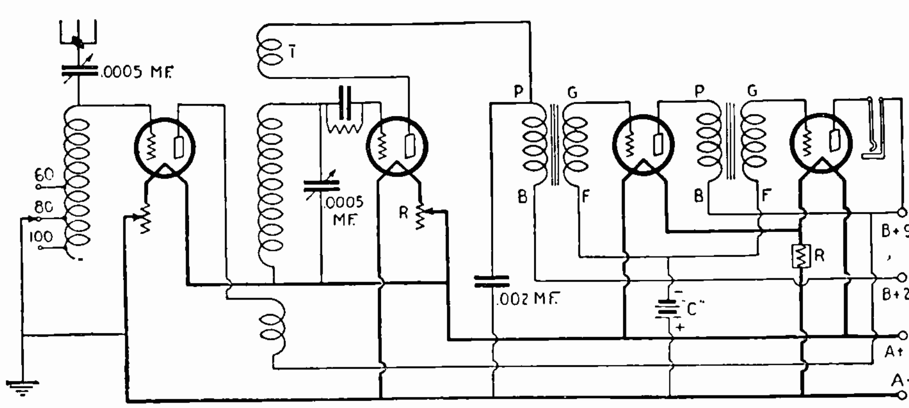
(Q.1.) A friend of mine is obtaining wonderful reception with a small four-tube receiver, which he says, is termed the "Arkay" receiver, and which was described in some radio section of a newspaper. I wonder if you can furnish me with any data or information concerning the construction and wiring diagram of this receiver? I am very much interested, due to its high efficiency, and would like to construct one similar to that of my friend.

(A.1.) The Arkay receiver, to which you refer, was described in the Newark Sunday Call, and the following is a reprint of the description of this receiver. All the necessary information is included.

"A stage of radio frequency, detector, and two stages of audio-frequency amplification are employed in this circuit. No 'trick' wound coils are employed. Single-layer inductances which can be constructed at home are ample. The two dials may be logged and after a short time the owner should be able to pick up many stations throughout the country. The set is quite selective and it has been possible during the tests to log DX through a great many locals.

R.-F. Input Circuit

"Unlike the majority of tuned-radio-frequency receivers of the neutrodyne type which make use of an 'untuned-primary' coil underneath or alongside of a secondary, the improved Arkay circuit employs a tuned primary coil directly coupled to the antenna circuit through a series condenser. In this manner a greater amount of radio-frequency current is obtained from the antenna than with the untuned primary coil. The latter system is not as efficient as the former, due to the losses which occur in coupling. The single-circuit idea appears to have considerable merit, and actual comparisons seem to favor this form of tuning for R.F. work.



An untuned R.F. stage with detector and two audio.

"Radio fans who were owners of single-tube 'single-circuit' receivers will recall the remarkable distances covered with this type of set, compared with a receiver making use of a coupler having separate primary and secondary windings. The former outfit, while not much on selectivity, certainly took the prize for sensitiveness. This circuit employed as a R.F. amplifier carries with it the efficient qualities of the one-tube set.

"The following is a list of parts required to complete this set:

1 Panel 7 x 14 or longer;
1 Baseboard to suit panel;
5 Binding Posts;
2 Variable Condensers, .0005-uf.;
4 201-A Sockets;
2 Audio Transformers; 1:6 and 1:2;
1 Self-adjusting Rheostat, ½ ampere, and mounting;
4 201-A Tubes;
1 Grid Condenser, .00025-uf., and 5-megohm leak;
1 .002-uf. Fixed Condenser;
2 3-inch Tube Forms, 4½ and 3½ inches long;
1 Binding-Post Strip;
2 30-ohm Rheostats;
1 Single-Jack Filament Control or cut-off switch;
6 Lengths of busbar wire;
2 4-inch Dials.

Making the R.F. Coil

"The radio-frequency coil is easy to make and consists of a single layer of wire wound on a cardboard or bakelite tube; the lighter the tubing, the better. The coil employed in the set was 2½ inches in diameter and 5 inches long. As it may be difficult to get tubing of this size, it is suggested that a 3-inch tube be used in its place. Start about half an inch from one end of the tube and wind 60 turns of No. 22 D.C.C. wire, taking a tap or loop at this point. Continue winding, taking another tap at the 80th turn, completing the coil at the 100th turn. Make sure to leave about an inch of wire at the beginning and end of the coil for connections. The coil should be mounted above the baseboard of the set on blocks of wood or by means of small brass rods; its end should point toward the front panel and be placed at the right of the baseboard.

"This coil is tuned by means of a .0005-uf. variable condenser, which is mounted on the panel a little to the left of the end of the coil. The taps are used for different aerials. No switch is employed for the taps, as this proper point will be determined by trial.

Secondary Coil

"The secondary coil has three separate windings. On one end is the R.F. 'reversed coil'; in the center is the secondary, which takes up most of the space; and on the remaining end is the detector-plate coil, T. The secondary coil, as well as the two smaller coils, are all wound with No. 24 D.C.C. wire. A quarter of an inch separation is left between each winding on this form.

"Starting one-quarter of an inch from one end of a 3-inch tube, which should be 3½ inches long, wind tightly 14 turns of wire, making provision at the beginning and end for holding the wires in place. Two small holes will be satisfactory for holding the start and finishing wires. Leave at least an inch of wire for connections.

"Then skip about one-quarter of an inch and in the opposite direction wind the secondary of 45 turns of wire. Leave another quarter of an inch and wind in the same direction the detector-plate coil of nine turns. This completes the entire inductance.

"The secondary coil is mounted at right angles to the radio-frequency coil and at least five inches away, so that the fields of the two coils will not interfere. Back of the secondary coil is the .0005-uf. variable condenser.

"The coil may be mounted on the condenser end-plate, provided the condenser has an insulated form. (The condenser used is a .0005-uf. straight-line wavelength type, with a hard-rubber end plate.) Or the coil may be supported by means of the busbar wires which connect to its six terminals.

"Keep all wires out of the end fields of the secondary coils. Do not run wires through the coil or across the ends. Run them away from the windings rather than parallel or too close.

Four Binding Posts

"Battery binding posts are mounted on a small panel to the rear of the baseboard. There are four in number; the "A—" is also ground. The antenna post is mounted on a separate small panel away from the battery and ground binding posts. This connection is brought out on the side near the .0005-uf. antenna tuning condenser, and run to the rotor plates.

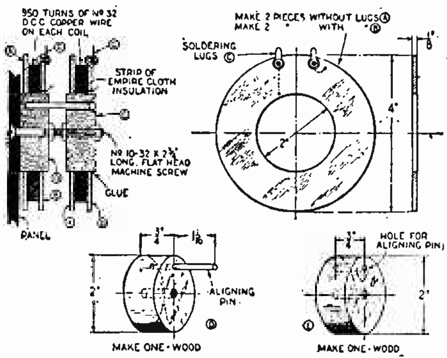
"The by-pass condenser, .002-uf., is connected between the detector plate coil winding and the "A—" battery wire. The .0005-uf. grid condenser is mounted close to the detector tube socket, underneath the secondary tuning coil.

"A single-circuit jack with filament control can be employed for the output, or a 'cut-off switch' may be mounted on the panel, for extinguishing the filaments. The two audio transformers are mounted at right angles to each other. The shielding will allow them to be placed close together in case the set is made compact. The baseboard is 9 inches deep."

Intermediate-Frequency Transformer Data

(61) Mr. R. Contini, Niagara Falls, N. Y., asks:

(Q. 1.) Due to present legal entanglements and injunction suits restraining the manufacturers from commercially producing Super-Heterodyne material, I am having difficulty in obtaining an efficient Super-Heterodyne kit, or at least the intermediate and filter transformers. Don't you think it would be a good idea to publish constructional data of various



The design and constructional data including all necessary dimensions of an intermediate frequency transformer, air core type, having an amplification peak at 10,000 *meters.*

types of intermediate transformers and filters designed to operate in conjunction with them? Many constructors who "roll their own" would be glad to obtain this data; I for one would. In fact the information that you will publish, I hope, contains the constructional data of the transformer I am going to use in my Super-Heterodyne receiver.

(A. 1.) The following are the constructional data for various types of intermediate transformers and filters. We are also including oscillator-coil design, thus making the necessary information complete; with the source of the information, so that more complete data and illustration may be obtained by referring to the original article.

The following are constructional data for an efficient 10,000-meter intermediate transformer, filter transformer and oscillator coupler, obtained from "The Radio Constructor" series of blueprints; the title of this particular one being "A Genuine Standard Super-Heterodyne." Incidentally, this blue-print is no longer being published, though it is possible that copies are obtainable from some dealers.

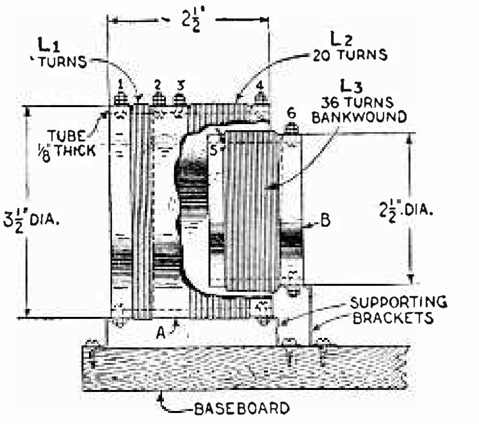
The Tuned Filter

A very important part of the Super-Heterodyne is the tuned-filter coupler. This coupler is very simple and yet must be accorded much care in construction. Practically all filters for this purpose consists of two coils placed close together. Each coil is tuned by a condenser, either fixed or variable, and is arranged to have a certain "tune" or wave-length which, once adjusted, is not touched again after the set is in operation.

The tuned-filter coupler determines the "intermediate frequency." One of the simplest and most convenient form for this purpose will be two standard "duo-lateral" or honeycomb coils, each having 750 turns. The wave-length advocated is 10,000 meters; and, in order to bring the coil up to this level, two fixed mica condensers, each of .0005-uf. capacity, are connected across the terminals of both coils.

As a great deal of the selective quality of the set depends on the filter, it will be necessary to arrange it so that the coupling between these two coils can be varied to the best position. The best efficiency will be obtained only if the intermediate-frequency transformers give maximum amplification at the particular wave-length for which the filter is designed. Therefore, when using the two duo-lateral coils as explained above, it will be a good plan to purchase or construct three intermediate frequency transformers that will give best amplification at about 10,000 meters. There are several types on the market which will give excellent results. If the builder desires to construct a special filter it can be made according to the following plans. Fig. 2176-A shows details of the disks and cores necessary.

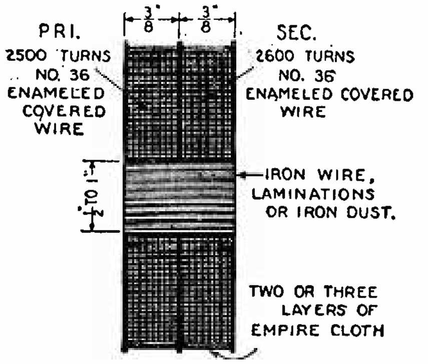
First assemble the disks on the cores and glue them fast, as indicated in the illustration. Now wind on each form 950 turns of No. 32 D.C.C. copper wire. Have these windings as near uniform as possible; that is, wind in layers from one side to the other. The windings are insulated from the core, as shown by means of a strip of empire cloth or insulating tape.



The design of an oscillator coil to operate in conjunction with a .001-*mfd. variable condenser for a* 10,000-*meter type superheterodyne receiver.*

The alignment pin shown in the illustration, in these pages, of the complete coupler, is merely a piece of wood driven into the first core. A hole about twice as large as the pin may be drilled in the other core to offer a recess in which the pin is to fit as shown.

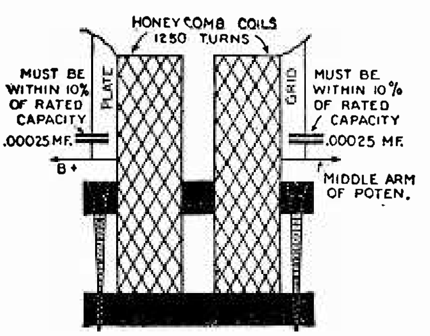
The ends of each coil are brought out, as shown, connected to small machine screw terminals fastened to the disks. This furnishes a convenient means of connecting to the coupler when wiring the set. In assembling the coupler, a brass screw (do not use iron) about 2¾ inches long and just



Design of an intermediate transformer which operates with maximum efficiency at 50 to 60 K.C. The correct amount of iron core must be determined experimentally.

large enough in diameter to fit the holes drilled in the cores, is used. This screw should be of the flat-head variety, and fits through a hole in the panel. It is then pushed through the hole in the core of the first coil unit of the filter coupler and a nut adjusted to hold it tight to the panel.

In placing the second coil on the shaft or screw, remember that the windings on both coils must be in the same direction. This is a most important feature, and must be taken into careful consideration when making the coupler. The second coil can now be fitted. Place another nut on the shaft and leave it about half an



The design of the filter or input transformer. Although these coils may be wound similarly to ordinary transformers, ordinary honeycomb coils may be used with the same efficiency.

inch from the other. Then place the second coil in position, by adjusting the core so that the aligning pin fits the hole and the core can be forced up to the second nut. The final nut for clamping may now be put on, and the coupler is finished except for adjusting of coupling.

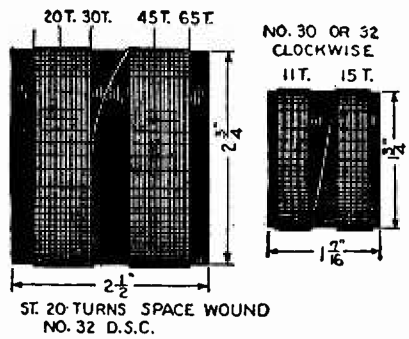
It is apparent that by turning the second nut on the shaft the second coil can be placed nearer to the first coil. The best operating position, that is, the proper coupling, will be found by test, as described later, and the second coil can then be clamped permanently in place.

Both primary and secondary coils are brought up to proper wave-length by placing .00025 uf. mica fixed condensers across the terminals of both coils.

Building the Oscillator Coupler

Below is shown graphically the constructional details of the oscillator coupler and it will be noted that, in effect, it consists of a primary, secondary and also a coupling coil. The coupling coil is used to pick up the necessary energy from the oscillator: it is what is usually known as a "pick-up" coil. This entire circuit is tuned by the .001-uf. condenser.

The illustration, on this page, shows a bakelite or fiber tube 3½ inches in diameter, 2½ inches long and 1/8 inch thick. A hole is drilled about 3/16 of



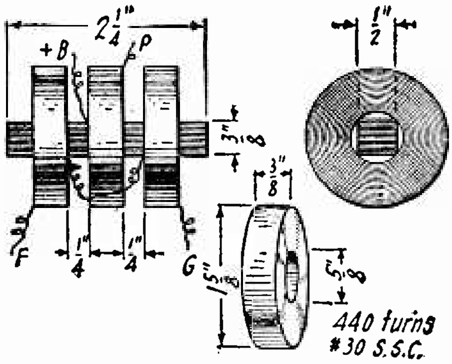
The design of an oscillator and an oscillator coil in conjunction with a .0005-mfd. condenser, in a super-heterodyne receiver employing 50 to 60 KC type intermediate frequency transformer.

an inch from one end and the brass-angle supporting-bracket mounted as shown. Directly above this mounting screw hole, another small hole is drilled to hold a small round-head machine screw and nut, terminal No. 1. Now take a spool of No. 20 or 22 double covered copper wire and wind 7 turns as close as possible. The end of this coil is then connected to a screw terminal, 2, in the tube in the same manner as done at the beginning. This is coil L1.

Use the same size wire to wind a second coil on the tube. Wind 20 turns, fastening both ends to these screw terminals, 3 and 4, as shown. To each of these screw terminals a lug can be attached if desired. These will serve for making permanent connections. his will be coil L2.

Coil L3 is wound on a separate form. For this purpose a bakelite or fiber tube, 2½ inches in diameter by 1¾ inches long and ⅛ inch thick, is used. Use the same size wire and wind 36 turns in what is known as "bank winding." This coil must be wound in the same direction as coil L2 in order to form a continuous winding through the fixed condenser.

One end of this bank winding can be connected to a screw terminal, shown as terminal 6 in the illustration, and the other end fastened by threading it through two small holes drilled close to the other end of the tube.



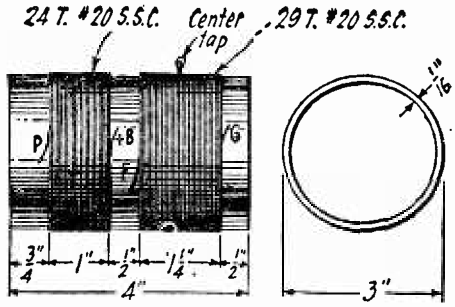
The design of a tuned intermediate frequency transformer, employing an iron core. A small variable condenser, approximately .00025-mf., is connected across the secondary and varies with wave-length range from approximately 2,000 to 7,000 meters.

This coil is then fastened to the baseboard by means of an angle supporting-bracket as shown; the placing coil L3 in proper relation to coils L1 and L2. The distance between coil L1 and L2 is not a very critical detail and the windings may be placed about ½ inch apart.

The relation of coil L3 to L2 is best determined after the set has been placed in operation. Also illustrated is the smaller for mon which coil L3 is wound, mounted only temporarily on the baseboard.

50 to 60 K.C. Filter and Intermediate Transformers

Herewith is shown the design of ar efficient intermediate-frequency transformer which operates very efficiently



Constructional data of an oscillator coil to operate in conjunction with the tuned intermediate-frequency transformer; *designed so that it may be use in the Tropadyne, which receiver incorporates both detector and oscillator in one tube.*

at a peaked efficiency of between 50 and 60 kilocycles (6,000 to 5,000 meters). The correct amount of iron core to be used must be determined experimentally.

Below is shown the design of a filter transformer which may be very easily constructed and designed to operate in conjunction with the above-mentioned intermediate-frequency transformer. The coil consists of two ordinary 1250-turn honeycomb coils mounted as illustrated.

Herewith is shown the construction and details of an oscillator coil for the above-mentioned.

Tropaformer

The tropaformer is an efficient tuned intermediate-frequency transformer; its amplification peak may be varied between 2,000 and 7,000 meters (150 to 43 kilocycles).

The complete details of this transformer are shown in the illustration in these pages. It will be noted that a variable condenser is permanently mounted on each transformer. This condenser is connected across the secondary winding; and in this way each transformer may be accurately tuned, making the intermediate-frequency amplifier very selective and efficient. Mica-insulated variable condesers are used because they occupy less space than those employing air as the dielectric. These condensers have a maximum capacity of .0005-*uf*. and, in connection with the coils used, the transformers may be tuned to any wave-length ranging from 2,000 to 7,000 meters. Although the coils used in these transformers were wound by machine, they may easily be wound by hand, haphazardly, on a suitable form, or spool. The number of turns, which in this case is 440 in each coil, is not critical. Two coils connected in series form a secondary, and one coil forms a primary. It is important to separate the coils at least a quarter inch. The core iron used is exceptionally thin, japanned silicon steel. This steel, which may be obtained from manufacturers of iron-core radio-frequency transformers, is not the same as that used in the construction of audio-frequency transformers. When constructing these transformers, it is important that all coils be wound in the same direction and placed on the core, as shown in the illustration. The leads are lettered to correspond to the vacuum tube connection.

The design for an oscillator coil to operate in conjunction with the above-mentioned intermediate-frequency transformer and which combination may be used for the construction of the popular Tropadyne receiver, is as follows:

The two windings (plate and grid) are wound in the same direction on a tube 3 inches in diameter and 4 inches in length. The plate winding consists of 24 turns of No. 20 S.S.C., whereas the grid coil consists of 29 turns of No. 20 S.S.C., and has a center tap (14½ turns). For exact specifications and details refer to the illustrations.

Best's 5-Tube Super-Heterodyne Set

(62) Mr. H. T. Borden, Portland, Maine, asks as follows:

Q. 1. I am advised that G. M. Best has designed a new super-heterodyne receiver, a 5-tube affair. Have you any constructional data on this receiver? Would appreciate any schematic diagram and any additional information.

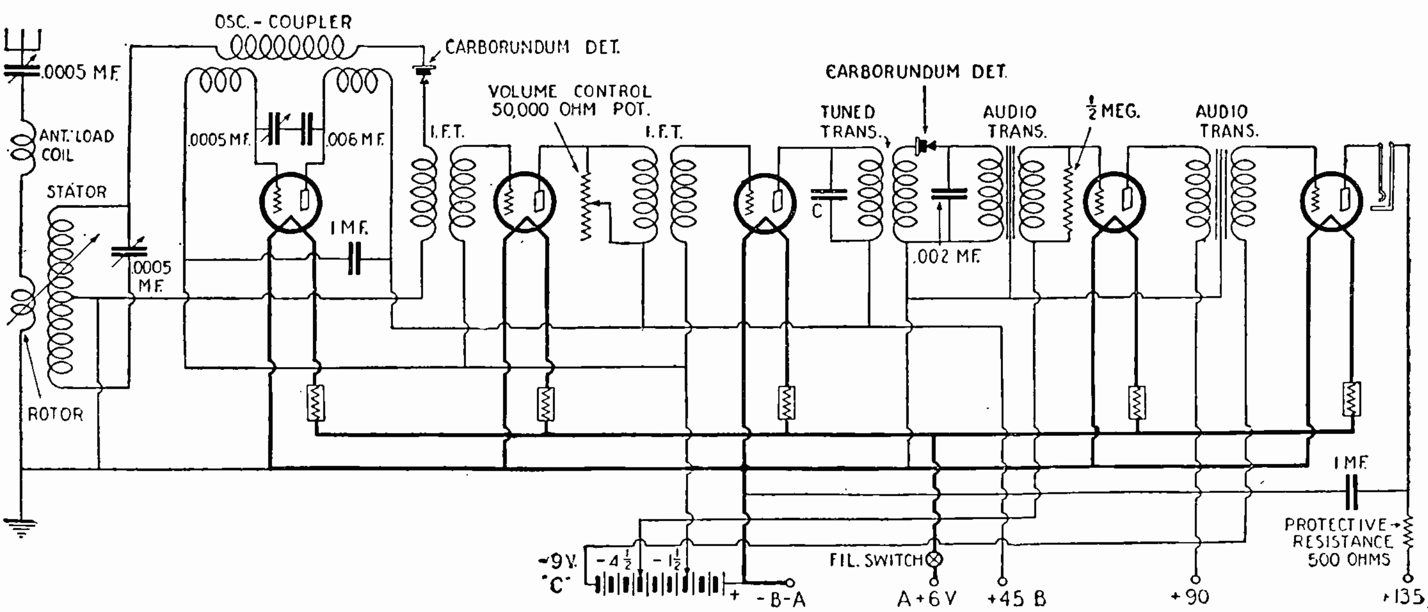
A. 1. The Best 5-tube super-heterodyne receiver was originally featured in the April, 1926, issue of *Radio* magazine. The following are parts of the description of this receiver from the article, written by G. M. Best, which appeared in the publication mentioned.

"The salient features of the circuit are selectivity, superb quality of output, excellent volume with cone loud speaker, by the use of a power tube, economy in battery consumption, as only five tubes are required, and ease of assembly by the use of both sides of the shelf for mounting the apparatus.

"The principal difference between this super-heterodyne and others previously described is in the use of two carborundum crystal detectors for the frequency changer and the detector, commonly called the first and second detectors. It has long been known that crystals could be used in these positions in a super-heterodyne; but the objections were that the crystal was not easily adjusted, had a low internal resistance which destroyed selectivity, and was not sufficiently sensitive.

"The new carborundum detector, however, has none of these disadvantages, as it has a permanent adjustment under pressure which prevents instability; has a high internal resistance, so that the detector will have little or no damping effect on the tuned transformer or antenna tuner; and is remarkably sensitive. The carborundum detector, in order to produce maximum results, requires a small battery to control the detector resistance and sensitivity. A new unit is now available which consists of a small flash-light dry cell, a potentiometer, by-pass condenser and carborundum detector, arranged for convenient panel mounting and adjustment.

"Working with two of these detectors as a basis, a five-tube super-heterodyne was developed, which had the sensivity of a seven-tube circuit, with greater selectivity and less battery



Best's 5-tube super. An innovation in supers, in that three tubes are eliminated by means of two crystal detectors. Although the sensitivity of the original receiver decreases somewhat, the set is unusually efficient and will satisfy particular constructors, especially as regards DX, volume, and clarity.

drain than conventional five-tube tuned R.F. receivers. (By reference to the schematic wiring diagram on page 65, the general arrangement of the circuit can be understood.)

Avoiding Radiation

"While the set can be operated with a loop antenna, many readers object to the loop for various reasons, and prefer to use an outdoor antenna. Realizing that the indiscriminate use of the set with the antenna without due regard to the radiation of the receiver when improperly operated, would cause a great amount of harm to neighboring receivers, an antenna system was selected, which, when properly adjusted, will cause a minimum amount of radiation of the oscillator output. The antenna circuit consists of a series air condenser, loading coil, and coupling coil. If the loading coil is the proper size, the antenna system will tune through the broadcast band without difficulty. The coupling coil is arranged so that very loose coupling can be obtained, and a center-tapped secondary is used to obtain greater selectivity.

"The antenna condenser is mounted on the left end of the panel, and the secondary tuning condenser, which is similar in size to the antenna condenser, is in the center of the panel.

"The frequency-changer circuit is connected to the secondary of the antenna tuner, and consists of a pick-up coil placed in the field of the oscillator, a carborundum detector unit, and the primary of the first intermediate-frequency transformer. The oscillator is of the conventional pattern, and is tuned by another variable condenser of .0005 mf. capacity in series with a protective .006 mf. fixed condenser; the latter preventing tube burn-outs in case the air condenser develops a short circuit.

The intermediate-frequency amplifier consists of two stages, with storage-battery tubes.

Parts necessary for the construction of this receiver are as follows:

3 Variable Condensers, .005 mf.;
1 Antenna Load Coil;
1 Antenna Coupler;
1 Oscillator Coupler;
2 Intermediate - Frequency Transformers;
1 Filter Transformer;
2 Audio-Frequency Transformers;
2 Carborundum Crystal-Detector units;
4 Automatic Filament Resistances, ¼-amp. size;
1 Automatic Filament Resistance, ½-amp. size;
1 Filament Switch;
2 Fixed Condensers, 1 mf.;
1 Mica Condenser, .006 mf.;
1 Mica Condenser, .002 mf.;
1 Filter Tuning Condenser;
1 Grid Leak, ½-megohm with mounting;
1 Tube-Protective Resistance Unit—500-ohm;
2 4½-volt "C" Batteries;
5 X-type Sockets;
1 Single-circuit Jack;
1 Variable Resistor, 50,000-ohm;
1 Binding Post Strip—7 posts;
1 Panel, 10x20x3/16 in.;
1 Bakelite or Formica Shelf, 5x18¾x¼ in.;
2 Brackets for Shelf;
Insulated and bare wire, 3 doz. ½-in. 6/32 r.h. brass machine screws, and four 1-in. flat-head brass 6/32 machine screws for fastening brackets to panel.

Coil Data

"The antenna coil may be made by winding 125 turns of No. 26 silk-covered wire on a 2¾-in. bakelite tube 3 in. long. The antenna tuning coil comprises a stator and rotor. The stator coil consists of 70 turns of No. 26 S.C. wire, wound on a 2¼-in. tube, 2½ in. long; a tap is taken off at the 35th turn, for connection to the ground circuit. The rotor, or antenna coupling coil, is wound on a 1½-in. tube, and consists of 10 turns of No. 26 S.C. wire. If the set is not sufficiently selective, it may be necessary to reduce the number of turns of wire on the rotor.

"The oscillator-coupler is identical in dimensions with the antenna coupling coil, except that when using the "A" tube as an oscillator, 5 turns in the pick-up coil will be ample; and it may be possible to reduce the turns to 3 or 4, where sufficient energy is obtained from the oscillator. In this connection, the "A" tube delivers more energy as an oscillator than does a type 99 tube under similar conditions; and it is a good idea to reduce the oscillator output by placing an additional filament resistance cartridge in series with the filament of the oscillator, which will serve to reduce the filament current of the tube. A variable filament rheostat at this point would give greater flexibility, but it has been found that two 6-volt automatic filament control units in series will reduce the oscillator output to just the right amount. If the type of 99 tube is used, the normal filament current of 60 milliamperes should be employed.

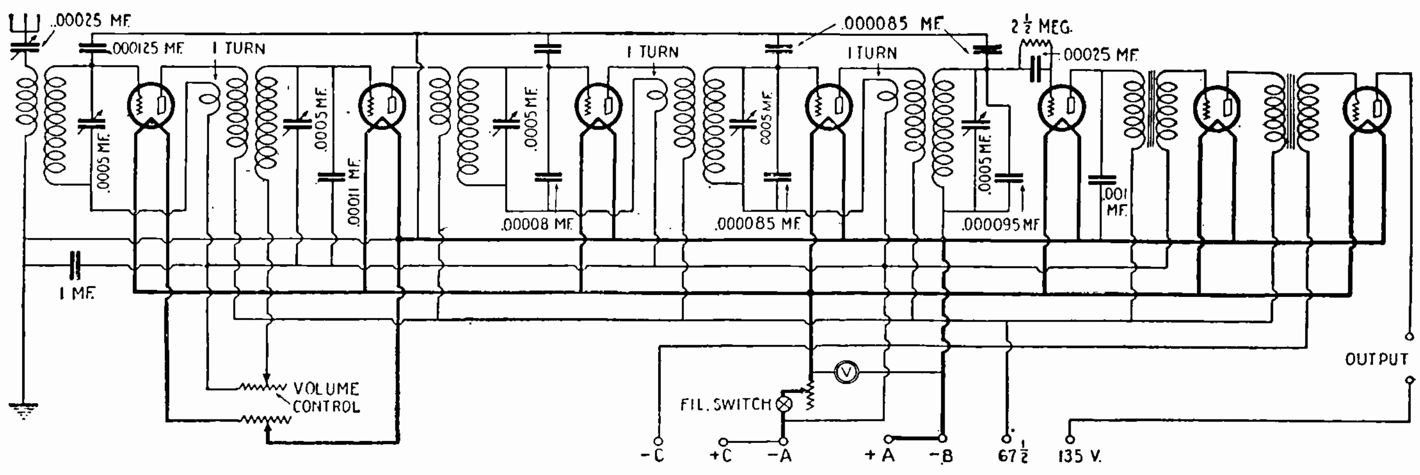
Kellogg R.F.L. Receiver

(63) Mr. W. D. Bridge, Scranton, Pa., asks:

Q. 1. I would like to construct the Kellogg R.F.L. receiver, bu lack the necessary constructional data, especially, the condenser and coil values. Can you furnish me with the desired information? Also whether the receiver is designed for power-tube operation, and the correct plate and grid voltages necessary for the power tube, if used?

A. 1. The following is all the constructional information we have available on the Kellogg R.F.L. receiver. Schematic wiring diagram given on this page.

The five tuning condensers are mounted on a common shaft, which is split between each two condensers by means of an insulating bushing. The station indicator is a transparent sheet mounted on a cylindrical metal frame, and placed in the center of the condenser group. The shaft is turned by means of a worm drive between the right-hand pair of air condensers. Back of the condensers are mounted the tube sockets, adjusting condensers and miscellaneous apparatus, while underneath the shelf are the four R.F. transformers, and the antenna tuned circuit, which is the unshielded coil. The filament rheostat and meter panel are mounted to the right of the condenser



The schematic wiring diagram of the Kellogg R.F.L. receiver. This set combines many desirable features which are very popular with the broadcast listener; the most important of which are four stages of tuned-radio-frequency amplification before a detector, and two stages of audio frequency amplification. A power tube is used in the last audio stage, using the voltage shown.

group, since the filament adjustment is seldom made; and it is not necessary to have the voltmeter on the panel for an operating indicator, as the dial is illuminated. On the left, at the rear, is the antenna series condenser, which is adjusted upon installation of the set to the point of greatest efficiency for that particular antenna system, and is left alone.

Each of the four R.F. transformers is tuned with a .005 mf. variable condenser, each condenser being shielded by a metal can. The antenna coil secondary condenser is not shielded, being at the extreme left front of the assembly. From the diagram it can be seen that the grid return for three of the tuned circuits is through a one-turn coil, which is coupled loosely with the primary of the next R.F. transformer, and permits efficient neutralization of the amplifier.

Coil Specifications

Each R.F. transformer consists of an 8-turn primary, wound on a 2⅝-inch form, and a 62-turn secondary wound on a 2¾-inch form, each coil being of the cylindrical, space-wound type, with No. 20 enameled wire. The balancing coil, in the case of those transformers which are so equipped, is placed close to the primary, and both coils are at the low-potential, or filament end of the secondary. The antenna coil consists of a 45-turn primary, and 51-turn secondary, both wound adjacent to each other on a 2¾-inch form, with No. 20 enameled wire. Copper cans enclose each R.F. transformer, and the connecting leads from the transformers to the condensers and tube sockets are brought up through holes in the tops of the cans. This prevents coupling between tuned stages, and is the reason for sensitivity and selectivity of the set.

Each variable condenser is adjusted for minimum setting by means of set screws with which the rotor plate groups are attached to the shaft; and after all rotor plate groups are adjusted, the individual tuned circuits are brought to resonance by means of small shunt variable mica condensers, which are shown in the diagram in parallel with the variable air condensers. Additional shunt to the positive filament circuit from the grids of certain of the R.F. amplifiers, is used in order to stabilize the circuit.

Volume control is obtained by varying the filament current of the first R.F. amplifier tube, and placing a variable high resistance in the grid return of the second R.F. amplifier. The two variables are mounted on the same shaft, and are so adjusted that the set does not oscillate at any time during the operation of the volume-control dial. The positive "A" and negative "B" battery circuits are grounded to the frame and shields, so that the shielding becomes the actual conductor for the A and B current. This reduces the number of wires in the set, and simplifies testing. A voltmeter enables voltage control through a master rheostat, which is in the negative filament lead.

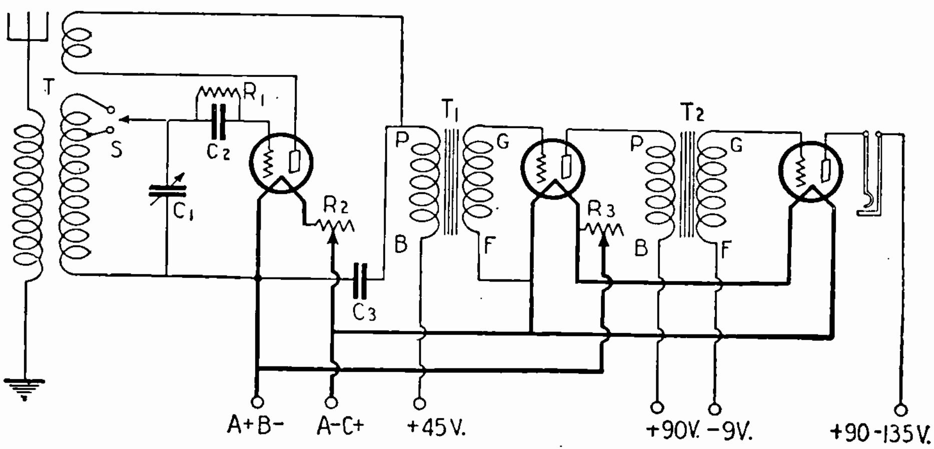
Increasing Range of Three-Circuit Tuner

(64) 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 have read that the Radio Commission considers the possibility of reducing the broadcast wave band 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 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 outer 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 wavelengths, since the tickler coil may be too large and excessive oscillation may occur.



Reramped three circuit tuner

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-megohms, 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.

It is extremely unlikely that the broadcast wavelength band will be extended beyond its present limits (200-550 meters), the Radio Commission having decided that millions of dollars worth of receivers would be made obsolete by the change. A comparatively simple set of the 3-circuit type can be adapted to lower waves without much trouble, but other receivers are not so flexible.

Garod Neutrodyne

(65) Mr. Clarence Selley, Benkelman, Neb., writes:

(Q. 1.) Please show the Garod Neutrodyne circuit, but using one stage of audio frequency amplification instead of two stages.

(A. 1.) We are showing this circuit in these columns.

All the neutroformers use 3-inch tubes for the secondaries. The primaries, on tubes 2¾ inches in diameter, fit just inside the filament end of the secondaries. Neutroformer N-1 has a primary of seven and one-half turns of No. 24 D.C.C. wire, the same wire being used throughout.

The secondary comprises 70 turns. Neutroformers N-2 and N-3 each have four one one-alf turn primaries and 65 turn secondaries. These two neutroformers are tapped 22 turns from the filament end of the secondary. Neutroformer N-1 is tapped in the center. They must be placed at the usual non-inductive coupling angle. All coils are wound in the same direction.

It will be noted that the connections to both the primary and secondary of neutroformer N-2 are reversed.

A variable detector grid leak may be used.

Standard neutralizing condensers may be used. While the point of neutralization is quite sharply defined it is not difficult to find.

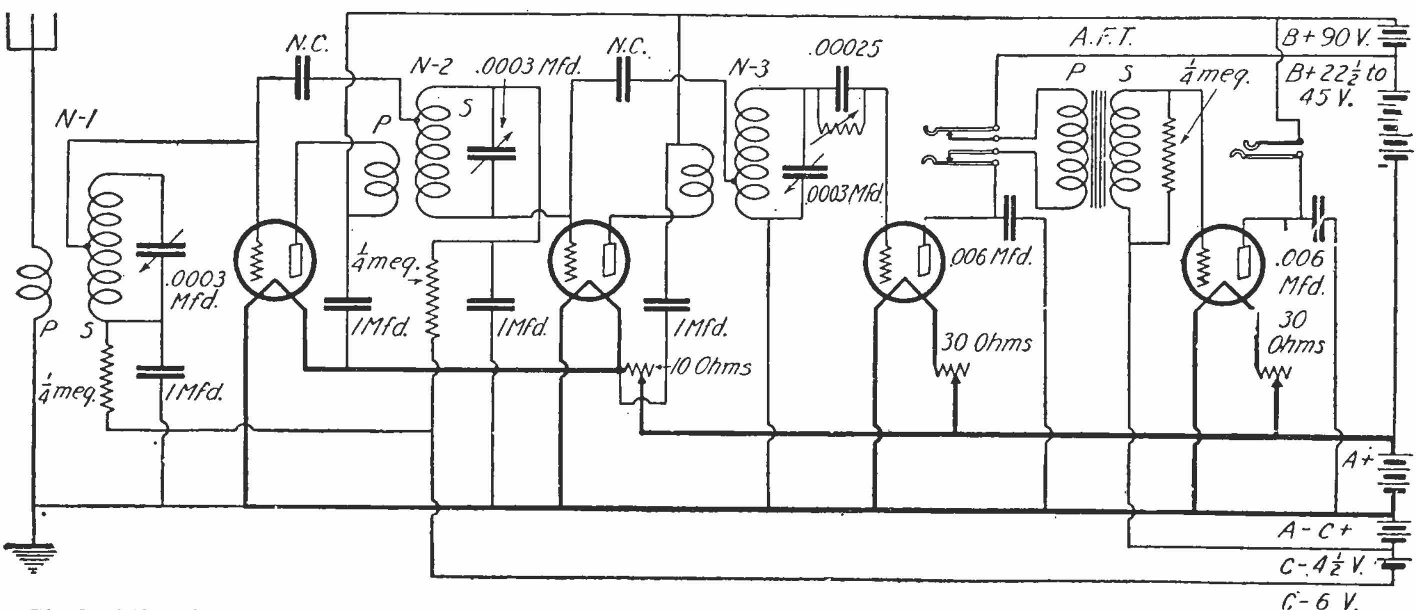
Although Stromberg-Carlson 4.3:1 ratio audiofrequency transformers are used, any other good make of transformer may be used.

This set is extremely selective, sensitive and clear reproducing. Signals are also very strong. "B" battery consumption is unusually low. All this is explained by the high negative "C" potential, the detector grid return to "A" negative, the one-quarter megohm resistances, correctly placed and proportioned condensers, and carefully designed neutroformers. Of course, the audiofrequency amplifier must be well designed in order to maintain the high quality signals of the detector circuit.

(Q. 2.) Does the long thin line or the short thick line denote the positive binding post of a cell or battery?

(A. 2.) The long thin line denotes

(A. 3.) It makes no practical differ-



The Garod Neutrodyne. A study of this circuit shows it to be one difficult to surpass, where a prime requisite is tone quality. But also, it is extremely sensitive. Although reception may be excellent at the detector, a very careful audio frequency amplifier design must be employed to retain this quality. Note resistances in the radio frequency amplifier grid return leads.

the positive connection. In some erroneous diagrams, this is shown reversed, the short line denoting the positive connection.

(Q. 3.) Does it make any difference whether the "A" battery connects to the switch arm, or to the resistance wire, of a rheostat?

ence whether the rheostat is connected one way or the other. Also, polarity markings on the tube sockets may be disregarded, if it will not be confusing to you.

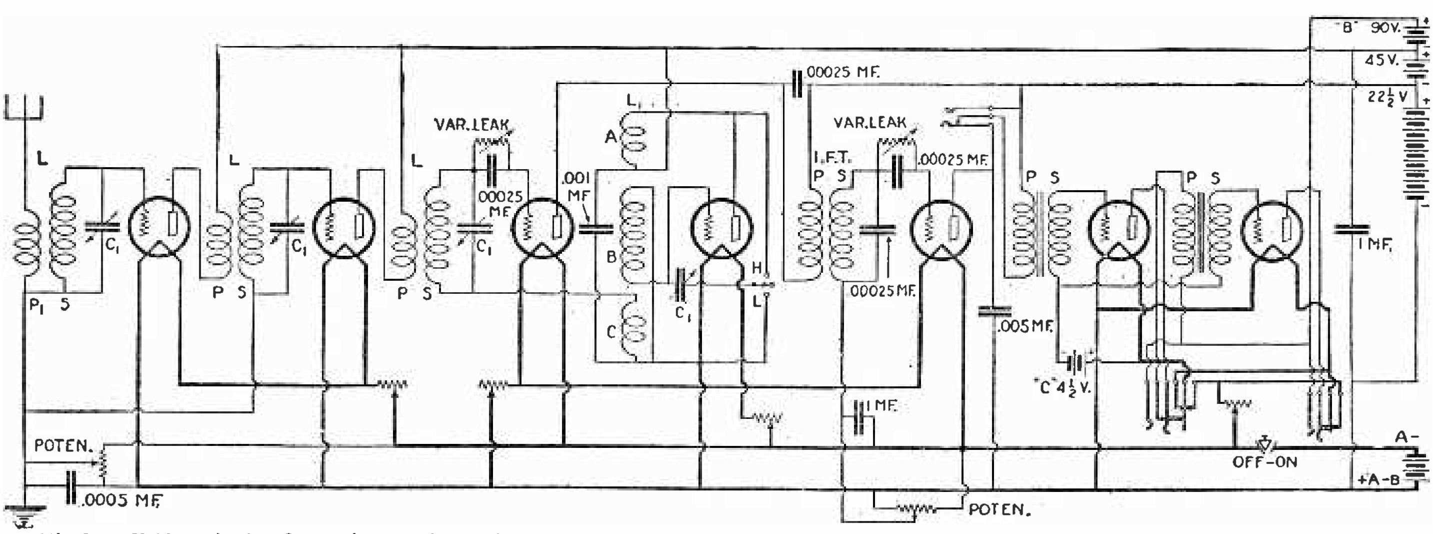
The Super-Unidyne

(66) Mr. H. S. Harris, New Albany, Miss., asks:

(Q. 1.) What is the diagram of connections used in the Super-Unidyne receiver? This is a seven-tube set employing the super-heterodyne principle. The receiver has three stages of short-wave, high frequency amplification, a first detector, and oscillator, a second detector and two stages of audio frequency amplification. The unusual part of the set is that no intermediate frequency amplification is used.

(A. 1.) We are showing the circuit of this very interesting receiver in these columns.

The radio frequency transformers marked "L" may be the standard type of so-called "tuned radio frequency transformer" designed to cover the broadcast wave-length band. Fresh-



The Super-Unidyne circuit. Storage battery tubes are best. Two stages of radio frequency amplification are used. The fourth tube from the left is the oscillator tube. There is no intermediate frequency amplification. The oscillator is used only to furnish selectivity and a certain amount of amplification which is the result of heterodyning.

man, Toroformer, Syckles, Erla "Balloon" Circloid, Andrews "Paddlewheel," Hammarlund, Rasco "R.F. Spiderweb," or even Neutrodyne coils may be used in the three radio frequency amplifier stages, if care is used in building this part of the set. The value of the condensers marked "C-1" will be dependent upon the constants of the particular coils selected for "L." The most important points to remember in placing these coils are the two we have stressed in almost every issue of *RADIO NEWS* for the past six months or more: the coils *must* be in *non-inductive* relation; leads *must* be short. The latter refers most strongly to the grid leads; the plate leads are next in importance.

Both potentiometers are of the 400-ohm type. The four rheostats may all be of twenty- or thirty-ohms rating, the first-named rating being best for the usual quarter-ampere tubes.

There is only one intermediate frequency transformer in this set and even this is more properly termed a "filter coupler."

It is the coil with the .00025-mf. condensers across the primary and secondary (P and S) coils. These condensers will, in practice, necessarily vary from this value. In order to tune this filter coupler properly, these two condensers should be of the very small, variable mica type having a maximum capacity of about .0005-mf. There are at least three such instruments on the market, the Amplex, "Grid-Denser," the X-L Laboratories "Vario-Denser," and the "Turn-It" condenser.

Both primary and secondary filter coils have the same constants, in the regular set, but other, nearly similar coils may be used; anyone having a stray Ultraformer or Tropaformer around will find it adaptable to this set.

An ambitious experimenter can make his own coil by winding 500 turns of No. 30 D.S.C. wire in a groove one-quarter inch wide and one inch internal diameter. This is the primary. Duplicate this for the secondary. Both coils are wound in the same direction. The outside of the primary goes to the plate and the outside secondary lead goes to the grid. By the time you have filled the two grooves, the diameters will have grown to about three inches. This groove proposition is easily attended to by having some cigar-box wood cut to the diameters of one inch and three inches. You will need three 3-inch, and two 1-inch disks. These are placed together alternately this way: 3-1-3-1-3, with a brass screw running through the center of the five pieces, to hold them together. Four sets of such coils may be used in any super-heterodyne. It is best to make the cigar-box wood impervious to moisture by painting it with colodion or thin shellac. The finest treatment is to place the wood in melted paraffin until air bubbles stop coming to the surface, then remove and allow the excess paraffin to drain off.

The three-coil oscillator L-1 is next on the construction list. All three coils are wound in the same direction, with No. 24 D.C.C. wire on a three-inch tube. Wind "A" to about 18 turns; leave one-quarter inch space and wind 45 turns for "B", and lastly, 12 turns for "C", one-quarter inch from "B."

There is nothing new or unusual about the filament control jacks for the audio stages.

Right here we wish to voice a warning. Keep the oscillator in non-inductive relation to the outer coils in the set.

As in all multi-tube sets, good tubes are a prime requisite.

Condenser rotor plates are indicated by the arrowhead. Body-capacity effects will be strong, at the oscillator condenser, unless a separately grounded frame condenser is used. Straight-line wave-length or straight-line frequency condensers should be used—not straight-line capacity.

The oscillator variable condenser dial readings may be made to closely match the remaining three variable condensers in the set, if they are of the same capacity, by changing the number of turns in grid coil "B." A little experimentation here will do the trick.

Q. 2) Why does removing the cat-whisker from the crystal of my reflex set cause a loud howl in the loud speaker? And, why is it necessary to change the catwhisker location when changing from one extreme wave-length to the other, in order to prevent a loud howl? Other reflex sets I know of do not have this trouble.

A. 2) Both these experiences are caused by the same major effect—the crystal detector has a variable resistance. This resistance is varied as the contact is changed. Your receiver is similar to thousands of others, in that a loud howl is heard when the cat-whisker is lifted from the crystal. All this is understood when one considers the fact that the damping, or oscillation control of the circuit is governed largely by the amount of resistance in the circuit. By reducing the number of turns in the plate coil of the tube circuit that is oscillating, it is possible to stop the oscillation of the circuit. The effect of reducing the number of plate turns is obtained by connecting a resistance in the secondary circuit of the R.F. transformer, the primary of which is in the tube plate circuit. The crystal is this resistance. At the longer wave-length adjustment, less resistance is required in the circuit to stop oscillation, than at the short wave-length. This variable resistance requirement is met by varying the catwhisker location and pressure, as stated above. Some receivers use fixed crystals. In this case, where other special conditions exist, such as a reduced number of the plate-coil turns, it may not be necessary to make any change in the detector resistance to control circuit oscillation. In general, it may be said that receivers having such a critical adjustment of the crystal are more sensitive than those not so blessed (?).

Super-Zenith

(67) Mr. L. E. Moore, Durham, N. Y., asks:

(Q. 1) Please show the Super-Zenith circuit, with constants.

(A. 1) We are showing the circuit in these columns. Note that the three, four and five turn coils rotate. They are fastened to the variable condenser rotor shafts and, therefore, turn as the variable condensers are adjusted. These rotating coils may be wound on tubes 2½ inches in diameter with No. 24 or 26 D.C.C. wire (No. 22 or 24 D.C.C. wire being used for the remaining coils).

The seven- and ten-turn plate coils are fixed, being wound on the same three-inch tube as the 61-turn secondaries, but spaced from them about one-quarter of an inch.

The object in dividing each plate coil into two sections, with one section rotable, is to maintain a constant plate condition at all wave-lengths, rather than have possible oscillation at certain wave-lengths.

It is quite necessary that each tuned radio frequency transformer (61-turn secondaries) be in non-inductive relation to one another. Placing at an angle to the baseboard, similar to a neutroformer layout, is satisfactory.

The 2,000-ohm variable resistance must be non-inductive. A regular carbon or graphite type of resistance will be satisfactory.

The aerial, if short, connects to the end of the 20-turn aerial coil which is wound on the same tube as the 61-turn secondary, but separated about one-quarter inch from it.

In the commercial set the variable condensers that tune the grid circuits of the second radio frequency tube and the detector tube are mechanically arranged to turn with only one knob.

Standard storage battery tubes will probably give best results.

We are showing one stage of audio frequency amplification, but the audio frequency amplification desired is optional.

Connect headphones to binding posts X1 and X2, if the audio frequency amplifier is not used.

If three variable condensers are used to tune the set, the balancing condenser will not be required. This is only used to compensate for any variations, when two variable condensers are geared together. The balancing condenser need only be of three or four plate size.

A single dry cell, or a single flash-light cell, will be satisfactory for the 1½-volt "C" battery.

Note that all constants shown (coil turns, etc.) must be considered as variable, depending upon individual conditions.

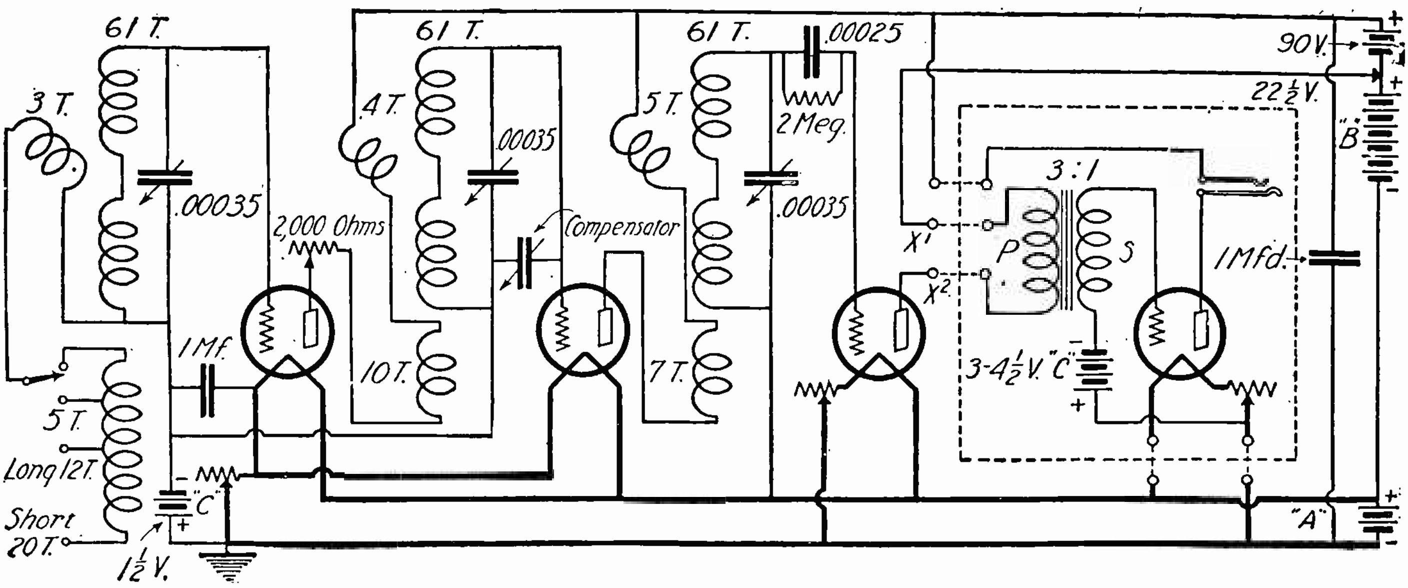
The construction of this receiver should not be attempted unless one has had considerable experience in making experimental sets.

(Q. 2) What could be the explanation of weak signals from local stations when using a Super-Heterodyne having intermediate frequency iron core transformers marked "10,000 meters"? The filter coupler consists of two 250-turn honeycomb coils. A .002 mf. fixed condenser is connected across each coil.

(A. 2) The filter coupler must be sharply tuned (or nearly tuned) to the wave-length peak (that is, the wave-length at which the amplification is greatest) of the intermediate frequency transformers selected. For that reason it will be necessary to use larger honeycomb coils than you now have. Try two 600-turn honeycomb coils shunted by two variable condensers having maximum capacities of about .001 mfd.

Code Signal Audibility at Receiving Station

R1—Almost inaudible.
R2—Perceptible.
R3—Extremely feeble.
R4—Very feeble.
R5—Very weak.
R6—Weak.
R7—Fair.
R8—Loud.
R9—Loud speaker volume.



Phone Audibility and Quality

M1—Speech garbled.
M2—"Hashed" speech.
M3—Uneven modulation.
M4—Clear voice.
M5—Very clear, modulation perfect.

Novel Plate Supply

(68) Mr. Jno. J. Ruby, Brooklyn, N. Y., asks:

(Q. 1.) Please show how to combine an amplifier using UX-112 tubes and the radio frequency circuit accompanying this inquiry.

(A. 1.) We believe you will find the circuit shown in the diagram below on this page will meet your requirements. (See page 1188.)

The constants are as follows:

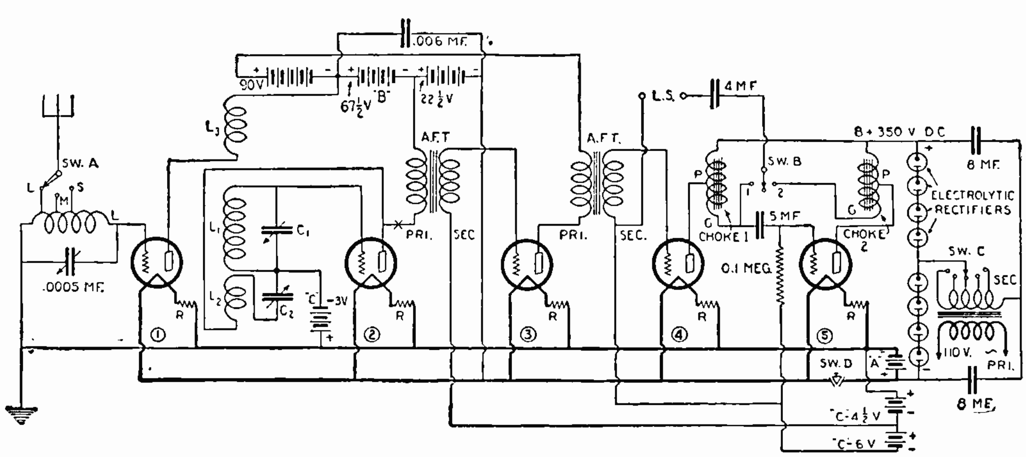
L 48 turns of No. 24 D.C.C. wire tapped at 2 turns from the filament end of the coil for "L" 8 turns for "M" and 15 turns for "S." L-1 50 turns of No. 24 D.C.C. wire wound on a 3-inch tube. One eighth of an inch from the filament end of this coil is wound L-2, 25 to 40 turns (depending upon tubes used) of the same size wire, wound on the same tube with a separation between L-1 and L-2 of about ⅛-inch. Four UV-201A type tubes 25 turns will probably be found about right. For dry cell tubes, more nearly 40 turns will be required. L-3, 15 to 35 turns (depending upon tubes used) of No. 24 D.C.C. wire, on a 3-inch tube. L-3 is separated from L-1 by a distance to be determined by test. It will probably be about 3 inches, and in inductive relation as shown. All coils are wound in the same direction. Condenser C-1 may have a maximum capacity of .0005. C-2 has a vlue of about .0025 mf.

It may be advisable to connect a choke coil at "X," this coil to consist of about 200 turns of No. 30 D.S.C. wire an a 2-inch tube.

To insure better quality, grid-bias rectification is used, instead of the more ordinary grid-leak rectification.

Good audio frequency transformers must be used. Chokes one and two may be autoformers with a voltage step-up ratio of 1:1½.

An unusual circuit employing the use of electrolytic rectifiers to supply B voltage for the plates of the last two amplifier tubes.



To eliminate strong hand-capacity effect, the writer has shown the rotor of C-2 connecting to the "C" battery side of the instrument.

An illustration of the radio frequency instrument and a lay-out that may be followed appear on page 796 of the December, 1925, issue of RADIO NEWS.

The electrolytic rectifiers are very easily made. The tubes are 1 x 6-inch test tubes filled with a solution of sodium phosphate, made by dissolving about a teaspoon full of the chemical to a cup of water (use the neutral salt, not acid sodium phosphate). The electrodes are thin aluminum and iron strips, ¼-inch wide and 6 inches long. The positive element, the aluminum, must be of the purest grade obtainable.

The iron or negative electrode serves only as a connection to the electrolyte. It is the aluminum oxide film, the formation to be described, with which we are most concerned.

The transformer is a 50-watt, 110-volt, 60-cycle transformer with a 220-volt secondary winding tapped about evenly. This secondary voltage, which is very critical, is the plate potential to be determined by test.

Although 8 mf. condensers are shown, condensers of larger capacity will reduce any ripple that may remain in the out-put.

Before using this rectifier on the set, switch Sw.C should be set for the lowest possible voltage and the transformer connected to the 110-volt line for about 10 minutes. The oxide film will by then be formed on the aluminum electrodes.

Switch Sw.B may be a push-pull arrangement, for selecting either the first or second stage of power amplification. The tubes recommended for the two-power stages marked 4 and 5, are UX-112-type tubes. Type UX-210 tubes can also be used in these two positions with extraordinarily good results. In the event that these tubes are used, no filament resistance is required at "R," with a 6-volt supply. When UX-112 tubes are used, a *resistance capable of carrying ½ ampere* per tube must be provided for the set. The UX-210-type tube will require a negative "C" bias in the neighborhood of 15 volts.

The 8 mf. condensers must have a high insulation value.

By use of the unusually efficient and high plate voltage supply described above, one need not give the attention needed by "B" batteries of the usual type which age rapidly under such heavy duty service and eventually become noisy, or the storage "B" battery that requires frequent recharging, or the next best proposition, the motor generator with its attendant and undesirable commutator noises.

This circuit is an unusually efficient one for driving cone-type reproducers.

Readers will be interested to know that a set built with this form of plate supply reproduced the signals of a broadcast station fifty miles away so loudly and clearly as to be perfectly understandable at excellent audibility, two miles from the loud speaker.

Experimenters desiring more detailed information regarding the tuning system and circuit, selected for the qualities of selectivity and sensitivity, and the plate supply selected for the reasons enumerated above, are advised to study these references:

"The One-Stage Radio Frequency Amplifier," page 21, in the November, 1925, issue of QST magazine (Hartford, Conn.); "The Reactodyne Circuit," page 796, December, 1925, issue of *Radio News;* "Electrostatic A.C. to D.C. Converters," page 1077, March, 1923, issue of *Science and Invention.*

(Q.2) In the November, 1925, issue of *The Experimenter* magazine, in the article "How to Make and Use a Wave-Meter" (A. P. Peck, Radio 3MO), page 18, is a circuit, Fig. 1, showing a Neon tube for indicating reasonance in transmitter wave-length determinations. I understand the Neon tube may be made to cause circuit oscillation. If this is the case at audio-frequency, I would like to know how to make an audio frequency oscillator using the Neon tube.

(A. 2) The circuit requested is shown in these pages. Resistance "R" may be a fixed unit. The value required is most easily determined by making "R" variable with a range of 25,000 to 250,000 ohms, for testing the initial set-up.

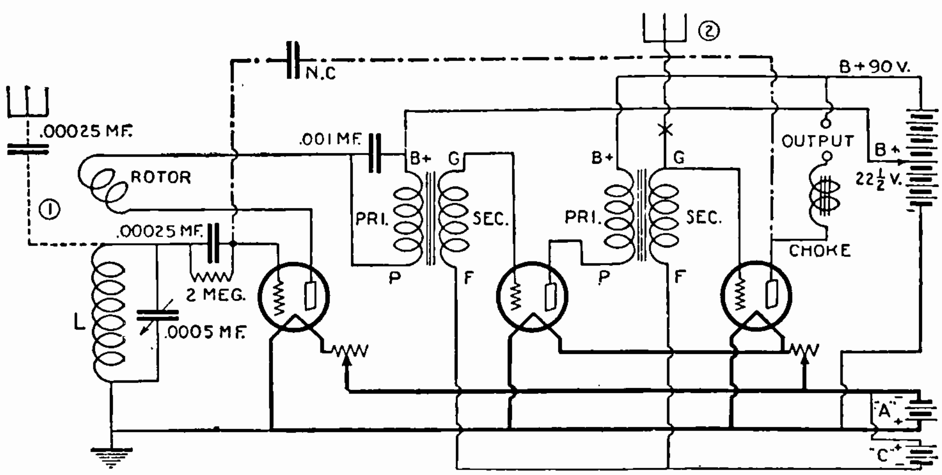
The output may be used for testing the response for loud speakers, audio transformers and headphones to various audio frequencies.

The Neon tube may be an "Osglim lamp" obtainable in England, or the more easily acquired Neon lamps used in the Westinghouse "Spark-C" automobile spark plug tester, or the Airco "Ignition Gauge."

Since this type of lamp only requires about 15 milliamperes at 200 to 300 volts, to "strike" the tube (the word "strike" is taken from electrical nomenclature, ordinarily used in connection with electric arcs, with reference to the starting of the arc action and relates in this instance to the lighting of the tube), and since the current required to *maintain* oscillation of the Neon tube circuit is only about *two* milliamperes, an ordinary "B" batterly will furnish amply sufficient current. In fact "B" battery current consumption is about one-third that of the ordinary vacuum tube. Another feature is the elimination of the "A" battery.

(Q. 3) If it is possible to incorporate the new DeForest Anti-Radiation device of Roy A. Weagant with a regenerative receiver of the so-called single-circuit type, so as to prevent radiation of squeals and whistles, please show how it can be done and give all details necessary. Would the large Acme audio transformer work satisfactorily in the set? Or would the Erla code transformer work best?

A. 3) Yes, it is possible to apply the principle you mention with no difficulty at all. The changes are probably made sufficiently clear in circuit diagram Q.2162-B on page 1163.



An interesting circuit for the experimenter.

The aerial is removed from its usual position (1) and placed as shown at (2). The .00025 mf. condenser shown in the first position of the aerial may be tried at point "X" of the aerial in the second position, but it will probably not be found at all necessary for its usual purpose—increasing selectivity.

The coil marked "Choke" may be the secondary of a good radio frequency transformer of the *aperiodic* type, such as the Acme R-2, the Duratran, the All-American R-201A, etc.

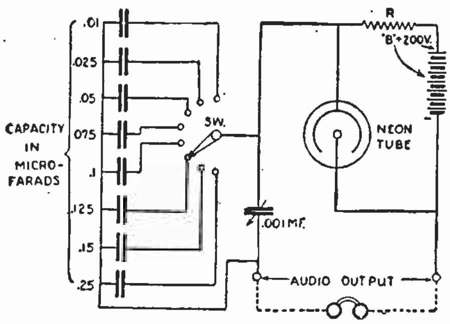
A Chelton Midget condenser may be used as N.C. Other condensers of the type used in neutrodynes for neutralizing purposes will probably prove satisfactory, if 50 mf. capacity can be obtained.

Any good make of audio frequency transformers may be used, with the lower ratio transformer in the second stage.

The ratios of the new and old model Acme transformers, and other comparative data are:

NO.	RATIO	HEIGHT	DEPTH	WIDTH	WEIGHT
A-2	4½ :1	3"	2"	2½"	8 oz.
MA-2 ..	5 :1	3"	4"	4 "	16 oz.

It is inadvisable to use the code transformers mentioned, unless it is desired to receive mostly code signals, in which case inductances "L" and "rotor" would be entirely different from their broadcast values; which may be, for example, "L," 50 turns of No. 20 D.C.C. wire on a 3-inch tube; rotor," 20 to 40 turns of No. 24 D.C.C. wire wound on a 2½-inch form, the exact number of plate coil turns determined by the particular tubes used.



The Erla code transformer is called the "1,000 cycle" transformer and at this frequency at which it peaks, a voltage amplification ratio is approximately 30:1 and is the most suitable transformer on the market for the amplification of code signals of 1,000 cycles frequency (approximately).

Model C-7 Superheterodyne

(69) 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 below.

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.;
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 master rheostats, 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 reform 3 inches in 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.

Wiring Data

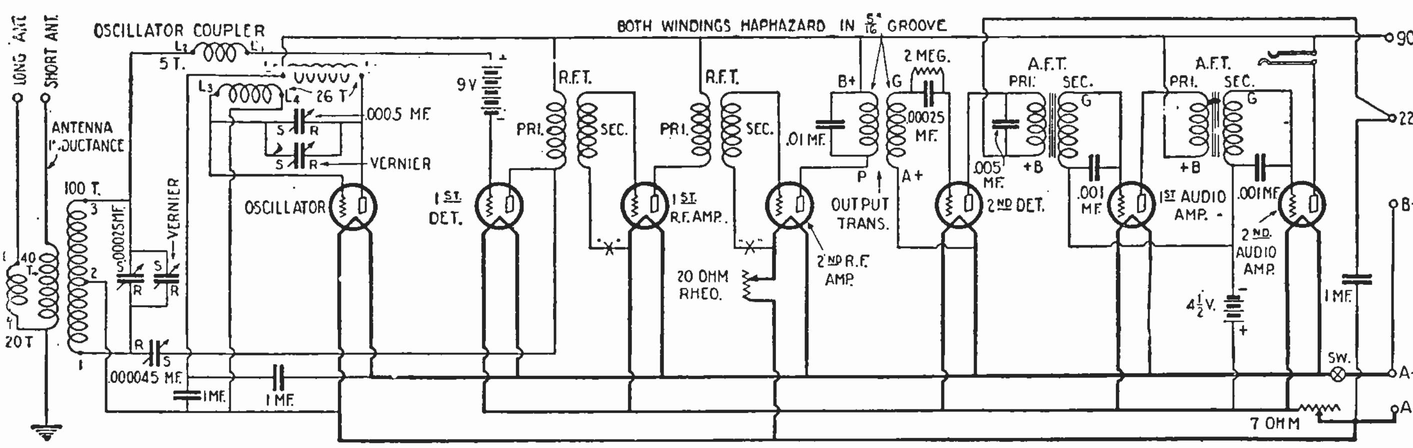
(70) Mr. A. S. Marriott, Toronto, Ont., Canada, asks:

(Q. 1). Is there any disadvantage in using spaghetti on all wires? Does spaghetti tubing absorb moisture?

(A. 1). This insulation should be used only when there is danger of one wire touching another. Air is the best dielectric. When replaced by something else, dielectric absorption losses are greater. Also, parallel wires carrying currents of two different potentials act as two plates of a condenser. With air as a dielectric the condenser effect is a minimum. In some sets this condenser effect may make the receiver inoperative.

(Q. 2). Which is the best to use, No. 14 enameled wire, No. 18 annunciator (bell) wire, or round or square bus wire?

(A. 2). Either the enameled wire or the bus wire. We do not believe there is any difference worth considering in the use of square or round bus wire,



Circuit diagram of the C-7 Superheterodyne unless one is wiring a set to operate on short waves, such as 50 meters or less. The annunciator wire has the disadvantage of causing considerable condenser effect due to the paraffined cotton thread used as a covering.

(Q. 3). Where can I secure information on the re-broadcasting systems in use?

(A. 3). Mr. Frank Conrad presented a paper on this subject before the Institute of Radio Engineers. The December, 1924, issue of the "Proceedings" of this organization contains a reprint.

Sectional Stand-off Insulator

The other day, while re-arranging his transmitter lead-in, the contributor fell in need of a stand-off insulator about eight inches long. He found, however, several porcelain receiving insulators in stock, and struck upon the idea of making them into a stand-off insulator, as shown in the accompanying illustration.

After fastening them together, end to end, with No. 12 copper wire run through the holes, a large, flat staple was made from a tenpenny nail and passed through the hole in the end of the last insulator before being bent. The staple was then driven into the side of the house, the insulator standing out rigidly at right angles. The lead-in wire was then passed through the hole on the end insulator and fastened.

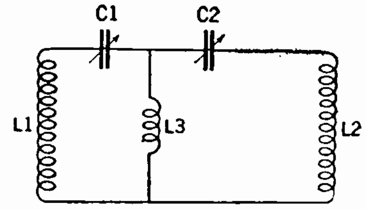
A stand-off insulator of this type can be made any length desirable, if the support is securely fastened.

Contributed by Y. M. Hoag.

A Practical Band Selector

(71) Mr. N. L. Allan, Brooklyn, N. Y., writes:

(Q.) "For some time I have thought of building a new radio set; but after reading the article in your March, 1928, issue, in reference to the "Full-Band" tuning system, I decided to wait until further data were available for a set using a tuning system of this type. Since that time I have watched every issue of *Radio News* but no further data have been published. The system has remarkable possibilities and I am sure that many of your readers would be interested in obtaining more information about this system. Can you supply us with experimental data or details for making one of these filters for the broadcast band, and also data for coupling it to a tuned-radio-frequency receiver?"



The coupling unit L3 governs the width of the radio-frequency band amplified.

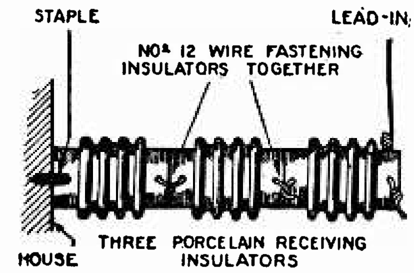
(A.) By referring to the diagram or to the diagrams published in the original article, you will see that the filter comprises two coils L1 and L2 tuned by condensers C1 and C2; these two resonant circuits are coupled together through an inductance coil L3. Since L3 acts only as a coupling device for the two resonant circuits, the coil may be replaced by a condenser of rather large capacity. However, for ordinary purposes, a coil is more practical; since the value may be changed more easily.

The theoretical discussion (in March *Radio News*) pointed out that, when an aerial is coupled to the filter, the capacity between the aerial coil and the first resonant circuit is sufficient to throw this circuit out of resonance with the other and, in order to gang the two tuning condensers together, it is therefore necessary to place a small compensating condenser (C6, C7) across each of them. A practical circuit with two stages of tuned-radio-frequency amplification is shown below.

Coil Constants

In the filter, coils L1 and L2 are wound on 3-inch forms. Coil L1 has a primary of 10 turns and a secondary of 47 turns of No. 24 S.C.C. wire; a space of about ¼-inch should be left between the two windings. Coil L2 is similar to L1 except that the positions of the two coils are reversed. It is absolutely necessary to shield L2 and L3; since the filter will not operate properly if a current is introduced into these coils from any other source than coil L1. Since coil L1 is coupled to the aerial, it will not be necessary to shield this coil.

a tuned-radio-frequency set, the other tuning circuits should be made rather broad, so that the good qualities of the filter are not lost. The easiest way to accomplish this is to make the coils small and use fine wire. With .0003- or .00035-mf. tuning condensers, L4 and L5 can be wound on 2-inch forms



A stand-off insulator

with No. 28D.C.C. wire; the primary with 12 turns and the secondary with 86 turns of the same wire. A space of about ⅛-inch is left between the two coils on the tube. The other parts of the R.F. amplifier are the same as in any other set and any convenient method of oscillation control can be employed. If it is so desired, the condensers C3 and C4 may be ganged together, since the tuning is purposely made broad in these two circuits. The resistors R2, R3 and R4 are filament ballasts; their value depends on the type of tubes employed. Any good audio-frequency amplifier may be coupled to the output of the detector tube.

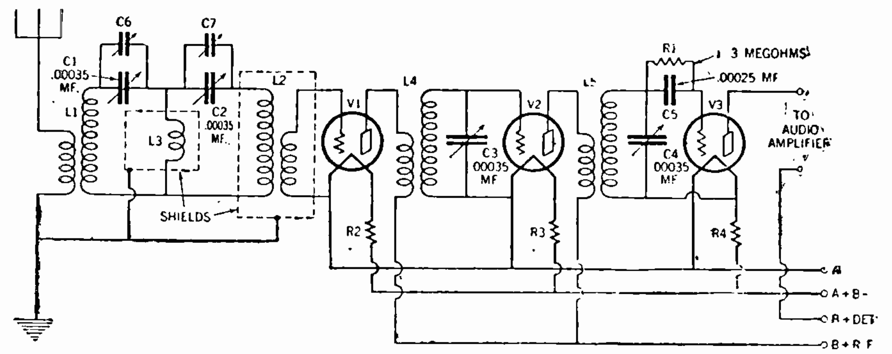


Diagram of a receiver in which a band-selector unit is followed by two R.F. stages. Data for L1, L2 and L3 are given above; L4 and L5 may be any coils suited to the condensers used.

The size of coil L3 is very important and these instructions should be followed exactly when building it. It is wound on a tube 1 inch in diameter and contains 5 turns of the same wire as used on the other coils. The inductance of this coil is approximately 1.2 microhenries and, if a condenser is used to replace it, one with a capacity of .024 mf. should be employed. The reason why coil L3 is so critical is that this coil is used to couple the two resonant circuits together. Its value determines the degree of coupling, also the width of the band covered by the filter; and any changes in the constants will also change the characteristics of the filter.

When using the Band Selector with

Coil or Condenser?

The data given for this band selector are experimental and a certain amount of alteration may be necessary in order to get the correct band width for your receiver. However, the inductance values were checked in an experimental model and found to give a band slightly wider than 20 kilocycles at 200 meters, and slightly narrower at the higher wavelength. The use of a condenser for coupling, in place of coil L3, will give slightly better characteristics on the longer waves; since it tends to broaden the tuning or widen the band on the upper waves and narrow it on the shorter waves. However, as explained before, the difficulty in obtaining the correct capacity to give the exact characteristics led to the use of an inductance in the experimental model. The experimental values for the coils and capacities were derived from the formulas and diagrams in the Bureau of Standards' Circular No. 74. For further information on the subject, we would suggest that the experimenter read the previous article on the theoretical operation of the band selector.

Output Coupling Devices

(72) Mr. M. J. Joseph, Chicago, Ill., writes:

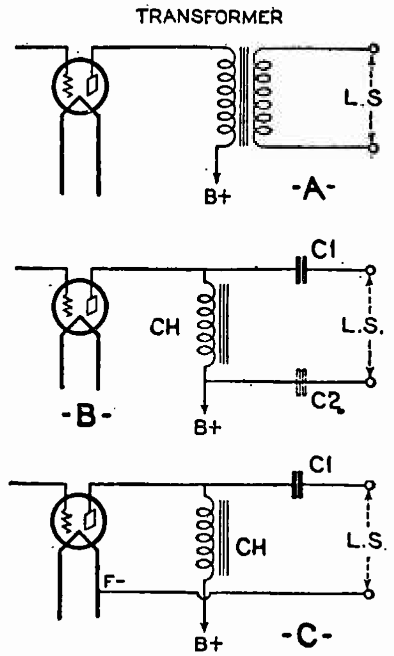
(Q.) "Will you please supply as much information as possible as to the use of an output coupling device for a receiver? When is one required, and just what type is necessary for a particular installation? I notice that almost every set now in use uses a filter of some type; although they differ greatly in their construction."

(A.) The value of the current which actually operates the loud speaker is constantly varying as the signal changes. The plate current, or output, of the last tube may be considered as an *alternating current superimposed on the direct current* in the plate circuit; since the variations in the current follow, exactly, the form of an alternating current. When an output filter is not used, the direct plate current of this tube is continually passing through the windings of the speaker; the amount of this current is dependent on several factors, including the plate voltage, the "C" bias and the resistance (of what?)

This direct current does no useful work in actuating the speaker, but is necesssarily produced by the normal operation of the tube. If some method is used to separate the alternating-current *component* from the continuous or direct-current, the speaker operates just as efficiently, and actually gives better quality, since it is not loaded with unnecessary current. Also, the windings of the speaker are not endangered, since the actual signal variation is comparatively small when compared to the plate potential.

The output filter supplies a means of separating the two currents; it has also another use, that of providing a means of *matching the impedances* of the tube and the speaker. In order to obtain the greatest efficiency from a speaker, its impedance should be close to that between the filament and the plate of the last tube in the set. A transformer with properly designed windings will supply these requirements.

On this page are shown three common methods of coupling. The first (A) is that of using an output transformer; as mentioned above; this serves the double purpose of keeping the plate voltage away from the speaker and matching the impedance. The second method (B) employs a choke coil CH and a condenser C1; the condenser prevents the direct current from passing



Three popular methods of coupling the loud speaker with the audio power tube.

through the windings of the speaker, while the choke coil prevents the alternating component from being by-passed around the speaker through the "B" battery. The choke coil has, usually, an inductance of about 30 henries and the condenser a capacity between 2 and 4 mf. There is one fault in this system, and that is the possibility of getting a shock when the speaker and the ground are touched at the same time, as the speaker is at the highest "B+" voltage. This may be overcome by connecting an additional condenser (C2) at the point shown by the dotted lines; the speaker is thus entirely insulated from the plate supply.

The same results may also be obtained, without using the additional condenser, by connecting the loud speaker between the condenser and the negative filament lead. In this case, as shown at C, the alternating component still passes through the speaker, but the direct current is entirely separate.

Screen-Grid Circuit Design

(73) Mr. A. H. Grindle, Fort Wayne, Indiana, writes:

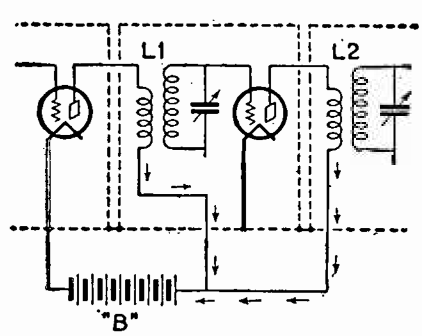
(Q.) "Will you please explain why choke coils and condensers are used so extensively in radio sets employing screen-grid tubes? In almost every such set I have seen described, a number of coils are placed in the plate leads, and sometimes in the screen-grid leads. However, none of the articles explain why these chokes are employed; can good results be obtained without them or are they necessary for correct operation?"

(A.) Although the circuits for screen-grid receivers do not differ materially from those comprising ordinary tubes, there are several points of difference which must be considered if effective results are to be obtained. It must be remembered for one thing that these tubes give very great amplification when used correctly. Also, the screen-grid tube does not require any neutralizing device to operate successfully and this alone is of great assistance in constructing multi-tube receivers.

The fourth element (the screen-grid) in this tube prevents any feed-back through the capacity of the tube elements; but, because of the very high amplification possible, it is necessary to use extreme care in shielding the receiver to prevent any interaction due to the capacities between wires, etc. The shielding for such a set should be effective as both the electromagnetic and an electrostatic shield.

With reference to the actual construction of the set, there are several rules which should be followed: use the best components available and be sure that they are designed for use with a screen-grid tube. All parts are not suitable even though they are well made otherwise. The coils should have a ratio, of primary to secondary turns, about 1 to 1; or, if impedance coupling is employed, the impedance should not be tapped to produce a step-up ratio of the turns in the primary and secondary.

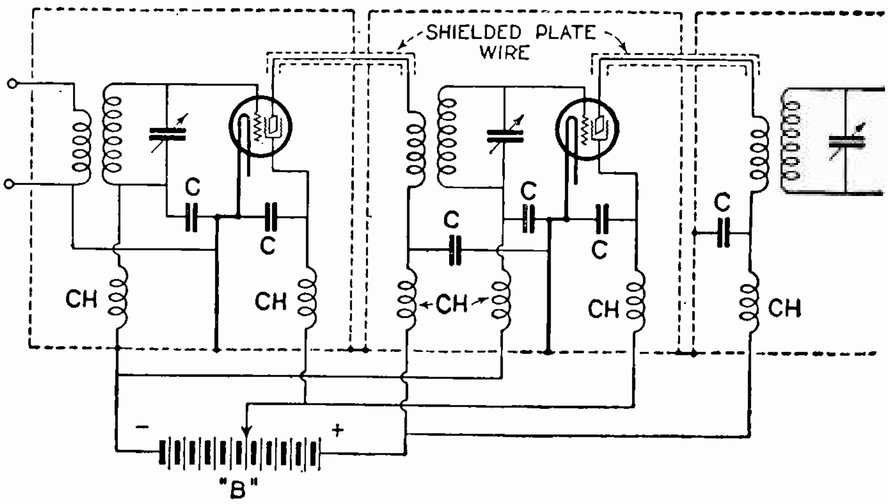
There is one other point which many a radio fan has discovered, much to his sorrow, in the use of the screen-grid tube as a radio-frequency amplifier. As an example, suppose we build a completely shielded set and use extreme care to prevent any interactions due to faulty shielding. We use the very best apparatus that we can obtain but, when the set is finished, we discover that the amplifier is uncontrollable and has a bad tendency to oscillate. In fact, the better the apparatus that we use, the greater will be the tendency to oscillate. We can cure this trouble by introducing resistors into the circuits; but this method is



The arrows show the electron flow.

not desirable because it will reduce the efficiency of the amplifier. This leaves us in a very unfortunate position, so far as the operation of the set is concerned; since the only other apparent means of overcoming the difficulty is to reduce the number of turns on the primary coils of the coupler, and this will also reduce the amplification.

Evidently our trouble is due to a feed-back, even though we have used care to prevent this. The answer to the riddle is that there is a feed-back *through the common plate-voltage supply.* The reason why we encountered this feed-back will be explained later, but let us look first at the diagram. This shows the insertion of choke coils CH in series with each of the plate leads and the screen-grid leads, as well as in the grid-return wires. This is the correct construction for getting the highest efficiency from the screen-grid R.F. amplifier. Now we will explain why these chokes are used.



By passing the Screen-Grid R.F. Amplifier, using R.F. Chokes CH and Condensers C.

Battery Coupling

In the following is shown a radio-frequency amplifier simplified so that we can more easily follow the circuits in question. The plate wires are connected to a common battery "B," which places the necessary positive potential on the tube plates. This method of operating the tubes would be quite satisfactory *if the battery or power unit did not possess any resistance or impedance.* The well-known Ohm's Law tells us that, when a current flows through a resistance, a voltage is set up which is equal to the product of the resistance and the current. Referring to the figure, it will be seen that as R.F. current is set up, due to the impedance of the power supply, and this current is then introduced into the plate circuits of these tubes; which provide a coupling, in spite of all our precautions in shielding the set.

Since we have now discovered the cause of the trouble in our set, it is necessary to find some way to prevent the interaction thus caused. The simplest way is to place radio-frequency choke coils in each of the leads which might cause trouble in this matter. The choke coils will restrain the currents from flowing in the incorrect paths, and by connecting also condensers of suitable capacity between the circuit in question and the filament wiring, we will provide a low-impedance return path for the radio-frequency currents. Because of the chokes they will not noticeably affect the "B" supply. These illustrations show how the choke coils and condensers would be introduced into the circuit. The chokes should be of the usual R.F. design, with an inductance of about 60 millihenries or up to 125; and the condensers have a capacity of one-quarter microfarad, or ever more.

The same system of isolation is applicable to all other circuits involved, both control-grid and shield-grid, as well as the plate. To follow through, we must then isolate each individual circuit by the condenser-and-choke arrangement; this is shown in the first diagram, Fig. Q2326A.

The manufacturers of the screen-grid tube recommend the use of a special shield on each tube and also the shielding of the grid and plate leads. This is especially important when the plate or grid wiring is run from one stage to another. A metal tube placed over the wires is shown as shielding the plate leads, Fig. Q2326A; this tube should extend directly from the plate terminal on the tube socket to the terminal of the coil in the succeeding shield. It must be grounded very carefully to the common shield connection, in the manner described above.

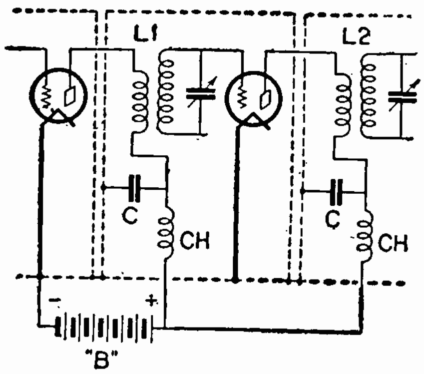
Gimball Loop

(74) Mr. J. Sildman, Kew Gardens, L. I., asks:

(Q. 1). What is a "Gimbal Loop?"

(A. 1). A loop mounted on "gimbals," a form of swivel support permitting movement in any direction, allowing the loop to move in "azimuth" and "zenith." All this is made clear from a study of the illustration. Two arrows indicate the motion. For broadcast wavelengths, about 100 ft. of wire will be needed. Arrange the number of turns and their diameters in any convenient manner to assure using about this length of wire.

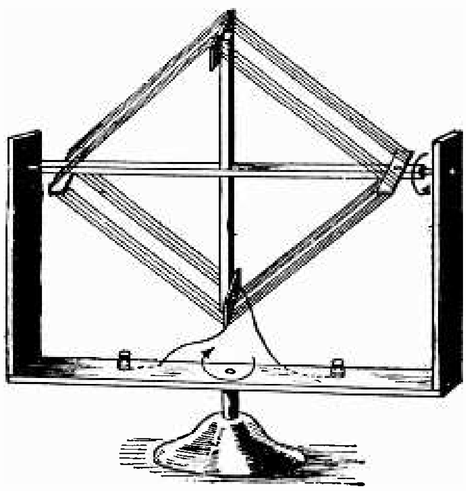
(Q. 2). Please show, in the "I Want to Know" department of *Radio News,* the circuit mentioned by the editor of that



A simple method of preventing battery coupling.

department, Thursday evening, August 13, 1925, from station WRNY, to be given to all those who wrote to the station asking for it, and include all data for the first radio frequency coil described.

(A. 2). The circuit mentioned was that of a standard regenerative receiver with two stages of audio-frequency amplification, showing how to add a single stage of radio frequency amplification. The particular feature of the arrangement was the emphasis laid upon the method of preventing feed-back by induction, the most troublesome form of feed-back in such circuits. A Circloid or similar coil may be used for the toroid shown, or it may be home



The Gimball Loop

constructed according to the directions given, just so it is of the "astatic" type of winding. The "Twin Cylinder" coil construction described in the "I Want to Know" department of the October, 1925, *Radio News,* page 480, may also be followed.

Astatic coils do not absorb energy (radiated, say, from the 3-coil unit), neither does it radiate energy (to the 3-coil unit). Upon a realization of this the astatic coil is seen to be the most desirable form of coil winding for the particular purpose for which it is here recommended.

The little tap marked "N" is not used. It is a Neutrodon tap for other circuits.

Circuit oscillation is controlled by varying the number of turns on the primary of the 3-coil unit. After the correct number of turns have been determined, there is no further change required in the constants of this unit.

A Dialless Set

(75) Mr. Stephen Jordan, Birmingham, Alabama, writes:

(Q.) "I saw the descriptions of two switch-operated sets in the December issue, but the instructions for each were omitted. I am thinking of building a set and I would like to arrange it so that the local stations could be picked up without the use of any dials. The set will use a screen-grid tube as a radio-frequency amplifier, and contain two stages as a radio-frequency amplification. If the screen-grid tube cannot be used in a set of this type, a regular 201A tube will be suitable. Can you supply me with the diagram and instructions for making such a receiver? It will not be necessary to show the audio amplifier, since an ordinary transformer-coupled system will be used."

(A.) Since the design of a switch-operated set will be of interest to a number of constructors, we are printing a diagram which will be suitable, for construction by the experimenter. It contains one stage of (screen-grid) radio-frequency amplification with a regenerative detector; the R.F. circuit is untuned, in order to keep the wiring as simple as possible. The detector is an ordinary 201A-type tube, and tuning in this stage is accomplished by switching semi-variable condensers into the circuit. The condensers for this purpose are so set that a different station will be tuned in by each condenser when it is shunted across the secondary coil. By using several of these instruments, the local stations can be selected without adjusting any tuning controls except the switches. If reception from distant stations is desired, a variable condenser of the usual design may be mounted in the set and switched into the circuit instead of one of the semi-variable condensers.

The radio-frequency amplifier and the detector are shielded in separate metal cans, and the plate lead of the screen-grid tube is run through a metal tube to shield it from the other wires in the set. This is done to prevent feed-back, which might otherwise occur. The radio-frequency tube is coupled to the aerial through a radio-frequency choke, of a value between 80 to 125 millihenries. The larger inductance is preferable, although good results can usually be obtained with a smaller one.

Grid bias for the R.F. amplifier is obtained from a single 1½-volt flashlight cell connected as shown in the diagram. The screen-grid and the plate circuits of the radio-frequency tube are isolated by placing a radio-frequency choke in series with each of these leads and connecting a by-pass condenser to the filament circuit. The coupling coil in the set is specially constructed, with a large primary which allows the radio-frequency tube to operate properly.

Construction

The first thing to do when building the set is to make the coil L2; this may be done in a number of ways with equally good results, but the primary should be made almost equal to the secondary in size, regardless of the construction. A large primary is needed to give the necessary impedance for the plate of the screen-grid tube and also to give the greatest amount of coupling between the primary and secondary. A suitable coil may be made by winding a secondary of about 80 turns of No. 22 D.C.C. wire on a tube 2 inches in diameter; the primary should be slot-wound on a tube or spool, 1¾ to 1⅞ inches in diameter, and placed inside the secondary coil. The fixed tickler is wound on the same tube as the secondary; it contains about 40 turns of the same wire used on the secondary. A space of about ¼-inch should be left between the two windings on the tube.

Other parts required for the set, exclusive of the audio-frequency amplifier, are as follows:

One screen-grid (222-type) tube, V1;
One 201A-type tube, V2;
One aerial choke coil (85- to 125-millihenry) L1;

Two radio-frequency chokes (about 85-millihenry) L3, L4;

Two semi-variable condensers, .0001-mf, maximum, C1, C2;

Four semi-variable condensers, .0005-mf., C3, C4, C5, C6;

One grid condenser, .00025-mf., C7;

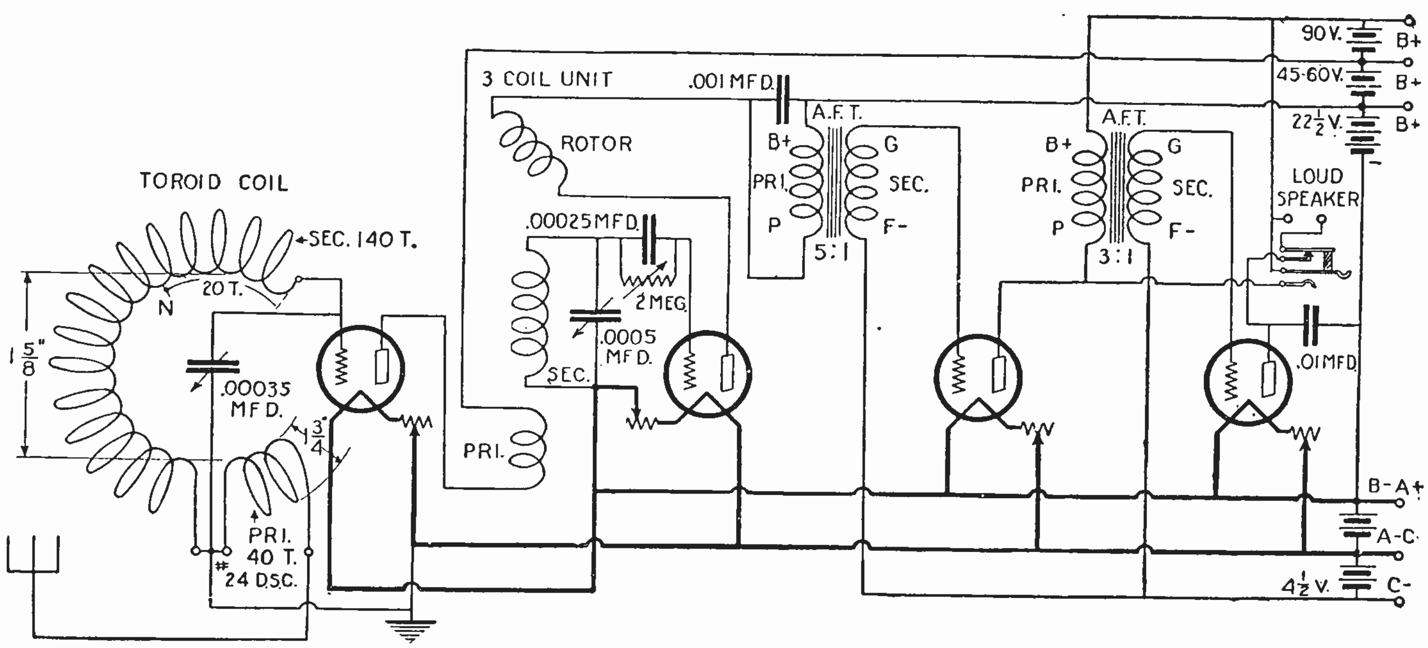
One condenser, .002-mf., C8;

Two by-pass condensers, 1-mf., C9, C10;

One fixed condenser, .00025-mf., C11;

Two filament ballasts, one 222-type, R2; one ¼-amp. type, R3;

One grid leak, about 2-megohm, R4;



A circuit employing the "Toroid Coil."

One variable resister, 0-500,000-ohm, R5;

Three S. P. D. T. switches, panel-mounting, cam-operated type, Sw1, Sw2, Sw3;

Two shield cans, aluminum or copper;

One panel and baseboard, to suit layout and amplifier;

Eight binding posts;

Two tube sockets;

One dry cell, 1½-volt "C";

Hookup wire, screws, copper tube for plate lead, etc.

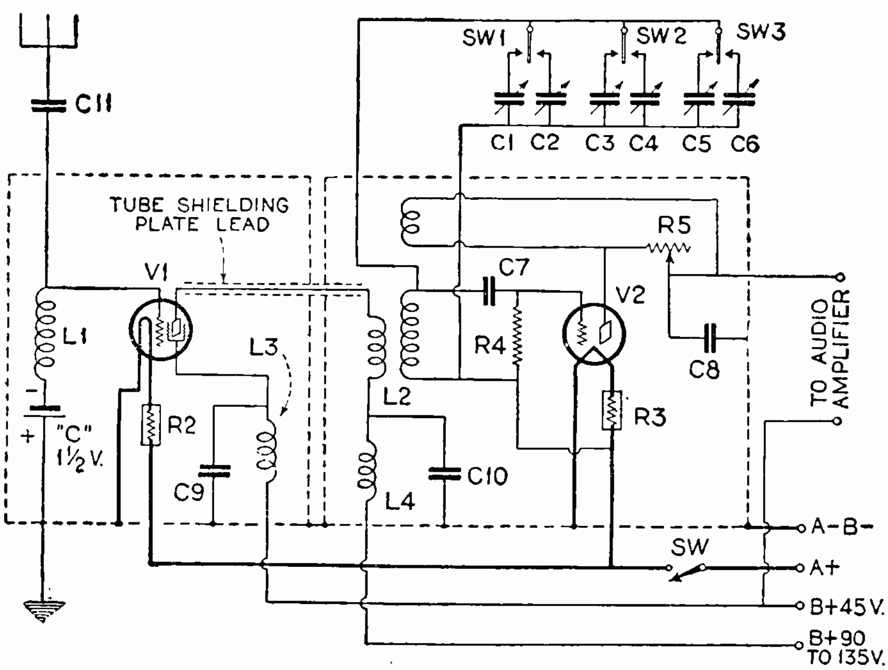
The set may now be assembled. The switches are mounted on the panel in a line. The volume-control resistor R5 is also mounted on the panel and, if a variable condenser is to be used as an auxiliary control for tuning in stations not covered by the switches, its dial is also panel-mounted. If a condenser of this type is desired, it should have a capacity of about .0005-mf. In laying out the parts, the coils L1 and L2 should be placed in the middle of the can, leaving a space of at least an inch between the coil and the shield. The control grid lead of the screen-grid tube must be made as short as possible to obtain the best results. The plate lead of this tube should also be short and, as mentioned above, should be run through a copper tube, which is then grounded very carefully.

Operation

After the set has been assembled, the condensers are adjusted. First adjust C1 to the station with the lowest wavelength of those to be received. This is done by turning on the set and then adjusting the condenser screw with a rod of wood or other insulator. Care must be taken to tune the condensers to maximum settings, as the volume and efficiency of the set for each station depend on this adjustment. After C1 has been tuned, each of the other condensers is adjusted to its respective station by switching it into the circuit and tuning it in the same manner as the first one.

The only other control on the receiver is the oscillation control R5, which acts also as a volume control. For local stations, this resistor may be set and left in a position at which there is no oscillation but which yields sufficient volume for ordinary needs. If body capacity is noted when the switches are adjusted, the panel should be shielded or, if they are made with insulated, metal frames, the frames should be grounded to the shields. It is a good plan to engrave the panel with the call letters of the station opposite the switches, so that anyone can tune the set without knowing the particular arrangement.

An interesting variation of this arrangement, for the enterprising experimenter, is a relay system to connect the various condensers from a distance which will give remote control of the set. This arrangement is rather too complicated for the average fan, but it consists mainly of switches at the remote points and relays, instead of cam switches, at the set proper. A "master" switch is also provided, to turn the set off and on without the necessity of going to the set. The switches at the remote points will be similar to those described for the original set; they close a local circuit operating the relay for the proper condenser. Each relay is provided also with an S. P. D. T. switch to operate the condenser circuits; or a separate S. P. D. T. relay may be used for each station.



The dialless receiver circuit.

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 this subject.

(A. 2.) When a piece of quartz of correct shape is placed between two metal plates, a condenser is formed with the quartz as the 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 alternating 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 imediately starts to expand and contract, which causes the plates to become charged. If the vacuum-tube circuit 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.

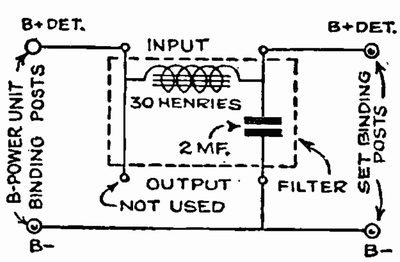
In making the crystals, they are cut very carefully on planes determined by measurements with optical instruments and they are then ground down with the opposite sides perfectly smooth and parallel. The thickness of the crystal is generally used to determine the frequency, and manufactured crystals are 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.

In testing the crystals, a vacuum-tube circuit with a receiving tube is used. The grid circuit of the tube contains the crystal shunted by the "C" battery, which has a radio-frequency choke coil in series with it. The plate circuit contains an inductance coil of suitable size, shunted by a variable condenser in series with a hot-wire milliammeter. As the condenser and coil are tuned approximately to the fundamental frequency of the crystal, the hot-wire milliammeter starts to register. When the two circuits are exactly in resonance, the tube stops oscillating because the turned choke circuit in the plate has an extremely high impedance at the working frequency. For this reason, in a transmitter, this circuit is always tuned to a slightly different wave-length than the crystal.

Quartz crystals are being used more and more. Practically all of the large broadcast stations employ them now to keep their waves constant.

Applying an Audio Filter to the Detector

Although "B" power units have been developed to a very high standard of efficiency, a hum is encountered in some few cases and demands a remedy. A rather unusual use of a "tone filter" has been made by one fan in reducing this hum to a much lower value. The filter was originally designed to be connected between the output of the set and the loud speaker, to keep the plate current out of the speaker windings. The choke coil in the filter condenser was connected in



A detector filter

one of the leads as shown. Three of the leads were used, as indicated in the diagram above.

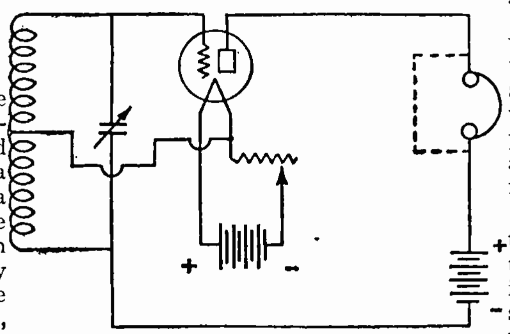
If a hum is encountered, after the filter is added to the regular filter of the power unit, it is evidently caused by an inductive pick-up in the wiring of the set and power-unit, and can be overcome only by proper separation of the offending leads. The filter increases the filtering action only in the detector tube, but this is the usual point at which a hum is encountered. The filter will have no effect on the operation of the amplifier stages.

Wavemeter and Resonance Indicator

(76) C. P. Sullivan, Johnsonburg, Pa., writes:

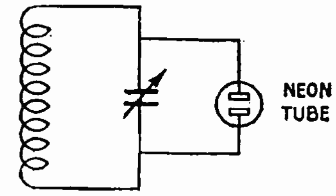
(Q.1.) Please publish a diagram of an oscillating wavemeter and a resonance indicator of simple design.

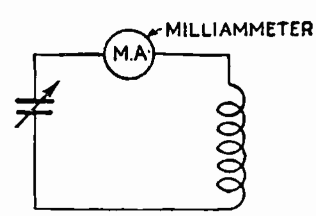
(A.1.) Illustrated below on this page you will find a diagram of an oscillating wavemeter. This uses the well-known Hartley circuit and the inductance of the coil and capacity of the condenser will depend upon the wave-length which the oscillator is to cover. The inductance, however, for covering the broadcast band should be the same as is used in the receiver with the same capacity condenser. The oscillator can be calibrated to wavelengths by means of standard signals. A procedure of calibration known as the zero-beat method, briefly, is as follows: First tune the receiver to the standard signal and then place the wavemeter about three feet from the set and turn the dial slowly. When the oscillator is tuned almost to the wavelength of the incoming signal, a whistle will be heard. This is a beat note whose frequency is the difference



The Hartley circuit.

between the frequency of the incoming signal and the oscillations of the wavemeter. The beat note changes to a lower pitch as the dial is turned and finally ceases altogether. If the dial is turned still further, the beat note will come in again and rise in pitch. Tests may be made for a number of different wavelengths and a graph plotted using the ordinates for the frequencies or wavelengths and the abscissas for the dial readings. When the phones are not used they are short-circuited as indicated by the dotted line. The second diagram shows how a neon tube may be used to indicate resonance. When a circuit consisting of a condenser and a coil is tuned to resonance, the voltage across the terminals of the condenser is at maximum. Therefore, a voltage indicating device such as the small neon tube can be used across the condenser. When the wavemeter is tuned to the frequency of the oscillations it is receiving, the current flowing between the coil and the condenser is at a maximum. The wavemeter is then in resonance at the frequency of the incoming signals a simple resonance indicator, in this case, is a hot wire milliammeter connected in series with the coil and condenser as shown in Fig. 3.





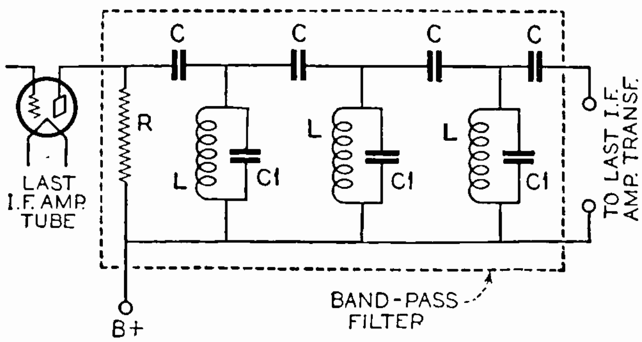
Resonance Indicator for a Wavemeter.

Band-Pass Filter

(77) C. P. Ashton, Sturgis, Michigan, asks:

(Q.1.) Will you kindly furnish me with a hook-up of a band-pass filter to be used in the i. f. amplifier of a superheterodyne and tell me how to wind the coils, in order to obtain a peak frequency of 90 kilocycles with a band-pass 10 kilocycles wide? I am now using 201-A type tubes.

(A.1.) On this page you will find the hook-up of a band-pass filter and the manner in which it is connected in the receiver circuit. This filter should be used between the last intermediate amplifier tube and the second detector. It serves to couple the plate of the last intermediate amplifier tube and the primary winding of the last intermediate frequency amplifier transformer. A band 5,000 kilocycles wide is afforded on each side of the peak frequency, which, in this case, is 90 kilocycles. The first condenser, C, would normally be connected to the plate of the last intermediate frequency amplifier tube, but under such conditions it would be impossible to apply any plate voltage, since the condenser would not pass direct current; therefore, it is necessary to adopt a means for feeding the plate voltage to the amplifying tube. The resistance, R, is used for this purpose, although a choke coil could be used. If the choke coil were employed, it would be necessary to eliminate coupling between the plate choke and the inductances in the band-pass filter. The output impedance of a 201-A type is such that the capacity of C should be .000175 mf. and that of C1 .00285 mf. These capacities cannot be obtained in one condenser, and a small variation in capacity is not appreciable. By obtaining a number of small capacities and placing them in parallel or series as required, a value closely approximating that needed can be obtained. The resistance, R, should be of the non-inductive type, rated at 18,000 ohms. The coils, L, should have an inductance of 0.98 millihenry. These coils consist of 272 turns of No. 30 enameled wire wound on a form having a diameter of 1½ in. Greater selectivity will be gained by using a band-pass filter, but the effective re-



sistance of the coils and condensers will cause losses. These, however, are usually slight, because most i. f. amplifiers have sufficient amplifying powers to permit a slight loss without changing the performance of the superheterodyne receiver.

both circuits are properly coupled the response curve is about 8 kilocycles wide and slopes steeply on each side and the response approaches zero much more rapidly above and below the resonant frequency. The flat por-

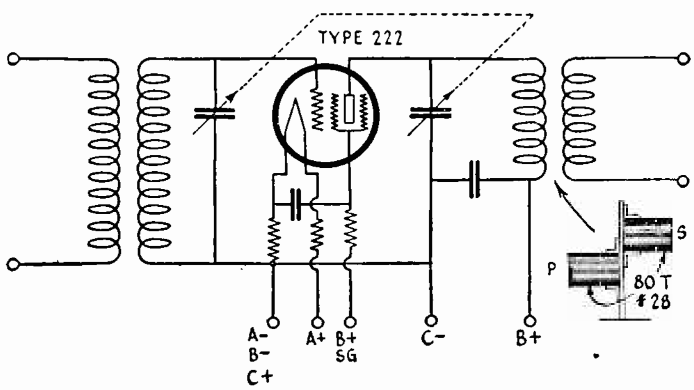
tion and width of the top of a response curve will influence the quality of the received signal. A receiver should be capable of passing and amplifying a band of frequencies if the program is to be reproduced faith-

Screen Grid Hi-Q

(78) R. Henly, Niagara Falls, New York, asks:

(Q.1.) I would appreciate your giving me some information concerning the radio frequency stages used in a Hi-Q circuit. I understand that a transformer of new design having a one to one ratio is employed with the shielded grid tubes. If possible, kindly publish a circuit diagram showing one of the radio frequency stages.

(A.1.) On this page you will find a circuit diagram of a radio frequency stage such as used in the Hi-Q. A specially constructed radio frequency coil is used and is illustrated here also. The primary and secondary both have the same number of turns, name-



The screen grid tube in the Band Pass Filter.

ly 80. The detector input has a tap at about the 20th turn from the grid end to which the grid of the detector tube is connected. Each of these similar coils is tuned with a variable condenser. When both the plate and grid circuits are in resonance, the maximum secondary voltage is obtained with a low coupling co-efficient. The loosely coupled tuned circuits really constitute a band-pass filter. When

fully. Broadcasting stations transmit on a band of frequencies with the width of side bands varying to a certain extent.

The tuned R.F. transformers of the Hi-Q type need four variable condensers but, since all the tuned circuits are identical, the condensers can be used with a common shaft. The antenna coupler is tuned with a separate condenser.

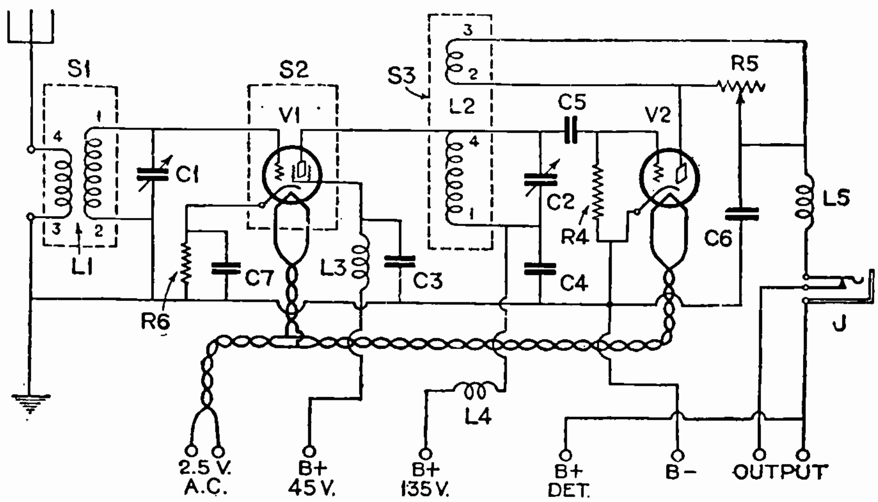
A.C. Milk-Shaker Special

(79) Mr. B. G. Till, Toronto, Ont., writes:

(Q.) "I am desirous of building the 'Milk-Shaker Special' receiver, described in your October, 1928, issue, using A.C. tubes and an audio-frequency amplifier. I will appreciate it if you advise me of the necessary changes in the circuit."

(A.) We have received a great number of requests for information about this set, and many fans would like to build it, substituting an A.C. screen-grid tube for the D.C. type specified. A few changes will be necessary in the apparatus and wiring; but these are very easy to make, and we believe that no one will encounter serious trouble in effecting these alterations.

By referring to the diagram on this page you will see that the grid-return leads must be changed and that it is necessary to use five-prong (UY)



A.C. tubes in a two tube Tuner

sockets in place of the usual four-prong type. A 227-type tube is employed as the detector and, since the filament voltage required for this tube is the same as for the screen-grid tube, the two filaments can be heated from the same transformer winding. The other parts for the set should be arranged in the same manner as for the original circuit. All the parts shielded in the original should be shielded in the A.C. model also.

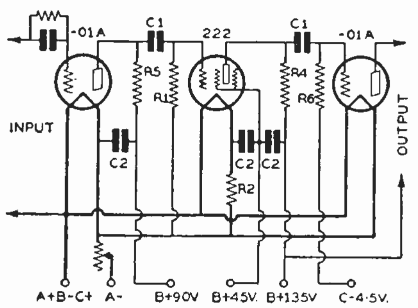
The grid bias for the radio-frequency amplifier must be obtained in a different manner from that used in the D.C. model, as it is not possible to use the voltage drop across the filament resistor. By connecting a resistor of correct value in the lead from the cathode to the "B—" post, the cathode will be given a positive bias with relation to the grid, which is connected directly to the negative terminal of the "B" battery. The resistor required for this purpose should have a value of 1000 ohms, to give the required voltage drop of 1½ volts at 1½ milliamperes, which is the plate current consumed by the tube. In order to provide a low-resistance path for the radio-frequency currents, a half-microfarad by-pass condenser (C7) is connected across the resistor.

The connections to the detector also are changed, to use a five-prong socket for the 227-type tube in the detector circuit. The cathodes and the by-pass condensers in all of the circuits are connected to the common terminal which serves as a ground connection and "B—" lead, *but is not connected to the filaments.* Twist all the filament wires, to prevent the hum from being excessive; and keep all of the grid and plate wires as far as possible from these filament wires, to further reduce this possibility.

Any good audio-frequency system can be employed with the set.

Screen-Grid Audio Amplification

Although the remarkable potentialities of the screen-grid tube are generally recognized today and are being



This resistance coupled amplifier employs the 222 tube as a space charge amplifier.

exploited more and more, the idea is generally prevalent that this tube is uniquely a radio-frequency amplifier and therefore unsuited to any other function. This is certainly not the case. As a space-charge audio amplifier, the screen-grid tube provides excellent volume per stage.

In employing the screen-grid tube as an amplifier, special transformers, designed particularly for this purpose, may be employed. However, a straight resistance coupled amplifier is preferable for many reasons, and is certainly the least expensive. The unusual characteristics of a very high impedance plate load and a very low capacity feedback of the screen-grid tube combine in producing a tonal quality of the first order.

Due to the enormous amplification factor of the screen-grid tube, it is advisable to employ only one stage of this kind, and to place the same immediately following the detector, in order that the power output of the tube may not be exceeded. The diagram Fig. 3, suggested by the engineering staff of the International Resistance Company, shows a good circuit, and is offered merely as a suggestion, since the radio experimenter may work out his own version of a screen-grid audio amplifier. It will be noted that the detector tube works into a resistive load of 50,000 ohms, R5. R2 is a 25-ohm resistor that provides the necessary 3.3 volts to the filament of the tube. R4 should have a resistance of 250,000 ohms, while R1 and R6 are grid leaks of 3 megohms each. R3 is a conventional rheostat of 6 ohms.

Due to the large amplification in a screen-grid audio amplifier, the resistors must be selected with care. They must be accurate, in the first place, and certainly must not be subject to sudden resistance changes or fluctuations. Resistors must be moisture-proof. The metallized type fulfill these various requirements and for this reason are being widely applied to experimental and commercial screen-grid circuits.

Atwater Kent Circuit

(80) Mr. H. Webb, Yonkers, N. Y., writes:

(Q.) "I have an Atwater Kent "Model 20 Compact" set. Will you print in your next issue of *Radio News* a wiring diagram of this set with "C" battery connections? At times it plays; but it goes off with a roar every once in a while."

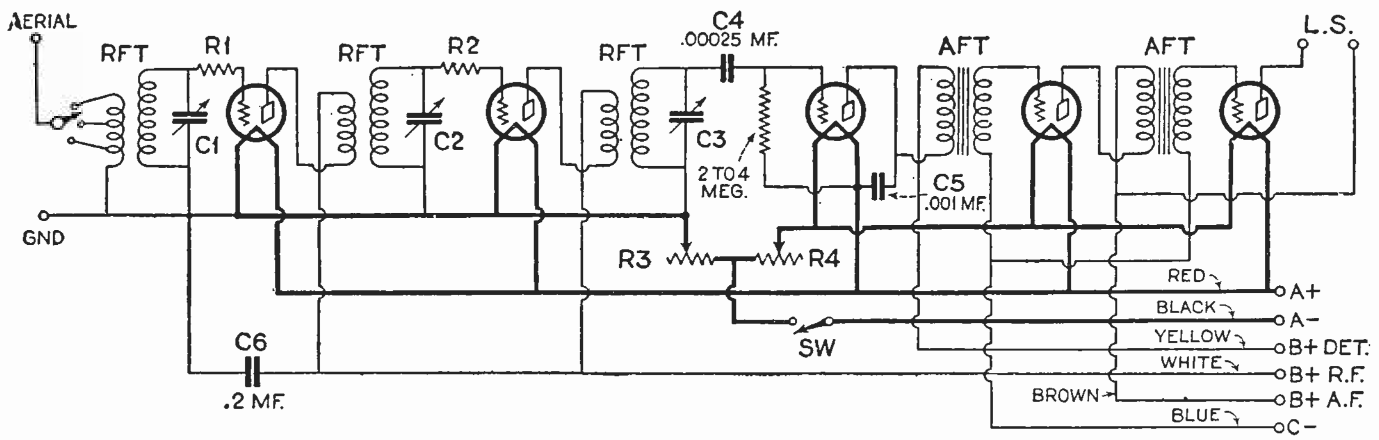
(A.) You will find the diagram of this set illustrated below on this page. By referring to the diagram, you will see that the set contains two stages of tuned-radio-frequency amplification, a detector and two stages of audio frequency. Transformer coupling is used in the audio-frequency amplifier and grid resistors are used for stabilizing the radio-frequency amplifier. The set is equipped with a cable for the battery connections, and the color of the various wires are indicated on the diagram. Two filament resistors are used; one controls the radio-frequency tubes and the other, the audio tubes and the detector.

Probably the trouble with your set is due to a loose connection or to a defective tube. First go over the wiring carefully, and bend up the prongs in the tube sockets. Then test the transformers and the fixed condensers with a battery and a pair of phones. When the phones are connected across the windings of the transformers, a distinct click will be heard, if the windings are good. The small fixed condensers will not give a very noticeable click if they are in good condition; while the filter condenser will give a click but no continuous noises. If all of the connections appear to be good and the parts test satisfactorily, the tubes and batteries should be tested and finally the aerial and ground should be checked.

Building a Resistance Amplifier

(81) Mr. D. W. Brown, Niagara, Falls, N. Y., writes:

(Q.) "I am going to build a resistance-coupled amplifier for my tuned-radio-frequency receiver. I want to use the amplifier also for receiving television signals with the unit described in the November issue of *Radio News*. I am afraid that I will have trouble with motorboating when trying to use the amplifier with a "B" power unit, and I am writing to find how I may make the amplifier so that I will not have any trouble from this score. By using choke coils in the correct combination with by-pass condensers, I believe an amplifier could be constructed with no tendency to motorboat."



The Atwater Kent "Model 20," one of the most popular receivers ever built, in its day, used the circuit shown above. In the July, 1928, issue of Radio News *(page 44) will be found an article on adapting this receiver to modern conditions with an added power stage for a large cone speaker.*

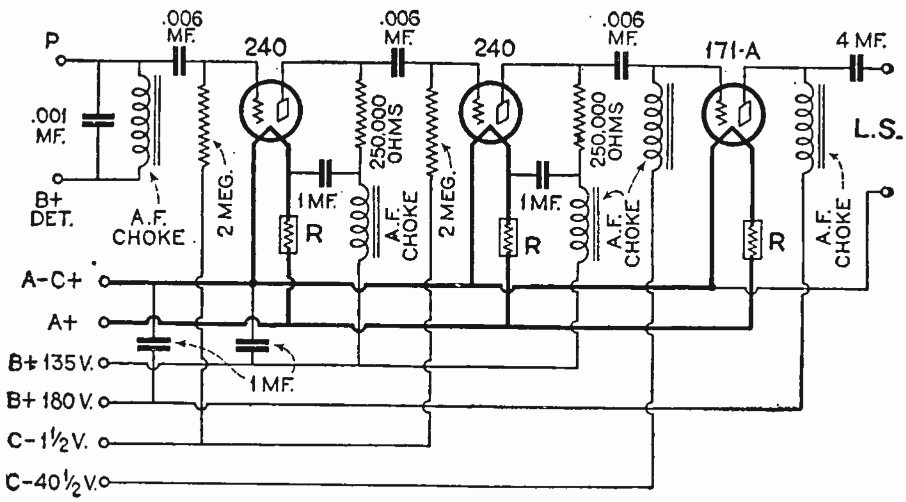
"I would also like to get some information for constructing a resistance-coupled amplifier using a screen-grid tube in the first stage and a power tube in the second stage. If this can be done, will you supply any information possible for the construction of one?"

(A.) "Motorboating" in an amplifier is simply a condition of oscillation brought about by the beating back of energy from the output circuit of an amplifier to the input. The feed-back currents usually occur through "B" power units or rundown "B" batteries. In the older types of audio transformers, where the bass-note response was poor, these feed-backs were usually in the form of high-pitched whistles. In the newer transformers and in the impedance and resistance-coupled systems, the feed-back usually appears in the form of low humming noises or the well-known "putt, putt" of motorboating, which is really only a very slow oscillation.

In a regular three-stage amplifier using any of the common types of coupling it will be found that the signal-current of A.C. component (this should not be confused with the direct current in the plate circuits which is read with a D.C. meter) will be *in phase* or traveling in the same direction, in the detector plate circuit and the plate circuit of the second A.F. stage at a given instant. The current in the first and third stages will be out of phase with the former, or traveling in an opposite direction at the same moment. The direction of the current in these circuits is not important if new batteries are used because of their relatively low impedance; but, if the impedance of the batteries or power unit is relatively high, two effects are possible. The first and second A.F. currents are opposing, giving a slight reduction in the signal strength; but, what is more important, the detector and second stages are in phase, which will cause regeneration.

Both effects are due to the impedance of the "B" supply being *common to all the plate circuits.* The regenerative effect to the second stage from the detector will increase as the impedance of the "B" supply increases, and also as the signal strength increases; and, if the combination of the two is large enough, the regeneration of the system may overcome the resistance of the circuits and the amplifier will oscillate.

The logical way to prevent these oscillations is to separate the plate circuits of the amplifier tubes, and the easiest way to do this is to insert audio-frequency choke coils and by-pass condensers in each of the circuits to prevent any feeding back of these currents.



A resistance audio amplifier by-passed to eliminate "motorboating."

Constructing the Amplifier

On this page you will find the schematic diagram of an amplifier with resistance coupling, incorporating the chokes and condensers recommended in the discussion above. Two other A.F. chokes are inserted in the circuit, one in the grid circuit of the last audio tubes and the other in the plate circuit of the detector. Both of these chokes will help to stabilize the amplifier and also in preventing motorboating. The first two tubes in the amplifier are high-mu tubes of the 240 type. The last is a power tube of the 171 or 210 types. The values of the grid and plate resistors are indicated on the diagram. The audio-frequency chokes in the detector plate, first and second amplifier plate, and third grid circuits, may be the secondaries of audio-frequency transformers or they may be obtained for the purpose. The choke in the plate of the power tube should be suitable for the plate current of this tube. The coupling condensers have a capacity of .006-mf. A .001-mf. fixed condenser is shown across the first impedance unit, but is not necessary if the detector in the set is already provided with a condenser in the plate circuit.

Loop Data

(82) Lawrence Vender, Barnegat, N. J., writes:

(Q. 1.) I have a loop frame measuring approximately 12 in. by 12 in. Can you give me winding data for a loop to be used with a .0005 mf. condenser with wire space about ¼ in.?

(A. 1.) A loop 1 ft. square has an area of 144 sq. in. and you will need approximately 21 turns spaced ¼ in. apart for covering the broadcast band working with a .0005 mf. variable condenser.

(Q. 2.) What are the advantages of this type of antenna?

(A. 2.) The principal advantage of a loop is that it greatly reduces the effect of atmospherics and any strays. Strays appear to be due to varying differences of potential between the earth and the space above it. Such variation of potential readily affects a flat top antenna, because this antenna forms one plate of a condenser with the earth as the other plate. The loop antenna, however, is not connected to the earth and therefore is not affected by and change of potential with reference to the earth. Furthermore, the loop antenna has directional characteristics.

Stabilizing Method

(83) A. T. Maxwell, West Philadelphia, Pa., asks:

(Q. 1.) Can you give me a method for stabilizing radio frequency stages without balancing similar to that used in the Atwater-Kent receiver?

(A. 1.) The coils used are wound with fine wire upon a small form and are enclosed in metal shields. The number of turns on the primary coils of the radio frequency transformers may be increased without loss of stability or tendency to oscillate. In the antenna circuit a radio frequency choke coil is used, which prevents the passage of the radio frequency energy of the received signal. The reaction of this inductance for audio frequency current is low, thereby shunting low or audio frequency currents from the grid of the first radio frequency tube, thus preventing the production of low audio frequency currents in the receiver. In the grid circuit of each of the radio frequency tubes, except that in the first stage, are placed resistances of such a value as to prevent regeneration or oscillation. To increase stability, the plate supply can be isolated by using filters. A further margin of stability will be gained if the radio frequency transformer secondary is tapped about one-quarter of the way from the grid end and this tap connected to the grid of the vacuum tube. The tuning condenser is placed across the total secondary winding. In this way, the tendency to oscillate and effects of undesired coupling are minimized without substantially reducing the desired voltage amplification of the circuit This method comprises reducing all fluctuating voltages impressed upon the grid, by reducing the impedance of the input circuit of the tube and decreasing the step-up ratio between the input circuit and the output circuit of the preceding vacuum tube, so that the desired signal voltage fluctuations are maintained upon the grid. The feed-back voltage impressed upon the grid is reduced in much greater proportion than is the signal voltage. The impedance of the primary winding should approximate the impedance of the circuit in which it is used, whereby the normal value of the signal voltage impressed upon the grid is restored.

Tuned R.F. Impedance

(84) Russel Gordon, Boston, Mass., writes:

(Q. 1.) What is the operating principle of the tuned impedance-coupled radio frequency amplifier?

(A. 1.) This sort of an R.F. stage is similar in operation to an impedance coupled A.F. amplifier. In both cases, a voltage drop is obtained across an impedance or a resistance in the plate circuit of one tube and through a fixed condenser, the changes in voltage across the impedance or resistance are applied to the grid of the following tube. The coupling device consists of a coil and a condenser in parallel placed between the plate of the tube and the "B" battery. By varying the capacity of the condenser, the circuit may be tuned to resonance with the signal to be received. When the coil and the condenser are tuned to resonance, they have the greatest impedance possible at the received frequency. The plate current meets a great coil- and condenser-impedance at this frequency and there is a drop of voltage across this impedance. From the connection of the impedance leading to the plate of the tube, a lead runs to a blocking condenser, the other side of which is connected to the grid of the succeeding tube. The changes in voltage across the impedance are carried through this condenser and applied to the grid. A grid leak is also connected across the grid terminal and the A positive. The principal objection to this sort of amplifier is the difficulty found in preventing self-oscillation. The tuned impedance circuit cannot be neutralized. Oscillation may be controlled by a potentiometer in the grid return or by any suitable method, such as placing a high resistance in series between the impedance and the "B" supply. In tuned impedance coupling there is no step-up of voltage as there is with transformer coupling where there may be an increase in voltage from the primary to the secondary. Since the entire amplification obtained is from the tube alone, it is advantageous to employ high-Mu tubes.

Minimizing R.F. Coupling

(85) Robert Sutton, Brooklyn, New York, asks:

(Q. 1.) In present day receivers using two or three stages of radio frequency amplification, the position of the coils appear. What is the advantage of placing coils at an angle to each other, or separating them some distance apart with their axes parallel or at right angles to each other?

(A. 1.) Coils of the solenoid type will be coupled together by their magnetic fields unless they are separated by quite an interval. With their axes directly in line, the degree of coupling depends upon the coil separation. Placing the coils so that the separation remains at a fixed value, and so that their axes or lines of center are at an angle to each other will reduce the coupling. When the axes are exactly at 90 degrees or at right angles to each other, this coupling is at a minimum. Feedback between coils can be effectively reduced in this manner. If two coils are placed parallel to each other, the magnetic field of one will pass through the other. If the magnetic lines of force cut one side of the turns of wire on a coil and do not cut the opposite sides of the same turns with equal strength, a voltage difference will be set up across the turns.

If the axes of the coils are parallel changing the angle they make to a straight line drawn through them, causes the magnetic lines of force sent out by one coil to cut through both sides of the turns of the other. This angular placement may be increased until a point is reached where the lines of force will cut evenly through both sides of the coil. In this position there will be minimum magnetic coupling between the coils. When the coils are placed parallel and close to each other, their efficiency and that of the associated circuit must be reduced so that the feedback will not cause oscillation.

Positive Bias

(86) Hugh Driggs, Thomas, Okla., asks:

(Q. 1.) What is the effect produced when using no bias or a positive bias on the radio-frequency tubes in a receiver? I have tried a positive bias of small value and can find no different effects than when operating the r. f. tubes with a negative bias.

(A. 1.) In normal vacuum tube operation, the flow of plate current is accompanied by a flow of electrons which are emitted from the filament and attracted to the positive plate. There is no flow to a point at negative or zero voltage. In Fig. 2 the electrons flow from filament to plate as shown by the arrows. In a circuit of this sort the grid is negative and will not extract the electrons in the vicinity. A millimeter placed in the grid and plate circuit will show all the current flowing in the plate circuit and none in the grid circuit. If the grid should be positive, it will attract some of the electrons, as shown by the arrows.

A curve may be plotted showing a part of the total current on the positive half of the signal. This will not go to the plate but to the grid and will be subtracted from the plate circuit. The rise of current in the plate circuit will be less than the fall of current in this circuit for equal falls and rises of signal voltage. Therefore, plate current rise and fall will not be exactly like the signal voltage rise and fall and distortion will result. For this reason, the grid bias voltage must be sufficiently negative, so that the greatest increase in signal voltage will not cause the grid to become positive and this is accomplished in the manner shown in Fig. 2.

(Q. 2.) In a vacuum tube, the electrons flow from the filament to the plate. How does current flow through the tube when a positive voltage is applied to the plate?

(A. 2.) The plate of a tube is connected to the positive side of a battery while the filament is connected across the battery or to both the negative and positive sides. The major portion of the filament is therfore at a lower voltage than the plate. It is well known that an electric current will flow from a body of higher potential, through a vacuum, to a body of lower potential when this body is heated above a certain point. If the voltage difference between the two bodies is increased a greater current will flow. The current flow is from plate to filament while the flow of electrons is from the heated filament to the plate in the opposite direction. Electric currents flow from points of positive voltage, to points of negative voltage. Consequently, in any circuit, the electron flow is opposite to the current flow. The electron flow is always toward a positive charged body since the electrons are negative they are attracted to positive or high voltage points.

Oscillator Trouble

(87) E. T. Bradford, Livingston, Montana, asks:

(Q. 1.) I am experiencing trouble with my superheterodyne receiver and have attributed the cause to the oscillator, which I think is not working properly. Is there any way in which I can determine if the oscillator is functioning properly?

(A. 1.) When the oscillator in a superheterodyne is not working properly, the "rushing" sound will not be heard and the receiver will have lost some of its energy. Sometimes, broadcast stations can still be tuned in, even though the oscillator is not working. The set is then functioning as a radio frequency receiver and signals can only be tuned in by rotating the tuning dial. Turning the oscillator dial does not affect tuning. A simple method of determining if the tube is oscillating is to touch the grid terminal with a piece of metal or with a moistened finger. If the oscillator tube is oscillating, a click will be heard in the headphones or speaker. Another test consists in tuning in a station and then removing the oscillator tube from its socket. If the signal still continues to be heard, the oscillator tube is not working properly.

POPULAR CIRCUITS

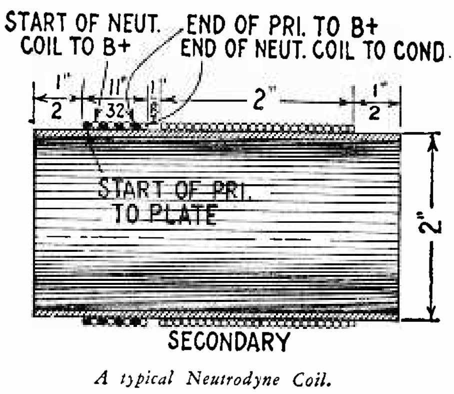
Another test is to connect a pair of phones in the plate circuit of the first detector between the plate terminal and the B+ lead, disconnecting the primary of the first intermediate frequency transformer. All the tubes, except the oscillator and first detector, should now be removed and a local station tuned in. The detector tube rheostat is now adjusted until the signal is just audible. The oscillator dial should now be rotated and if this causes a number of whistles, or if the signal becomes distorted or muffled, the oscillator tube is working properly. If no interference is noticed, the oscillator circuit is defective. Usually this will be found to be due to a poor tube, and when a new one is substituted, the set will again work satisfactorily. Connections should also be examined and sometimes the plate and grid leads to the coupling unit will be found to be reversed. The oscillator will not function if any section of the coupling coil or the primary of the first intermediate transformer is short-circuited. Lack of oscillation may also be caused by too low or too high a voltage on the oscillator tube.

NEUTRODYNE DATA

(88) T. Evans, Brooklyn, New York, asks:

(Q. 1.) Please give me the necessary information for winding neutrodyne coils on a 2 in. form to be tuned with a .00035 mf. variable condenser. Also describe briefly the best method of neutralizing a set with two R.F. stages.

(A. 1.) On this page you will find an illustration of a neutrodyne coil wound on a 2 in. form. The primary and the neutralizing coils are wound parallel as illustrated. Both of these coils consist of fifteen turns of No. 30 enameled wire. The secondary consists of 87 turns of No. 28 D.C.C. wire, close wound. It is important that the primary and neutralizing coils be wound together in the same direction with the turns interleaving as shown.



A typical Neutrodyne Coil.

On account of the difficulty of accurately measuring or calculating very small capacities, particularly neutralizing capacities, the proper neutralizing capacities in practice are best determined by trial. A suggested procedure for neutralization is as follows: first, with the filament of the second radio frequency tube cold, and those of the first and detector tube lighted, a strong signal is tuned in and the capacity of the neutralizing condenser of the second radio frequency stage is then adjusted until the signal disappears, showing that no coupling exists between the plate circuit and the grid circuit of the second radio frequency tube. Then, with the filaments of the detector and the second radio frequency tube lighted and that of the first radio frequency tube cold, the process is repeated with the first neutralizing condenser. On account of the proximity of the radio frequency transformers to one another, and because of the loop formed between the leads of each secondary and its tuning condenser, the actual inclination for zero magnetic coupling may diffed slightly from its theoretical value of 55 degrees; hence, the proper inclination of the radio frequency transformers must also be determined by trial. This angle of inclination may be ascertained by employing the following procedure: with all the coils at the same inclination, the two neutralizing condensers are adjusted for zero coupling as described, with the circuits first tuned for a low frequency and then for a high frequency. In general, the settings found for the two frequencies will be different, showing that the capacity coupling which varies with the frequency, is being called upon to compensate for some magnetic coupling. The coil inclinations are then varied together, until the settings of the two neutralizing condensers are found to be the same at the two extreme frequencies. The determination of the proper coil angle need ordinarily be made only once for a given design of receiver, but the adjustment of the neutralizing condensers is made in each individual receiver in order to insure complete stability.

OSCILLATION TROUBLE

(89) A. L. Starett, Jersey City, N. J., writes:

(Q. 1.) I have an Abbey model Splitdorf receiver which worked excellently until a week ago, when it suddenly broke into violent oscillation, which I have not been able to correct. Some trouble-shooting hints will be appreciated.

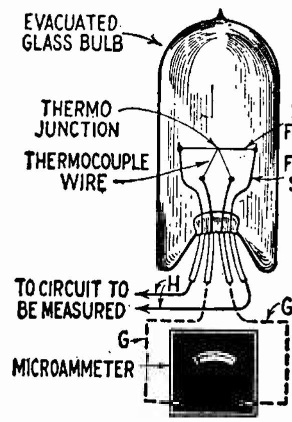
(A. 1.) In the service manual for Splitdorf receivers, the following causes for oscillation in this set are mentioned: The antenna may be open or grounded, and we would suggest that you inspect the aerial system for possible breaks in the wire, and also be sure that it does not come in contact with any metal work. The "B" voltage on the radio frequency tubes may be too high. The one-half mf. by-pass condenser may be open or disconnected from the circuit. Another cause may be poor tubes or the ground connection may be poor or open. The angle at which the radio frequency coils are placed is also important. Also, these coils may have too many primary turns. The correct number of turns is 13½. There is also a possibility of the grid resistor being shorted or the shield bushings may be short-circuited.

THERMOCOUPLES

(90) C. A. McAndrews, Quebec, Canada, writes:

Q. 1.) Please show the construction of a vacuum thermocoupler and how this is used to measure small radio frequency currents of one-half ampere or less?

(A. 1.) In many radio experiments or in research work, accurate measurements of feeble alternating currents are essential. For measurements of currents present in radio receiving apparatus, a vacuum thermocoupler, such as that shown on this page, is used.



The actual construction of a typical vacuum tube thermo-couple is illustrated here, connected to a D.C. galvanometer. The leads marked G and G come from the thermo couple wire, H and H from the heater filament.

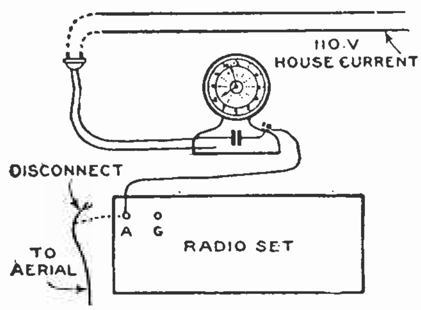
The heater element is caused to supply heat to a thermo-junction which is connected to a sensitive microammeter. The heated element and thermo-junction are combined in one unit, known as a thermocouple. The combination of thermocouple and galvanometer may be calibrated by passing through the heater element a known direct current and the combination may therafter be used to measure the value of an alternating current. Vacuum thermocouples measure the square root of the mean square of an alternating current and within wide limits, the accuracy is independent of the frequency of the alternating current. The inductance and capacity of vacuum thermocouples are so low that these factors can be considered negligible, except where extreme accuracy is required and when multiplier resistances are used. The smaller sizes have a heat lag which is negligible, and the larger show a greater lag. With the largest thermocouple, it takes approximately 30 seconds to reach the full value corresponding to the current being measured. The latest vacuum thermocouples consist essentially of a thermocouple composed of two wires of small diameter, the junction of which is attached to the midpoint of a heater element consisting of a length of resistance wire, the dimensions of which depend on the strength of the current to be measured and the sensitivity required. The heater and thermocouple element are connected to separate wires of low resistance and are sealed inside of a glass bulb which is evacuated to a pressure of 1×10^{-4} mm. or less.

Loop Capacity

(91) Howard Moon, Weston, W. Va., writes:

(Q. 1.) I have a twelve turn box loop and would like to know if this may be changed in any way so that hand capacity can be eliminated or reduced?

(A. 1.) Hand capacity may be eliminated by removing the winding and rewinding by starting from the center of the frame and winding toward one edge of the loop. The wire is then run to the opposite edge and the winding is completed from this edge to the center of the frame. The two leads are thus brought out from the center of the loop, resulting in a noticeable reduction in the hand capacity.



Antenna clock connected to the receiver.

Antenna Clock

(92) A. Burtow, Brooklyn, N. Y., writes:

(Q. 1.) In the June issue of *Science and Invention*, on the New Radio Devices page, a description of an antenna clock was published. Can you furnish me with a diagram of the internal wiring, showing how the light lines are used as the aerial?

(A. 1.) An illustration showing the internal connections appears at the right. The two leads from the line are led into the base of the clock, but only one of them is used for the antenna. A small fixed condenser is connected in series with the lead used and the radio set. This prevents the flow of the direct current or the low frequency alternating current. The radio frequency signals are, however, able to pass through the condenser to the set. All of the present light-socket antennas use the same principle, employing a fixed condenser in series with one side of the line. An aerial of this nature can be made at home in a few minutes' time and can be used with almost any of the present-day receivers employing two or three stages of radio frequency.

Keep the Loud-Speaker Cord Away from the Lead-in

In running a length of wire from the receiver proper to the loud speaker, if the latter is separated any distance from the former, be careful to keep this wire away from the aerial lead-in. If the two are too close together, a very persistent and annoying howl will develop.

Second Harmonic Super-Heterodyne

(93) Mr. O. Leslie, Argonia, Kansas, asks:

(Q. 1.) Will you please show the diagram of connections employed in the R. C. A second harmonic Super-Heterodyne, together with construction data and an explanation of the principle of operation?

(A. 1.) In the following illustrations are illustrated in a general way the principle involved in the second harmonic Super-Heterodyne.

In the circle A of the picture diagram is a representation of the weak incoming broadcast signal. Circle A-1 represents this same signal made stronger by the amplified action of the first vacuum tube. This tube does nothing but amplify signals. It is reflexed in a manner to be described later.

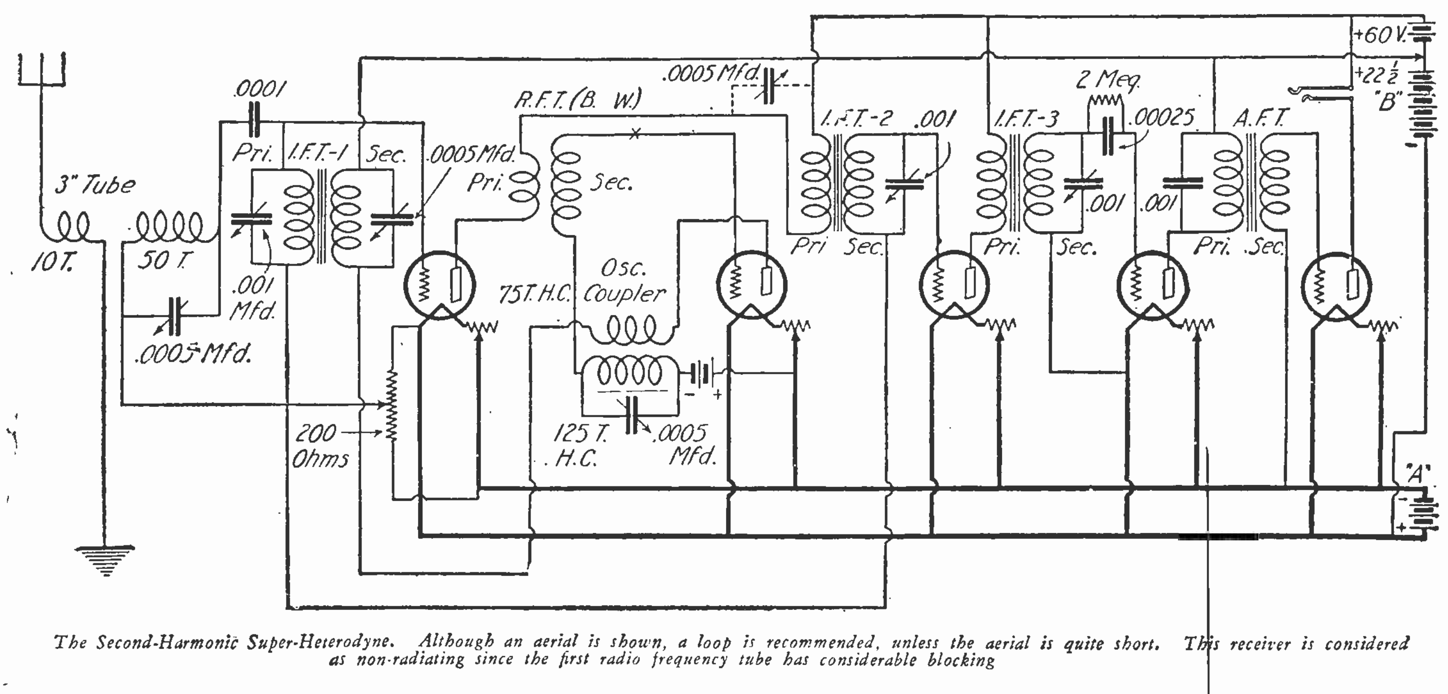
The amplified plate current of the first tube is transferred by induction to the grid circuit of the second tube. This grid current is shown in circle A-2.

This second tube acts as the first detector and also as the frequency changer.

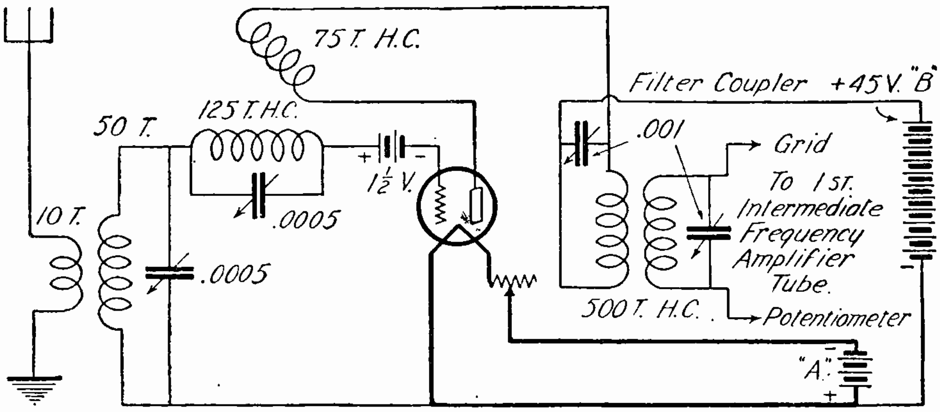
If you will count the number of cycles represented in A, A-1 and A-2, you will see that there are nine complete cycles.

You will note that in B-1 we have only four cycles. This is the strong fundamental oscillator frequency produced by the second tube, which must act as an oscillator as well as the second detector.

Heterodyning is the next operation to be considered. When one frequency is added to a different frequency the combination of the two produces beats which may be considered as another frequency. This "beat" frequency is the difference in frequency between the first two. For instance, if an audible note of 1,000 cycles is sounded at the same time that an audible note of 400



The Second-Harmonic Super-Heterodyne. Although an aerial is shown, a loop is recommended, unless the aerial is quite short. This receiver is considered as non-radiating since the first radio frequency tube has considerable blocking



A novel oscillator circuit.

cycle is sounded, a listener will hear these two and still a third note having a frequency which is the difference between the two, or 600 cycles. This, the production of a third frequency by adding one frequency to another, is "heterodyning." In our example of audio sounds, the third frequency of 600 cycles is called the "beat," or "beat frequency." In a superheterodyne this beat frequency is ordinarily termed the "intermediate frequency."

Our fundamental oscillator frequency B-1, of 4 cycles, heterodynes the A-2 frequency, producing a beat note or intermediate frequency of 5 cycles. However, let us suppose our intermediate frequency C-1 to be 1 cycle. Consequently, a beat frequency of 5 cycles does not affect the filter coupler in the second tube plate circuit, tuned to the frequency C-1 of 1 cycle.

Due to what is termed "asymmetrical action" in the tube, the oscillator tube is capable of producing a "second harmonic," or second frequency B-2, which is very much weaker than the fundamental. (The need for utilizing the 8-cycle harmonic of 4 cycles rather than producing a fundamental of 8 cycles will be stated below.)

The second harmonic of any frequency is just double that number of vibrations (½ the wave-length) in a given time.

B-2, the second harmonic, consists of 8 cycles (*i. e.*, twice x 4). When these 8 cycles are caused to heterodyne (to be added to) the A-2 frequency of 9 cycles, the difference of only 1 cycle. This beat frequency of 1 cycle is the same as the adjustment of the filter coupler which is designed for 1 cycle.

C-2 is the beat frequency or intermediate frequency which has been reflexed into the grid circuit of the first tube, which now amplifies once more. The output, C-3, of this tube is stronger than C-2 and considerably more powerful than the original incoming signal A.

The output, C-3, continues on to other tubes which act consecutively to further amplify at the intermediate frequency, detect, then amplify at audio frequency.

Explanatory Circuit.

The above is a schematic circuit illustrating the system. The 50-turn coil may be the secondary of a standard aerial tuning coil wound with No. 22 or 24 D.C.C. wire on a 3-inch tube. The primary may be wound directly over the filament end.

The two honeycombs are in variable inductive relation and must not be in inductive relation to other coils in the set.

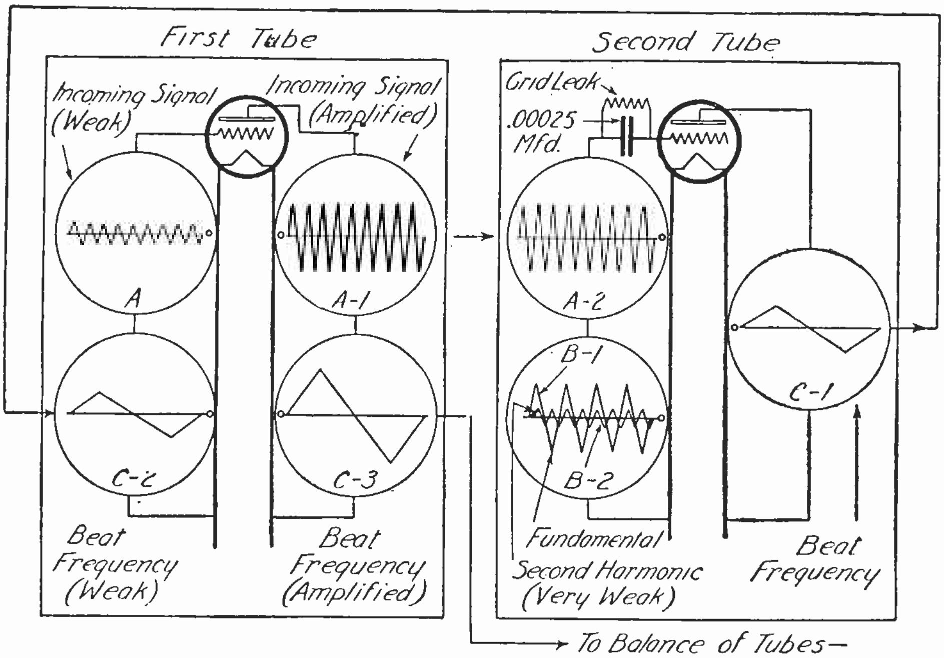
The 500-turn honeycomb coils and the two variable condensers comprise the standard filter coupler which, when Giblin-Remler coils are used, will respond to wave-lengths between approximately 1,730 and 7,900 meters. If intermediate frequency transformers are used having a higher wave-length, it will be necessary to connect two fixed condensers, each of .001 mfd. capacity, in parallel to each of .001 mfd. variable condensers.

If we consider an actual example of an incoming signal having a frequency of 500,000 cycles (600 meters), to which the 50-turn coil and its variable condenser are tuned, and an intermediate frequency amplifier and filter coupler tuned to 50,000 cycles (6,000 meters), it becomes necessary to heterodyne some frequency with the incoming signal frequency in order to produce a difference of 50,000 cycles.

Adding 50,000 cycles to 500,000 cycles we derive a total of 550,000 cycles (554 meters), the frequency required of our oscillator.

If the oscillatory circuit now including the 125-turn honeycomb coil were to include a much smaller honeycomb coil instead, so as to cover practically the same wave-length range as the broadcast stations, in the same manner as the regular oscillator system of a Super-Heterodyne, a peculiar effect would be noted; it would not be possible to adjust this circuit so as to heterodyne with the incoming signal without de-tuning the input circuit. Inversely, it would not be possible to tune the input circuit without de-tuning the oscillator circuit.

It is an entirely different matter when the wave-length range of the oscillator circuit is placed considerably outside the operating range of the input tuning circuit, which is accomplished by doubling the wave-length;



The Second Harmonic Super-Heterodyne principle of operation, graphically shown. The text explains the system in considerable detail.

tuning the 125-turn honeycomb circuit designed for this new wave-length range no longer has any appreciable de-tuning effect on the input circuit.

Our beat frequency, we have decided, is to be about 50,000 cycles. The asymmetrical tube action mentioned above causes our oscillator to produce the desired frequency, which will result in a beat of 50,000 cycles. Granting an arbitrary incoming signal frequency of 500,000 cycles (600 meters) and the requirement of an oscillator frequency of 550,000 cycles (545 meters) the 125-turn honeycomb coil circuit is tuned to 275,000 cycles (1,090 meters). Tuning this circuit does not appreciably affect the input tuning, while the second harmonic of 1,090 meters occurs at the required 545 meters (550,000 cycles).

Remember that these figures are used only for illustrating the principle. They will be different for every wave-length received and for the different intermediate frequencies for which the set may be designed.

Experimental Circuit

The above circuit shows a complete set having one stage of short-wave amplification (tube No. 1), first detector (tube No. 2), oscillator (tube No. 2), first intermediate frequency amplifier (tube No. 1), second stage of intermediate frequency amplification (tube No. 3), second detector (tube No. 4, and one stage of audio frequency amplification (tube No. 5)—seven operations being performed with five tubes.

In this circuit the instrument marked R.F.T. (B.W.) can probably be a regular radio frequency transformer, air core, designed to cover the broadcast wave-lengths.

We are showing a "C" battery in the oscillator tube circuit. This tube must act as detector as well, and, therefore, it may be advisable to try connecting a grid condenser and leak, or a crystal detector, at "X."

Although iron core intermediate frequency transformers I.F.T. 1, I.F.T. 2 and I.F.T. 3 are shown (if the experimenter has a set of Tropaformers, they will readily adapt themselves to many experiments with this circuit), it is possible that air core transformers which amplify best at about 6,000 to 8,000 meters could be used.

It will be noticed that the primary I.F.T. 1 is connected into the circuit in a different manner than usual. It is a particularly efficient method of connection in this circuit.

The second harmonic Super-Heterodyne is generally conceded to be the most difficult type of receiver to construct outside of the laboratory. Only a skilled engineer can hope to successfully build a set incorporating this particular principle.

Long Wave Receiver

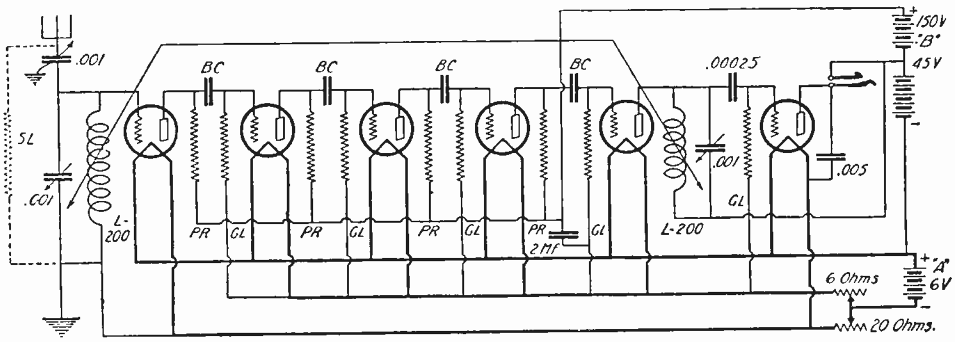
(94) Mrs. Lowell Price, Pelham Bay, N. Y., asks:

(Q. 1.) Please furnish me with a diagram which will enable me to construct a set capable of receiving the programs broadcast by certain French, Swedish, German, Italian, Spanish, Swiss, Dutch, Danish, Belgian and, I understand some South American stations, on long wave-lengths.

(A.1.) The long wave broadcast programs of stations in these and other countries may be tuned to with a set constructed in accordance with the diagram shown in these columns.

The wave-length range is dependent upon the values of inductance and capacity used. Variable condensers of .001 mfd. capacity are more to be desired when tuning to the longer wave-lengths than those of lesser capacity. Otherwise, it would cause the unnecessary inconvenience of frequent inductance coil change.

The coil values shown will cover a wavelength range of approximately 1,000 to 3,000 meters. Simplification



A resistance R.F. amplifier.

of control results by the use of only two honeycomb coils. The correct honeycomb coil value for various wave-length ranges may be determined from the table given in the "I Want to Know" department of the January, 1925, issue of *Radio News*, page 1229. When changing to a different wave-length range, it will be necesary to replace both coils.

Plate resistors "PR" have a value approximately 70,000 ohms. The exact resistance, which is not critical, is readily determined by test. The value is governed mainly by the "B" battery voltage (which should be high, 135 to 150 volts) and tubes used (practically any make of amplifier tubes will be satisfactory, with the proper resistor values).

Good tubes, preferably balanced, are essential.

The grid resistors, or "grid leaks" as we know them (marked "GL"), may all be of the same size (about 2 megohms).

Blocking condensers "BC" are all of .0005 mfd. capacity. The detector grid condenser value is .00025 mfd. capacity, as usual.

The two L-200 honeycomb coils shown are placed in variable inductive relation; this is indicated by the arrow-head lines placed to show coupling.

Two variable condensers are shown in the aerial-grid circuits. If only one is used, either the aerial circuit or the grid circuit will be out of tune on all but one wave-length—the natural period of the aerial system or of the grid circuit.

Hand capacity will be evident from the aerial series condenser, unless the usual precautions are taken.

Investigators have termed a particular form of static prevalent at the lower frequencies (high wave-lengths) as "long wave" static. A "static leak" (SL)) of about 50,000 ohms is shown as a method for reducing, somewhat, static effects. This leak is of particular value as a means of causing a slow discharge to ground of static electricity (particularly the kind known as "snow static, often observable during snowfall) which would otherwise accumulate on the aerial, due to the direct current insulation afforded by the antenna series condenser; fitfully discharging to ground, this stored-up electricity would cause loud, annoying clicks in the headphones.

Variable condenser rotors are indicated by the arrow-head.

Bus Bar Wire

(95) Miss Ann Sempere, New York City, asks:

(Q. 1.) Is square or round bus wire best for wiring up a set?

(A. 1.) It makes no practical difference whether one or the other is used.

(Q. 2.) Can an indoor aerial be used with a Neutrodyne receiver?

(A. 2.) Excellent reports have been received from radio fans who have used indoor aerials, not only with Neutrodyne sets, but with other types of sets as well.

Magnavox One-Dial Set

(96) Mr. George A. Bell, Bethany, Mo., asks:

(Q. 1.) What is the circuit of the Magnavox one-dial receiver type TRF-5?

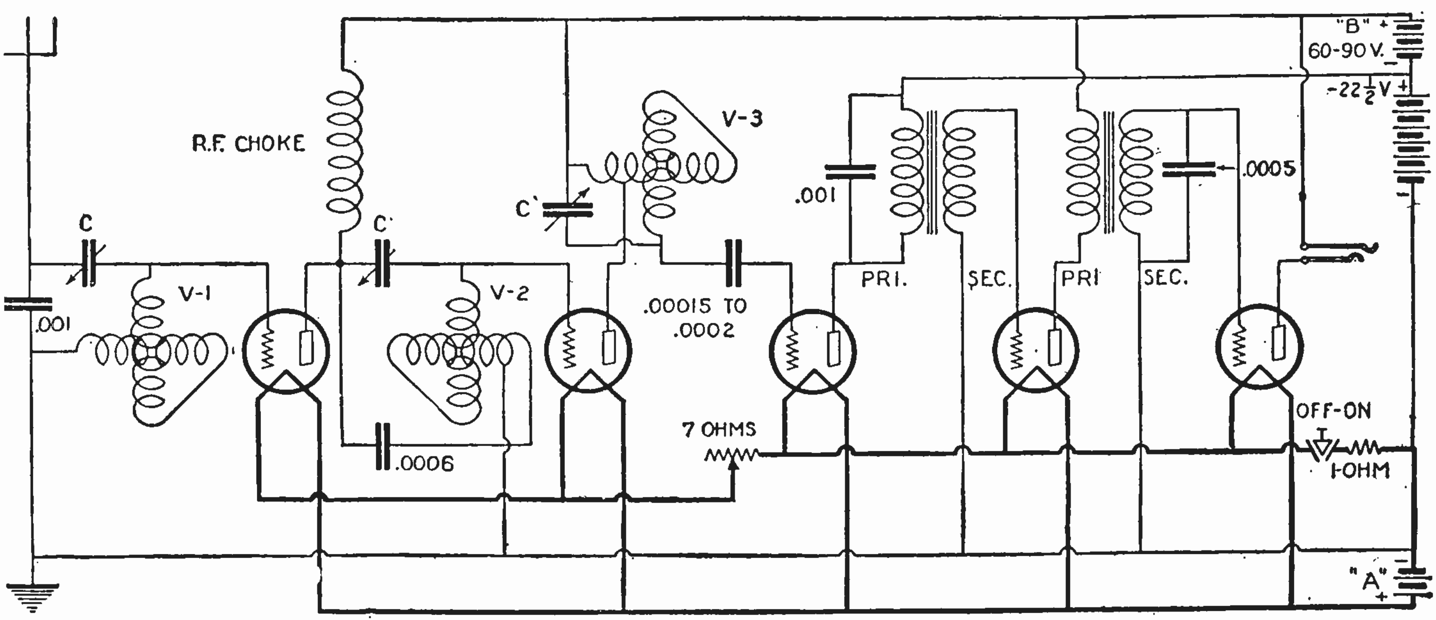
(A. 1.) The circuit of this and the TRF-5 receiver is shown.

Condensers "C" are variable between .00001 and .00015 mfd. These are called "ratio" condensers. They are controlled by the three white porcelain knobs. When a distant station is being received, these three ratio condensers are varied until maximum signal strength is reached and need not again be adjusted unless the set is moved or the tubes are changed.

When balancing the tuned circuits, it is advisable to make the adjustments while a low wave-length station is operating. If the variable ratio condensers are adjusted for a high wave-length station, there is a possibility of circuit oscillation when receiving stations at the shorter wave-lengths.

The radio frequency choke may consist of 300 turns of No. 30 D.S.C. wire, wound on a 2-inch tube.

It will be noticed that no detector grid leak is used in the manufactured set. The experimenter may wish to use the customary grid leak from the detector grid to "A" plus. A variable one will be satisfactory.



The Magnavox One-Dial Receiver has aroused considerable interest by reason of the excellent results that have been secured by its owners. Tiny, white knobs control the "ratio condensers" used to balance the circuits to the particular tubes and local conditions encountered.

Audio frequency transformers having a ratio of about 3:1 will probably be found best.

Variometer V2 may be tapped at about 8 to 15 turns from one end of the stator winding, as shown, the exact number of turns being determined by experiment. Variometer V-3 may be tapped 5 to 10 turns from one end of the stator winding. The three variometers are mechanically arranged to be controlled by a single dial.

The 7-ohm rheostat is marked "Volume Control," and used in the following manner: With "Volume Control" at maximum, a whistling note is heard on tuning in a station. Turning "Volume Control" towards minimum, thus reducing the filament current of the first two radio frequency amplifier tubes, will now eliminate the whistle.

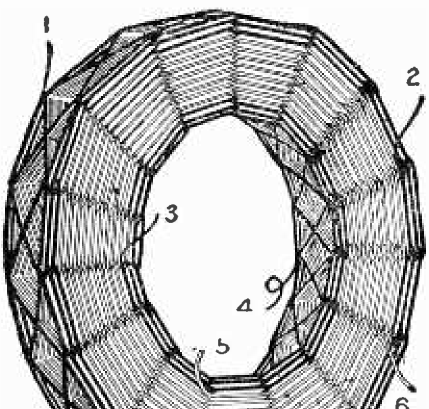
Airtrola Non-Oscillating Receiver

(97) Mr. Emil Johnson, La Crosse, Wis., asks:

(Q. 1.) Please show the schematic circuit of the Airtrola receiver. This uses an adjustment called the "Compentrol" for controlling oscillation.

(A. 1.) We are showing this curcuit in these columns.

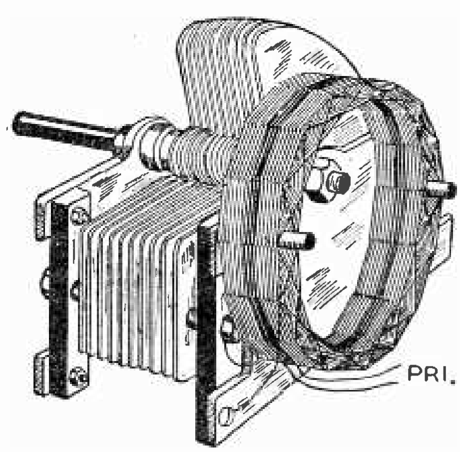
The "Compentrol" unit comprises the three-turn coil wound on the outside of the secondary and connected through the 200-ohm (or 400-ohm) variable resistance. A standard potentiometer may be used as these are obtainable in 200- and 400-ohm size.



The "shorte turns" method of preventing oscillation in tuned radio frequency receivers is described in the text referring ot this inductance coil.

The construction of the tuned radio frequency transformer containing this absorption coil is shown in the drawing above on this page. The tuned radio frequency coils must be placed in non-inductive relation to one another. The winding having terminals one and two is the stabilizing coil. This set is being shown without the second stage of audio frequency amplification since this is standard.

These are not the most efficient form of inductance, solenoid coils (the type of coil made by winding a single layer of wire on an ordinary tube)



The Freshman "eddy currents" method of oscillation control. The inductance is placed sufficiently close to the condenser end-plate for the lines of force of the coil to cause eddy currents (a form of loss).

being best from a "loss" standpoint, but this type of coil and the one marked "Q. 2126" are being used by radio set manufacturers to a great extent because they do not have as strong an external field as solenoids, a fact which makes it much easier to prevent coupling of the fields. If the fields couple, undesirable oscillation starts. Both coils require less space than solenoids. The one marked "Q. 2126" is a modified Lorenz winding.

(Q. 2.) Is it possible to use a transformer in such a way as to increase the response when a pair of ordinary 75-ohm receivers are used?

(A. 2.) We have shown, in the above circuit of the Airtrola, the requirements of a transformer to be used with a pair of head-phones having a total D.C. resistance of about 150 ohms—two 75-ohm receivers connected in series. If head-phones of standard high resistance (1,000 to 3,000 ohms) are used, they should be connected into the circuit in place of the 1,000- to 3,000-ohm primary of the transformer shown. The high resistance primary is adapted to the high resistance plate circuit and the low resistance secondary is adapted to the low resistance head-phones, resulting in efficient operation; the low resistance phones are not well adapted to vacuum tube plate circuits, unless this transformer-adapter is used.

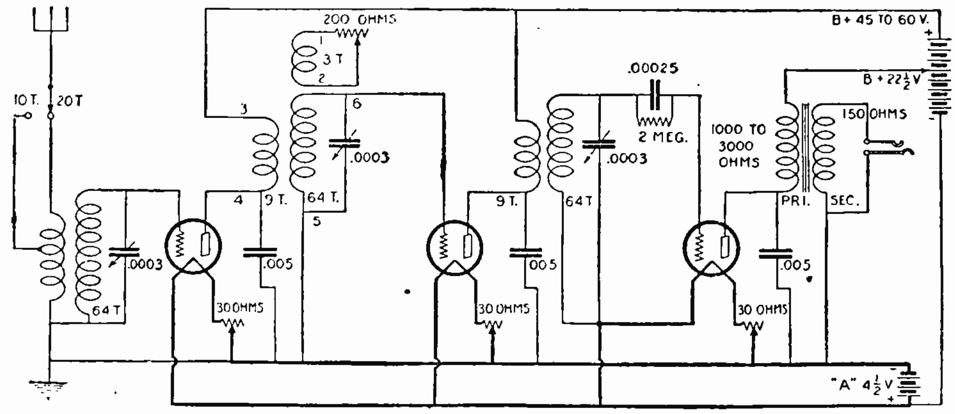
Also some circuits are extremely sensitive to the approach of the hand ("hand-capacity" or "body-capacity" effect). Using a transformer to insulate the phones from the plate circuit of the detector tube often eliminates or greatly reduces this effect. Of course, a high resistance secondary must be used if a pair of high resistance head-phones are being used.

A 1-to-1 telephone transformer of the high resistance primary, high resistance secondary type is advisable where phones of high resistance are being used. Often these are wound with very fine wire not capable of carrying the high amperage direct current that occasionally flows in the plate circuit. The transformer supplies the head-phones with alternating current of a lower amperage, thus preventing a burn-out. The transformer losses are compensated for by good design and the advantages derived.

Tuned Radio Frequency

(98) Mr. Richard Walters, Shanghai, China, asks:

(Q. 1.) What is the Starr system of "tuned absorption," as used to prevent oscillation of tuned radio frequency circuits? It is desired to use



one stage of push-pull audio frequency amplification with a phone jack so arranged that plugging the phones into the detector jack will automatically disconnect the push-pull amplifier tube filaments. When the head-phones are removed from the detector jack, the loud speaker should be automatically connected to the output of the amplifier.

As has been occasionally explained in these columns, the reason manufacturers try in so many ways to prevent oscillation without the use of a potentiometer or connecting the R.F. tube grid return leads to "A" positive, is two-fold. First, if a positive potential is put on the grid, *i. e.*, if the grid is "biased positive," "B" battery consumption is considerably increased. Second, the tuning is not then as sharp. In cheap sets the practice is to run the grid return lead to "A."

Consider the three tuned radio frequency transformers, having primaries and secondaries, as regular neutroformers designed for the Neutrodyne circuit. One make has a secondary winding of 58 turns of No. 24 D.C.C. wire wound on a 2¾-inch tube. The primary consists of 6 turns of No. 26 D.C.C. wire wound on a 2½-inch tube, which tube just fits inside the secondary. This primary may be rewound to 12 turns. The absorption coil "A" is tuned by means of the .00004 mfd. fixed condenser to a wavelength of about 250 meters. The "A" coils are made by winding 36 turns of No. 26 D.C.C. wire on a tube the same size as the one used for the primary winding, viz., 2½ inches.

Picture Diagram

(99) Mr. John W. Smith, New York City, says:

(Q. 1.) Please show the picture diagram of a reflex receiver having only one tube.

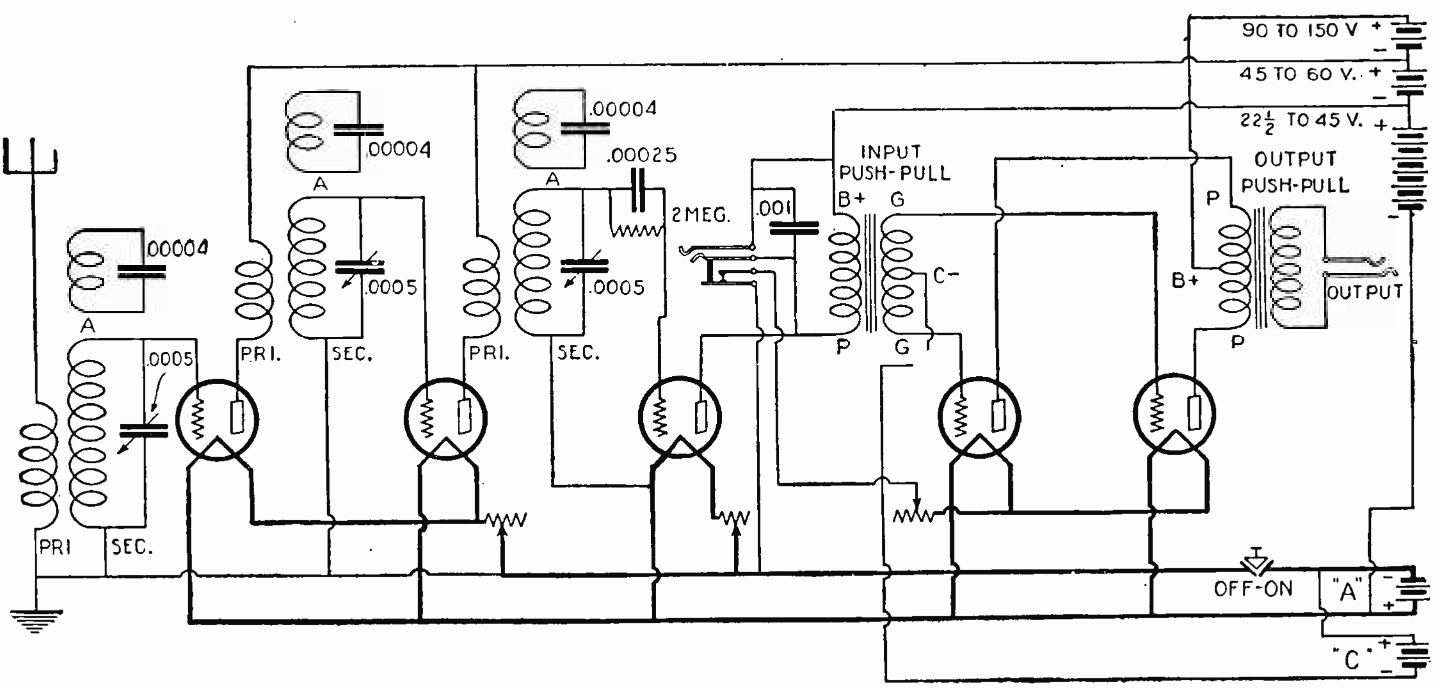
(A. 1.) We are showing the circuit below.

The crystal detector is shown connected to a center tap on the second radio frequency transformer secondary. The object of this is to increase selectivity. The dotted line indicates how one side of the radio frequency transformer secondary may be connected to "A" minus. This connection sometimes improves reception considerably, strong capacity effects being noted until this connection is made.

All coils are wound in the same direction, with any convenient size of wire. Three-inch tubes may be used. If larger tubes are used, less turns are required; if smaller, more turns. Although the spacing between the 12 (and 15) turn primary and the 50-turn secondary looks large, the spacing of a single turn of wire will probably be found quite sufficient. A greater spacing will considerably sharpen the tuning, but also decrease the volume. This reduction is most noticeable when receiving signals from distant stations. Enamel, cotton or silk may be used as wire insulation, the latter two being preferable.

The potentiometer controls amplification (regeneration).

Any good audio frequency transformer may be used. Those of high ratio are not desirable in regular sets, but in reflex receivers high ratio transformers seem to be desirable, rather than otherwise. The UV-712 trans-



A circuit employing an absorption method former (of which there are two types) was originally designed for high amplification of spark signals. (That is, one type was.) In regular broadcast receivers considerable distortion results when these are used. This circuit may be used with these audio frequency transformers with quite excellent results.

Different tubes and different audio frequency transformers (and different placing of apparatus) require different "by-pass" condenser (that is, the condensers connected to the primary and to the secondary windings of the audio frequency transformer) values. Other values than those shown should be tried and the result noted.

This is an extremely efficient circuit for the reception of local stations. Tone quality is very good. If the radio frequency coils are not crowded together, selectivity should be quite sufficient for all ordinary needs.

Although an adjustable crystal detector is shown, one of the fixed variety may be used. A dozen different minerals should be tried. At least two different "detector stands" should be tried.

The size of the "A" battery used will depend upon the tube used and the tube selected is a matter of personal like and dislike. A regular "storage battery tube" will give best results. You are fairly safe in buying a tube that will oscillate.

(Q. 2.) Is a loud speaker any good when made by clamping a pair of head-phones on the horn? Some of the loud speakers of this type require only a single unit.

(A. 2.) Head-phones are not designed for adequate handling of the strong currents necessary for proper loud speaker operation. There are many "units" obtainable that may be incorporated in some of the various types of horns. These units are entirely satisfactory for loud speakers.

A pair of head-phones designed to be really sensitive to weak signals will rattle greatly if forced to operate for even "moderate" loud speaker volume. Although not recommended, a simple expedient that permits of loud speaker operation with most head-phones (with the exception of the Brown and the Baldwin brands) is the raising of the diaphragm from the pole-pieces. It is the touching of the diaphragm against the pole-piece which causes the rattle. Sometimes merely reversing the diaphragm, so that the inside now becomes the outside, is sufficient to stop the rattle. A thin paper washer, one-eighth inch wide and with an outside diameter equal to the diaphragm diameter, may be used to raise the diaphragm slightly from the pole-pieces, a sufficient number of washers being used to prevent the rattling.

Another thing. Some head-phones are wound with wire much finer than that used in other makes of receivers. The wire is large enough for ordinary signal strength, but is insufficient when taxed by the output of a 2-stage audio frequency amplifier. The result is a burn-out which renders the phones useless until repaired.

MICROPHONES

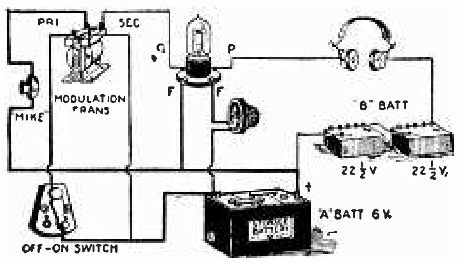
(100) Mr. Eugene Moussean, Basin, Wyo., asks:

(Q. 1.) What is the highest radio station in the world?

(A. 1.) We understand the recently opened station on the Pic-du-Midi Mountain, in the Upper Pyrenees, near the Spanish border, is the highest station in the world. It is located 9,439 feet above sea level.

(Q. 2.) Can the very small "B" batteries of the size called "Signal Corps" be used in a superheterodyne?

(A. 2.) These batteries have such a short life that they should be used



A simple microphone amplifier.

in a portable receiver only. Larger batteries should be used in permanent installations.

(Q. 3.) How can microphone currents be amplified by a vacuum tube?

(A. 3.) Picture diagram numbered Q. 2134 shows how this is done. The microphone requires a high current at a very low voltage. The vacuum tube requires a high voltage but a very low current. The "modulation transformer" serves to adapt the microphone circuit to the requirements of the vacuum tube circuit.

Any firm selling transmitting apparatus will have this form of transformer, which has a low resistance primary (about 25 ohms) and a high resistance secondary (about 1,000 ohms). An ordinary Ford spark-coil is often quite suitable.

A regular telephone transmitter may be used instead of the microphone, but it will not be as sensitive. Several telephone companies manufacture hand transmitters and microphones.

While the regular "A" battery used to supply the tube is shown as supplying the necessary microphone current, it may be necessary to have a different microphone current supply depending upon the constants of the microphone used.

The regular 2-stage audio frequency amplifier of your radio set may be used. The modulation transformer may be used in place of the first audio frequency transformer; or the set may be left connected up in the regular way and then the microphone made up as a separate unit. When it is desired to use the microphone, it is only necessary to connect the secondary of the modulation transformer to the secondary of the first audio frequency transformer. Since one side of the modulation transformer and one side (the filament side) of the audio transformer may always be connected, it then becomes necessary only to have a regular push-pull switch to connect the remaining two transformer posts, in order to use the microphone. The microphone may also be connected directly across the primary of the first audio frequency transformer.

Those who are hard of hearing will find the system explained in the diagram marked Q. 2134 a great improvement over a microphone used alone, in the customary manner. The ordinary microphone connection uses only a small battery, the receiver and the microphone. It is usual for this combination to be very noisy, particularly when the battery is new. This is due to an overloading of the microphone. This overloading is prevented by using the tube amplifier shown. The microphone is operated with much less battery current, eliminating the loud, rushing sound usually present. In addition, quality is very greatly improved and greater volume is obtainable.

If the microphone is used with the 2-stage amplifier of a regular set, as described above, the exceptionally high amplification resulting may cause the loud speaker output to feed into the microphone, resulting in a "reflexing" of the audio sounds that builds up until a loud, continuous howl is heard. This may be prevented or reduced in one or more of several ways. The howl will stop if the microphone is moved to another room. Try reducing the tube filaments current. Mount the microphone in a framework in such a way that the entire "mike" is suspended by springs. Rubber bands fastened to the "mike" and to the framework will afford the necessary spring suspension. The microphone may be suspended in a metal box open at one end, the box being grounded. This is an improvement over the plain framework mounting mentioned above. The microphone should not touch the metal at any point.

SUPER-REGENERATOR

(101) Mr. Boyd Wilson, Toledo, Ohio, asks:

(Q. 1.) Do double grid tubes operate as well as single grid tubes?

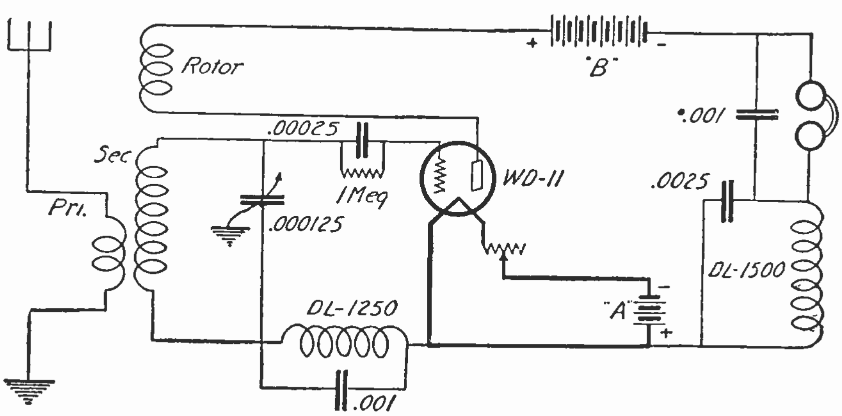
(A. 1.) In the main, no. There are circuits where double grid tubes are of greater value than single grid tubes. The principle of the double grid tube is correct, but the great majority of these tubes are not made as perfectly as the three element tubes. The special construction of the better known three element tubes is not available to the present manufacturers of four element tubes.

For experimental purposes, the available four element tubes will usually be found satisfactory.

(Q. 2.) Is it possible to use Super-Regeneration on the short wave-lengths?

(A. 2.) It has been found that Super-Regeneration on the short wave-lengths seems to be a considerably better proposition than Super-Regeneration on the regular amateur or broadcast wave-lengths. The standard circuit will be found in these columns. The circuit used is that of the standard regenerative receiver with the addition of the coils DL-1250 and DL-1500, with their accompanying capacities. These two honeycombs are in variable inductive relation. When receiving short wave-lengths between 50 and 110 meters for the primary, six turns of No. 20 D.C.C. wire wound directly over the secondary will be satisfactory. The secondary may consist of about 15 turns of No. 24 D.C.C. wire wound on a three-inch form. It will be advisable to use some special form of low lose winding, such as the pickle bottle, spiderweb, honeycomb, lattice, or Morecroft type.

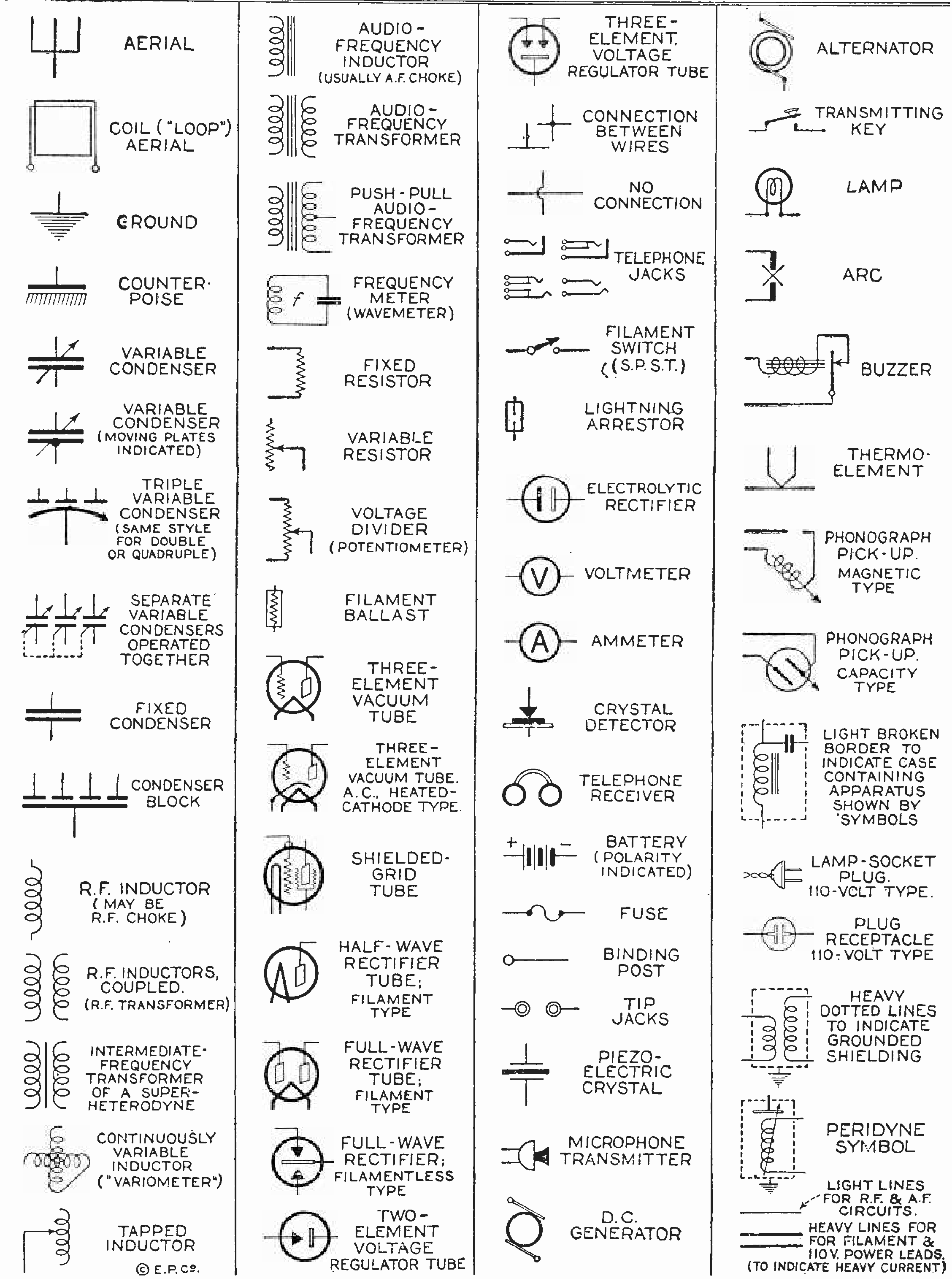
The winding method for the latter form of coil is similar to that shown on page 55 of the July, 1924, issue of *Radio News*. However, the method of using insulating strips should be applied to the secondary winding as well as to the primary winding. The tickler may be wound on a solid tube in a manner similar to the primary coil construction shown in the above mentioned article.



A Super-Regenerative Circuit

STANDARD RADIO SYMBOLS

ADOPTED BY "RADIO NEWS", FEBRUARY, 1928



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