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Lesson Text No. 28

BATTERY ELIMINATORS AND POWER AMPLIFIERS

Originators of Radio Home Study Courses
···Established 1914···
Washington, D. C.

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PERSEVERANCE

A Personal Message from J. E. Smith

Perseverance is gained largely through practice. It is true that persons differ in their natural attitude toward methodical habits, but relatively few of us are endowed with the readiness to stick to difficult, and sometimes tiresome, things without making any special effort at perseverance. Nearly all of us have to train ourselves to habits of work, and study, however pleasant much of it may be, is after all work. It requires perseverance.

There is no short cut to perseverance. It is simply a matter of practice, of habit. The oftener one goes ahead and finishes a job of any kind, the easier the next job will be.

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BF3M3531 Printed in U.S.A.

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Radio-Trician's

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Complete Course in Practical Radio

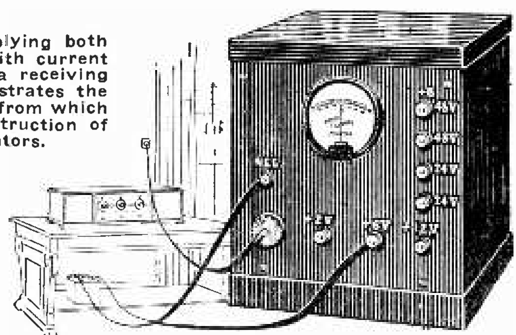
NATIONAL RADIO INSTITUTE, WASHINGTON, D. C.

BATTERY ELIMINATORS AND POWER AMPLIFIERS

Power Units to supply "A" or filament lighting circuits of D. C. vacuum tubes used with some radio receivers may be divided into two classes:

In the *first* class, the early "A" unit comprised a step-down transformer, a storage battery and a charger that would supply a continuous trickle of electricity. See Fig. 1. This trickle charger would refurnish in 20 hours what the receiving set drew off in 4 hours of use at heavy current drain.

A rectifier unit supplying both A and B batteries with current in order to operate a receiving set. This really illustrates the stage of development from which we start in the construction of battery eliminators.



Then came the event of the automatic relay which worked from the switch on the receiver to connect the battery to the receiving set when reception was desired and disconnect the charger. This action was reversed to connect the charger to the battery when the receiver was turned off. The latter type did not use a trickle charger but a high-rate charger which tapered off the current as the battery became fully charged, and stopped charging when the battery was fully charged. The automatic relay consisted of a small magnet placed in the lead from the battery. Closing the receiver switch allowed current to energize this magnet, the magnet drawing down an arm which was really a switch in circuit leading to the charger and cutting it off. When the set was turned off, the magnet lost its energy and the

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arm flew back, reconnecting the charger to the battery to replace current drawn off while the receiving set was in use.

The basic elements used in the *second* class of A power units are: First, a transformer to step down the voltage, then a rectifier to change alternating current to direct current and, third, a filtering system to remove pulsations and make the

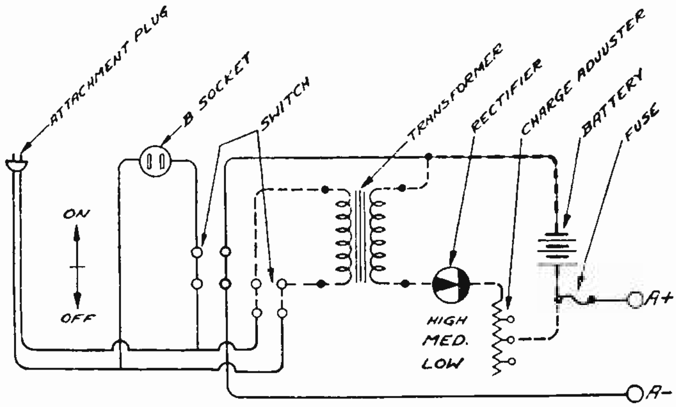

Fig. 1—Wiring diagram of Philco Socket Power "A" with manual control switch. This unit is a combination of a transformer, rectifier, storage battery and a trickle charger.

output a steady, unvarying flow of power. See Figs. 2 and 2A.

Power units of this class to supply A or filament lighting circuits vary chiefly in their rectifiers. Alternating house lighting current travels in one direction for an instant, and then reverses

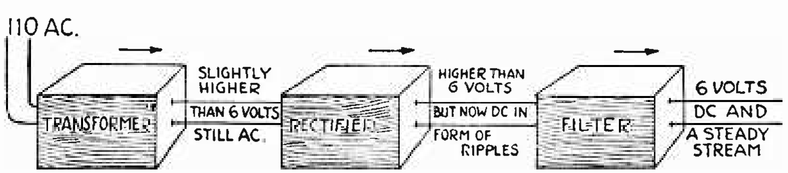

Fig. 2—Diagram showing how "A" Socket Power Unit transforms 110 volts A. C. to 6 volts D. C.

and goes the other way. This it does 60 times per second if the power company supplies 60-cycle electricity; 25 times per second if they supply 25 cycles. The rectifier must either block off the current going one way or must cause it to travel in the same direction without going the other way.

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A rectifier which changes alternating current into pulsating current utilizing only one-half of each cycle is called a half-wave rectifier; one which causes both halves of the cycle to travel in the same direction during each half cycle of the alternating current supply is called a full-wave rectifier. It is well for students to remember these terms as you will see them very often in future text-books and service manuals. In *half-wave*

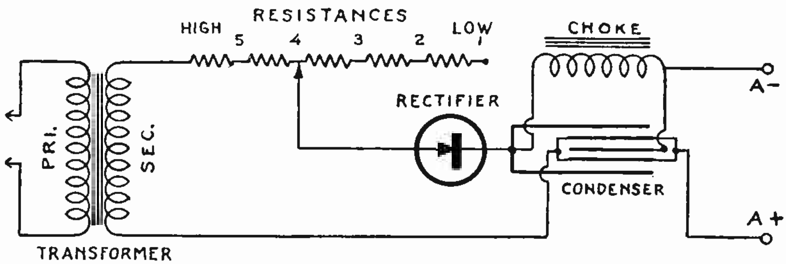

Fig. 2A—Wiring diagram of Balkite "A" Socket Power Unit. This unit does not use a storage battery and charger but a step-down transformer, rectifier and a high capacity electrolytic condenser with a choke coil and a resistance to regulate the output of the unit.

rectification only one part of the current wave is utilized, the rectifier acting as an electrical gate which allows the current to flow in one direction but stops the flow of current in the opposite direction. In *full-wave* rectification the action is more like that

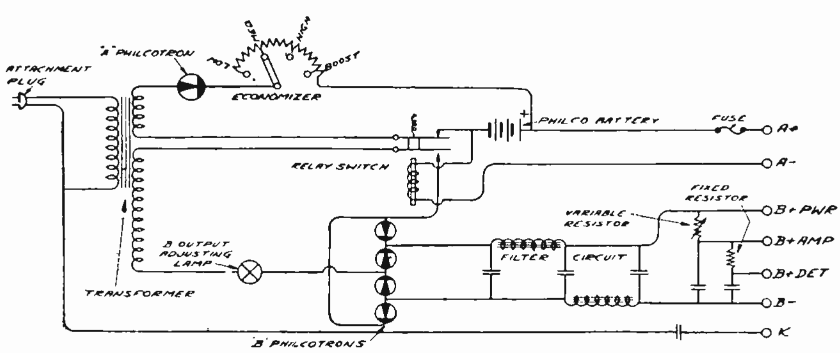

Fig. 2B—Wiring diagram of Philco AB Socket Power types AB-656 and AB-652.

of a specially designed turnstile which takes two lines of people going in opposite directions and turns them all into one line going in a single direction. The output from either type can be successfully filtered to make it suitable for filament supply. After rectification, the current is in a series of pulsations or

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surges which must be smoothed out. The smoothing out process consists of holding back part of each surge and releasing this part between the surge from which it was taken and that which follows. The more evenly a filter does this, the more successful

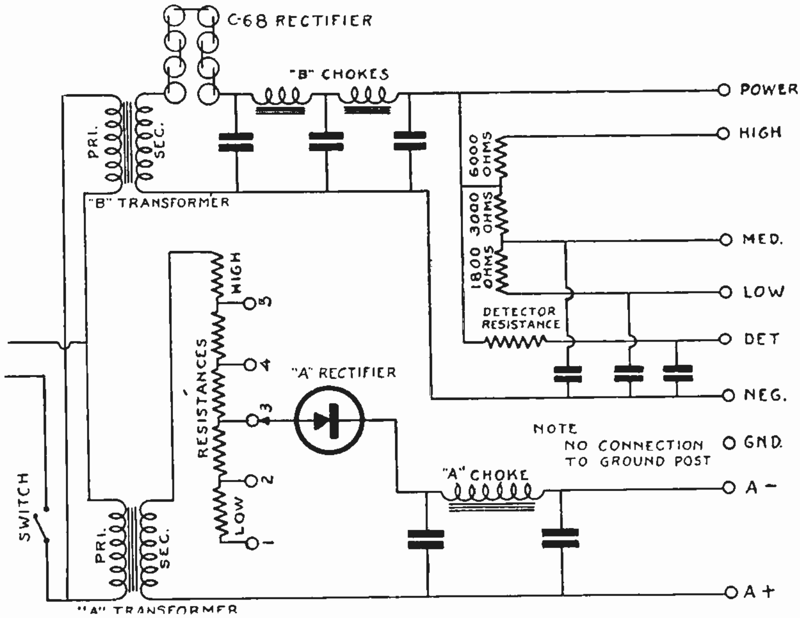

Fig. 2C—Wiring diagram of a Balkite AB Socket Power Unit 6-180 Form A.

it is considered to be. If the pulsations or surges are not smoothed out, there will be heard in the loud-speaker a steady, low musical note (hum) which will spoil reception if present.

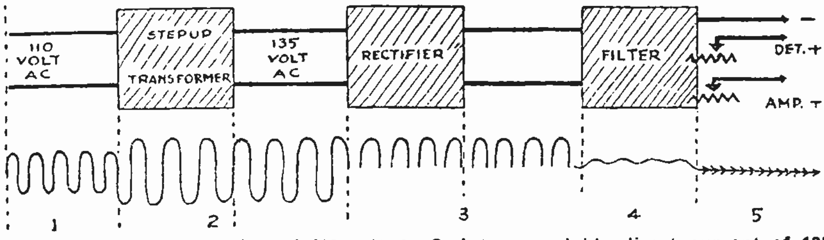

Fig. 3—The transformation of 110-volt A. C. into a variable direct current of 135 volts is shown graphically above. Section 1 shows the character of the incoming 110 volt alternating current; Section 2, the change in its character as it passes through the step-up transformer to 135 volts; Section 3, the rectification of one-half of the cycle as delivered by the tube. In the 4th Section, the process of filtering and smoothing the ripples is accomplished, and in the 5th can be seen the straight line of the direct current as delivered to the plates of the tubes in the receiver.

Filters to remove this hum usually contain a large coil of wire wound on an iron core, which is known as a choke, and condensers, the current coming into the filter as a series of sharp

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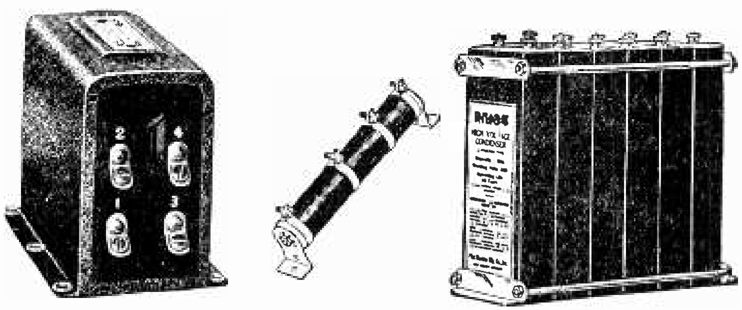
surges passes to the choke, the action of which is just what its name implies.

The condensers have the capacity of storing the electricity—not chemically as a battery—but keeping the electricity in the same form in which it flows along the wires, thus when an over-average pulsation of rectified current passes to the choke, part of it is crowded back and the condensers are provided at the proper place to take care of the excess for a moment and release it between surges. The result is a steady direct current output from the filter.



(A) (B) (C)

Fig. 4—Important units used in Battery Eliminators.
(A) Filter choke unit containing two iron core inductances for smoothing out D. C. pulsations. (B) Resistor unit strip for obtaining different voltage values. (C) Large condenser block used in filter section.

There are quite a number of different types of rectifying units used in A power units. There is the Tungar (or Rectagon) bulb, such as used quite often in battery chargers. This Tungar bulb contains a filament lighted by one winding of the transformer in the A power, and a plate to form the other element in the tube. When properly connected in an alternating current circuit, that half of the cycle which tends to flow from the plate to the filament can pass, but that which tries to go from the filament to the plate is blocked. This action is very similar to the action in a regular vacuum tube, but there is no grid in this tube, and it is a half-wave rectifier capable of handling 2½ amperes of current.

The *electrolytic rectifier* is also used in A power units. This type of rectifier contains an aluminum rod and a rod of another metal immersed in an electrolytic solution.

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Another type of rectifier is the *dry disc* unit. It is named a dry rectifier as it does not use any liquid or give off light. It secures its rectifying action from the fact that if small discs of different metals (cupric sulphide as one active agent and magnesium as the other active agent) are placed against each other, and alternating in the metals used, current can pass through the pile of discs in one direction but not the other.

Still another method of obtaining D. C. power when only A. C. is available is to use the latter to operate heating coils which are in close proximity to a series of thermo-couples. It is well known that when the junction of two dissimilar metals are heated, a direct current will flow and while the potential of a single couple is quite low, the desired voltage may be obtained by using a battery of them connected in series.

A full-wave chemical rectifier changed to a "B" eliminator by the addition of a suitable filter is shown in Figure 5.

The Values to Use With Eliminator in Fig. 5

The following table tells you the values you will require for the inductance L, the condensers C^1, C^2 and C^3, and the resistance R, according to the number of tubes in your set:

Number of Tubes	Inductance of L	Allowable D.C. Resistance of L	C^1	C^2	C^3	R
3	20-40 henries	2000 ohms	2 mfd.	4 mfd.	2 mfd.	5000 to 10,000 ohms, variable
5	20-40 henries	1500 ohms	4 mfd.	4 mfd.	2 mfd.	ohms, variable
7, 8, or 9	20-40 henries	1000 ohms	6 mfd.	8 mfd.	2 mfd.	ohms, variable

THERMIONIC RECTIFIER TUBES

The two-element Tungar tube previously described depended upon the so-called "Edison" effect which is the emission of negative ions by a heated body, for its rectifying properties.

There are quite a number of commercial two-element thermionic rectifier tubes used in "B" supply units such as the UX-213, UX-218B, UX-280 and UX-281. The UX-216B and the UX-281 are half-wave rectifiers, and the UX-213 and UX-280 are full-wave rectifiers.

4

GASEOUS OR NON-THERMIONIC RECTIFIER TUBES

Gaseous Rectifiers are non-thermionic because they operate without a filament. Their structure is simple, consisting merely of two electrodes sealed in a glass tube containing a trace of a certain rare gas, neon, helium, etc.

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The rectifying action of this tube depends upon a great difference in size between the electrodes. The polarity of the electrodes changes with each half cycle, so that if one has a much

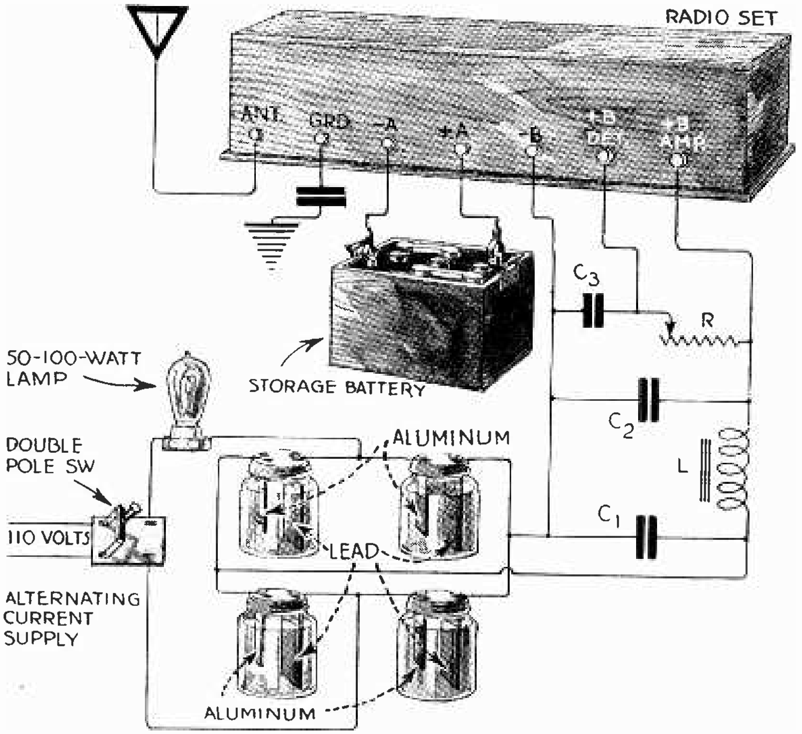

Fig. 5—This diagram shows how to wire the parts of the rectifier and connect it with your set. The values of the inductance, resistances and condensers you will need are given in the table on page 6.

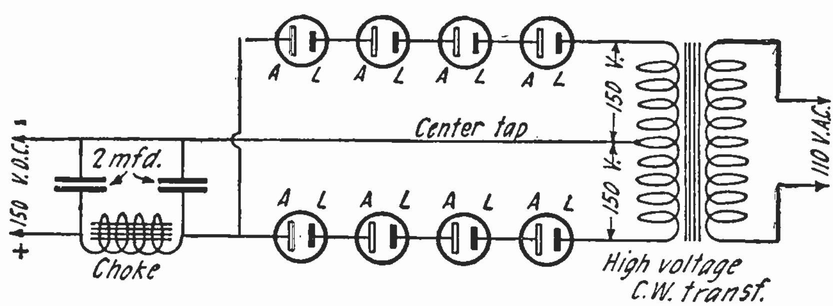

Fig. 6—Illustrates the use of a large number of rectifier jars in series in order to obtain higher voltages for the B battery supply.

greater area than the other, the larger will throw off many more electrons and establish a unidirectional current by ionizing the gas in the tube. Other factors are the pressure and purity of

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the gas, the quality of the material of which the electrodes are made, the frequency of the current, and the voltage with reference to the distance between the electrodes.

A helium tube following the general design features of the

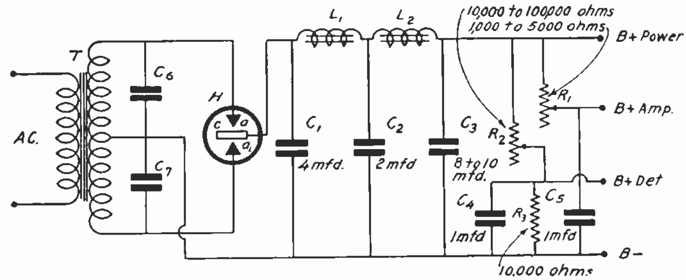


Fig. 6A—The Raytheon Full-wave Rectifier Circuit for "B" Power Supply.

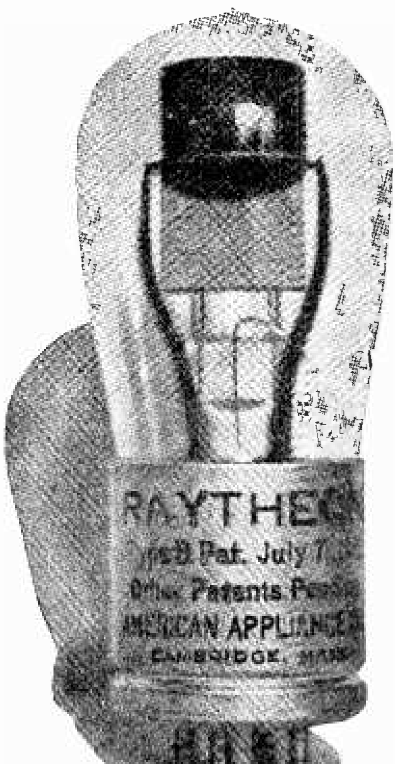
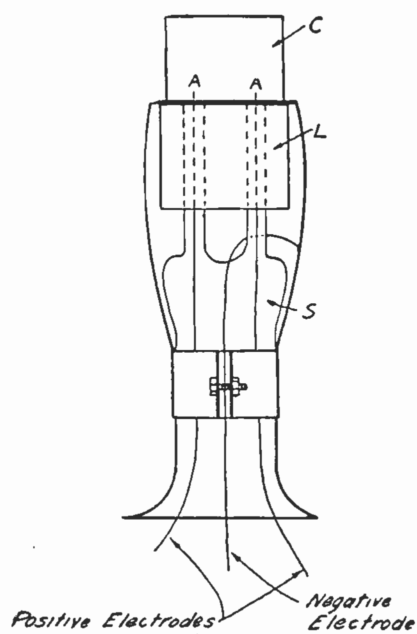


Fig. 7.



Constructional Details of Helium Tube.

Fig. 8.

These two pictures illustrate the appearance and constructive features of the Raytheon tube. (Type B.)

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style which approaches the ideal rectifier is on the market under the trade name "Raytheon."

This gaseous rectifier operates upon "the short path principle," whereby a rarified gas acts as an insulator between points which are in close proximity. This is an apparent contradiction of the observed phenomenon that the smaller the distance between two points the more rapidly a spark will jump between them due to the ionization of the gas. But if the distance is small enough and a suitable gas is used at sufficiently low pressure an electron may encounter no gas molecules in its path between the points and there will be no ionization by collision. Consequently the inert gas helium may be made to act as a perfect insulator at low pressures.

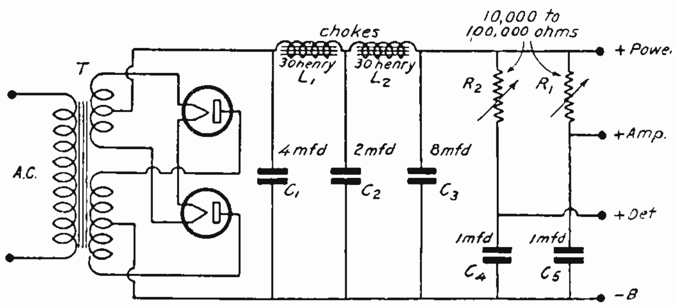

Fig. 9—"B" Power Supply using two half-wave filament type rectifying tubes for full-wave rectification.

Figure 7 indicates the appearance of the tube and Fig. 8 shows its construction. The two small positive electrodes AA are carried through two small glass tubes imbedded in a lava insulating block L so as to project very slightly into a relatively large cup C. The walls of this cup, being connected to the negative terminal through the base, constitutes the negative electrode. The diameters of the small wires and the diameters and position of the holes whereby they enter the cup are so proportioned as to give the necessary short path to the negative electrode. The cup C contains helium gas at such low pressure (high vacuum) as to prevent gaseous conduction. This construction makes possible extremely minute anode surface and consequently the "back" current is negligible, an important factor if the tube is to be used as an element in a "B" Eliminator.

Heretofore, the difficulty of insulating the electrode in the presence of a gaseous discharge gave a practical limitation to

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the reduction of its size. But in the tube the "short path principle" eliminates the difficulty.

Since the tube has two positive electrodes, full-wave rectification is performed in a single tube; because the minute anode surface rectification is unusually complete and since the tube has no filament, its life is usually long.

Figure 9 shows a typical installation, a two-tube rectifier in which the filter has been added. The rectifier tubes are lighted by A. C.

Commercial Non-Thermionic Rectifiers (Raytheon)

Type	Use	Max. A.C. Per Plate (volts)	Max Output (Milliamperes)
B	Full Wave	275	60
BH	Full Wave	350	125
BA	Full Wave	350	350

Commercial Thermionic Rectifiers

UX-213	Full Wave	220	65
UX-216B	Half Wave	550	65
UX-280	Full Wave	300	125
UX-281	Half Wave	750	110

How to Build a Universal "B" Battery Substitute Which is Highly Satisfactory in Operation and Low in Cost—The Parts Are Readily Obtainable.

Certain prevailing types of eliminators are suited for particular types of receivers, while they are entirely unsuitable for use on others. In order to make a choice between these various designs, the broadcast listener has had to try out one after another until he has obtained satisfaction. Even after a comparatively thorough test, he may find that the short life of the rectifier elements will cause an expense equal to that of maintaining "B" batteries.

It is the purpose here to describe the theory and construction of a universal B-battery substitute having excellent operating characteristics on all types of receivers, and an unusually long life. The cost of construction will not exceed twenty-five dollars, and, as all parts are readily available, the entire unit may be

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constructed at home. Several advanced features are present in the design described below.

Battery eliminators generally consist of three major elements: A **Transformer** to convert the 110-volt A. C. supply to the required voltages; a **rectifier** which converts the A. C. into pulsating D. C.; and a **filter circuit** which smooths out the irregularities of the rectified voltage to a uniform D. C. The study and development underlying the design of eliminators has brought forth new facts which are extremely important in the attainment of high quality performance. Many weaknesses were present in the early designs, but the research Radio Engineers have succeeded in building up units of recognized quality and dependability.

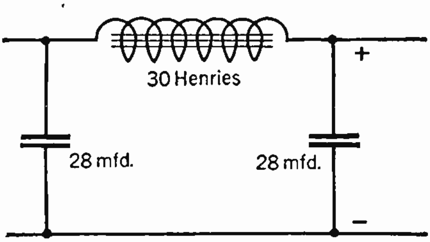

Fig. 10—Shows what is called a "brute force" or reservoir type of filter.

In the discussion given the student will find complete instructions and drawings for making a B battery substitute. The general design is similar to that developed by several manufacturers of B battery substitutes that are on the market. Complete dimensions, list of materials, size and turns of wire, etc., are given for those who want to make up a complete unit at home. This construction can be very easily accomplished, but for the convenience of those who prefer to use factory-made transformers and choke coils, units are described wherein use is made of these parts manufactured by the Acme Apparatus Company, General Radio Company, Dongan Electric Manufacturing Company and Jefferson Electric Manufacturing Company. On 60-cycle supply, any of these manufactured parts may be employed with excellent results, and the appearance of the unit using them will certainly surpass that of the home-made model. The photographs, Figs. 14 and 16, show the construction of models employing factory parts.

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THE RAYTHEON TUBE

The very heart of the unit is the Raytheon rectifier tube, which has been developed for this purpose. In this tube, two anodes are provided, so that the tube rectifies both halves of the alternating current wave. This feature is of importance because it greatly simplifies the problem of filtering to obtain a pure D. C. supply. An additional feature made possible by the small anode area is that it permits but a minute fraction of the current to flow during the reversed voltage period of the current-flow cycle. Many rectifiers operating on the gaseous conduction principle give forth an extraordinarily high "back current," as it is called, which frequently rises to such a value as to become dangerous to the life of the tube and unnecessarily complicates the filter circuit problem. In the Raytheon tube it is extremely difficult to detect the back current by even the most sensitive measuring instruments.

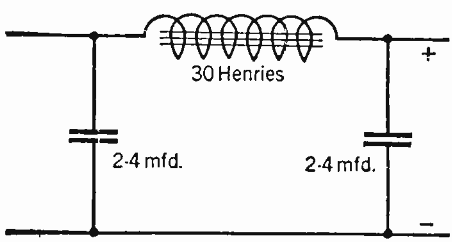

Fig. 11—A smoothing out type of filter.

The Raytheon rectifier has been designed to meet the requirements of most of the standard "B" battery substitutes. Its starting voltage is very low—approximately 155-160 volts—and its current carrying capacity is high. The Raytheon tube type B is rated at 60 milliamperes at 150 volts D. C. output. As there is no filament to burn out, the life of the rectifier is extremely long. Standard Raytheon tubes have been on test at maximum output for more than 4,000 hours, and have not yet shown signs of deterioration. It is doubtful if the maximum life of these tubes can be determined at intermittent operating periods such as they would receive in the ordinary operation of a current tap. If not abused by overload or continued short-circuit, they should last for years.

The operation of the Raytheon tube in a B-substitute is unusually quiet, the reason for this is that the gaseous dis-

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charge is entirely enclosed. There cannot be any sputtering of the discharge such as might occur if the elements were exposed to the glass tube or insulators. This conserves the helium gas with which the tube is filled, and greatly prolongs the tube life.

The operation of a properly designed current tap employing the Raytheon rectifier tube has unusually good characteristics. Some of these will be mentioned in connection with points previously explained. First of all, we have exceptionally good "regulation." The increased impedance of the Raytheon tube with load is less than that obtained from other types of rectifiers, causing an upward curve in the load characteristic, in distinction to the usual straight line falling curve of other rectifiers that give low voltage at full load current. The fact that the output voltage does not fall off as rapidly as usual obviates the necessity of providing an excessively high transformer secondary voltage. The lowered A. C. voltage is an important contribution to the safety of operation of the device.

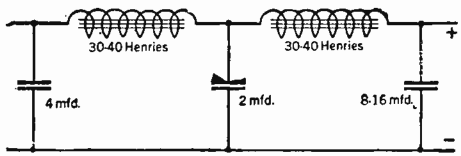

Fig. 12—Filter circuit common in new models.

List of Raw Materials Required

6 lbs. Silicon Steel	$ 1.20
28 ozs. No. 31 d. c. c. wire	2.19
12 ozs. No. 32 d. c. c. wire	.94
7 2-Mfd. Condensers	12.25
1 0.5 Mfd. Condenser	.90
2 0.1 Mfd. Condensers	1.40
1 Bradleyohm No. 10	2.00
1 Raytheon tube	6.00
1 Standard Socket	.25
1 10,000-ohm resistance	1.00
	$28.13

The prices quoted above are maximum retail prices. In some cases substantial reductions can be obtained from the costs given.

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The current and power capacities of the Raytheon tubes are sufficient to supply the greater majority of radio receivers. The current output is rated at 60 milliamperes at 150 volts and it has been found from measurements of the plate current consumption of a large number of receivers that this value is more than sufficient for the demands of most receivers.

The filtering problem in plate current supply units is usually one of high cost and considerable difficulty. When the Raytheon tube is employed, the filtering requirements are much simpler, since it gives rectification of both halves of the A. C. wave. Here one tube does the work of two at a great saving in cost, and at a

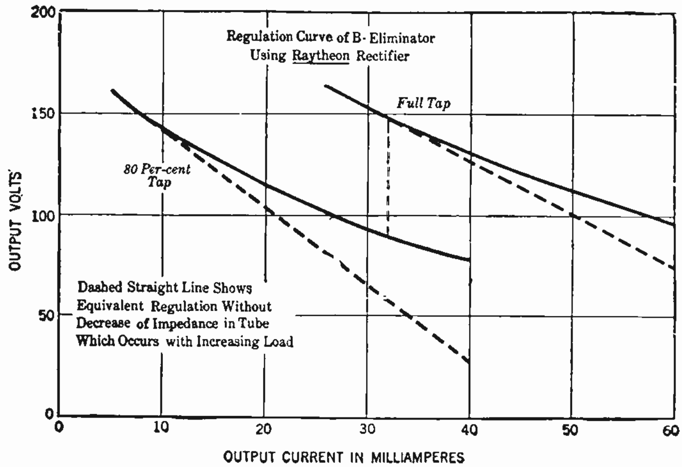

Fig. 13—Curves showing output current in milliamperes plotted against the voltage.

higher efficiency. As indicated previously, there is no back-current perceptible. Back-current is a bad feature from a filtering standpoint, as it complicates the filtering problem, and often heats up the choke coil windings to an injurious degree.

Another important feature of the Raytheon rectifier is that it requires no power for lighting a filament. This power very often demands a large transformer supply, the cost of which is an item of great importance. With the use of the Raytheon tube, a complete B-substitute can be made up in a space no larger than a heavy-duty B-battery.

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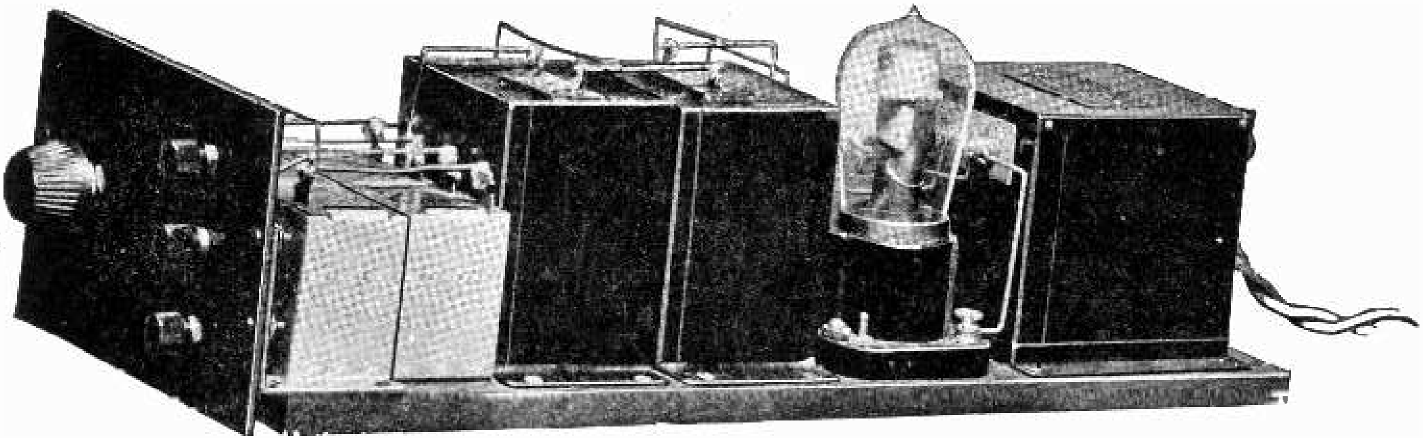

Fig. 14—A compact model of the battery eliminator described here. Note the large condensers which are employed in the filter circuit to insure a smooth D. C. output.
(Courtesy of Radio Broadcast.)

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HOW TO BUILD THE APPARATUS

We will now proceed with the building of the eliminator. Figures 14 and 16 show the arrangements of the parts when the unit is assembled from factory models. The basis of these models is the circuit diagram, a schematic drawing of which is shown in Fig. 17. The values of capacity, inductance, and resistance shown in this diagram have been determined after considerable investigation, and should be adhered to as strictly as possible. These instructions also apply to the construction of the home-made transformer and chokes described below.

Dimensions for the transformer used in this eliminator are shown in Figure 18.

The transformer is made up of three coils of insulated copper wire wound over a core composed of a large number of strips of No. 29 gauge Apollo special electrical steel. These strips are carefully cut by hand from an old power transformer or from sheets of the proper material, and shaped into the forms shown in Fig. 18. Enough pieces are cut out to make up a complete core of the dimensions given in Fig. 18, when they are assembled and clamped together in a vise to determine if the required amount of steel has been prepared. All rough edges must be removed, and the dimensions uniform.

There are three windings on the transformer which are wound in place on the winding form illustrated in Fig. 19. The winding spool may be assembled on a long stove bolt with nut and clamped in a hand drill, carpenter's brace, or in the chuck of a lathe for convenience in winding the coils. Some means should be provided for counting the turns exactly as they are applied. If the ratio of turns of the hand drill is known for one turn of the handle, it is a very simple matter to use this in counting the turns as they are applied. Care should be used to obtain within one per cent of the specified number of turns on each winding. The primary winding is applied first over the entire length of the winding form, and consists of 1250 turns of No. 31 enameled copper wire, with a tap taken out and insulated at the 1000th turn. Two layers of Empire cloth are placed over the primary winding, then two separate secondary windings are wound, each of which consists of 2750 turns of No. 32 enameled copper wire. These two secondary windings are insulated from

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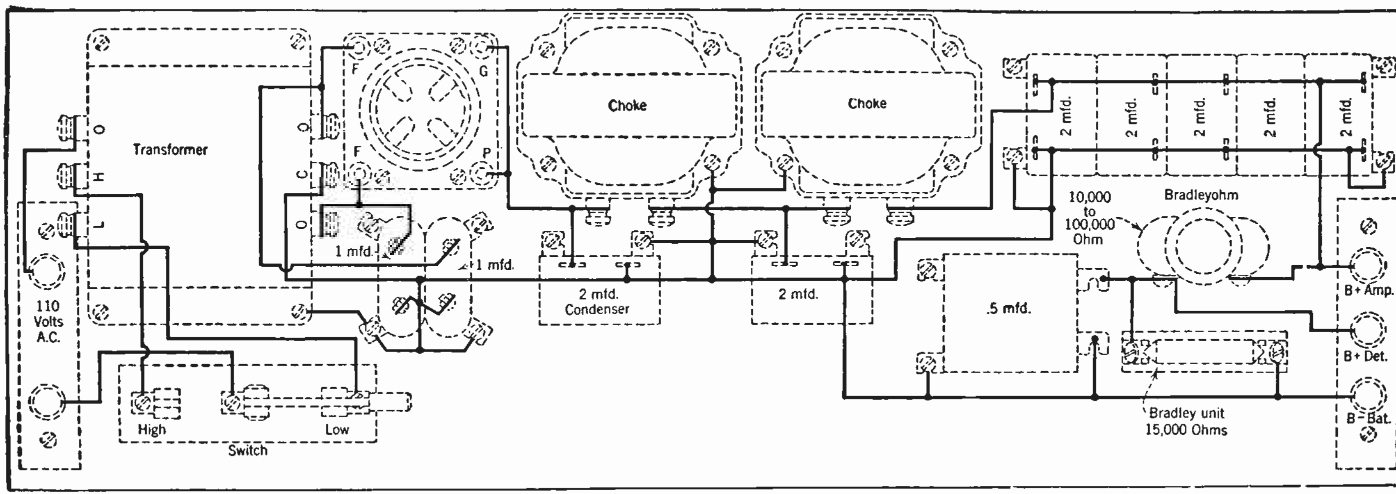

Fig. 15—A picture diagram and wiring layout of the eliminator whose circuit is embodied in the diagram Fig. 17.
(Courtesy of Radio Broadcast.)

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each other at the middle of the winding form by means of a rectangular separator of .010-inch fiber. This separator is cut out after the primary insulation has been applied, and is put in place by means of a slot cut in one face of the separator. See Fig. 19.

While the first secondary is being wound, the remaining winding space is tightly filled up with a number of strips of cotton muslin or cotton tape, in order to prevent the wire from crowding the winding separator out of place. In all cases, insulated leads 8 inches long, of flexible stranded wire (six No. 30 D. C. C. wires twisted together are satisfactory) are soldered to the ends of the windings for terminals, before the ends are brought out from the winding. Each terminal is tied in place in order to prevent its being ripped from the coil by accident. If it is necessary, thin strips of paper may be laid over each layer of wire as it is completed, in order to insure smooth layers in the winding. When the coils are completed, the outside is wrapped with two layers of Empire cloth or heavy manila paper as a protection and insulator.

The steel laminations are now inserted one by one in the completed winding, as shown in Fig. 18 and the transformer is bolted together. If it is not convenient to drill holes in the laminations for the clamping bolts, the builder may cut out clamping plates from hard-wood or angle iron. In such case, the bolts will pass through the ends of the clamping plates at the ends of the core, instead of through the holes therein. Figure 22 shows the method of clamping adopted by the author in preference to drilling holes in the core. If the builder desires, he may put mounting brackets on the base of the transformer to aid in securing the instrument to the base board.

The Choke Coils

The choke coils, shown at L^1 and L^2, Fig. 17, are constructed in a manner similar to that employed in the making of the transformer. Each of these coils will have an inductance of approximately 20 henries if care is taken in constructing and assembling the cores. All rough edges should be removed and the cores assembled in an orderly manner. (See Figs. 20 and 21.)

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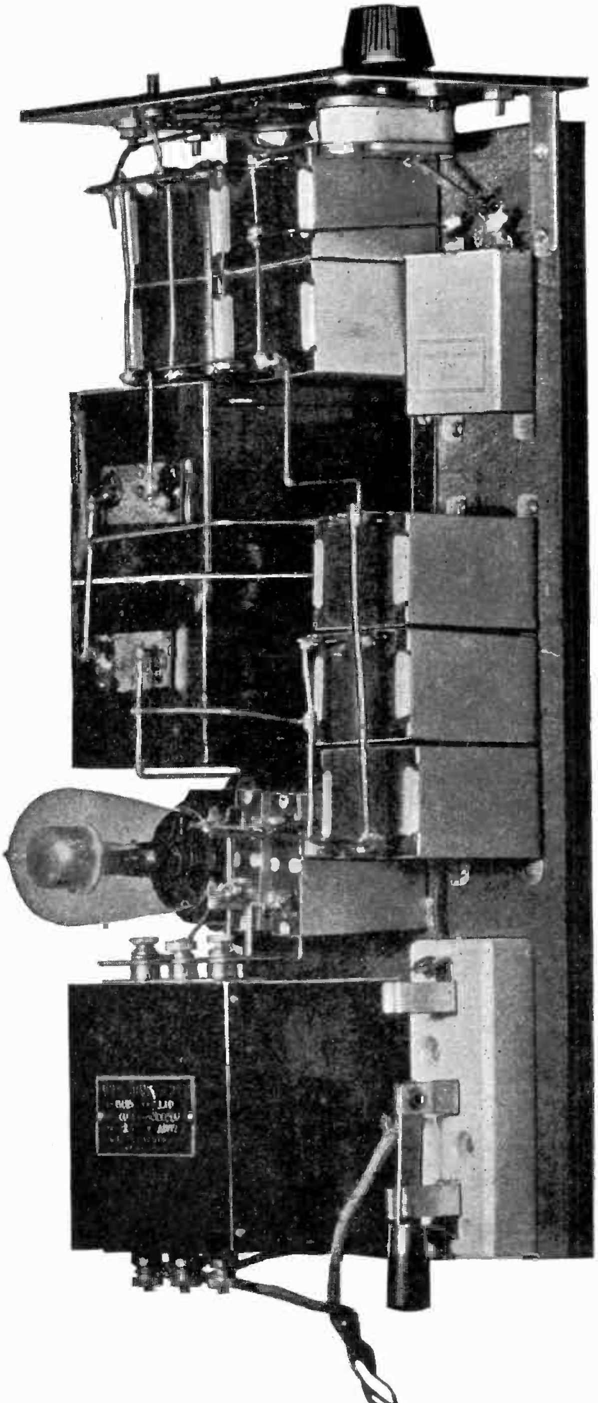

Fig. 16—A different view of the eliminator employing manufactured parts.
(Courtesy of Radio Broadcast.)

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The winding on each choke coil consists of 5000 turns of No. 31 enameled copper wire, wound in smooth layers with the necessary interleaving papers. The outside of the completed coil is wrapped with one layer of heavy manila paper as a protection. The laminations shown in Fig. 20 are inserted in the completed windings, and the entire coil is assembled in accordance with the description of the power transformer above. A piece of .010 red fibre strip is inserted in the air gaps of the choke coil cores, to insure the magnetic stability necessary under the operating conditions. When this has been accomplished, the clamping plates are secured as described above.

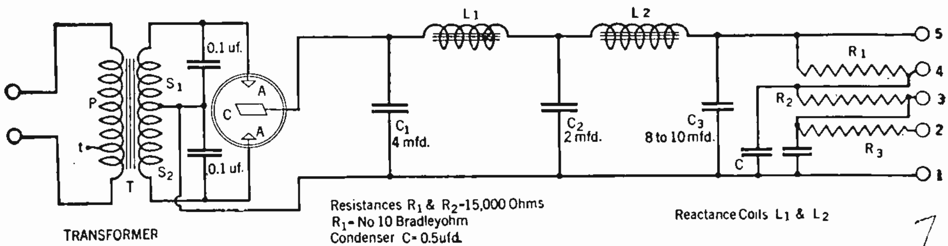

Fig. 17—The circuit diagram of "B" eliminator using Raytheon tube. The transformer at the left steps up the line voltage, passes it to the double-wave tube which rectifies both halves of the cycle. Thence it is passed to the filter where it is smoothed out into pure D. C. The resistances permit the tap-off of the desired voltages necessary to the operation of the receiver.

The filter condensers, shown in Figs. 14 and 16 were procured from Tobe Deutschmann, Canton, Massachusetts, and have passed the most severe operating conditions. They were subject to repeated charging and discharging at 700 volts D. C., and withstood the strain upon the dielectric successfully. None of the samples examined in this way were broken down. The equivalent series resistance was found to be low enough to give excellent results in connection with the "B" battery filter circuit. The particular arrangement of the filter circuit shown in Fig. 17 requires a total capacity of 14 mfd. and the distribution of this quantity is more important than the absolute value. If this circuit does not meet with the requirements of attached receiver and loud-speaker, a slight improvement will be effected by increasing the value of C^3 to 12 or 16 mfd. Increasing this capacity beyond 20 mfd. does not add greatly to the standard of quality already established and, for average conditions, this capacity need not exceed 8 mfd.

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the usual series resistance method. A 0.5 mfd. condenser is used to by-pass any disturbance that might reach the detector through

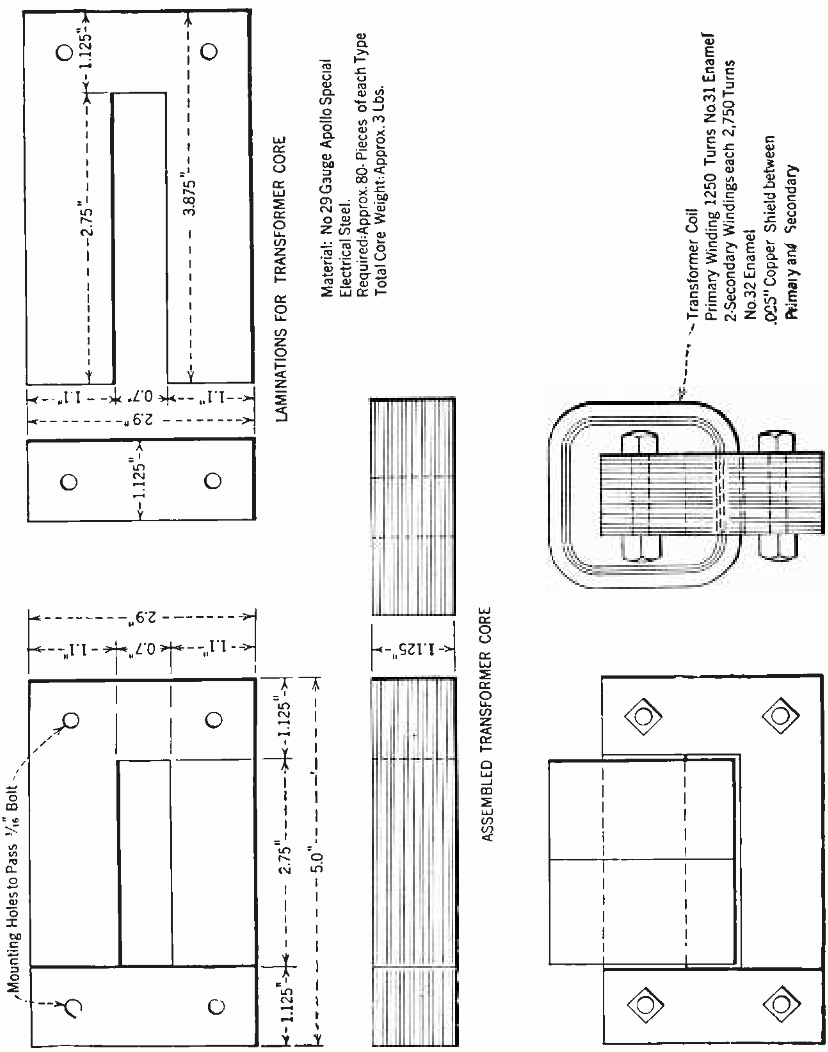

Fig. 18—This illustrates the important features in the design of the transformer and shows the dimensions, also specifies details in regard to the material to be used in its construction.

other paths. The amplifier voltage is controlled by means of the switch shown in Fig. 15. The blade of this single pole, double

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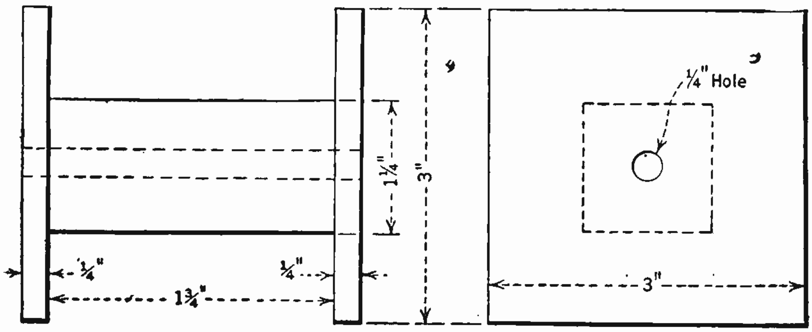
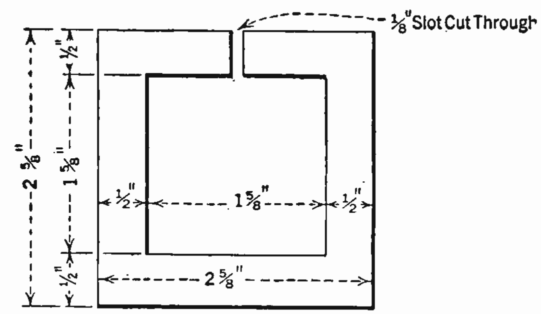
throw switch is connected to one side of the 110 volts A. C. line; one lug goes to the 1000th turn tap on the primary, the other lug goes to the full primary terminal at 1250 turns. When the switch is thrown to the 1000-turn tap, the output voltage will be from 30 to 50 volts higher than on the 1250 tap, depending upon the connected load.



WINDING FORM FOR TRANSFORMER COILS



WINDING SEPARATOR FOR SECONDARY WINDINGS-⅛" FIBRE

Fig. 19—Illustrates the construction of the winding forms for the transformer coils.

The Raytheon rectifier tube will ordinarily run at a temperature in the neighborhood of 200 degrees F. In case the cup becomes red hot, there is evidence that the circuit is being overloaded. Although no permanent damage will be done, it is not advisable to continue this load for more than a few minutes. Continued overloading will soon saturate the cores of the choke coils and render them useless as filter chokes.

In order to prevent the transmission of power line noises

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through the eliminator circuit, a copper shield has been placed between the primary and secondary windings, and thoroughly insulated therefrom. This consists of a strip of .005-inch copper carefully wrapped over the Empire cloth insulation, and extending to within ¼ inch of the entire surface of the primary winding. A flexible lead is soldered to the shield, brought out from the winding, and later connected to the ground terminal of the eliminator. All cores of the instrument should be connected together and to the ground terminal. The home-made unit should be placed in an iron or steel case which completely encloses it.

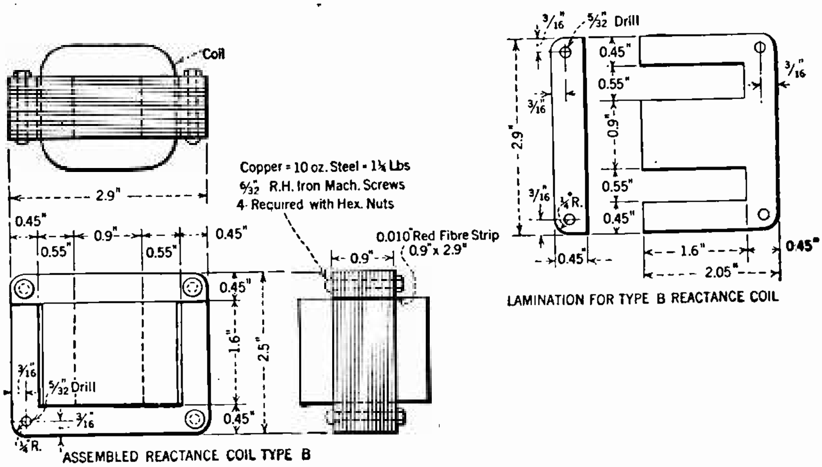

Fig. 20—This illustrates the constructive features for the choke coil.

In the case of the factory units, each part has been placed in an iron magnetic shield, and this is connected to ground to prevent induction of hum in the receiver. Another means for preventing the transmission of line noises through the eliminator is the use of the buffer condensers, shown shunted across the mid-tap and outer leads of the secondary of the transformer, Fig. 17. These each have a capacity of 0.1 mfd. and serve the purpose of balancing the admittance of each secondary to the neutral or ground side of the line. In this way an easy path to ground is provided for any disturbing unbalance that might arise in any part of the circuit. The inclusion of these condensers is an important feature, and one that will more than repay their cost.

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SPECIFICATIONS FOR THE DESIGN OF "B" BATTERY SUBSTITUTE

I. Transformer

1. Power loss should not exceed 10 watts.
2. Should operate on 25 to 75 cycles A. C.
3. Secondary voltage should not exceed 300 volts for safety.
4. Should be shielded in magnetic shield.
5. Should have electrostatic shield between primary and secondary windings to prevent transmission of line noises to radio receiver. Secondary winding should be balanced for inductance and capacity.

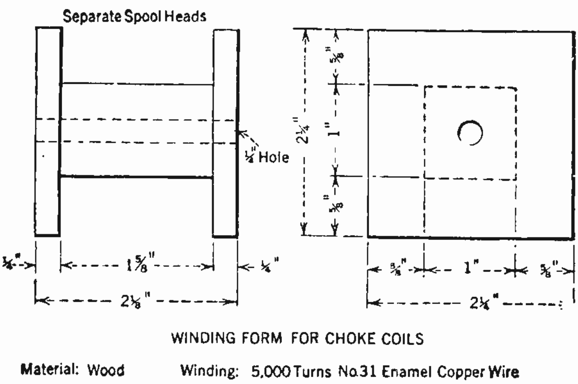

Fig. 21—Illustrates the construction of the winding forms for the choke coils.

II. Rectifiers

1. Should have life of at least 5000 hours.
2. Should deliver sufficient current at all times.
3. Should have low impedance, preferably rising characteristic. (See Fig. 13.)
4. Should rectify completely with no reverse current, and with quiet performance at all times.
5. Should rectify both waves of cycle.
6. Should have low starting voltage—i. e., not greater than 160 volts.

III. Filter Circuit

1. Should filter perfectly, leaving no hum in head-phone or loud-speaker.
2. D. C. resistance should not exceed 750 ohms.
3. Should consist of two or more sections.

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IV. Miscellaneous

1. Should give complete control of amplifier and detector voltages.
2. Should be small and light in weight.
3. Should be capable of being installed in receivers without producing interference.
4. Cost of construction and maintenance should be low.

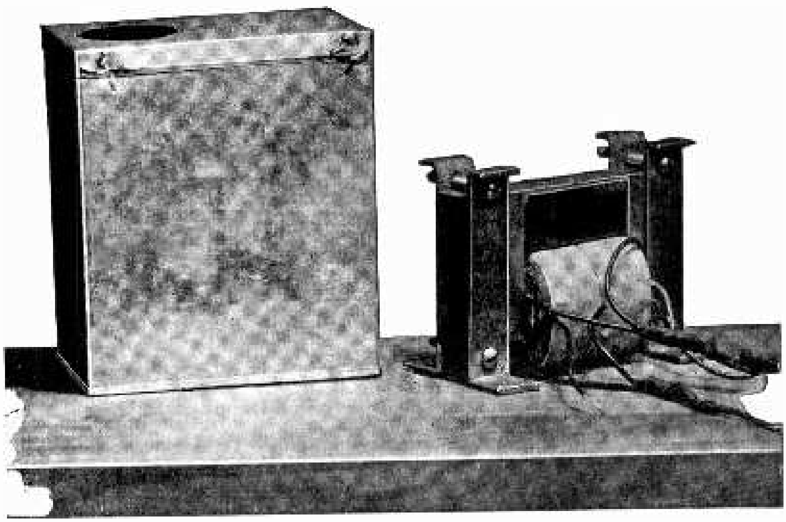

Fig. 22—This shows the made-up transformer with the metal can for shielding.

POWER AMPLIFIERS AND POWER UNITS

We have just given a detailed description of the construction and operation of a "B" battery eliminator and now we will present for the student's consideration some power amplifiers and power supply units.

The power amplifier consists of two main divisions: first, the power supply which furnishes high voltage plate current, as well as low voltage filament current; and second, the audio-frequency amplifier which steps up the incoming signal voltage to a point where it will operate the power tube.

In turn, each of the two main divisions may be further subdivided. By looking at a power amplifier as being made up of many simple parts, all problems are greatly simplified.

The power supply consists of portions furnishing the high voltages for the amplifier tube, plate circuits and of portions furnishing the filament current to amplifier tubes. The high

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voltage supply includes: first, a transformer for increasing the voltage received from the house lighting circuit; second, a rectifier which changes the alternating current into a pulsating direct current; third, a filter system which smooths out the

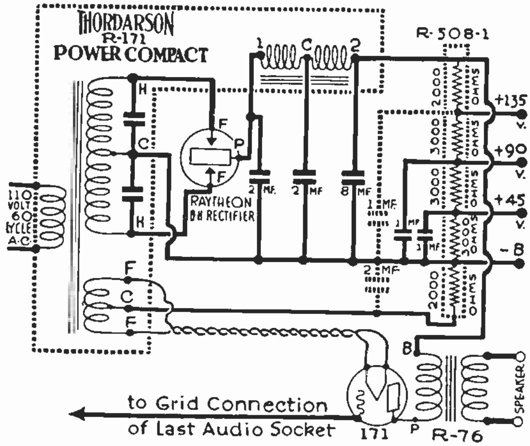

Fig. 23—Circuit of power amplifier using 171 tube and Raytheon rectifier.

variations or ripples in the direct current; and fourth, a voltage divider which divides the output between the various plate circuits and, in some cases, between the grid biasing circuits.

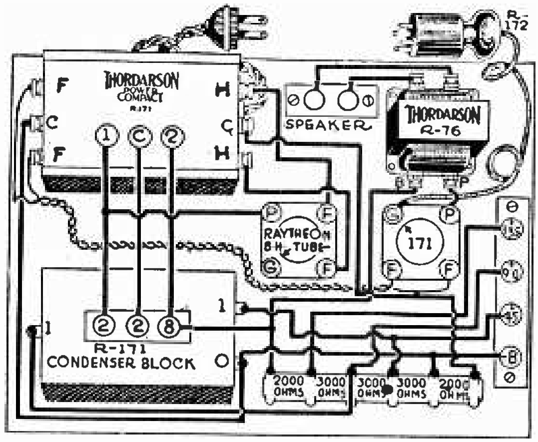

Fig. 23A—Showing apparatus mounted on baseboard.

NOTE: (Terminals marked H & H of power pack should be connected to filament terminals of the 171 tube socket and H & H terminals to the filament terminals of BH tube socket.)

Figure 23 shows a popular power amplifier and B supply unit using a Raytheon rectifying tube. Such an amplifier is very simple to assemble. This unit contains a power supply transformer, filter choke system, 171 tube filament supply, and two

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0.1 mfd. buffer condensers placed across the high voltage winding, all assembled in one case as shown in Fig. 23A. It is designed for 110 volts 60 cycles alternating current.

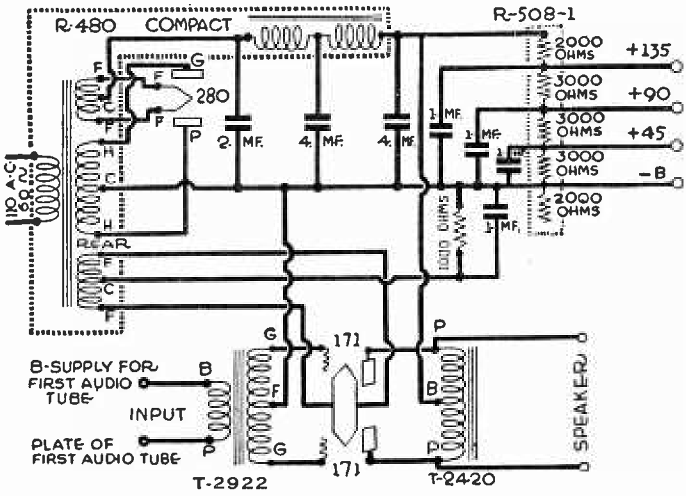

Fig. 24—Push-pull amplifier using 280 tube for rectifier.

Figure 24 shows a power amplifier using two 171 tubes as a push-pull amplifier, with a 280 full-wave rectifying tube. This

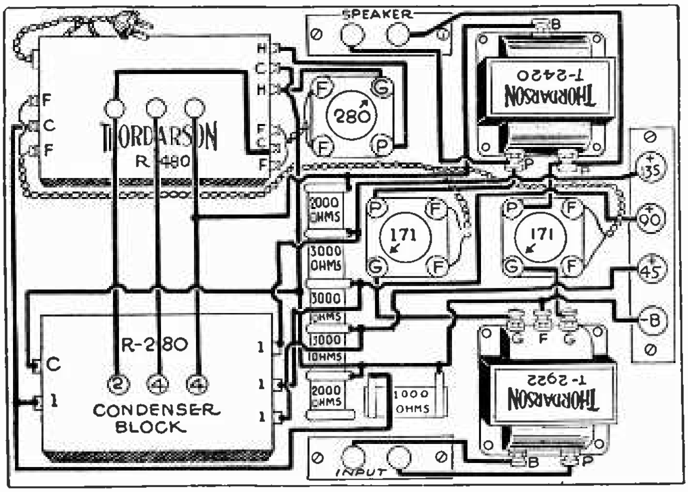

Fig. 24A—Push-pull amplifier and power unit apparatus mounted on baseboard.

unit supplies 5 volts center tapped for the filament of the 280 rectifier tube, 5 volts center tapped for the filaments of the 171 tubes, and high voltage center tapped, for the plates of the

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rectifier tube. The high voltage current, when rectified, and passed through the filter system, which consist of the two 30-henry chokes and the necessary filter condensers, is delivered to

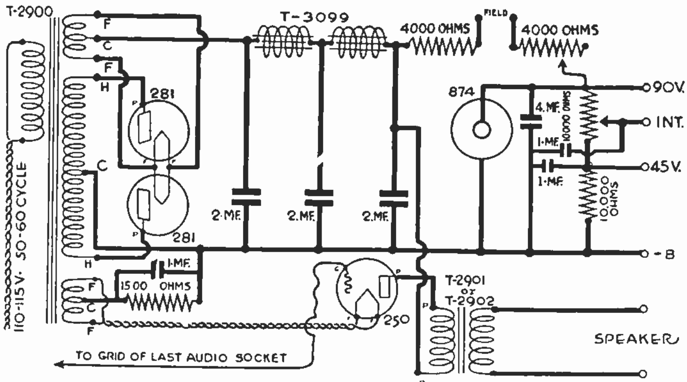

Fig. 25—Circuit of power amplifier using 250 tube, two 281 rectifying tubes for full-wave rectification and regulating tube 874.

the plates of the 171 tubes and the voltage divider as pure direct current.

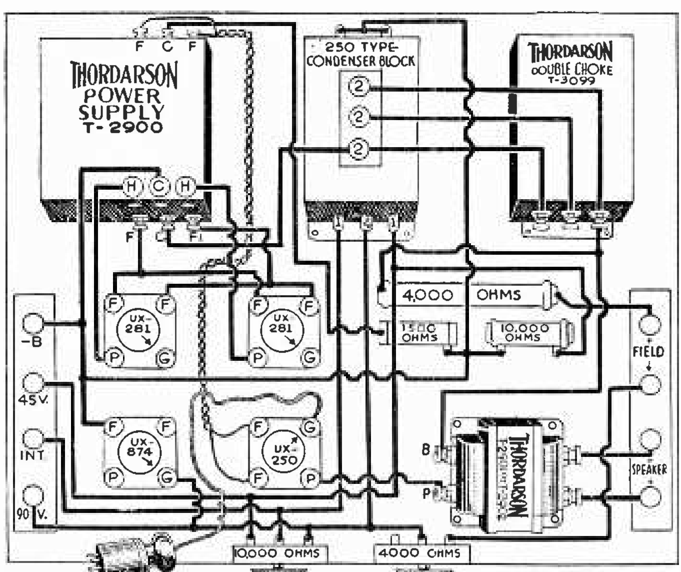

Fig. 25A—Arrangement of apparatus on baseboard for 250 amplifier and power unit.

Where a dynamic speaker is to be employed, the 171 push-pull arrangement is to be preferred since the undistorted power output of a single 171 is hardly adequate for the satisfactory operation of dynamic speakers.

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The one stage power amplifier and B supply unit shown in Figure 25 incorporates the 250-type power amplifier tube and is designed for last stage audio amplification in receivers for home or demonstration use, and may be used with either dynamic or ordinary high impedance speakers.

In order to supply the field of the dynamic speaker, the voltage divider circuit is opened between the two 4,000 ohm resistance units. The field winding is placed in series with the output and by adjusting the 4,000 ohm variable unit, 100 volts is allowed to act upon this winding. From 40 to 60 milliamperes of current is put through the field. When high impedance speakers which employ no externally operated field circuits are used, the dynamic field binding posts should be connected together.

TEST QUESTIONS

Number your answers 28 and add your **Student Number.**

No. 1. Describe the thermo-couple rectifier for changing A. C. to D. C.

No. 2. Illustrate by a drawing the transformations (showing steps) to change 110 A. C. to steady D. C.

No. 3. Make a wiring diagram for a "B" battery eliminator for a five-tube set using four lead-aluminum rectifier jars with filter (mark values for filter parts).

No. 4. Name a few types of tubes which are well adapted for use in a rectifier.

No. 5. Give a wiring diagram for a "B" battery eliminator using two tubes with full-wave rectification.

No. 6. What is the output current and D. C. voltage of the Raytheon (B type) rectifier?

No. 7. Make a circuit diagram of "B" eliminator using Raytheon rectifier tube.

No. 8. Give the approximate length and dimensions of the cross-sectional area of the iron core, also size wire and number of turns in both primary and secondary windings for the rectifier transformer.

No. 9. How would you construct a 20-henries choke coil for the rectifier?

No. 10. What method is used in building the rectifier transformer to prevent noises from the power line?

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