The eliminator replaces bothersome batteries.

A-Battery Eliminator

By RYLAND HOBSON

RADIO servicemen realize the advantages a battery eliminator has over the battery. At their best, storage batteries require a lot of attention, are usually messy, and must be kept charged. The eliminator described in this article can be built for less than the cost of a good storage battery, and because of variable output voltages, has many more applications.

Because most builders prefer to follow their own design in respect to appearance, and because the constructional details can be clearly seen in the photographs, no plans are given for chassis, panel, or cabinet. The information in the schematic diagram will be enough for the experienced builder; nor, with the help of this article, will the less experienced builder have any difficulty in building this highly efficient battery eliminator.

Special attention is given to winding the power transformer. As is the case wherever a transformer is used, a certain amount of mathematics is involved. The simple formulas used here are sufficiently accurate for all practical purposes.

The laminations used for the transformer and choke were taken from old burned-out radio power transformers. The area of cross section (A in Fig. 1) is 3.375 square inches for the transformer and 3.28 (3¼ approximately) square inches for the choke. Laminations from two identical transformers were used for the power transformer and were stacked until the calculated area of cross section was obtained. (It is advisable to draw the transformer to full size and check the window space for the winding.)

The first step in designing the transformer was to calculate the power required from the secondary winding. The current for the secondary was set at a little more than was actually needed, and as there is a voltage drop across the dry-disc rectifier and choke, this, too, had to be taken into consideration. The maximum secondary voltage was therefore set at 16 volts and 10 amperes. Wattage was therefore 160.

To determine the primary wattage, the formula, "primary wattage = total secondary wattage / efficiency expressed as a decimal," was used. The efficiency was assumed to be 90%, which, expressed as a decimal, becomes 0.9. When the known values are substituted, the formula becomes "primary wattage = 160/0.9=178 watts."

With the primary and secondary wattage known, the next step was to calculate the turns per volt for the primary winding. As the transformer used is of the shell type (see drawing) and is to be operated from 60-cycle a.c., the formula, "turns per volt = $32/\sqrt{\text{Primary Wattage}}$," was used. (If the transformer is to be of the core type and the unit is to be operated from 60 cycle a.c., the formula, "turns per volt $42/\sqrt{\text{Primary Wattage}}$," should be used.)

By substituting the known values in the formula, it becomes, "Turns per volt = $32/\sqrt{178} = \frac{32}{13.34} = 2.4$ turns per volt" for the primary. "Turns per volt" means that for each volt impressed across the primary winding, there must be 2.4 turns of wire.

The size of the core in square inches was determined by the formula, "area of cross section = voltage per turn × 7.5." "Voltage per turn," as used in the formula, is merely equal to 1 divided

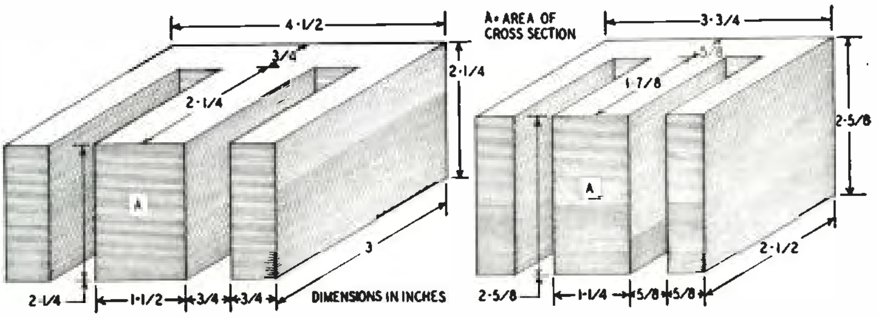
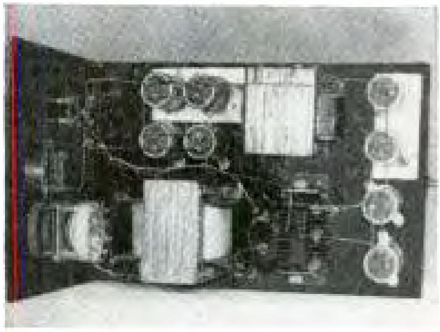


Fig 1—Transformer laminations are interleaved from opposite ends, not stacked up as shown (see any transformer). Choke laminations are all inserted from one end, with a gap between them and the straight end pieces. A piece of fiber inserted in the gap keeps it constant.



Chassis-top view shows how parts are mounted.

by the "turns per volt." Since the turns per volt, as already calculated, is 2.4, the volts per turn is equal to $1/2.4=0.42$ approximately. Due to the core losses, etc., the figure 0.42 can be rounded out to a little more than actually calculated. We made it 0.45 for convenience. Area of cross section is then $0.45\times7.5=3.375$ square inches.

To determine the wire size needed for the primary winding, the formula, "current × watts / volts," was used. Since the primary wattage was found to be 178 and is to be connected to a 115-volt (maximum) lighting circuit, the approximate current will be $178/115=1.5$ amperes. A conductor cross section of 1,000 circular mils for each ampere of current flowing through the primary winding was chosen. 1,000 circular mils per ampere$=1.5\times1,000=1,500$ circular mils. A wire table showed that No. 18 (A.W.G.) enameled wire has a conductor cross section of about 1,600 circular mils, and it was chosen for the primary winding. The primary has 6 layers of wire, 46 turns per layer or a total of 276 turns—approximately 245 feet of wire (see Fig. 2). Insulating paper .008 inch thick was used between all layers of wire.

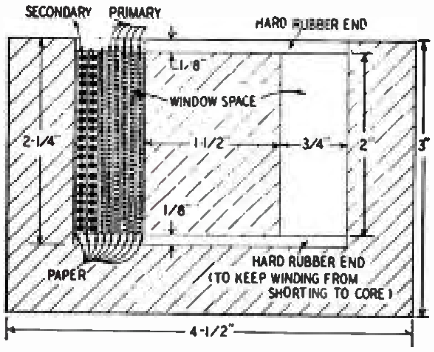


Fig. 2—The transformer core drawn to scale.

As the line voltage in this area is not always 110, the primary was tapped for 100, (low) 110 (medium), and 115 (high) volts. For the 100-volt tap, 240 turns of wire were used ($100\times2.4=240$); for the 110 volt tap, 24 turns were added to the first tap ($110\times2.4=264$); and for the last tap (end of winding), 12 turns were added to the second tap ($115\times2.4=276$). Different positions on the primary switch will vary the d.c. output in small steps. The eliminator has been operated for over an hour with the primary switch in the LOW position and with a line voltage of 115 volts, without the transformer getting hot.

The number of turns for the secondary winding per volt output was calculated a little high, to allow for resistance drop and possible losses. Thus, we used 2.5 turns per volt. For every turn per volt on the primary, there is 0.1 more on the secondary ($2.5-2.4=0.1$).

No. 12 enameled wire was used to wind the secondary. At 1,000 circular mils per ampere, No. 12 will carry safely 6 amperes or a little more. (Only 700 circular mils per ampere is used by a number of manufacturers of radio receiver power transformers.) For the first secondary tap, 15 turns of wire were used ($2.5\times6=15$). For the second tap, 5 turns were added to the first tap ($2.5\times8=20$). Another 5 turns were added for the third tap ($2.5\times10=25$); 5 turns were added for the fourth tap ($2.5\times12=30$), the fifth tap ($2.5\times14=35$), and the sixth and last tap ($2.5\times16=40$). The last tap is not used until the rectifier ages and its efficiency decreases. The maximum no-load a.c. voltage should not exceed 14.4 volts for the rectifier specified. The secondary has two layers of wire, a total of 40 turns and approximately 30 feet of wire. If the window space of the transformer and choke will permit, a larger size wire can well be used.

The finished home-made transformer and choke.

No formulas were used in designing the choke. Various charts, technical books, and so on were consulted, and the choke was wound on a trial basis.

Laminations from two similar transformers were also used in the choke and stacked until the desired area of cross section was obtained. (If the builder will use the same area of cross section as stated here, good results can be expected.) Unlike transformers, the laminations of the choke should not be interleaved, but should be butted. As the choke is to carry mostly d.c., it should have an air gap in its core to prevent magnetic saturation of the core by the heavy d.c. The effective air gap will be that of the sum of individual air gaps. The air gap was kept constant by a piece of insulating paper .008 inch thick, and can be adjusted if need be.

Approximately 33 feet of No. 12 enameled wire was used to wind the choke. The choke has four layers of wire, 16 turns per layer, a total of 64 turns. Insulating paper .008 inch thick was used between each layer of wire.

As shown in Fig. 3, a capacitance-input filter was used, but a choke input filter gives good results. If a choke-input filter is chosen, a capacitor of not less than 4,000 μf should be used.

Eight 1,600-μf, 12-d.c.-working-volt electrolytics were used in a series-parallel circuit so as to give a total of 1,600 μf at 24 working volts each side of the choke.

With the eliminator connected to a pure resistive load drawing 6 amperes at 6 volts, there is no measurable a.c. in the output (measured with a v.t.v.m. on the 3-volt a.c. scale, and with a 'scope turned to full gain, .06 volt root-mean-square per inch). With the above load connected to the output terminals, there is a measured d.c. drop across the choke of ½ volt (measured with a v.t.v.m. on the 3-volt d.c. scale).

As shown in the diagram, an ammeter is used in the output to indicate current drain. The ammeter was chosen instead of a voltmeter because an external ammeter is the most troublesome meter to connect and because most radiomen do not have an ammeter in their volt-ohm-milliammeters. An ammeter will, at times, indicate a defective vibrator, and is capable of standing heavy overloads.

From the secondary winding to the output terminals, the eliminator is wired with No. 12 enameled wire. The line cord is conventional, and is brought up through the chassis, directly under the primary switch.

There are a number of dry-disc rectifiers on the market from which to choose, but this eliminator was built for a Mallory 1S16CB7J. Most dry-disc rectifiers will stand severe intermittent overloads, but should not be overloaded for constant duty.

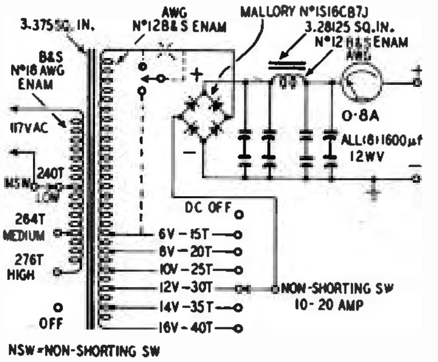


Fig. 3—Complete schematic of the eliminator.

Two automobile radios (6 tubes each) have simultaneously been connected to the eliminator, drawing 10 amperes at 5½ volts, and both radios operated in a normal manner.

The d.c. voltage from the eliminator will vary with load. The secondary switch is calibrated with a load drawing 5½ amperes at 6 volts, starting at the 8-volt position, working backwards, which gives the approximate voltages as shown in Fig. 3.

Whatever type cabinet is chosen for the eliminator, plenty of ventilation should be allowed.