Continued from page 2

be detected with the D. C. voltmeter-peak voltmeter combination. Hence the determination of the rating of this condenser may be made by a D. C. test. The steady voltage across "C2" is smaller than that across "C1" by an amount equal to the voltage drop in "L1". Similarly, the steady voltage across "C3" is smaller than that across "C2" by an equal amount.

The question now arises: "In view of the poor regulation of battery eliminators, shall we rate our filter condensers for no-load voltage, or for voltage under load, and what shall we consider as an average load?" The no-load voltage of an eliminator may be twice the working voltage; and if it were necessary to provide condensers to withstand this no-load voltage, the price of an eliminator would be prohibitive. The condensers must be rated, therefore, for the less severe working conditions. With such a rating, however, the user must be careful to turn on the set before he turns on the eliminator and to turn off the eliminator before he turns off the set. In order to assure an adequate factor of safety, the working condition should be regarded as that state in which the minimum load is drawn from the load (and the highest WORKING voltage impressed upon the condensers). This load may run from 30 to 80 mils depending on the type of amplifier and number of tubes used.

If a filter is designed with this assumption, the condensers will be perfectly adequate under working conditions. But if the load is removed from the eliminator in one way or another, the voltage will rise to dangerous values, and the filter condensers will be subject to stresses they were never intended to withstand. While the condensers may stand this abuse for some time, the strain will inevitably tell in shortened life and possible puncture.

In the design of receivers where the power unit is incorporated as part of the receiver, it is a simple matter to so design the circuit that the current is turned off from both receiver and power unit at the same time, thus reducing any possible chance of damage to the condensers from no-load high voltages.

In those cases where the power unit is designed as a separate entity to be connected externally to the receiver as is the case with most "B" eliminators designed for use with existing receivers, the user should be strongly cautioned to follow the procedure of turning on the set before the eliminator and then reverse the process by turning off the eliminator before turning off the set. A practical solution of course is to install an automatic relay control which performs that function automatically.

In either case the user should be cautioned never to take any tubes from the receiver without first turning off the power.

The condensers selected for use in power units should be selected carefully to withstand safely the maximum working voltages which obtain in operation as explained above and not merely the nominal D. C. working voltages measured with a D. C. voltmeter.

Continued from page 3

the power unit. Condenser "C1" is a 2 mfd. section conservatively rated for a working voltage of 800 volts D. C. Condensers "C2" and "C3" are 4 mfd. sections rated at 600 volts D. C. working voltage.

An Aerovox Type C, tapped Pyrohm resistor is used as the voltage divider. Jacks "J1" and "J2" are provided to permit the use of a milliammeter to check up the current drawn by the unit.

It is recommended that this unit be constructed in two sections, the amplifier being built in one section and the power unit in another, so as to prevent any interaction.

Aerovox Wireless Corp.,
70 Washington Street,
Brooklyn, N. Y.

I am interested in building the "Ideal Amplifier and Power Supply Unit to Bring the Old Phonograph Up to Date" and would like to have you send me full details if you decide to publish complete constructional information.

Name ....

Address ... .

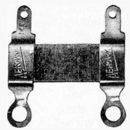
City .... State ....

Demands of New Circuits Met by Aerovox Resistors

The following items of the Aerovox line of fixed resistors are filling a real need in the new circuits. Complete details regarding electrical and mechanical characteristics, stock sizes and prices are contained in the new Aerovox catalog which may be had free on request.

Type 1098

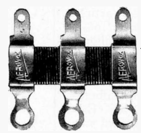
The Type 1098 Lavite non-inductive resistors are proving very popular for use in heavy duty resistance coupled audio amplifiers, television amplifiers, grid bias resistors and filter resistors in grid circuits. They are available in values of from 2,000 to 500,000 ohms.



Type 980

Type 980 wire wound resistors are ideal for use as grid suppressors or for any other purpose where a wire wound resistor for comparatively light duty is required. They are available in values of from 100 to 2,000 ohms.

The Type 985 wire wound resistance units are similiar in every re-



Type 985

spect to the Type 980 units but are furnished in values of from 10 to 100 ohms, accurately center-tapped for use in A. C. filament circuits or for any other purpose where center-tapped resistors are required.

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The AEROVOX Research Worker

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Vol. 1 June 25, 1928 No. 6

Notes on the Design of Filters

PART 1

By the Engineering Department, Aerovox Wireless Corp.

THIS paper was prompted by the lack of quantitative data on the design of filters for "A" and "B" eliminators. While a moderate engineering literature is available on the subject, it is of little help in assisting the engineer to design the most effective economically practicable filter, or to choose filter condensers with an adequate safety factor. With this need in mind, an investigation was made into the effectiveness and operating characteristics of the component condensers of various "A" and "B" eliminators.

The data for this paper was obtained by means of the vacuum tube instruments described in previous issues of the "Research Worker." A peak voltmeter was used to determine the operating characteristics of the various condensers, and a ripple voltmeter to determine the efficiency of various filter combinations.

The first condenser of the typical three - condenser - two - choke filter

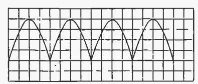

Fig. 2A

("C1" of Fig. 1) plays very little part in reducing the hum of the rectifier that feeds into it. Its function is to control the available output voltage and the regulation of the eliminator. "Regulation" is a term used to signify the degree of constancy of the output voltage of an electrical device under varying loads. The regulation of battery eliminators, as compared to that of other electrical devices, is poor. In fact, it is not at all unusual for the voltage of an eliminator at full load to be only half of that at no load.

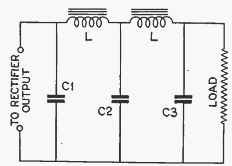

Fig. 1

The poor regulation of battery eliminators is due to the internal resistance of the rectifier, the resistance of the choke coils, and last, but most important, the first condenser of the filter. As we shall show below, an eliminator without any first condenser has the best regulation of any eliminator. But since this results in a very low output voltage, a condenser is almost universally used at "C1", in spite of the poor regulation that it entails.

The ability of "C1" to control the available output voltage is due to the fact that the condenser is charged by a source whose resistance is much lower than that of the load into which the condenser discharges. Since the rates of charge and discharge are functions of the charging and discharging resistances, the condenser is charged up faster than it is discharged, and hence always has some voltage available for the load. In this regard it acts in much the same way as the air chamber in a force pump.

This state of affairs is shown diagrammatically in Fig. 2A. This graph shows the output of a full wave rectifier, a rectified sine wave (assuming the rectifier to introduce no distortion.) If no condenser were connected across this output, the voltage across the load would have exactly the same waveform, since the load is non-inductive. If, now, a condenser is connected across the output of the rectifier, it will charge up in phase with the rectifier voltage until it has attained a charge equal to the maximum rectifier voltage. The rectifier voltage then decreases sinusoidally. The condenser voltage

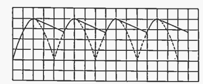

Fig. 2B

however, decreases at an entirely different rate, determined solely by its capacity and the magnitude of the load resistance. This rate is expressed by the formula shown in Fig. 3.

The condenser voltage falls at this rate until it meets the increasing rectifier voltage, by which it is charged up again to its maximum value. The cycle then repeats itself, as shown by Fig. 2B.

$$E = E_0 \epsilon^{-\frac{t}{RC}}$$

E = INSTANTANEOUS VOLTAGE.
E_0 = MAXIMUM VOLTAGE.
ϵ = BASE OF NAPERIAN LOGARITHMS = 2.71828
t = TIME (DISCHARGE PERIOD).
R = LOAD RESISTANCE.
C = CAPACITY OF FILTER CONDENSER.

Fig. 3

It is obvious that the way to obtain the maximum available voltage is to make the rate of decay of the condenser voltage so slow that it will not have fallen very far before it is again restored by the rectifier voltage. The formula in Fig. 3 tells us that the way to make the discharge period long is to employ a condenser of high capacity, or to have a high load resistance (that is, to draw a small load current), or both. The load resistance, however, is fixed by the radio set, and is usually low so that we are limited to the use of a high capacity condenser in our efforts to increase the available output voltage. The formula tells us that the rate of decay of the condenser voltage is a logarithmic function of its capacity. That is, the voltage falls rapidly at first, and then more slowly. In order to make the voltage fall relatively slow at first, so large a capacity is required as to be economically unfeasible. With small values of capacity, the available voltage is raised less and less for equal increments of capacity, until a point of diminishing returns is soon reached, where the cost of the additional capacity is not met by the slight rise in voltage gained thereby. This "compromise" capacity is in the neighborhood of two or three microfarads under average conditions.

Curves showing the actual available voltage for various values of capacity at "C1", and for various load currents are shown in Fig. 4. It is seen that the increase in voltage due to changing "C1" from 0 to 1 microfarad is greater than the increase from changing "C1" from 1 to 2 microfarads. It is also seen how much more the voltage is raised by a given capacity for a small load than for a large load. It will be noticed that the curve for "C1"=O has the best regulation. This is due to the fact that in this case the lower limit of the rectifier voltage is constant at all loads; whereas when "C1" is finite, the lower limit of the rectifier voltage varies with the load, as explained above. Since the output voltage is approximately the mean of the upper and lower limits of the rectifier voltage, it is readily seen that the output voltage in the first case will have a much better regulation than in the second case.

While on the subject of regulation, the part that the choke coils play in it will be shown. The ohmic resistance of the choke coils introduces an unavoidable drop in voltage in the output of the rectifier. For chokes of moderate resistance—100 to 200 ohms—this drop is not objectionable; but when the resistance is higher than this, the regulation is made even worse than before.

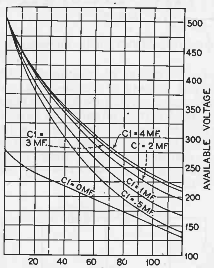

Fig. 4

Poor regulation is the most serious fault of an eliminator, and it should not be aggravated by the use of high resistance chokes. The loss in voltage due to the resistance of the filter chokes is shown graphically in Fig. 5.

If the readings of a D. C. voltmeter were used to determine the working voltage of "C1", the resultant filter would soon come to an untimely end. For, as we have shown above, the voltage across "C1" varies from a maximum equal to the crest value of the charging voltage to a minimum determined by the capacity of "C1" and the magnitude of the load resistance. Now the D. C. voltmeter will give a reading which is approximately the mean of these two quantities. The stress on a condenser, however, is proportional to the crest value of the voltage across it; and it must be rated to withstand this maximum value rather than the D. C. component thereof. Hence the proper instrument to use in determining the working voltage of "C1" is not a D. C. voltmeter, but a peak voltmeter. Some of the interesting results obtained by the use of this instrument are shown in the curves of Fig. 6. Curve "B" of this figure shows the peak voltage across "C1", while curve "C" shows the D. C. component of the voltage across the same condenser at the same time. The difference in magnitude is striking, and the fallacy of determining the working voltage of "C1" by a D. C. test only is readily apparent.

It will be seen that the peak voltage is not constant, but decreases slowly with the increased load. This is due to two causes: voltage drop due to the internal resistance of the rectifier, and regulation of the transformer. Curve "A" shows the drop in peak voltage, measured at the output of the rectifier, due to these two causes. If the rectifier had no internal resistance, and the transformer had perfect regulation, the peak voltage would be constant at all loads, and equal in value to the peak voltage of the transformer secondary.

The jagged waveform of the rectifier is strongly attenuated by the combined action of condenser "C1" and choke "L1" so that the voltage across "C2" has but a small ripple in it. A peak voltmeter shows that the maximum voltage across "C2" is only a few volts higher than the steady voltage. The difference is so small that the working voltage of "C2" may safely be determined by a D. C. test only, provided we add

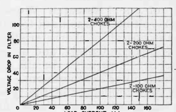

Fig. 5

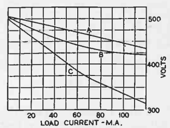

Fig. 6

10% to this reading to allow for ripple. The ripple at the terminals of "C3" is so small that it cannot

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An Ideal Amplifier and Power Supply Unit

to Bring the Old Phonograph Up to Date

TIME was when the tone quality of a radio receiver suffered by comparison with that of the phonograph. Today intensive research carried on by manufacturers of audio amplifying equipment has so improved the reproduction of audio amplifiers that phonograph manufacturers have adopted electrical reproducing equipment on the highest quality phonographs.

With the audio equipment now available, it is a simple matter to transform the most ancient phonograph into an instrument that will perform as well as the most expensive phonograph.

All that is necessary is to replace the ordinary soundbox or reproducer of the phonograph with a magnetic pickup, install a high quality audio amplifier and press the radio loudspeaker into service.

A wiring diagram of an efficient amplifier and power unit for the purpose is shown with this article. It consists of a standard phonograph pickup "P" such as the Pacent Phonovox, Bosch, Victor, Stromberg-Carlson or Erla units coupled to a high grade AmerTran-Aerovox amplifier and power unit.

The usual volume control supplied with these units should be discarded and a Centralab HP-010, 10,000 ohm potentiometer "R1" should be used in its place, as the resistance of this type of unit is better suited to the impedance characteristics of the pickups and audio transformer with which it is to be used.

A special input transformer "T1", an AmerTran Type 410 should be used for the input to the phonograph unit because the ordinary type of transformer is not suited as a coupling means between a phonograph pickup and an audio amplifier. A C-327 heater type of tube is used in the first audio stage while two CX-310 power tubes connected in push-pull are used for the second stage. The output of the amplifier is fed to the speaker by means of output transformer "T3".

Resistors "R2", "R3" and "R4" are Aerovox Type 1098, 50,000 ohm Lavites and are used as filter resistors to prevent any disturbance or hum from affecting the grids of the amplifier stages.

The Aerovox Type 250, 1 mfd. bypass condensers "C4" and "C5" are used to keep the signal impulses out of the power supply circuits.

The standard power supply unit employed consists of a half wave rectifier, using a CX-381 rectifier, an AmerTran Type PF-281 power transformer, "T4", an AmerTran heavy duty No. 709 choke, "CH1" and an AmerTran standard No. 854 choke "CH2".

An Aerovox AM-281 filter condenser block "CB" consisting of three filter condensers, "C1", "C2" and "C3" is used in

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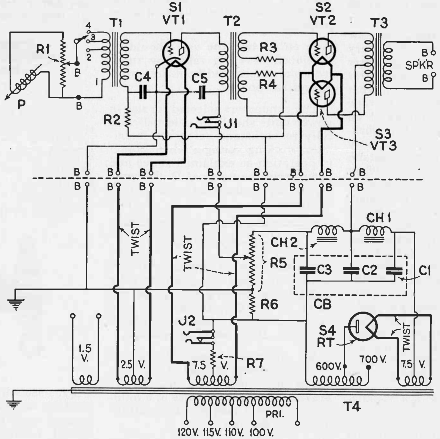

LIST OF PARTS

B: Eby binding posts
CB: Aerovox Type AM-281 condenser block.
C4, C5: Aerovox Type 250, 1 mfd. condensers.
CH1: AmerTran Type 709 choke.
CH2: AmerTran Type 854 choke.
J1, J2: Carter No. 2A, short jacks.
P: Standard Phonograph Pick-up Unit.
R1: Centralab, HP-010, 10,000-ohm potentiometer.
R2, R3, R4: Aerovox Type 1098, 50,000-ohm Lavite resistors.
R5: Aerovox Type C, tapped Pyrohm resistor.
R6: Aerovox Type 992, 500-ohm Pyrohm resistor
R7: Aerovox Type 992. 900-ohm Pyrohm resistor.
RT: Cunningham CX-381 rectifier tube.
S1: Benjamin No. 9036 "Y" socket.
S2, S3, S4: Benjamin No. 9040 sockets.
T1: AmerTran Type 410 transformer.
T2: AmerTran Type 151 transformer.
T3: AmerTran Type 152 transformer.
T4: AmerTran Type PF-281 power transformer.
VT1: Cunningham C-327 radio tube.
VT2, VT3: Cunningham CX-310 power tubes.