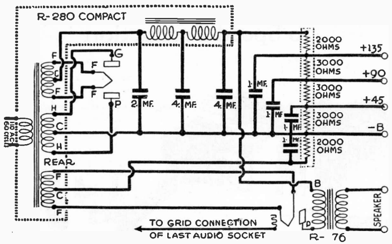
The New Thordarson 280-171 Power Amplifiers



List of Parts for R-280 Amplifier

1 Thordarson R-280 Power Compact.
1 Thordarson R-76 Speaker Coupling Transformer.
1 Thordarson R-172 Power Input Plug.
1 Aerovox R-280 Filter Condenser Block.
1 Aerovox Type 996-171 Tapped Pyrohm Resistor.
2 Eby four-prong sockets.
6 Eby binding posts.
1 Piece Westinghouse - Micarta panel, 1" x 5" x 3/16".
1 Piece Westinghouse - Micarta panel, 1" x 3" x 3/16".
1 Wood baseboard, 1" x 8" x 13".
1 Cunningham CX-371A power tube.
1 Cunningham CX-380 full wave rectifier tube.

The new R-280 and R-480 Power Compacts just announced by Thordarson make available to the experimenter and professional set builder power units which can be used to advantage on comparatively low power amplifiers which utilize a single or push-pull stage using CX-371A tubes.

The R-280 is for use in amplifiers using a single CX-371A power tube in the last stage, while the R-480 is for use in amplifiers using two CX-371A tubes in push-pull for the last stage.

The new Aerovox R-280 Filter Condenser Block is designed especially for use with either the R-280 or R-480 Thordarson Compacts and the terminals are brought out of the block to match the corresponding terminals of the Power Compacts.

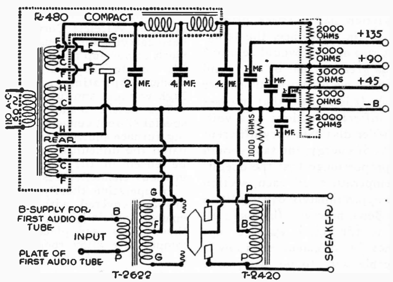
The Thordarson R-280 and R-480 Compacts are designed for use from 110-volt, 60-cycle A. C. lines. They supply 5 volts center-tapped for the filaments of the CX-380 full wave rectifier tube, and high voltage, center-tapped winding for the plates of the rectifier tube.

When a single CX-371A amplifier is used, the Aerovox Type 996-171 tapped Pyrohm should be used as a voltage divider to provide voltage taps of 45, 90 and 135 volts for use with the receiver in addition to the 180 volts for the CX-371 tube.

The 2,000-ohm section of this voltage divider also provides the proper grid bias resistor for the CX-371A tube. When two CX-371A tubes are used in push-pull in the last stage, an Aerovox Type 992, 1,000-ohm Pyrohm resistor should be used in place of the 2,000-ohm section of the voltage divider as shown in the diagram of the R-480 Compact. This lower resistance is necessary to match the increased plate current drain of the two CX-371A tubes.

Both amplifiers may be used with any cone or air-column speaker. When a dynamic speaker is to be employed, the push-pull arrangement is recommended.

Because of the limited output of the 380 type rectifier, there is no provision for supplying the field of a dynamic speaker in either type of amplifier. If a dynamic speaker is used, the speaker should be of the type which operates directly from alternating current.



List of Parts for R-480 Amplifier

1 Thordarson R-480 Power Compact
1 Thordarson T-2922 Push - Pull Input Transformer.
1 Thordarson T-2420 Push - Pull Output Choke.
1 Aerovox R-280 Filter Condenser Block.
1 Aerovox Type 996-171 Tapped Pyrohm Resistor.
1 Aerovox Type 992, 1,000-ohm Pyrohm Resistor.
3 Eby four-prong sockets
8 Eby binding posts.
2 Pieces Westinghouse - Micarta panels, 1" x 3" x 3-16".
1 Piece Westinghouse - Micarta panel, 1" x 5" x 3-16".
1 Wood Baseboard, 1" x 10" x 13".
2 Cunningham CX-371A power tubes.
1 Cunningham CX-380 full wave rectifier tube.

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The AEROVOX Research Worker

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Principles of Voltage Divider Design

PART 2

By the Engineering Department, Aerovox Wireless Corp.

IN the last issue of the Research Worker, the design and functioning of voltage dividers were considered, paying especial attention to the matter of voltage variation at the various taps. It was seen that the voltages at the various taps varied very considerably with different loads, even when high-current, low-resistance dividers were used. The use of the so-called regulator tube, a device which will hold the voltage of the 90-volt and lower-voltage taps absolutely constant within very wide limits of load at any or all these taps, will be discussed in this article.

A regulator tube is a gas-filled vessel containing a rod-like anode or positive terminal surrounded by a cylindrical cathode or negative terminal. Subjected to the necessary voltage, which is approximately 125 volts, the gas in the regulator tube becomes ionized or conducting, and offers a path to the current. The electrodes are so designed and placed in the gaseous atmosphere that regardless of the magnitude of the current flowing through the tube, the drop maintained between the anode and the cathode will be constant at 90 volts. However, if the current flowing through the tube is so small that the gas is no longer ionized, the tube begins to flicker, and may even go out.

One manufacturer has minimized this possibility by providing a third, or starting anode. This anode is a straight wire placed quite close to the inside wall of the cathode, and because of this proximity, is capable of maintaining a certain degree of ionization at all times, regardless of the impressed

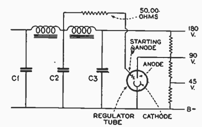


Fig. 5

voltage between the main anode and the cathode. The starting anode is connected usually to the mid-tap between the two chokes of the filter circuit through a 50,000 ohm resistor; in this way providing a voltage source free from that actually controlled. The main anode is connected to the 90 volt terminal, and the cathode to the B minus terminal, as shown in Fig 5.

Since the voltage across the tube remains constant at 90 volts, the tube acts as an automatic regulating resistance shunted across the circuit to be controlled. The tube, together with the voltage dividing resistances across it, and the load, provides a steady current drain on the filter circuit, although the respective currents in the regulator tube, the fixed resistances, and the load may vary. The regulator tube behaves as the compensating resistance, taking more or less of the total current according to whether the load decreases or increases.

The maximum capacity of the regulator tube is 50 milliamperes. It will provide regulation as long as a current of 5 to 10 milliamperes flows through it. Keeping these principles in mind, we can design a voltage divider to operate with a regulator tube. We will assume the same eliminator and load as were discussed in the first part of this article in last month's issue. Since we are going to obtain our regulation from a regulator tube, and not from the leakage current, we may make the leakage current quite small. We will set it at 5 mils. In order to afford as wide a current range as possible, we will allow 30 milliamperes to flow through the regulator tube at the calculated load. Then the load may vary by 20 to 25 mils either way without affecting the load voltage. Such a latitude is ample justification for the use of a regulator tube.

The load on the eliminator will be 69 mils, distributed as follows: 20 mils to the power tube, 12 mils to the amplifier tubes, 2 mils to the detector tube, 30 mils to the regulator tube, and 5 mils leakage current. Consulting the output curve of the eliminator, Fig 1 of Part I, we see that the voltage obtainable at this total load is 239 volts. The first part of the voltage divider will be a resistor to cut down this 239 volts to 180 volts. With 69 milliamperes flowing through it, its resistance will be 239 minus 180 and divided by .069 amperes equals 855 ohms. At the 180-volt tap, the current divides, 20 mils going to the external load, and 49 mils to the 90-volt tap through "R_2" (see Fig. 6). The resistance of "R_2" will have to cause a 90-volt drop of potential with 49 mils flowing through it. Hence its resistance will be 90 divided by .049 equals 1836 ohms. At the 90-volt tap the current divides again, 12 mils going to the external load, 30 mils to the regulator tube, and 7 mils to the 45-volt tap through "R_3". The resistance of "R_3" will be 45 divided by .007 equals 6430 ohms. At the 45-volt tap the current divides

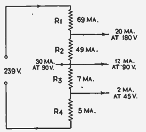


Fig. 6

finally, 2 mils going to the external load, and 5 mils being wasted in "R_4", whose resistance will be 45 divided by .005 equals 9000 ohms.

Now suppose that the 90-volt load was 17 mils instead of the 12 mils that we had assumed. If there had not been a regulator tube in the eliminator, the voltage at the 90-volt tap would have been 70.1 volts instead of 90; that at the 45-volt tap would be 34 volts instead of 45; and that at the 180-volt tap would be 171.6 volts instead of 180. These figures are taken from the data in Table 1, published in Part 1 of this article. But since a regulator tube is in the circuit, the voltages at all three taps will remain absolutely constant; the extra 5 mils being supplied by the regulator tube, whose characteristics are such that the voltage across its terminals remains constant regardless of the load.

Curves showing the action of the regulator tube under actual operating conditions are given in Figs. 7 to 9. Fig. 7-B shows the voltage at the 90-volt tap of the divider as the 90-volt load is varied from 0 to 50 mils and then back again. It is seen that perfect regulation is obtained up to 32 mil load; then the voltage falls slowly until the load is 44 mils. At this load, the tube is extinguished, and the regulating action of the tube ceases. The voltage falls very rapidly with a great-

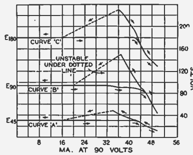


Fig. 7

er load until at 50 mils, the voltage is but 44 volts. As the load is decreased, the voltage increases rapidly. Regulation does not recommence at 90 volts, however, because a potential of 125 to 150 volts is necessary to break down and ionize the gas in the tube. The voltage immediately falls to 92 volts, and the current to 20 mils. The regulator tube has taken the energy represented by the difference between this current and voltage and that which obtained immediately before it broke down. It is evident that in the neighborhood of the breakdown voltage the tube is quite unstable, and should not be operated at this point.

Fig. 8 shows how the third, or starting electrode, prevents the extinguishing and subsequent breakdown of the regulator tube. The regulation curve for a tube with this third electrode is seen to be

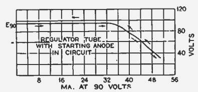


Fig. 8

smooth and gradual, with no kink at the breakdown point. To counterbalance this advantage, however, the over-all regulation of this type of tube is not as good as the other type. Since this type may be operated without using the third electrode, we may formulate the following working rule. The starting electrode in a regulator tube should not be used except when the drain on the tube is so great that it operates near its point of instability.

Fig. 7-A and Fig. 7-C show how the voltage at 45- and 180-volt taps vary when the 90-volt load is varied from 0 to 50 mils. The regulation at these taps is comparable to that at the 90-volt tap while the regulator tube is functioning. When the tube is extinguished, the voltage falls rapidly, and when the load is decreased, it rises above its nominal value until the tube breaks down again. The phenomenon is exactly the same as that at the 90-volt tap, except that the magnitude of the variations is different. The action for a varying 45-volt load is exactly the same as for a varying 90-volt load, and therefore the curves for this case are not presented.

Although the regulator tube cannot completely control the 180-volt tap, it improves the regulation of this tap very appreciably and prevents variations of load at this tap from affecting the 45- and 90-volt taps. This is shown graphically by Figs. 9-A and 9-C, which are

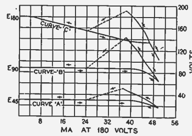


Fig. 9

plots for the regulation at the various taps for a varying 180-volt load.

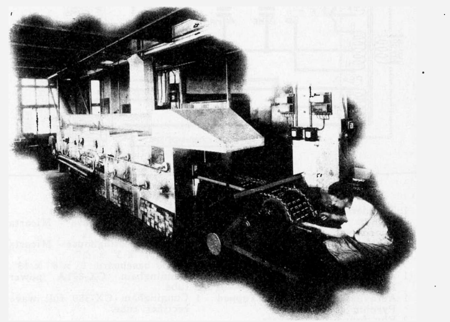
Besides the primary purpose of controlling voltage, the regulator tube also acts as a reservoir of electricity, performing much the same function as the last condenser in the filter.

So far in our discussion of voltage dividers, we have not said any thing about mechanical design. This is a very important point; just as important as correct electrical design. The size of the divider, and the location of the various taps are determined by the resistance of the taps, and the heat dissipated in each of them. The size (length and diameter) of the divider must be large enough to allow a practicable wire to be employed. For instance, while wire 1 mil (.001") thick may be used, giving a very compact divider, it is not commercially feasible to employ it. It is much more desirable to use wire 2 to 2.5 mils thick and wind it on a larger tube.

In the second place, the location of the taps is determined approximately by the amount of heat they have to dissipate, and not by the resistance. To take a concrete example, we will refer to the voltage divider designed in Part 1 of this article. It has a total resistance of 14,750 ohms, tapped as follows: 2750—3750—3750—4500 ohms. Offhand, one would say that the space allotted to each tap would be proportional to its resistance; that is, the 2750 ohm tap would get the smallest amount of space; the two 3750 ohm taps equal, and slightly larger spaces; and the 4500 ohm tap the most space. But before laying out the resistor in this manner, let us calculate the heat dissipated in each tap. Section "R_1" has to dissipate 5.25 watts; section "R_2" has to dissipate 2.16 watts; section "R_3" has to dissipate 0.54 watts; and section "R_4" has to dissipate 0.45 watts. Here is a case where the section of smallest resistance dissipates 10 times as much energy as the section of largest resistance. If each section had a space proportional to its resistance, the temperature rise of "R_1" would be 6 to 7 times as great as that of "R_4", and the former would burn out sooner or later. It is evident that in cases where different sections of a voltage divider dissipate very different amounts of energy, the taps should be so proportioned that the operating temperature of each section will be approximately equal. When this is done, however, the space allotted to the lower wattage taps may not be sufficient to allow a practicable wire to be used; take "R_4" for instance. In such a case, the most practicable balance between wire size, tube size, and operating temperature must be chosen. Of course, each section does not have to run at exactly the same temperature.

The designer of a divider should leave the mechanical specifications to the resistance manufacturer who is able to furnish a mechanical design which is conducive to low cost, long life, and low operating temperature.

New Automatic 42-Foot Conveyor Furnace Installed in Aerovox Plant to Speed Production

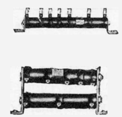


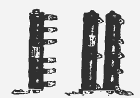
During the past three years, the Aerovox Wireless Corporation has been carrying on intensive research work to develop a vitreous enamelled resistor capable of meeting modern operating conditions at high voltages and heavy currents.

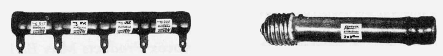
The recent installation of the special 42-foot conveyor system firing furnace shown above has eliminated the difficulties generally experienced in the manufacture of vitreous enamelled resistors.

In operation the Pyrohm resistors are covered with a vitreous enamel specially developed for these units, are placed on high temperature alloy rods suspended between the conveyor links and fed into the furnace at a constant speed which is automatically regulated to a given standard depending on the size of the wire and unit.

The Aerovox Wireless Corporation is prepared to furnish to manufacturers, at short notice, standard and special Pyrohm vitreous enamelled resistors in ratings of from 10 to 100 watts and in resistance values up to 100,000 ohms in fixed and tapped combinations. Individual units may be connected in series or parallel to give any desired values of resistances and current carrying capacities.





A Group of Pyrohms produced by the New Automatic Conveyor Furnace



Detailed Descriptions and prices of these units will be furnished gladly on request