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The Aerovox line includes a complete variety of replacement units for every condenser and resistor requirement.

- ELECTROLYTIC CONDENSERS
- FILTER and BY-PASS CONDENSER BLOCKS
- PAPER WOUND CARTRIDGE CONDENSERS
- UNMOUNTED REPLACEMENT CONDENSERS
- METAL CASED CONDENSERS
- MICA CONDENSERS
- WIRE WOUND CEMENT COATED RESISTORS
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Type PB

Type PR

Type PR units are completely sealed in cardboard tube containers with wire leads securely riveted to the condenser terminal tabs.

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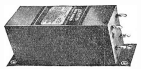

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The AEROVOX Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

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LAST CALL!

THE announcement in the November issue of the RESEARCH WORKER that we have placed a small subscription charge of 50 cents a year, and 60 cents in Canada, on this publication brings gratifying response, and we wish to take this opportunity to thank all who have so generously co-operated with us in maintaining this unique engineering service.

We repeat, we want to continue to make this little paper still more effective—and we want it in the hands of everyone interested in obtaining instructive, non-commercial information on the latest developments in radio. To this end we merely ask your co-operation with us in defraying only a part of the postage and mailing expense in sending to you 12 issues of the RESEARCH WORKER a year. If you have not already sent in your subscription, do it NOW! Send 50 cents using the enclosed coin card and your subscription will begin with the January, 1934 issue.

Please understand, if you want to receive the next issue of the RESEARCH WORKER, your subscription should reach us before January 15, 1934.

Rectifier Developments During 1933

By the Engineering Department, Aerovox Corporation

THE year about to close saw rapid development of new types of tubes, and some improvement in the characteristics of existing tubes. New amplifiers, oscillators, detectors and rectifiers made their appearance in profusion. In addition many tubes were brought on the market which combined the functions of several previous types.

While there are several methods of obtaining the required selectivity and sensitivity, there is but one known method of securing the required high d.c. voltages for plate and screen supply from a source of 110 volts a.c. This is the familiar process of smoothing out the pulses of unidirectional current by means of inductances and condensers. The power supply system, therefore, is vital to the radio receiver. Hence it is worth while to review what the year 1933 (and late 1932) has brought forth

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to improve—or to make less expensive—the power supply system.

For several years the 280 full wave rectifier (now known as the type 80 tube) assumed all the burdens of furnishing power to home radio receivers. It performed this task well. Fortunately only a few manufacturers exceeded the tube designer's limiting figures.

In keeping with the trend of developments, however, new rectifiers were necessary. Late in 1932 two new gaseous, and in 1933 several new vacuum type rectifiers were introduced. These were the types 82 and 83 (See Table 1) which are mercury vapor tubes with a voltage drop almost independent of the current drain and of very low value compared to the internal resistance of high vacuum rectifiers such as the 280 and other rectifiers given in Table 2. While these types of tubes have been in use for some time it may be well to review briefly their theory of operation.

MERCURY VAPOR TUBES

Both high vacuum tubes and mercury vapor tubes are highly pumped. But in the latter a globule of mercury is placed within the tube after the pumping process. When the cathode of the mercury vapor tube heats up this mercury volatilizes, i.e., becomes vaporized, and mercury molecules are then available for a very important and interesting phenomenon.

This phenomenon is that known as *ionization by collision.* An electron leaving the cathode in a high vacuum tube tends to go toward the plate because the latter electrode is at a positive potential and the electrons are negatively charged, and, as is well known, oppositely charged bodies attract each other. But as soon as the electron leaves the cathode the latter becomes positively charged since it has lost some of its negative charge. Furthermore, all the electrons are negatively charged and therefore repel each other. The net effect is the assembly of a cloud of negative electricity not far from the filament through which electrons must shoot to reach the plate.

This cloud, called the space charge, limits the number of electrons that actually get to the plate. The effect of this space charge is modulated by the voltages put on the grid of the tube and, if this grid is sufficiently positive, the cloud will be neutralized and all those electrons which do not get caught by this positive grid go to the plate. For this reason a positively charged grid causes a high plate current. If this space charge could be eliminated, without the necessity of losing a great number of electrons to a positive grid, the plate current of the tube would be limited only by the emission characteristics of the cathode.

Now consider a molecule of mercury floating about in the vacuum. An electron leaves the cathode, is attracted toward the plate and gets up more and more speed as it approaches. If an electron strikes a gas molecule with sufficient force the molecule will be disrupted, and an electron will be lost leaving the mercury molecule positively charged. It is then said to be *ionized.* The electron produced will join the others moving toward the plate while the positively charged molecule, called an *ion*, will drift toward the least positive element in the tube, i.e., the cathode. Since it is positive it will neutralize a portion of the space charge.

The mercury vapor, then, has as its function the elimination of the space charge and within a fraction of a second after the liquid metal vaporizes the space charge is gone and the plate current is unrestricted except by the external load resistance and the emission of the tube. Thus, a tube the size of the 210, which will have a plate current of 50 milliamperes at 300 volts on the plate and zero grid bias, will have a plate current of perhaps 1000 milliamperes under the same conditions if mercury vapor at the proper pressure is admitted.

It is characteristic of mercury vapor rectifiers that little current flows until the plate voltage reaches a certain positive value. Therefore a steep surge of current takes place on each half cycle which makes the plate positive. These steep surges will cause nearby circuits to oscillate just like opening and closing any electrical circuit. For this reason

Table 1

MERCURY VAPOR RECTIFIERS

Tube type	82	83	866	1
Filament voltage	2.5	5.0	2.5	6.3
Filament current	3.0	3.0	5.0	0.3
Type of cathode	filament	filament	filament	heater
Max. a. c. voltage per plate rms	500	500	—	350
Max. peak inverse voltage	1400	1400	7500	1000
Max. d. c. output current, continuous	125 ma.	250	—	50
Max. peak plate current	400 ma.	800	600	400
Max. tube voltage drop (approx.)	15	15	15	15
Type of rectifier	Full W.	Full W.	Half W.	Half W.

Table 2

HIGH VACUUM RECTIFIERS

Tube type	5Z3	80	1-v	81	12Z3	25Z5	84 (6Z4)
Filament voltage	5.0	5.0	6.3	7.5	12.6	25.0	6.3
Filament current	3.0	2.0	0.3	1.25	0.3	0.3	0.5
Type of cathode	filament	filament	heater	filament	heater	heater	heater
Max. a. c. voltage per plate rms	500	350	350	700	250	125	225
Max. d. c. output current ma.	250	125	50	85	60	100	—
Type of rectifier	Full W.	Full W.	Half W.	Half W.	Half W.	Doubler	Full W.

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these tubes usually have a radio-frequency choke (one millihenry or more) in the plate leads to iron out this abrupt current characteristic. The tubes are often put in shielding cans to further limit radio frequency disturbances.

Since the current that can be taken from the tube may be very high, precautions are taken to protect the tube or transformer in case of short circuits: such protection is provided by resistance or reactance to limit the current to the safe value.

As in high vacuum tubes it is desirable to use an inductance input filter rather than a capacity input type. The advantage is that the peak currents taken from the tube on the positive half cycles will be less and therefore higher voltages may be impressed upon the circuit without danger of exceeding the factor of safety.

Thus the mercury vapor rectifier is a tube for supplying quantities of power at excellent regulation to receivers needing more energy than high vacuum rectifiers will supply.

VOLTAGE DOUBLERS

Voltage doubling is not new. Amateurs used it years ago with many tiers of parallel and series glass jars of rectifying solution to secure the proper voltages for transmitters. It is strange that its entry into the realm of radio receivers came so late as 1933.

The 25Z5 is a voltage doubling rectifier. It consists of two cathodes, heated from a single heater, and two plates with all connections brought out to terminals. Thus the plates may be used as two half-wave tubes, each section furnishing power for its own portion of the radio circuit; for example, one section powering the loud speaker, the other section supplying the plates of the various tubes. The two plates and cathodes may be operated in parallel as a half-wave rectifier with a 25 volt heater. This is an advantage in universal receivers where some voltage must be wasted, and this wastage might as well be applied to some useful purpose.

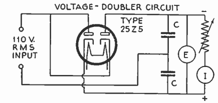

FIG. 1

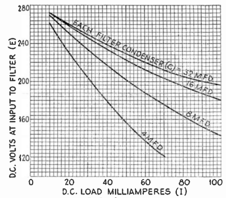

FIG. 2

The most interest, however, attaches to the 25Z5 as a voltage doubler. By this circuit 220 volts d.c. may be secured from 110 volts a.c. without the use of a power transformer. The circuit for such a system is shown in Fig. 1 as well as characteristics showing the effect of increasing the input capacity, Fig. 2.

To obtain the highest output voltage a condenser type of filter is recommended. If a large capacity is used, say 16 mfd. or more the output voltage and the regulation will be improved. Since the peak voltage applied to the input condenser is relatively low the condensers need have only moderate ratings.

Ratings of Electrolytic Condensers

In the use of electrolytic condensers it is naturally important that the condensers are not subjected to voltages in excess of their ratings. For this reason it is essential that one understands clearly the significance of the electrolytic condenser ratings.

In the use of electrolytic condensers there are three principal factors, namely, the d.c. voltage at which they are normally operated, the a.c. ripple voltage across the condenser, and thirdly, the maximum instantaneous voltage across the condenser at any period of time, as for example, at the moment the receiver is turned on. These three factors are defined in the following manner:

D.C. OPERATING VOLTAGE—D.C. potential as measured with a potentiometer or equivalent method.

PEAK RIPPLE VOLTAGE OR A.C. COMPONENT—The peak a.c. ripple voltage is the maximum instantaneous value of a.c. voltage across the condenser due to the a.c. current component in the condenser. This can be measured with a cathode ray oscillograph or with a vacuum tube voltmeter.

MAXIMUM SURGE VOLTAGE — This represents the maximum potential the condenser will withstand without breakdown or permanent injury, for a period of five minutes when applied to a series combination of the condenser and a resistance, the resistance having a value in Ohms, equal to $\frac{20,000}{C}$ where C is the rated capacity in mfd.

STANDARD VOLTAGE RATINGS

D. C. Oper. Volts	Max. Surge Volts	MAX. PEAK A. C. RIPPLE VOLTAGE AT 120 CYCLES Mfd. 1, 2, 3	Mfd. 4, 5, 6	Mfd. 7, 8, 9	Mfd. 10-12	Mfd. 13-16	Mfd. 17-25
350	400	30	27	25	20	15	10
400	450	30	27	25	20	15	10
450	525	30	27	25	20	15	10
475	600	30	27	25	20	15	10
500	600	30	27	25	20	15	10