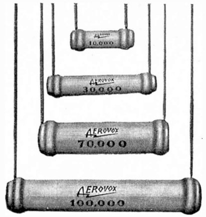
New Aerovox Wire Wound Resistors

We take pleasure in announcing a new line of wire wound resistors designed especially to meet requirements for low priced high resistance units of small dimensions and high wattage carrying capacity. In addition to our line of Pyrohm vitreous enamel resistors and carbon resistors which are extensively used in all forms of radio and electrical equipment, these new resistors meet many special needs in apparatus of various types.

The new resistors, Types 930, 931, 932 and 933 illustrated herewith, are wound on a porcelain tube with a special high grade resistance wire of low temperature coefficient. The entire unit is completely coated with a newly developed refractory compound which resists wear and will not chip or crack. The 5 watt resistors, Type 931, of the same dimensions as our standard 1 watt carbon resistors, Type 1094.

All units are provided with pig tail terminal leads 2″ long for mounting and wiring and can be made in all standard resistance values up to the maximum indicated with an asterisk (*) in the accompanying table.



Types 930, 931, 932 and 933 Resistors

Standard Values, Sizes & List Prices

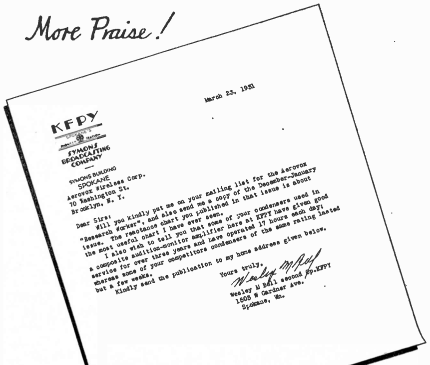
Type No.	Watts	Dimensions	Resist. Ohms	List Price
930	2	¼″x1″	500	$ .35
930	2	¼″x1″	1,000	.35
930	2	¼″x1″	5,000	40
930	2	¼″x1″	10,000*	.40
931	5	¼″x1¾″	1,000	.40
931	5	¼″x1¾″	5,000	.45
931	5	¼″x1¾″	10,000	.45
931	5	¼″x1¾″	20,000	.50
931	5	¼″x1¾″	30,000*	.55
932	12	7/16″x2″	5,000	.50
932	12	7/16″x2″	10,000	.50
932	12	7/16″x2″	20,000	.55
932	12	7/16″x2″	30,000	.60
932	12	7/16″x2″	40,000	.65
932	12	7/16″x2″	50,000	.70
932	12	7/16″x2″	70,000*	.80
933	18	7/16″x3″	10,000	.60
933	18	7/16″x3″	20,000	.60
933	18	7/16″x3″	30,000	.65
933	18	7/16″x3″	40,000	.70
933	18	7/16″x3″	50,000	.75
933	18	7/16″x3″	75,000	.90
933	18	7/16″x3″	100,000*	1.00

All units packed one in a box.
Standard Package—10 Boxes.

Enclosed with this issue of the Research Worker will be found a circular giving an outline of two new text-books recently published by the Radio Technical Publishing Co., in which Aerovox Condensers and Resistors are illustrated and described as typical examples of modern components for use in various radio circuits.

Aerovox products have not only been chosen by the authors of these books to illustrate the text of their work for the instruction of radio students and servicemen, but are also extensively used in the laboratories of leading technical schools and colleges throughout the country.

More Praise!



KFPY
SPOKANE'S PIONEER STATION
SYMONS BROADCASTING COMPANY
SYMONS BUILDING
SPOKANE

March 23, 1931

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

Dear Sirs:

Will you kindly put me on your mailing list for the Aerovox "Research Worker", and also send me a copy of the December-January issue. The reactance chart you published in that issue is about the most useful chart I have ever seen.

I also wish to tell you that some of your condensers used in a composite audition-monitor amplifier here at KFPY have given good service for over three years and have operated 17 hours each day; whereas some of your competitors condensers of the same rating lasted but a few weeks.

Kindly send the publication to my home address given below.

Yours truly,
Wesley M Bell
Wesley M Bell second Op.KFPY
1503 W Gardner Ave.
Spokane, Wn.

Thanks Mr. Bell

Write For The 1932 Condenser and Resistor Manual and Catalog of Aerovox Products

Free of Charge on Request to

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

Manufacturers of

The Most Complete Line of Condensers and Resistors in the Radio and Electrical Industries

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The AEROVOX Research Worker

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

Vol. 5 February - March, 1932 No. 2

Resistance - Capacity Filters for Plate and Grid Circuits

By the Engineering Department, Aerovox Wireless Corporation

PLATE and grid circuit filters consisting of resistors and condensers prove very effective in reducing the coupling between the input and output circuits of vacuum tubes and amplifiers. Consider, for example, the circuit shown in Fig. 1 which represents a typical detector circuit with a resistance capacity filter consisting of R2 and C2 connected in the plate circuit. Such a circuit eliminates common coupling between the detector and other tubes.

In a circuit such as is shown in Fig. 1, the B plus terminal would be connected to the proper tap on the rectifier filter system. It is desirable that the A. C. audio currents in the detector circuit be prevented from flowing through the B supply circuit. The audio currents can be confined to the detector circuit by means of the filter consisting of R2 and C2. Let us analyze this circuit and see how this filter functions in order to keep the audio frequency currents confined to the detector circuit.

To the input of the detector, we apply a modulated radio frequency voltage and let us assume that, as a result of the detector action, we get in the plate circuit, at a certain moment, a one hundred cycle signal with a magnitude of ten volts. This voltage will cause a current to flow through the plate resistance of the detector tube, through the load resistance R1, and hence through the condenser C2 back

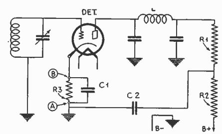

Fig. 1

to the cathode of the detector tube. Since the impedance of the condenser C2 should (for proper design) be low in comparison with R1, the A. C. current will be nearly equal to

$$\frac{E}{R_p+R_1}$$

If Rp, the plate resistance of the detector, is 25,000 ohms and R1 is 100,000 ohms, then the current will be

$$I = \frac{10}{25{,}000+100{,}000}$$
$$= 0.00008 \text{ AMPERES}$$
$$= 0.08 \text{ mA}$$

This current has two paths to follow. One path is through C2 to B- and bias resistor to cathode and the other path is through R2 then through the B supply circuit, hence to B minus and back to the cathode. Since we want the current to follow the first path, through C2 direct to B-, we must make the reactance of C2 much less than the resistance of R2. By referring to the reactance chart published in the preceding issue of the "Research Worker" we find that the reactance of the 10 mfd. condenser is 160 ohms at 100 cycles, the reactance of a 1 mfd. condenser 1600 ohms, and the reactance of a .1 mfd. condenser, 16,000 ohms at 100 cycles.

An idea of the value of R2 can be obtained from the curve shown in Fig. 2 which shows to a closer approximation how the degree of filtering depends upon the relation between the resistance of R2 and the reactance of C2. It will be noted that the percentage of the total current flowing through C2 the desired path increases very rapidly with increase in the ratio of R2 to the reactance of C2. Beyond the ratio of about 50, there is but a slight increase in filtering efficiency and we can therefore say that the resistance in such a filter should

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have a value of about 50 times greater than the reactance of C2 at the lowest frequency it is desired to filter. If we design the filter to function efficiently at the lowest frequency, then it will be even more efficient at higher frequencies due to the fact that the

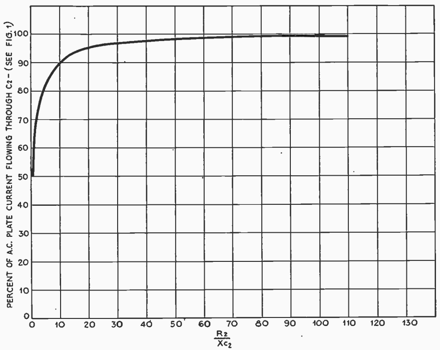

Fig. 2

reactance of the condenser decreases as the frequency increases.

It will be appreciated that there is nothing absolute about this ratio of 50 and that in certain circuits higher ratios may prove desirable. Our purpose here is simply to indicate the basis of operation in such circuits without attempting to do the impossible of setting down any hard and fast rules.

If we assume a ratio of fifty, then the following resistance values would be used:

If C2 is	Then R2 should be
10.0 Mfd.	8,000 ohms
1.0 "	80,000 "
0.1 "	800,000 "

Any one of these combinations will reduce the current through the B supply circuits to about 2% of what it would be without the filter. It is not surprising therefore that such filters are to be found in practically all high quality amplifiers.

Which combination of the above capacities and resistances would actually be used would depend somewhat upon the circuit of the amplifier. In most cases the combination of a 1 mfd. condenser and 80,000 ohm resistor would prove most desirable. Higher values of capacity would increase the cost and smaller values of capacity would necessitate a resistance of such a high value as to cause a serious reduction in the voltage actually applied to the plate of the tube. It is necessary that the experimenter determine in a particular amplifier which combination will in his particular case give the best compromise between cost and efficiency.

Such circuits also have the effect of reducing the hum voltage applied to the tube. No B supply filter circuit is perfect and there will always be some hum voltage across the output of the filter. This hum voltage will cause a small A. C. current to be present in the plate current circuits of all the tubes. Referring again to Fig. 1, this A. C. current will have to flow through R2 and hence through either C2 or R1. Since the impedance of C2 should be much lower than the resistance of R1, practically all the current flows through C2 and the A. C. hum voltage effectively in the plate circuit of the tube is therefore the same as the A. C. hum voltage across the condenser.

In terms of the hum voltage output from the B power filter circuit, the A. C. hum current flowing through R2 and C2 will be equal to

$$I = \frac{E}{\sqrt{R_2^2 + \left(\frac{1}{\omega C_2}\right)^2}}$$

and working with this equation, we finally can determine that the ratio of the hum voltage from the B supply to the hum voltage present in the tube circuit is proportional to

$$\sqrt{(R_2 \omega C_2)^2 + 1}$$

Since $(R_2WC_2)^2$ will, in a proper filter circuit, be much larger than unity, we can neglect the latter in the above square root and say that the reduction in hum voltage applied to the tube is proportional to R_2WC_2 which is really the ratio of the resistance of the reactance. If we refer to Fig. 2, we find that the degree of filtering of the A. C. signal currents is proportional to the same ratio since R2 divided by Xc_2 is the same as R_2WC_2.

We can say in conclusion therefore that a resistance capacity filter in the plate circuit of a tube does two things: It keeps the audio currents in the proper circuit and thereby prevents common coupling, and secondly, it reduces the hum voltage applied to the tube. In both cases the effectiveness of the circuit is proportional to R_2WC_2 the ratio of the resistance to the reactance.

The fact that such filter circuits reduce the hum applied to a particular tube does not necessarily mean that the hum in the loud speaker will be decreased

by the same amount. The hum in the loud speaker depends upon many things, and one of the most important of these is the manner in which the hum voltage from one tube combines with the hum voltage in another tube. If the hum voltage in one tube is such as to balance out the hum voltage of another tube, then the overall hum is decreased. In a circuit in which this was occurring, there would result an increase in hum from the loud speaker if a hum filter circuit was placed in the plate circuit of any tube, since reducing the hum from the tube would mean that the balancing out effect could no longer occur and the loud speaker hum would therefore increase. If, on the other hand, the hum voltages from the various tubes were such as to aid each other, then reducing the hum in any one circuit would cause a corresponding reduction in the hum from the loud speaker.

An example of this was recently experienced in the laboratory in some tests to reduce the hum output from a midget receiver. It was found possible to decrease the hum to a negligible value by decreasing the effectiveness of the filter in the plate circuit of the detector. This increased the hum in the detector circuit which balanced out the hum produced in the power tube circuit and caused a marked overall reduction in the hum audible from the loud speaker. Consideration of these facts must be realized in any experimental work on amplifiers for it is such effects which cause the hum to increase when a change is made in a circuit that at first thought would appear to be one which ought to cause a reduction in hum.

There are of course various ways in which resistance capacity filters may be connected to the tube. Certain possibilities are illustrated in Fig. 3. In this circuit we show a resistance capacity filter in plate circuit of T1 and indicate how the condenser C3 may be connected either to ground or directly back to the cathode of the tube. In such circuits, it is usually better to connect the condenser directly back to the cathode since this arrangement returns the A. C. audio currents directly to the cathode of the tube. In this connection, however, it must be realized that such an arrangement causes the hum currents from the B supply circuit to also flow through the C bias circuit. In certain cases this may prove desirable, and in others undesirable, and it is a matter of experiment to determine which arrangement gives the best results.

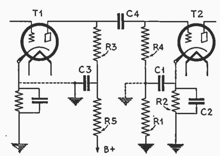

Fig. 3

Resistance capacity filters are also connected in the grid circuits as shown in Fig. 3. Here we also show two possible arrangements; one which utilizes a resistance R1 and a condenser C1 with the condenser returned to the cathode of the tube and the resistance connected to the ground. The alternative arrangement is to eliminate the resistance capacity filter and connect the lower end of R4 directly to ground. The latter arrangement is usually best for the following reasons.

The A. C. current in the plate circuit of T1 causes current to flow through R3 and C4 R4. Since these currents originate from T1, it is necessary that they be returned by the most direct path back to the cathode of T1. The currents through R3 are returned to the cathode by C3. The currents through R4 must also be returned to the cathode of T1. If we use a resistance capacity filter R1 C1, in the grid circuit of T2, then the currents in R4 must flow through C1 and the C bias circuit of T2, in order to return to the cathode of T1. Such arrangement is obviously undesirable and it is therefore better not to use any filter in the grid circuit but to connect R4 directly to ground. With such an arrangement the currents go directly to ground and hence back to the cathode of T1. To use a resistance capacity filter in the grid circuit of T2, would actually cause an increase in the common coupling between the two tubes. Such filters in the grid circuit should therefore not be used in resistance coupled amplifiers. They can be used in conjunction with transformer coupled amplifiers since in such amplifiers the primary and secondary of the transformer isolates the two circuits. Using grid circuit filters in resistance coupled amplifiers, may actually cause an increase in hum and increase in coupling between the two circuits.

In the circuits of Figs. 1 and 3, we also indicate condensers connected across the C bias resistor. The size of this capacity is determined largely upon the value of the C bias resistor and the amplification constant of the tube. It is usually sufficient, however, to make the bypass condenser across the C bias resistor of a value such that the impedance of the C bias circuit is small in comparison with the value of the C bias resistor. Let us, for example, consider a power tube circuit in which no resistance capacity filter is used in the grid circuit of the power tube. The A. C. current developed in the plate circuit must return to the filament through the C bias circuit. The A. C. voltage drop across the C bias circuit will be equal to the A. C. plate current times the C bias impedance. The voltage drop across the C bias circuit is impressed back on the grid of the power tube and it has a phase relation such as to decrease the amplitude of the signal. The overall gain of the power tube circuit is therefore reduced if any considerable amount of A. C. voltage appears across the bias circuit; to keep the voltage across the circuit low it is necessary to use bypass condensers across C bias resistors.