Choosing Resistors

PROPERTIES OF VARIOUS TYPES OF RESISTOR

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THE two most important features of a resistor are its power rating and the resistance value. If these two quantities are chosen correctly, the resistor will normally function satisfactorily in simple low frequency circuits, but for some applications it is necessary to choose a resistor more carefully.

TABLE I.
Typical sizes of ordinary composition resistors.

Power Rating (W)	Diameter (in.)	Length (in.)	
1/10	0.15	0.4	Ceramic tube
½	0.25	0.7	Ceramic tube
1	0.25	1.25	Ceramic tube
2	0.4	2.0	No ceramic tube
5	0.7	2.5	No ceramic tube

The power rating of a resistor in watts is the voltage across it multiplied by the current in amps passing through it. If excessive power is dissipated in a resistor, it will become hot, will probably change in value and may burn out completely if the overload is very great. Calculations of the power rating which a resistor should have for a particular purpose was discussed more fully on page 402 of the July, 1959, issue of PRACTICAL WIRELESS by F. G. Rayer.

Carbon Composition Resistors

The ordinary cheap composition resistor usually consists of a composition carbon rod inside a ceramic tube. There are brass caps at each end of the carbon rod and connecting wires are fastened to these caps. The body of the resistor (consisting of the ceramic tube) is colour coded and is an insulator. There are certain types, especially for high power ratings, in which the ceramic tube is omitted. Care must then be taken to prevent the body of the resistor from touching the chassis or any wire.

If the power rating of a resistor is unknown, the approximate rating may be found from its size. Table I shows the actual sizes of some resistors of various power ratings. If the resistor becomes too hot, a waxy material may often be seen dripping from it.

The composition resistor usually generates from ten to one hundred times as much noise as the cracked carbon type of resistor and the noise increases with the amount of power being dissipated in it. Composition resistors should not, therefore, be used as load resistors in the early stages of high gain audio amplifiers.

H.F. Frequencies

Composition resistors are the best type for use at radio frequencies. Nevertheless, the resistance at high frequencies is usually less than that at low frequencies. At 30Mc/s a normal 1M resistor only presents an impedance of a little over 1/10M. This effect is less for resistors which have a small value and for frequencies which are not too high. If the resistance in ohms is multiplied by the frequency and the product obtained is not greater than about 5×10^{10}, then the resistance at that frequency will be approximately equal to the resistance to direct current. For example, a 1M resistor may be expected to have an approximately constant resistance up to about 50kc/s, a 10,000 ohm resistor up to 5Mc/s and a 100 ohm resistor up to 500Mc/s. Generally resistors for use at high frequencies should be long rather than have a large diameter and the connections should be short.

Resistors for use at high voltages (over 2,000V) should be long. It is better to use two or more resistors in series than to use a single resistor for very high voltages in order to reduce the possibility of flashover.

TABLE II.
Typical sizes of high stability cracked carbon resistors.

Power Rating (W)	Diameter (in.)	Length (in.)
¼	0.17	0.75
½	0.18	1.1
1	0.32	1.3
2	0.32	2.0

Cracked Carbon Resistors

Cracked carbon resistors are also known as high stability or grade 1 resistors and are much more expensive than composition resistors. They consist of a ceramic tube with a thin carbon film deposited on it by means of a special process. Metal caps are fitted over the ends for making connections. A spiral cut is made in the carbon film so that the current has to go a longer distance through the carbon. The value of the resistor can thus be raised somewhat as desired. A coating is painted over the carbon track, but the insulation is not always very good and it is advisable to keep the body of the resistor away from the chassis and other metal objects. Measured sizes of some typical grade 1 resistors are shown in Table II. These resistors are not usually made in 1/10W size.

Grade 1 resistors normally have a tolerance not greater than 5 per cent. and even though they may be marked with this tolerance, they are almost always within 1 per cent. or at least 2 per cent. of their marked value. The value and tolerance are normally written on them, i.e., they are not colour coded. The value of these resistors remains very constant during use—hence the name high stability. Grade 1 resistors should always be used when accurate values are required, e.g., in certain devices such as filters which depend on accurate phase changing.

Noise

The noise generated by a cracked carbon resistor increases with applied voltage approximately as shown in Fig. 1. The graphs are for one particular value of resistor. It will be noted that there is some noise even when no voltage is applied across the resistor. This noise is called

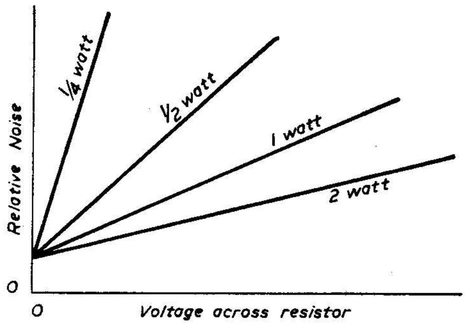

Fig. 1.—Graph of noise generated by a cracked carbon resistance against applied voltage.

"Johnson noise" and it can be shown theoretically that it is not possible to make a resistor which generates less noise than this. Grade 1 resistors are very useful in the anode circuits of the early stages of high gain amplifiers where minimum noise is important. A resistor of much larger power rating than the actual power which it will have to dissipate should be used when any current is passing through it. When the current is extremely small, however, a ¼W grade 1 resistor gives no more noise than a 2 watt resistor (see Fig. 1).

Cracked carbon resistors have the disadvantage that they possess considerable inductance owing to the fact that the current has to pass along the spiral carbon track which acts as a coil. They are not, therefore, very suitable for use at high frequencies.

Vitreous Resistors

Vitreous resistors are wire wound resistors, the wire normally being wound on a ceramic tube and being covered with a green or blue vitreous enamel. This type of resistor is always made for high power ratings, as vitreous resistors operate satisfactorily at temperatures up to several hundred degrees centigrade. They are smaller than carbon resistors of the same power rating because they can work at a high temperature; typical sizes of vitreous resistors are shown in Table III. This type of resistor normally has a tolerance of 5 per cent. or better. Vitreous resistors have a considerable inductance because of the number of turns of wire on them and are not therefore suitable for use at high frequencies. The inductance of a vitreous resistor is high enough for it to be used as a combined choke and resistor for certain purposes.

TABLE III.
Typical sizes of vitreous resistors.

Power Rating (W)	Diameter (in.)	Length (in.)
4½	0.27	1.5
6	0.30	1.5
10	0.43	2.3

An Experimental "Super" Transistor Receiver

(Continued from page 660)

72.0—86.4—100.8—115.2—129.6—144.0 — 158.4—172.8 — 187.2—201.6—216.0—230.4—244.8—259.2—273.6—288.0—302.4—316.8 — 331.2 — 345.6 — 360.0. Draw radii through these points. Add two parallel lines ¼in., one at each side from the 8½in. diameter circle to the edge of the board. Cut out 25 radial slots ¼in. wide, between the two parallel lines, from the edge to the 9in. or 8½in. or 8in. if necessary. File the saw cuts smooth and round off all the sharp edges. If the coil is wound into this square frame, it can be used for the back cover of the receiver. If it is fibreboard, apply two coats of varnish.

Plug-in Coils

If it is to be a plug-in coil, cut off two opposite corners around the 12in. diameter circle. Shape one end for holding the coil and the other end for fixing on to a block with four valve pins, to which tap leads can be soldered. The coil is wound with 20 s.w.g. 0.036 wire (plastic insulated). Starting from the plug-in corner, pass the wire into a slot from the front and back out of the next slot, pull and flatten the wire at the back, against the board, then into the third slot and out of the fourth, zig-zag all round, pulling and flattening the wire at each section to make a neat, evenly spaced coil almost up to the 12in. diameter circle. There should be 28 turns.

The coil for the aerial, if wanted, should have 20 turns up to the 12in. diameter circle. Ferrite rod coils were tried, but did not give good results even when Litz wound with spaced turns.

Construction

The construction is not critical; a small panel may be used or the components may be mounted on to the middle of the coil board. The R.F. choke should be near to the collector of Tr1 and C2, with its turns not magnetically coupled to the loop but at right angles, or screened.