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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.

VOL. 9, NO. 1 JANUARY, 1937

60c per year in U.S.A.
60c per year in Canada

Interference Elimination

By the Engineering Department, Aerovox Corporation

PERHAPS the greatest obstacle yet to be overcome in radio communication is interference. In the popular mind, interference or "static" is any kind of sound other than the desired program. Therefore it is best to begin by defining terms. Interference may be divided into four kinds:

1. Natural static.
2. Interference originating in the receiver.
3. Interference from other stations or the neighbour's receiver.
4. Interference caused by electrical machinery in the vicinity.

Natural static cannot be completely eliminated at the present time. It is however but a small part of the interference which mars radio reception. The types 2 and 3 are clearly due to faulty receivers and should be remedied by competent servicemen. This article is concerned with interference of the last type.

WHAT CAUSES INTERFERENCE?

Whenever switches are closed, a spark jumps or there is any sudden change in the current carried by a conductor, a damped radio wave is radiated. This radio wave may eventually reach receivers in the neighbourhood and because it is damped it will cause interference at different frequencies by impact excitation. The result is a multitude of noises in locations where many electrical devices are used, such as apartment houses and most locations in large cities. To mention but a few causes, radio interference is created by ordinary switches, vacuum cleaners, oil burners, electrical refrigerators, elevators, thermostat controlled devices. It is also caused by dial telephones, buzzers, passing streetcars, trains and automobiles.

One other cause not usually considered is any intermittent contact between two conductors both of which may appear quite dead since they are not connected to any electric wiring system. This is for instance the case if two aerial wires sway in the wind and touch each other. This causes interference in the receivers to which these aerials are connected but also affects reception in all other receivers in the immediate neighbourhood. The same effect is obtained by any other wires, not aerials, which may be swaying in the wind and touching another conductor such as guy wires connected to chimneys, etc. The remedy is obvious.

HOW INTERFERENCE TRAVELS

The damped wave can travel to the receiver by any or all of four ways. First, it may be radiated directly by the wires; second, it can be conducted along the power wires and reach the receiver in that way. Third, it may be conducted along the power wires and radiated by them to the aerial. Fourth, it can be re-radiated by another conductor nearby.

The directly radiated interference reaches the receiver by way of the antenna and is therefore encountered on battery receivers as well as on line operated receivers. Obviously it cannot be eliminated except by suppression at the source or by means of a special antenna situated away from the interference zone and supplied by a noise-cancelling lead-in. This is often possible because directly radiated interference does not travel very far, perhaps no more than 50 feet.

The second type, conducted interference, appears on line operated sets only which suggests a way of testing for it. It can be reduced by means of a line filter at the outlet of the power line where the receiver is plugged in. Of course, suppression at the source is still better. This type of interference is usually accompanied by the third type which is by far the most common of the four. The interference travels by wire and is radiated by the wiring in the walls if it is not perfectly shielded and by the power cord. This type may travel for several blocks and the radiation may take place by the wiring in the neighbour's house as well. One suggested remedy is to filter the power wiring at the point of entrance to the house but this may not be sufficient in apartment houses and other crowded locations where the unfiltered wiring of the neighbour is still near enough to cause damage. The special aerial may have to be used as well if the noise cannot be stopped at the source.

The fourth type of interference comes in by the antenna and the same remedies as for the first type should be employed.

HUNTING THE CAUSE

When interference is encountered the first thing to do is to determine in which one of the four ways it is reaching the receiver. It will then be easier to decide on the best way of elimination. It is of course best if the search continues until the offending device is found. Many electrical appliances have their own characteristic noise which can be recognized by an experienced man.

Before blaming the interference on the surroundings it must be established that the receiver itself is not to blame. Bad connections may cause a frying noise and defective tubes may cause intermittent buzzing. These are often hard to locate; the old test of

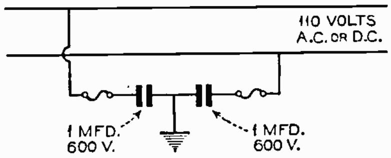

Fig. 1

disconnecting aerial and ground is not always reliable because some noises occur only when a signal is coming in. Tapping various parts of the receiver and the tubes will often help finding the cause. Wherever possible another receiver should be tried in the same location.

Assuming that the receiver is blameless, disconnect aerial and ground and short circuit the aerial and ground binding posts by a short wire. If the noise remains equally strong, it is the second, the conducted type. If the noise did disappear completely it came in by the antenna alone and belongs to the radiated or re-radiated type. If the noise became weaker it probably belongs to the third type, that radiated by the powerline, or it is a combination of several types.

A test for direct conducted interference is the use of a battery receiver which will not pick up this type. Interference radiated by the power line can usually be identified by tuning through the dial and down to the short waves. If the trouble becomes worse on the short waves it is usually due to direct radiation and the source is probably within fifty feet. If the interference is worse on the long waves, the interference is probably carried along the power line and radiated by it. The source may then be several blocks away.

The above tests wil give a clue to the probable location of the cause; it can be further traced by the use of a portable battery receiver and by a process of elimination, turning off the power in the house or in separate circuits. This will establish whether the line is at fault because the line radiated interference will disappear if a battery receiver is used and the power in the house is turned off.

REMEDIES AT THE RECEIVER

The best cure of course is the suppression of the noise at the source but the radio listener can do several things to eliminate or minimize the interference.

Noise created elsewhere and carried into the house by the power line may be suppressed at the point of entrance into the house. Of course this will not prevent interference from devices in the house itself. The type of filter employed for the purpose can consist of two condensers in series across the line with the centertap grounded. It is recommended that fuses be employed in the circuit as shown in Figure 1, so as to prevent damage if one or both condensers might fail. It is also important that all the leads be short and that a good ground be used. The best ground in this case is the cold water pipe at the street side of the water meter. The size of the condensers may be 1 or 2 mfd. each, they must be non-inductive and have a liberal voltage rating.

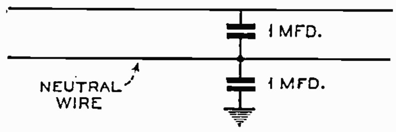

Fig. 2

If this is not sufficient or the noise originates within the house it is desirable to employ a filter at the outlet where the receiver is plugged in. The filter here can again consist of two condensers with the centertap grounded. On a.c. the centertap will be "hot" unless it is effectively

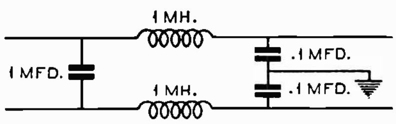

Fig. 3

grounded. The alternative circuit of Figure 2 has been suggested but there is little danger of shock if one is careful to connect the ground first when installing the filter. It may be necessary to try different grounds such as the cold water pipe, the radiator or the conduit of wiring. In any case, the ground wire should be as short as possible and should not be the same as the one used for the receiver.

Where simple condenser filters are not sufficient it is necessary to employ a filter of the low-pass type consisting of coils and condensers as shown in Figure 3. More than one section can be employed with different size coils so as to bring maximum attenuation in the center of different wave bands. Inductance values up to 1 millihenry have been employed for the broadcast band with condensers of .1 to .5 mfd. These values are not critical. It is necessary to shield the filter carefully. Mounting the coils in inductive relation to each other helps the efficiency of the filter.

The third measure an owner may take is to employ one of the special aerials employing a noise reducing lead-in. A typical antenna of this type is shown in Figure 4. Note that it is the lead-in only which does not pick up noise but the antenna itself will. Therefore the flat top should be installed in a location where it is outside the interference zone. The lead-in may be as much as 500 feet in length. Experimentation with the direction and location of the flat top will be worth while. Some commercial aerials of this type afford protection on the broadcast band but others do not since the circuit is changed to a simple T antenna. The type shown in Figure 4 allows reduction of noise on all bands. When using this type of antenna it may also be necessary to experiment with grounds. If a shielded lead-in is used the shield should also be grounded at the antenna end.

SUPPRESSION AT THE SOURCE

In many cases the interference can be suppressed at the source in an inexpensive manner. Electric motors of the series type, both a.c. and d.c. may be rewired from the circuit of Figure 5a to the one of Figure 5b which makes the field serve as choke. The centertapped condensers are to be connected across the brushes—not across the line. If the frame of the motor is grounded the centertap of the two condensers can return directly to the frame of the motor. When this is impossible, the circuit of Figure 5c is suggested. Dangers of shock are reduced by the additional series condenser of .01 mfd.

Motors of the shunt type must have the condensers directly across the line which is also directly across the brushes. In all cases the wires should be short so as to prevent them from being effective radiators. Whenever condensers are not sufficient chokes may have to be added making a circuit like the one in Figure 3 but the chokes must be of heavy enough wire to carry the current.

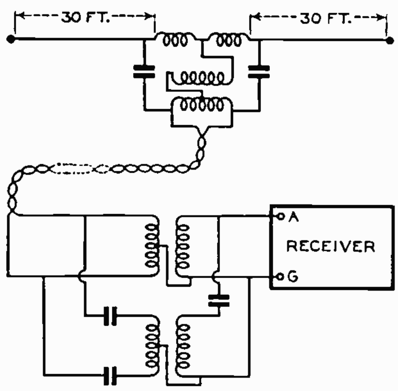

Fig. 4

Noises caused by switches can be eliminated by the resistance-capacity filter shown in Figure 6. This is to be connected across the switch, not across the line. The proper size of the resistor and condenser depends on the current drawn by the circuit. In most cases, .1 mfd. and 500 to 1000 ohms will be found satisfactory.

Thermostat controls and flasher signs are nothing but switches and can

TABLE I

Size, B & S gauge	Safe current (Amperes)	Power (Watts) on 110 v. line	Turns per inch Enamel	Turns per inch D.C.C.
10	25	2,500	9.6	8.9
12	20	2,000	12.1	11
14	15	1,500	15.2	13.6
16	6	600	19.1	16.7
18	3	300	23.9	20.2

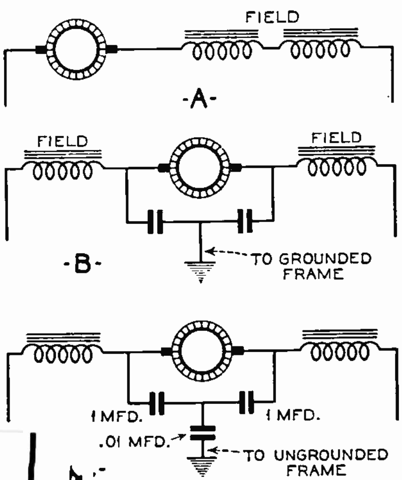

Fig. 5

ERRATA: Vol. 9, No. 1, Jan., 1937, P. 3.
(Place this label over Table I)

TABLE I

Safe current (Amperes)	Power (Watts) on 110 v. line
6.9	690
4.4	440
2.7	270
1.7	170

d the same way. One circuit as been found effective for igns is shown in Figure 7. ic doorbells and buzzers can ed with the customary filter ne in Figure 3.

lerable difficulty is encoun- neon signs. If the neon sign 1 by high-voltage a.c. conden- be fitted across the primary ure 8; it is also effective to in-

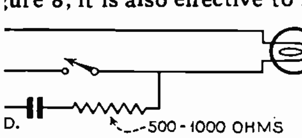

Fig. 6

clude a choke—properly insulated—in between the letters of the sign. If r.f. is used the remedy is a narrow metal band around the glass tube near the middle of the sign, this band to be grounded. The proper place is found by sliding the band over the tube.

Diathermy machines, X-ray machines, violet rays, etc. are small radio transmitters and cause severe interference. The power line should be filtered at the source of the interference by a filter similar to the one in Figure 3. The directly radiated interference can only be stopped by a complete shielding of the room and filtering of all wires passing through the shield. If a power line filter is used at the machine, however, the special aerial will probably take care of the direct radiation.

THE CONDENSERS

Condensers for interference suppression should be able to withstand the high-voltage surges which occur on the line. Those connected to the 110 volt line should preferably be rated at 600 volts, continuous working voltage. They should be of the paper type and non-inductively wound. Fuses are recommended as mentioned earlier.

CHOKES

The chokes should have a maximum of impedance over the tuning range of the receiver. In general, the larger the choke, the better if it does not have too much distributed capacity. Economic considerations and space limitatons usually fix the size of the choke. Standard sizes for chokes have been anywhere between 100 and 1000 microhenries. Smaller sizes are used for the short waves and an all wave filter usually consists of several sections with different size chokes.

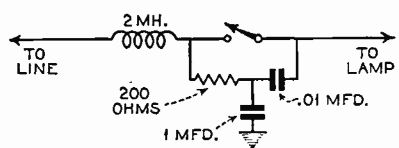

Fig. 7

In designing a choke the current carrying capacity of the wire should be taken in consideration. Since heavy wire means an expensive and large choke, the filter is often designed to carry no more than the current for a good sized receiver and care should be taken not to overload it. Table 1 shows the current carrying capacity of several wire sizes as given by the

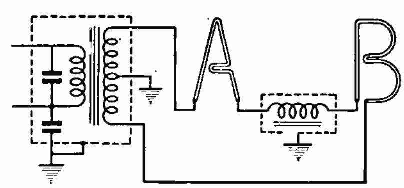
Fig. 8

National Board of Fire Underwriters, together with the maximum allowable number of watts on a 110 volt line. It is best to employ a liberally large size of wire since the choke is likely to be ill ventilated.

The inductance of multilayer coils of square cross section, Figure 9, is given by the equation

$$L = \frac{.8a^2 N^2}{6a+9c+10b} \text{ microhenries}$$

where N is the number of turns and all dimensions are in inches. The most efficient coil is had when $b = c = .667\,a$. If one assumes these relations they can be inserted in the above equation

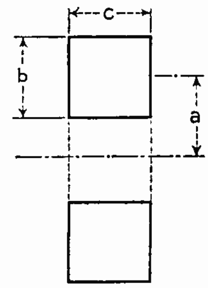

Fig. 9

and after some mathematical juggling be put in the following form.

$$a = \sqrt[5]{52.6\ \frac{L}{d^2}}$$

$$b = c = .667a$$

$$N = .44a^2d^2 = bcd^2$$

d is the number of turns per inch and can also be found in Table 1.

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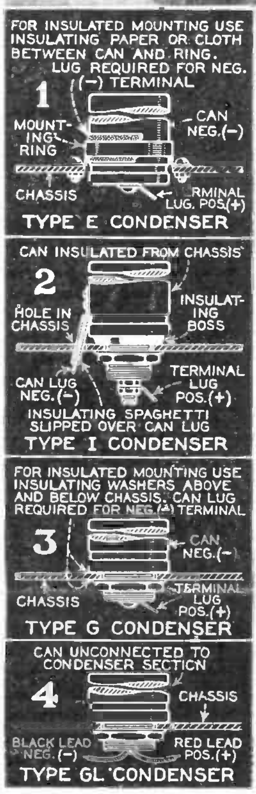
Further details may be had from Radio & Technical Publishing Co., 45 Astor Place, New York City.



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