NATIONAL RADIO INSTITUTE

Complete Course in PRACTICAL RADIO

NRI

Radio-Trician
(Trade Mark Reg. U. S. Patent Office)

Lesson Text No. 29

(2nd Edition)

RADIO INTERFERENCE AND ITS ELIMINATION

Originators of Radio Home Study Courses
··· Established 1914 ···
Washington, D. C.

REST

A Personal Message from J. E. Smith

Students should not use their eyes too steadily. At intervals of half-hour or so, they should close their eyes for three minutes, or, if it is daylight, look out upon the green grass, or trees. Green is very restful to the eyes.

If they need glasses, as a large proportion of people do, they should certainly wear them.

It is a very simple thing to follow common sense practice in matters connected with one's work. Disregarding such practice always has a decidedly unfavorable effect on one's attainments.

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RADIO INTERFERENCE AND ITS ELIMINATION

Radio interference consists of any kind of electrical impulse, other than the desired signal, which may be heard from the radio receiver when in operation.

Notwithstanding the excellence of our broadcasting stations and the general high quality of radio receiving sets, a percentage of broadcast listeners do not have normal reception on their sets because of local outside interference. This interference may take the form of harsh non-descript sounds, so-called "static," crashing, buzzing, clicking noises, etc., which either spoil the program or blot it out altogether.

Almost any piece of electrical apparatus is a potential source of disturbance to a sensitive radio receiving set. Wherever an electric spark is formed, waves of high-frequency electrical energy are sent out. They are identical, though untuned and uncontrolled, with those transmitted from the broadcasting station. Consequently, they are picked up by the radio installation and amplified in the same manner as radio speech or music.

There are two methods of suppressing the interference due to sparking electrical apparatus. One is to eliminate the spark by removing the apparatus or placing it in a condition so that the spark will not occur. The other is to use a filter device so as to confine the electrical waves set up by the apparatus to a very small area and thus prevent interference to the reception of radio programs.

Classification of Outside Interferences.

(A) Static. Static is a broad term used to cover noises in reception caused by electrical discharges in the atmosphere. There is always a certain amount of this present, and the more sensitive the receiver, the more readily it is detected.

(B) Code Signals. This is in the form of an intermittent buzzing or "peeping," resembling telegraphic code (dots and dashes), and is due to the operation of a powerful radio code transmitter, either commercial or amateur, in the immediate vicinity. Although this transmitter may be sharply tuned, if it is powerful and sufficiently close, it may cause interference through forced oscillation which cannot very well be prevented.

(C) Radiating Receivers. The familiar "squeal," varying in intensity and volume, which is sent out or broadcast when a regenerative or other oscillating receiver is tuned in, is gradually disappearing. This is one of the annoyances to which the broadcast listener is subject. This type of set is rapidly becoming obsolete and is being replaced by the stabilized type. Interference of this kind can only be eliminated at the source, by proper operation of the offending receiver.

(D) Electrical Apparatus and Wiring. Electrical machinery in operation and defective electric wiring is responsible for a great deal of noise in radio reception. This is particularly true in a city or town where there are always many electrical devices, appliances and machinery in more or less continuous operation. The nature of the noise in each case depends upon the type of machinery causing it and the defect of electrical wiring or electrical discharge responsible for the radiation of the disturbances. Among the more common sources of trouble of this nature, classified by the National Electric Light Association, are the following:

Power Circuits. (1) Lines; (2) Insulators; (3) Lightning Arrestors on power lines; (4) Transformers; (5) Generators and Motors; (6) Induction Voltage Regulators.

Industrial Appliances. (1) Street Lighting Circuits; (2) Telephone and Telegraph Lines; (3) Street Car and Electric Railroads; (4) Mechanical Interrupters; (5) Motors.

Household Appliances. (1) Electric pads; (2) Violet-Ray Machines; (3) Flat-irons; (4) Door Bells, Light Switches, Various Small Motors, etc.

Miscellaneous. (1) X-Ray Machines; (2) Storage Battery Chargers; (3) Annunciator Systems; (4) Stock Tickers; (5) Ignition Systems; (6) Electric Elevators and Electric Furnaces; (7) Moving Picture Equipment; (8) High Voltage Test Equipment.

The above list covers in a general way most household and industrial noise makers.

Radio-Tricians in all parts of the country continually encounter cases of interference from local electrical apparatus, defective power transmission apparatus and lines, radiating radio receivers, and other sources.

Locating Radio Interference.

Before the Radio-Trician can determine how the interference in any particular locality may be suppressed, he must first locate the source of it. This can be found by using a sensitive loop-operated portable receiver.

Since the output of the receiver, as indicated audibly, may have the same apparent intensity over a considerable distance on either side of the disturbance, it is necessary to use visual means for indicating the source of the interference. The construction of such a visual indicator is relatively simple, this being nothing more than a simple type of vacuum tube voltmeter.

A transformer having a one-to-one ratio is connected at the output of the portable receiver. The secondary of this transformer is connected to a 201A tube having some means of varying the grid bias. A D. C. milliammeter having a full scale deflection of not over 25 milliamperes is connected in the plate

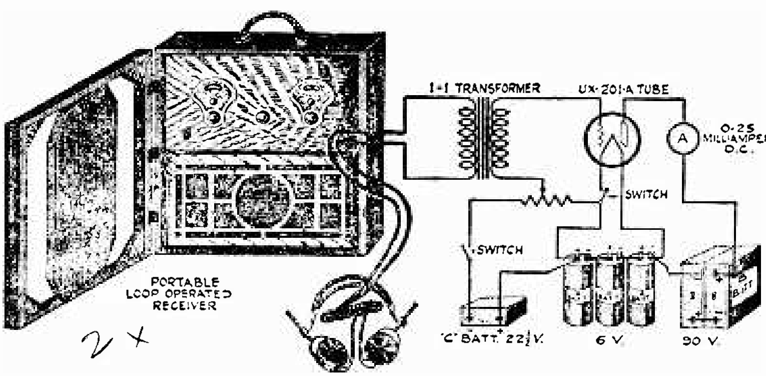

Fig. 1—Visual Indicator connected to a portable loop operated receiver. Used to locate Radio interference.

circuit of this tube. The grid bias of the 201-A tube is so adjusted that when a minimum of interference is being picked up, there is no deflection of the plate current milliammeter. The indicator should not be operated from the batteries which are supplying current to the receiver.

When this device is used, it will be found that the deflection of the meter increases rapidly as the source of the interference is approached and decreases with equal rapidity when the source of the interference is passed. For best results, it should be used in conjunction with a head-set in order that this visual and aural indications may be compared. Fig. 1 shows the proper manner of connecting this device.

When the interference has been located, it is sometimes difficult to determine just what piece of apparatus or circuit is causing the trouble. An analysis of the sounds produced by different types of apparatus will help solve this problem. A steady howl is usually caused by a radiating receiver. A rapid and steady clicking noise is often caused by a vibrating armature, battery charger or other electrical apparatus which has a vibrating reed for opening or closing circuits. (The electric bell is one example of this type of apparatus.) Intermittent rasping and crackling noises may be due to defective insulation or loose connections in power lines, or they may be static caused by natural means. A more or less steady crackling noise may be caused by an arc light or some medical apparatus. A rapid whirring noise, or a hum, may be caused by a generator or motor in the neighborhood.

Reducing Static Disturbances.

Many anti-static devices have been suggested from time to time for eliminating the intensity of the static crashes so that the signals can be distinguished above the static noise. Some are simple and others are rather complicated in theory. It is necessary by trial to find a particular arrangement that most perfectly meets the local conditions.

Any static eliminator which reduces the interference to a point where the crackling is not audible during the program, and can only be heard faintly during the intermissions, can be considered highly successful from the broadcast listener's point of view. With careful attention to the following principles, the Radio-Trician can generally install a small device which will greatly improve the clarity of the signals.

Both static and radio signals are the result of electrical disturbances, and both strike the aerial at the same time. It is therefore rather difficult to unscramble them so that the charges induced by the electromagnetic waves are retained, and the impulses, due to atmospheric electrical charges, are grounded and rejected. The separation is partly made possible by the fact that some radio signals are of much higher frequency (or shorter waves) than the static impulses. Hence the two can sometimes be separated by a tuning or filter system. By a suitable arrangement of choke coils, that will stop the radio waves, but allow low frequency and static to escape to the earth, it is possible to greatly reduce the crackling and other disagreeable noises.

Tuned circuits, tuned to a given frequency or wave-length, are not set into oscillation by other wave-lengths or frequencies unless these waves are unusually strong. Most receivers will oscillate at their resonant frequency in the vicinity of a powerful broadcasting station, even when the station is operating on a widely different frequency or wave-length. The shock must be many times the ordinary signal strength to set up such a condition and the atmospheric charges are heavy enough to do this very thing. In other words, we now have no means of separating the desired signal from the undesired static, since both disturbances cause the set to oscillate at the same frequency. The tuning unit is ineffective in such a case and must be given outside aid.

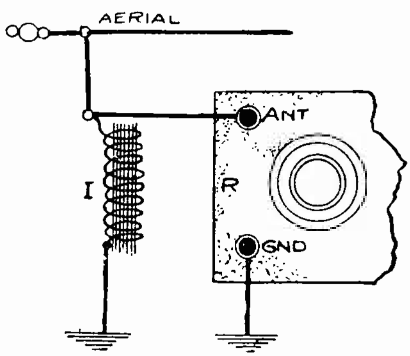

Fig. 2—Ground choke.

Simple Static Reducers.

It is generally considered that the elimination of static means a reduction of signal strength, and this is true of most static eliminators so far devised. Weakening of the signal is not so important as the relative weakening of the static, or the signal static ratio, as it is sometimes called. If a certain system weakens the static at a more rapid rate than it weakens the signal, then a point is eventually reached where the static will disappear entirely with some of the signal still in evidence. It is only when the strength of the static greatly exceeds the signal that it becomes highly objectionable. A simple, and often very effective static eliminator is the choke coil shown by Fig. 2. This is suitable only with inductively coupled receivers having a primary aerial circuit electrically separated from the secondary circuit.

The choke must have a sufficiently high inductive value to hold back the longest radio waves that are expected to be received. The long wave static passes freely through the choke without the high-frequency radio waves following. There are all sorts of values used for the choke coil, ranging from the 400 turn honeycomb coil to the secondary winding of an audio transformer. Good results can be obtained by using the primary coil of the audio transformer, leaving the secondary coil open. However, this may not suit in every case. In any event, the inductance of the choke coil must be very much higher than that employed for tuning in broadcast wave-lengths.

An alternative arrangement can be had by placing the choke coil in series with the ground wire of the receiver. In some cases, and with certain types of receivers, it may work better than the arrangement shown in Fig. 2.

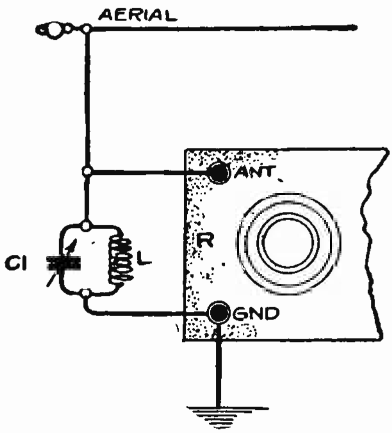

Fig. 3—Wave trap in parallel with antenna and ground terminals of receiver.

Tuned Traps (Selective).

Very often the wave-trap idea works out successfully, and it has a further advantage in that it can also be used to increase the selectivity of the receiver. In Figure 3, we have a combination of a variable condenser, C1, and a honeycomb coil, L, connected across the aerial and ground post of the receiver, R. This arrangement is adaptable only to receiving sets using an inductively coupled aerial circuit.

By varying the capacity of the variable condenser, C1, the frequency or wave-length of the trap is varied so that all the radio-frequency signals are shunted into the receiver, while the undesired waves of different frequencies pass through to ground without entering the receiver. Under some conditions, this is highly effective. It is difficult to prescribe any definite size for the condenser and coil due to the great variations in conditions, but a 23 plate .0005 mfd. variable condenser with a 50-turn coil, L, on a 3½″ diameter tube, should be about right. A vernier arrangement should be used, as the trap tunes very sharply. Fig. 4 shows the trap placed in series with the set. The condenser and coil can be mounted in a separate cabinet, making a convenient unit for tuning the set.

Aerial Specifications.

To minimize the reception of static, the aerial conditions must be carefully controlled, even when static drains are employed. For summer reception, a low aerial not more than 25 or

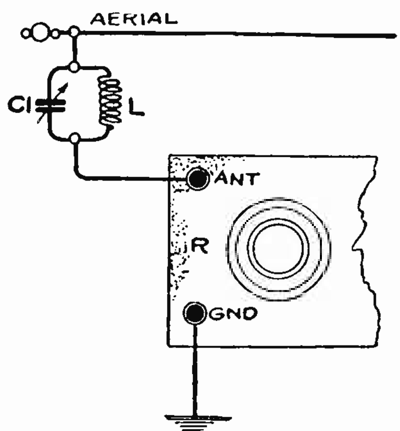

Fig. 4—Wave trap in series with aerial and ground.

30 feet above the ground should be used, since atmospheric potentials increase rapidly as the altitude. A single wire, not more than 50 ft. long, is the best, and while this may reduce the signal strength slightly, it decreases the static rapidly, thus giving a better signal static ratio than a longer aerial.

Inductive Type Reducers.

A type of tuned absorption reducer is frequently very successful in eliminating static, and it is easily adjusted to local conditions. This is a modified form of the type of trap already described. In addition to reducing static, this arrangement makes the receiver more selective. Figure 5 is a common form of coupler having an aperiodic primary, P, and the secondary, S, the latter being tuned as usual by the variable condenser, C1. This is a common unit which can be used to good advantage in some radio receiving sets.

Very loose coupling between the primary and secondary of the radio-frequency coils will, to a certain extent, eliminate noises and give selectivity, but it will reduce the signal strength slightly. The ratio of signal strength to static will be greatly improved. Shielding a radio receiver will also eliminate static to a certain extent.

Interference from Devices Outside the House.

Power lines and lightning arrestors used on same only cause interference when they are not in proper condition. It is only possible to eliminate the interference from such devices

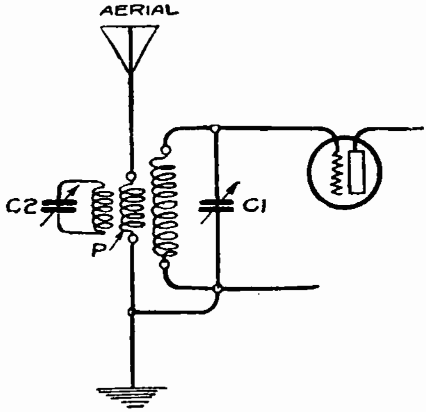

Fig. 5—Wave trap inductively coupled to a receiver.

merely by putting them in perfect order. It is also possible to eliminate, in part, the interference caused by arc light circuits, telephone and telegraph lines, electric street railways, farm lighting plants, etc. This is usually rather difficult and each individual case requires careful study by an expert or someone who has had previous experiences with that form of interference.

Some of these forms will be considered and whenever possible, a general solution will be given.

Power Circuits.

Lines. The electrical power system contains two varieties of transmission lines for connecting the customer with the generating apparatus.

Transmission lines comprise relatively large voltage circuits of long length and considerable energy which are susceptible to transient disturbances. The great length and large amount of energy carried by these lines makes any radio-frequency regeneration caused by them very serious. In general, it is only possible for the power lines themselves to cause interference when there is some defect, as an over voltage causing a discharge to take place at the surface of conductors, or by the line operating through a partial ground. Neither of these is a usual working condition.

In low voltage power lines, the factor of safety used in insulator installation is high. Practically the only possible source of interference is "arcing," due to defective insulation on the conductors themselves. In most cases, the interference is due to arcs, to trees through which the wires are run, to partial

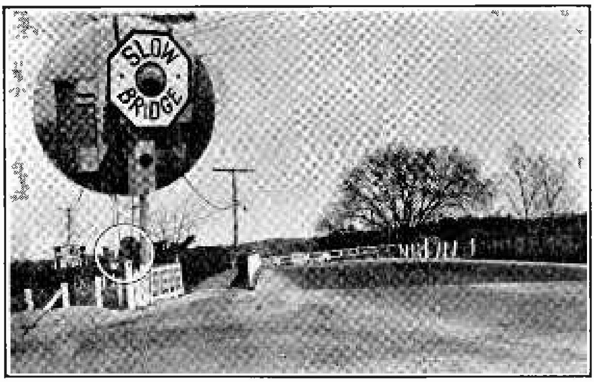

Fig. 6—Blinker causing interference.

contact with some other conductor running to ground, or to partial contact with a sheath or casing when the wires are run underground in conduit.

Insulators. In the case of transmission lines, defective insulators are quite often a source of interference. The arc or spark formed is due to either leakage along the core, a cracked porcelain, a low resistance path of ice or sleet, or a conductive coating on the surface. The high voltage arc generates a highly damped disturbance which travels for a considerable distance along the transmission line and sometimes it radiates to an appreciable extent.

A defective insulator which is simply leaking energy down the core and not spilling over, will tune to a very short wave-length and, generally, will not travel over more than one span, while if there is an external discharge, the whole line is excited, resulting in a long wave-length fundamental.

Lightning Arresters (Used on Power Lines).

The oxide film arrester consists of a number of plates operated and insulated from each other by a porcelain ring. The surface of these plates is covered with an insulating varnish and the space between filled with lead peroxide. When a lightning surge occurs on the power line, the varnish coating is punctured and the current drains to the ground through the resistance lead peroxide. The heat generated, however, changes the lead peroxide to red lead or litharge, a very high resistance conductor, so that the current flow is stopped. Accordingly, the breaking down of one of these arrestors will cause disturbance, for a short period, but normally no trouble will occur.

Transformers. Faulty transformers are sometimes to blame for grounded conditions. In case of defective insulation of winding or bad connections, very severe interference is generated, but as a rule, transformers are kept in good condition by the Power Companies.

Generators and Motors. The normal arcing of generators and motors will produce considerable interference with radio receivers located nearby, especially where there is close coupling to power leads leading direct from the generator. Usually the output from an A. C. generator is fed directly to step-up transformers which insulate the line from the radio-frequency disturbance. If bad arcing exists and the generator is directly connected to the line, the interference may travel over the entire line, or to the first transformer.

Induction Voltage Regulators. Induction voltage regulators are used where it is desired to have a constant voltage on a line which would otherwise have poor voltage regulation.

In order to make their operation automatic, it is necessary to use additional apparatus, consisting of a transformer, relay switch, line drop compensator, etc. All of the above mentioned parts are possible sources of radio disturbance due to poor contact or grounded windings and leads, resulting in the formation of an arc.

If the interference caused by the regulator can be detected, it is possible to by-pass the interfering energy to the ground by connecting two condensers, of approximately 1 mfd. each, in series with the outgoing feeders and then grounding the common connection of the condensers. If one side of the feeder is grounded, only one condenser is necessary.

STREET LIGHTING

Troubles on street lighting circuits are usually obvious as to their source, since they are experienced only during the hours the circuit is energized. The complaints assigned to this cause are in most cases due to slight grounds on the circuit such as tree grounds, touching of guy wires, the lead-in rubbing on a cross-arm or brace, grounds in the lamp itself, etc. Other sources of trouble may be a loose contact in the lamp, the bayonet holding a film cut-out, etc. The remedy in practically all cases is careful maintenance.

Improvement in the design of street lighting fixtures has cut them down as the sources of noise. If the series arc circuit

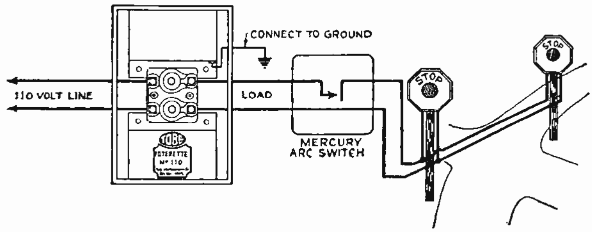

Fig. 7—Method of attaching filter to stop blinker interference.

is fed by mercury arc rectifiers or brush arc generators, serious radio disturbances may be produced along the circuit. When an abnormal vacuum is obtained in the tube, the mercury arc rectifier will generate high-frequency current. Condensers cannot be used, as they interfere with the normal operation of the rectifier, but choke coils of special design will eliminate the disturbance, as will replacement of the tube. Trouble from the brush arc generator, which is inherently a high-frequency source because of poor commutation, may also be eliminated by the use of chokes. If trouble is experienced on these types of equipment, the matter should be taken up with the power company.

Telephone and Telegraph Lines.

The wires used in telephone and telegraph communication carry such small amounts of energy that the condition of the lines themselves should never become sources of trouble.

Some of the equipment used in telegraph communication and for signalling purposes on telephone lines are productive of high-frequency waves. They radiate over their connecting lines, and where these are open wires, many homes may be affected. Ringing machines, lighting devices, automatic telegraph and tickers have been found to be sources of such disturbances. Because small currents are handled at low voltages, the elimination of radio noises traceable to this type of apparatus is comparatively easy. Proper chokes and filters have been developed and are now available to all communication utilities, although these have not been installed in every case.

ELECTRIC STREET RAILWAYS

Interference from this source presents a problem for which no really satisfactory solution has yet been found. Some suggestions are offered which will be found helpful.

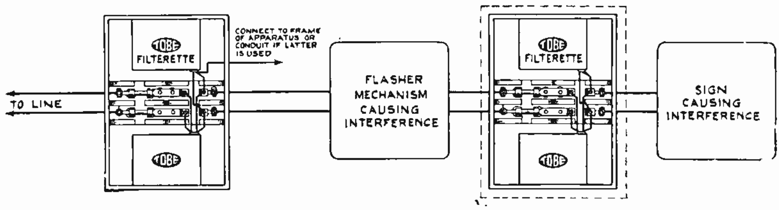

Fig. 8—Filters connected between line and flasher mechanism and also between sign and flasher mechanism to eliminate interference.

If the antenna is installed at the front of the building, facing the car lines, it should be shifted to the rear as far as possible. If conditions permit, it should be run at right angles to the line of interference. One or two feet variation in the plane will make a difference. We suggest when installing the aerial that one end of the horizontal portion be permanently fixed; the other end temporarily attached to a pole which may be carried backward and forward on the roof. In this way you are able to locate the position of minimum interference.

After noting the relative intensity of the interference at each setting, a permanent pole is fixed at the proper point. Remember that lighting and power circuits nearer the residence than the trolley feeders are involved in transferring the disturbance to the antenna, and distortion of direction is more or less bound to occur.

Sparks at the trolley wheel that cause clicking interference is another source of trouble. If the positive lead of the station generator goes direct to the trolley wire, interference will probably result. If this lead goes to the series field winding first, the free end of the series field going to the line, the choking effect of the coil tends to suppress any commutator interference.

Greater efforts are being made in every city to keep the rail bonding in good shape. More careful attention to car motors and equipment will tend to alleviate the situation.

Mechanical Interruptors.

Current interrupting devices are usually a source of radio disturbance. Many of these devices employ a high-voltage

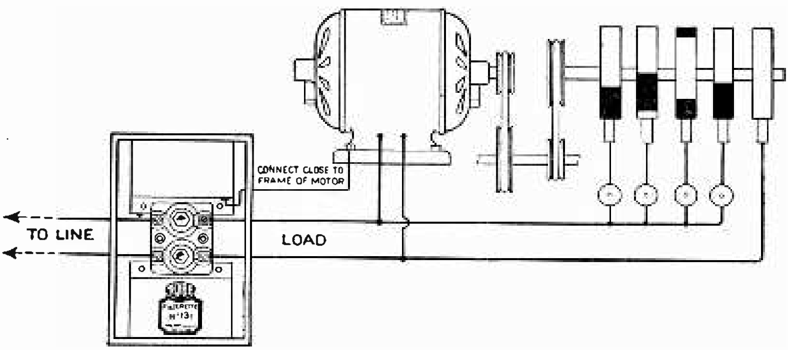

Fig. 9—Modern type of electric sign flasher, a common source of industrial interference, silenced with a filter designed for that purpose.

mechanical rectifying device which have in the past often been bad offenders against the radio public. The smaller vibrating or mechanical rectifiers used for battery charging are inherently a source of disturbance due to the vibrator contact or interruptor, which even with the best possible adjustment, will spark to a certain degree. A one-half mfd. condenser placed across the contact will usually lessen the disturbance; suitable chokes will eliminate it entirely.

Sign-flashing devices and light equipment are in the same class. The use of a condenser in the supply lead directly at the flasher mechanism will prevent the radio disturbance from spreading back over the supply wires if the latter is not too closely coupled with the wires extending from the flasher mechanism to the sign itself. This will not entirely prevent the disturbance from being received by nearby radio sets. The radiation from the vertical sign lead is appreciable unless they are inclosed in grounded piping.

Since the spark is generated by the make and break of each of the several contacts, riding on the rotating drum, a condenser should be placed across the common lead and each contact arm. A series choke should also be placed in each supply lead in order to entirely eliminate the disturbance.

Motors.

Commutators are always a possible source of trouble if allowed to accumulate dirt and their maintenance generally neglected. Apartment house elevator motors are often the cause of complaints, because of their proximity to receiving sets. An ordinary motor, well maintained, is seldom the source

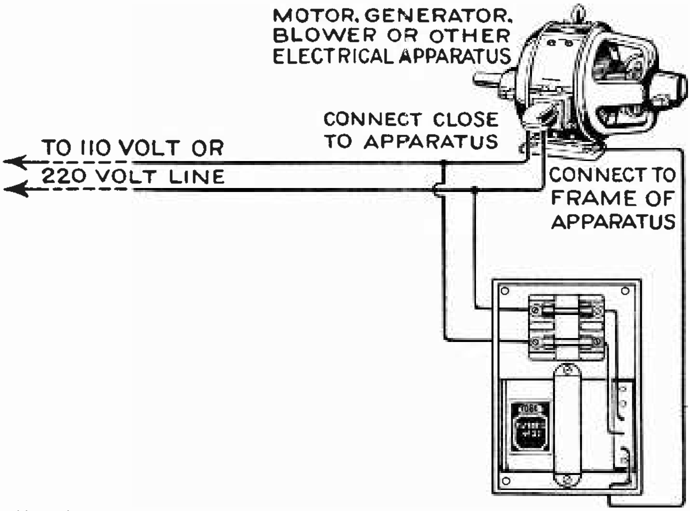

Fig. 10—Filter connected to motor, generator 110 or 220 volt AC or DC line.

of appreciable disturbance, except in the case of certain series motors and repulsion-induction motors, such as used in electric refrigerators and oil burners. These will be taken up under Household Appliances.

With the knowledge that practically all radio disturbances are caused by sparks, brush discharge, arcs and like phenomena, an endeavor should first be made to eliminate the cause. If this proves impracticable, recourse must be had to shields, chokes and condensers. The idea of the shield is self-explanatory, but complete shielding is expensive and should be adopted only as a last resort. Even with complete shielding, filter units are necessary in all leads entering the screened area. On the other hand, condensers are comparatively simple and inexpensive and they are usually the first remedial measure attempted. Care must always be taken to see that they are of the proper voltage rating. Usually two 1-mfd. condensers in series across the line with the midpoint grounded, offer the best solution. The ground leads should be as short and well grounded as possible, and attached to the frame of the apparatus causing trouble. For protection against short-circuiting the line if the condensers puncture, two fuses should be used. They are not necessary, however, if condensers of sufficiently high rating are used. In cases of severe disturbance, it is well to use choke coils in addition to condensers.

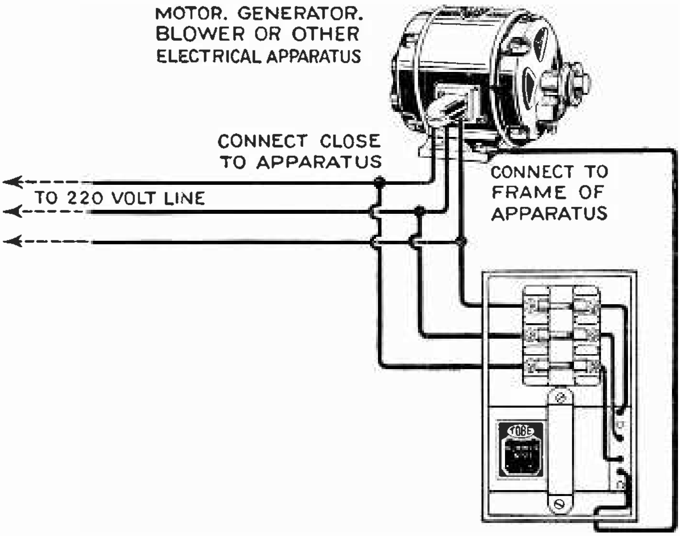

Fig. 11—Filter connected to motor, generator, where a three-wire system is used.

These chokes should, of course, be placed in series with each line of the supply circuit as close to the source of disturbance as possible, but beyond the condenser connections. A 2-millihenry choke is generally sufficient, though ones of larger inductance are occasionally necessary.

A 200-turn coil wound on a 3-inch non-metallic spool will give roughly 2 millihenries.

There are now on the market commercial filters of various kinds approved by the Fire Insurance Underwriters—their use is recommended both from an efficiency and safety standpoint.

Most of the public utility companies now employ trained radio men, whose duty it is to locate and remedy any interference caused by their apparatus. As this class of interference is beyond the control of the average Radio-Trician, it is well to take up in detail how to reduce the interference caused by our own household appliances.

INTERFERENCE FROM HOUSEHOLD APPLIANCES

In the succeeding pages, the interference caused by the use of household electrical appliances will be discussed and methods suggested for its elimination.

Let us consider for a moment the number of electrical appliances now in use in many homes which create interference with radio reception. In the basement, there may be an oil burning furnace with its electric motor and thermostatic control, an

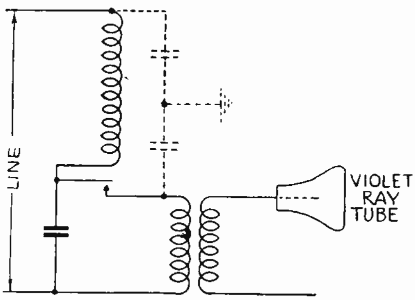

Fig. 12—Showing connections for condensers.

electric washing machine and ironing machine, and the motor and automatic starter for an electric refrigerator. In the kitchen, there may be an electric range, perculator, waffle iron and in some cases, an electric dish washer. In the living room, an electric heater, fan, and the Radio itself, perhaps an electric victrola. In the bedroom, there may be an electric curling iron, heating pad, electric hair drier, vibrator and massage machine, and the violet-ray machine. In the bathroom, various forms of electric water heaters. In another room, an electric sewing machine, vacuum cleaner, and various other household appliances. In the boys' room, an electric train and other small toys containing electric motors. The average home today also contains an increased number of electric lights, bridge lamps, table lamps, and numerous outlets, switches and other forms of sockets and conveniences. Of course, if every home contained all of these items, the interference created would be enough to render radio reception impossible. Since only some of these appliances create continuous interference and others create it when they are turned on or off, the situation at present is bearable.

We know that whenever we turn an electric light on or off or make or break any other electric circuit, we create a certain amount of interference, because when a spark occurs it is picked up by the set and can be heard in the loud-speaker.

Some forms of household appliances use a vibrating or thermostatic contact. Whenever the circuit is made or broken by such a contact, a high-frequency current is generated and a crash is heard in the loud-speaker. If the circuit is made or broken only once, only one crash will be heard. If the circuit is made and broken several hundred times per minute, a crash will be heard at each make and break of the circuit. These crashes can

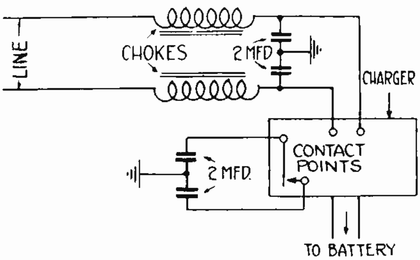

Fig. 13—Filter for charger.

be heard in the speaker regardless of whether or not there is any direct connection between the receiving set and the appliance.

Some means must be devised to prevent the high-frequency disturbance from traveling along the wiring system and being radiated, or the disturbance following the lines from the house to the power lines and being radiated over a wider area by the power mains. The real remedy lies in preventing this radiation by the main power lines as well as the household wiring. This can be done in most cases by means of a smaller filter and anti-sparking arrangement which is described later.

In the near future whenever a customer purchases an electrical appliance they will demand that the appliance must not create any disturbance which will interfere with either his own Radio reception, or that of his neighbor. The sooner we come to this condition, the better off we will all be. We will have the engineering forces of all the manufacturers competing with each other, and each will see that the article he manufactures will be equipped so as to prevent any disturbance which might affect Radio reception.

In the outline given herewith, the appliances have been divided into three types according to the following classification: a vibrating contact, electric motor, or a circuit made and broken only infrequently.

(A) Interference arising from appliances using vibrating contacts.

(a) Door-bells.
(b) Violet-ray outfits.
(c) Annunciator systems.
(d) Contacts on electric refrigerators.
(e) Contacts on oil burning furnaces.
(f) Heater pads.
(g) Vibrating storage battery chargers.
(h) Thermostatic contacts of various classes.

(B) Appliances using motors.

(a) Electric sewing machines.
(b) Electric vacuum cleaners.
(c) Electric refrigerators.
(d) Electric dish-washing machines.
(e) Electric oil burning furnaces.
(f) Electric washing and ironing machines.
(g) Electric fans.
(h) Electric hair driers.
(i) Electric vibrator or massaging machines.
(j) Electric toys.

(C) Miscellaneous sources of interference.

(a) Electric irons.
(b) Electric ranges.
(c) Electric percolators.
(d) Electric toasters.
(e) Electric waffle irons.
(f) Electric heaters.
(g) Electric curling irons.
(h) Electric water heaters.
(i) Electric pads.
(j) Electric switches, sockets and wherever current is turned on or off.

In order to determine whether or not the interference is coming from the electric light line, entirely disconnect the aerial and ground wires from the receiver. If the interference ceases, it is proof that it was picked up by the aerial or ground systems and not caused by the electric light line or any appliance connected to it. If the interference does not stop, it shows that the interference is caused by some appliance connected to the electric light line. All appliances in the house using electricity should then be disconnected. If the interference continues it shows that it is caused by some appliance not used in the house. By connecting one appliance at a time to the line and listening to see whether or not the interference is present will show definitely if the interference is caused by appliances used in the house.

Interference Arising From Appliances Using Vibrating Contacts.

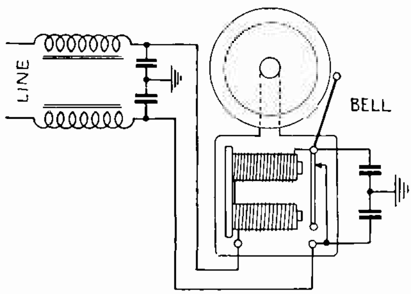

Fig. 14—Showing filter connected to an electric bell.

Experiments have been performed to determine the feasibility of eliminating all classes of interference caused by household electrical appliances. In most cases, it was possible to either eliminate the interference entirely or reduce it so that it was not noticeable. Various forms of filter arrangements were used, these being the most practical way of reducing or eliminating this form of interference. Such filters will be taken up later on.

The violet-ray presented the most difficult problem on account of the fact that we not only had a vibrating contact, but also a high-frequency current with which to deal. By shunting two condensers of 2 mfd. each, in series, across the vibrating contact and the induction coil (see Fig. 12 dotted lines), and grounding the center point of the condensers, a large portion of the interference was eliminated. All other filter arrangements reduced the interference to a certain extent, but as they reduced the strength of the violet-ray they could not be used.

All experiments were performed using a Super-heterodyne receiver operated by means of a "B" eliminator and deriving its power from the A. C. (alternating current) mains. The appliance, under consideration in each case, was plugged in at the same outlet. The high-frequency surges had as direct a connection as possible with the receiver, and could react directly on it, without having to travel through other parts of the wiring system.

A vibrating contact storage battery charger was found to create almost as much interference as the violet-ray. The charger was placed directly underneath the receiving set, and the interference was enough to overcome the signals from a local high powered Broadcasting Station. Nevertheless, it was found that

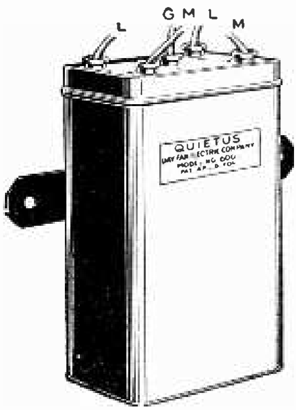

Fig. 15.

the interference could be entirely eliminated by using an arrangement shown in the diagram, Fig. 13.

The successful elimination of the interference caused by the charger led to other experiments on various classes of household appliances. In each case, it was found that by inserting a choke coil in each side of the line, and between the choke coils and the appliances two condensers connected in series, with the center point grounded, and the outside terminals connected to each side of the line, the interference could be entirely eliminated, or reduced to a point where it would not interfere with reception and could only be heard by listening very closely.

In some cases, it was found that it was necessary to shunt either one or two condensers, in series, across the vibrating contacts. When two condensers were used, the center point was grounded. This reduced sparking at the points and also provided a low reactance path to ground for all high-frequency current. By this means, the interference from a large bell or buzzer operated directly from the A. C. mains, and placed very near the receiving set, was entirely eliminated. See Fig. 14.

In a few cases, it was found that the frequency of the interference was changed and could be heard at another setting of the dial. However, either an increase or decrease in the size of the chokes would entirely remove the interference from the broadcast band, so that it could not be heard at any dial setting.

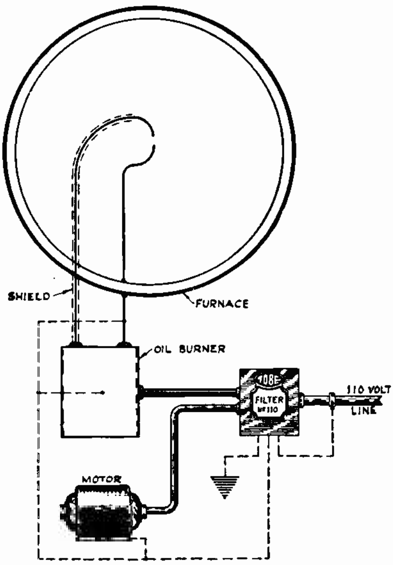

Fig. 15A—Filter used for suppressing Radio interference from oil burner having grounded ignition system.

APPLIANCES USING MOTORS

The interference arising from the use of an electric motor, can be classified either as a steady hum, or a sputtering, crackling noise, similar to static. It has been found that the sputtering or crackling noise is frequently due to sparking at the commutator. Fortunately, this form of interference can be easily eliminated, since it is due only to the rough surface of the commutator.

A small piece of fine sandpaper, about 00 grade, held against the commutator while the motor is running, will clean the commutator and decrease the amount of sparking. With the decrease in sparking, the interference will be eliminated. This is an easy method of eliminating this class of interference. About all that is necessary is to frequently examine the motor, see when excessive sparking is occurring and sand the commutator as above. When the owners of these motors realize that in order to prevent this form of interference, they must keep their equipment in good condition and go over it frequently. If one is not familiar with the apparatus, an expert from the Power and Light Company or from any Electrical Company, can perform the operation in a few minutes and at a very small cost.

The second form of interference, arising from the use of electric motors, the humming noise, cannot be prevented quite so easily. It can be effectively eliminated without a great deal

Fig. 16.

of expense. Several manufacturers have recently put out filter systems designed for this purpose and two such are illustrated in Fig. 15 and Fig. 16.

The filter shown in Fig. 15 is connected between the appliance and the line supplying it—that is, the terminals marked "M" should be connected to the line leading to the motor, and the terminals marked "L" to the supply line. The terminal marked "G" should be connected to the ground. This filter is not designed to be used with or connected to the receiving set, but only near an electric motor.

The Tobe filter shown in Fig. 16 is connected between the line and the appliance. The two left-hand posts marked "line" are connected directly to the electric light line supplying the appliance, and the two right-hand leads are connected to the appliance or motor. The center post is connected to the frame of the motor and the motor frame grounded.

This filter is suitable for use with all types of fractional horsepower motors consuming 8 amperes or less at 120 or 200 volts. As most motors used in household appliances are not larger than ¼ horsepower, this filter is very well suited for eliminating this class of interference.

Figure 17 illustrates a typical filter circuit used with electric motors. The two inductances shown, L1 and L2, are small iron core chokes of approximately 200 milli-henries each. The condensers, C1 and C2, should be at least 1 mfd. capacity or better yet, 2 mfd.

The function of the chokes is to prevent the disturbances created by the electric motor from entering the house wiring system and power lines and being radiated over a wide area.

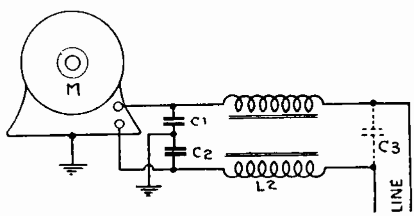

Fig. 17—Schematic diagram of Motor Filter System.

They prevent a high reactance to the flow of high-frequency current and effectively prevent it. By shunting the two condensers, C1 and C2, across the line, and connecting the center point to the ground, a low reactance path is provided for this high-frequency current to flow to the ground. The condenser shown as C3 in the diagram is not absolutely necessary and in most instances, it is not used. However, it is shown here as it sometimes helps in eliminating this type of interference.

For those who wish to "build their own," a description is given herewith. Each choke consists of a total of 176 turns of No. 16 DCC copper wire on a porcelain tube 1 inch in diameter, and approximately 6 inches long. They are layer wound with 88 turns to the layer—two layers being used, and one thickness of Empire cloth inserted between each layer of wire. The whole is given a good coat of insulating varnish when complete, with one layer of Empire cloth on the outside.

A small piece of ordinary stove pipe iron, about 18 gauge, is cut to form the core. It should be rolled and inserted in the porcelain tube in such a way as not to make a complete circle; that is, a small arc of at least 1/8 inch is left out. The iron should be approximately 5x3 inches to be used with the porcelain tube having an internal diameter of 1 inch. The condensers used should be preferably mica condenser of 2 mfd. each. However, a paper dielectric may be used, if the condensers are constructed so as to withstand the voltage. A very suitable condenser for this purpose is the WS-3735 condenser manufactured by the Wireless Specialty Company, or the Dublier No. 902-2 mfd. condenser.

The ordinary 1 mfd. condenser used in the receiving set is not suitable for this purpose, as it will not stand the voltage to which it will be subjected. Precaution must be taken in order

TABLE I.

Current Carrying Capacity of Copper Wire Used for Choke Coils.

American (B & S)	Amperes Allowed by Underwriters	
Wire Gauge	Rubber Covered	Other Insulation
18	3	5
16	6	10
14	15	20
12	20	25
10	25	30
8	35	50
6	50	70
4	70	90
3	80	100

to prevent these condensers from breaking down, and causing a short on the line. It is best to use a condenser having a much higher voltage rating than the voltage to which it will be subjected.

Whenever there is a permanent installation of a motor, such as in the electric refrigerator, the oil burning furnace, the washing machine, or elsewhere, one of these filters can be installed between the motor and the line. All that is necessary to do is to cut the leads running to the motor and insert the filter with the connections as shown in Fig. 17. The ground connection is attached to the water pipe system and the condenser side of the filter always goes next to the motor.

MISCELLANEOUS SOURCES OF INTERFERENCE

Under this heading, you will note that most of the household heating appliances are listed. Very little interference arises from this source, except when the circuit is made or broken. In some instances, a thermostatic attachment is used (see Fig. 18), whereby the circuit is made or broken automatically, of course, interference arises here because as previously stated, whenever an electric spark occurs, or a circuit is made or broken, a disturbance will be created which will be manifested by a crackling sound in the head-set or loud-speaker. It is possible to reduce this class of interference to a minimum, and several experiments have been performed in order to determine just how it could be eliminated.

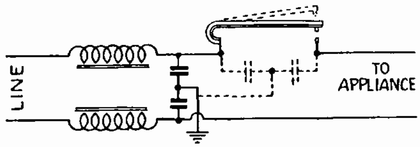

Fig. 18—Filter connections for Thermostatic contact.

nated. However, there are practical limits to installing some form of filter arrangement at every electric switch or plug. A diagram though is given herewith in order to show just how this can be accomplished. See Fig. 19.

The fundamental idea in reducing interference is to prevent the high-frequency disturbances from entering the power lines and being radiated by them. A great deal can be accomplished by inserting a filter on all of the permanent installations. A filter inserted near the meter will prevent disturbances from coming in on the line.

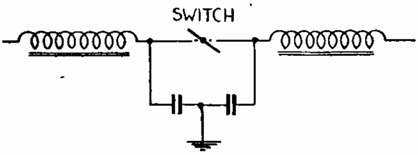

Fig. 19—Filter connections for a switch.

Such a filter is illustrated in Figs. 20 and 21. The chokes should consist of a total of 264 turns of No. 10 DCC wire on a tubing 2 inches inside diameter. The tubing should be bakelite or some non-combustible material. The wire should be wound in three layers of 88 turns each with two layers of Empire cloth between each layer of wire. After the winding is finished, the whole should be given a coat of insulating varnish. The winding form or tubing should be approximately 9 inches long and small feet are attached to each end for support. The core can be formed by rolling a piece of ordinary black sheet iron approximately 6x8 inches. It will then just fit on the inside of the form without the edges coming in contact and making a cylinder; that is, an air gap of $\frac{1}{4}$ inch should be allowed between the edges as shown in the diagram. The condensers should have mica insulation, and they should have a rating of at least 1 mfd. capacity, and perhaps 2 mfd. would be better.

Condensers having a rating of at least 1,000 volts should be used to prevent any short occurring in the line. The whole should be mounted in a steel cabinet such as specified by the Underwriters for switches, fuses, etc.

This filter will prevent to a certain extent any disturbances or interference arising from appliances used in the house from entering the power lines and being radiated over a wide area. It will also prevent to a certain extent, any disturbances arising

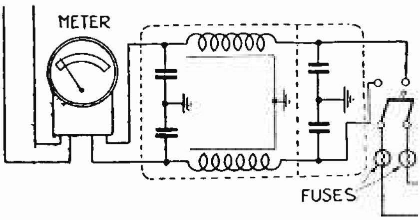

Fig. 20—Showing how filter circuit is connected to meter.

in the power lines from entering the house and being radiated by the house wiring system.

Before installing any of the filters described herein, it is advisable to consult the local power company for aid in making the installation.

FARM LIGHTING PLANTS

Interference from this source is confined to rural districts. The characteristic click, click, corresponding to the ignition spark, reveals the source at once. Trouble rarely originates from the commutator. This continuous clicking is very loud on nearby radio receivers, and because of the large number of plants in operation in communities not served by electric power companies, the total interference is very annoying.

Complete elimination of the disturbance created is relatively a simple matter. Nearly all these plants being bolted down to a wooden platform, are insulated from the ground. Two 2-mfd.

condensers in series, midpoint connected to the engine frame, and bridged across the outgoing D. C. feeder, will clear up the clicking. Ground connection of the series wire should not be

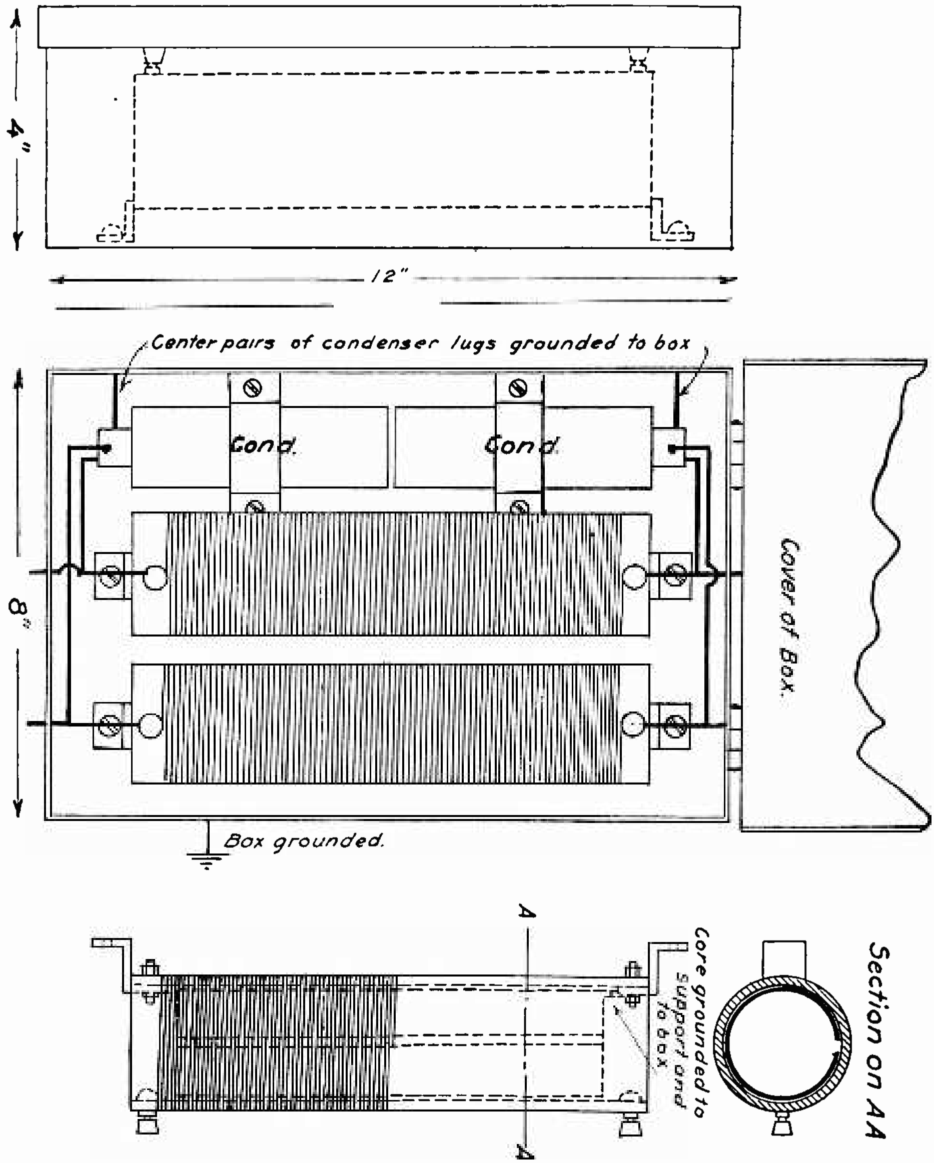

Fig. 21

made to a water pipe or earth rod in this case. Even 1-mfd. condensers will be found suitable for small plants.

If the engine bed is of concrete or the plant is grounded in some other way, complete elimination is not obtained by the above method, although the reduction (about 80%) is material. The remaining interference is not likely to be serious. Where it is desired to clear this out choke coils should prove effective.

It is not uncommon to find the exhaust pipes of such plants

TABLE II.
Commercial Filtering Devices
(TOBE FILTERETTES)

MODEL	Applications for Filterette	Capacity
Junior	Small motors, as on: barbers' clippers, cash registers, hair dryers, electric fans, vacuum cleaners, and similar devices.	110 Volts D.C. or A.C. 500 Watts
No. 10	D.C. motors, generators, chargers, house lighting plants, etc.	110 Volts D.C. 5000 Watts
No. 11	Motors, generators, chargers, transformers, house lighting plants, etc.	110 Volts D.C. or A.C. 5000 Watts
No. 20	D.C. Motors, generators, chargers, house lighting plants, etc.	220 Volts D.C. 10,000 Watts
No. 22	Motors, generators, chargers, transformers, house lighting plants, etc.	220 Volts A.C. or D.C. 10,000 Watts
No. 23	Same as No. 22, but where three wires are required instead of two.	3 phase 220 Volts A.C. Single phase 110-220 Volts A.C. 3 wire 110-220 Volts D.C. 15,000 Watts
No. 55	Motors, and any other apparatus operating on 440 or 550 volts A.C.	440-550 Volts A.C. 25,000 Watts
No. 56	Same as No. 55, but where three wires are required instead of two.	3 phase 440-550 Volts A.C. 30,000 Watts
No. 60	Motors, generators, chargers, house lighting plants, etc.	600 Volts D.C. 25,000 Watts
No. 110	Refrigerators, oil burners, chargers, dental motors, electric heating pads, small electric signs or blinkers, and any type of apparatus within maximum potential named. Also properly shielded violet-ray or diathermy apparatus.	110 Volts A.C. or D.C. 500 Watts Maximum current 5 Amperes
No. 221	Same as No. 110.	220 Volts A.C. or D.C. 1000 Watts—5 Amperes

TOBE FILTERETTES FOR MOTOR DRIVEN SIGN FLASHERS
(Maximum potential 110 volts A.C. or D.C.

No.	Maximum Cur.	Maximum Load	Outside dimensions
131		1,000 watts	13″x9⅜″x3⅛″
132	20 amperes	2,000 watts	13″x9⅜″x4⅛″
133	30 amperes	3,000 watts	19″x12⅜″x4⅛″
134	40 amperes	4,000 watts	19″x12⅜″x4⅛″
135	50 amperes	5,000 watts	19″x12⅜″x4⅛″

carried to a muffler drum in the ground. Such a connection to earth offsets the effect of the condensers and more satisfactory results will be obtained if this pipe is cut and a section of asbestos or other suitable piping is inserted.

In all cases attachment of the condensers is made at the switchboard, under the same terminals to which the two lighting mains are connected.

TEST QUESTIONS

Number your Answer Sheet 29—1 and add your **Student Number.**

Never hold up one set of lesson answers until you have another set ready to send in. Send each lesson in by itself before you start on the next lesson. In that way we will be able to work together much more closely, you'll get more out of your course, and better lesson service.

1. What are the two methods for suppressing Radio interference due to sparking electrical apparatus?
2. What apparatus is necessary to locate any interference caused by electrical apparatus?
3. Draw a diagram showing how to install a simple anti-static device in a receiving aerial.
4. What effect will reducing the size of the aerial have on the strength of the in-coming signals?
5. Draw a diagram of a wave trap that can be used with a receiving set.
6. What is the advantage of using a wave trap?
7. Do motors having their commutators and brushes in good condition cause interference with Radio reception?
8. How would you clean the commutator of a motor to prevent sparking?
9. Draw a diagram showing how to connect a filter to a motor.
10. Give the dimensions for building a choke coil suitable for an electric motor.

RADIO BY MAIL

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