HOW TO ELIMINATE MAN-MADE INTERFERENCE

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PIONEER HOME STUDY RADIO SCHOOL

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STUDY SCHEDULE NO. 46

For each study step, read the assigned pages first at your usual speed, then reread slowly one or more times. Finish with one quick reading to fix the important facts firmly in your mind. Study each other step in this same way.

☐ **4. Answer Lesson Questions and Mail Your Answers to NRI for Grading.**

☐ **5. Start Studying the Next Lesson.**

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How To Eliminate Man-Made Interference

A GROWING PROBLEM

THE radio public is today being supplied with receivers of greater sensitivity than ever before; short-wave reception of foreign as well as local programs is an accepted feature of the modern home receiver, and listeners are gradually becoming conscious of the superior performance of high fidelity receivers. These three important factors make the problem of man-made interference more and more important as new receivers reach the hands of the public.

Radio receiver manufacturers are now capable of building receivers which create only a negligible amount of interference within themselves; older receivers which develop internal noise can readily be repaired by the Radio-Trician, but still program-spoiling interference increases.

Oil burners, electric power-generating systems, refrigerators, motor-driven appliances, medical equipment, electric signs and scores of other new electrical appliances are man's contributions to radio receiver interference. Thus man creates more interference at the same time that he builds radio receivers which are more sensitive to interference; profitable work for the serviceman trained in interference elimination is the result. Remember that no radio installation is complete and satisfactory until it is as free from interference as is humanly possible. The man who can render this interference elimination service efficiently and intelligently will "cash in" on an opportunity for profit and prestige which grows bigger every day.

NOISE NOT DUE TO RECEIVER DEFECTS

We know that when noise is heard in a receiver, the first step is to eliminate receiver defects as possible causes of the trouble. A line filter is inserted in the power line of the receiver, the antenna and ground leads are disconnected from the receiver, and antenna and ground binding posts are shorted together; if, when this is done, the noise disappears or is reduced an appreciable amount, the trouble is definitely not a receiver defect. It is, therefore, an external disturbance which can or cannot be eliminated, depending upon its nature.

External noise disturbances which cannot be eliminated may be divided into two groups: (1), those due to *local* electrical storms or lightning; (2), those due to the accumulated effects of distant electrical storms, sun disturbances and disturbances created by distant industrial or electro-medical equipment.

The new frequency modulation system of broadcasting almost completely eliminates atmospheric interference, but both broadcasting systems (f.m. and a.m.) have serious man-made interference problems.

The accumulated noise disturbance is often referred to as background noise; * this has a definite level (microvolts per meter) which will vary with the antenna location. Industrial towns and cities will usually have a high noise level, this being exceptionally high near factories and shopping centers. The only remedy in such cases is to cut down the sensitivity of the receiver or confine tuning to broadcasts whose intensities are much greater than the noise level. In localities of high noise level the customer should be taught to listen only to local or high-powered stations.

When receivers having automatic volume control are tuned off a broadcast signal, the AVC acts to boost the gain, and background noise becomes disturbingly prominent. This has led to the development and use of inter-carrier noise suppressors, found on a number of receivers.

Man-made static, usually of local origin and having an intensity comparable with that of the normal received signal, is often so annoying that the usefulness of a receiver is destroyed. It is the purpose of this text to show the origin of such disturbances and suggest ways and means of eliminating or at least greatly reducing such interference. The "cure" is generally applied in two steps: first, by seeking to keep the noise signal out of the receiver; and second, by "killing" the interference at its source.

ORIGIN AND NATURE OF NOISE SIGNALS

Wherever there is an electric spark or arc, there you will find a source of possible noise interference. The spark need not be large or even visible to create a disturbing effect. Contrary to general belief, the spark itself does not radiate interference, nor is it generally true that the spark creates a broadcast band radiation.

*** This background noise should not be confused with noise originating within the receiver due to thermal agitation of the electrons in the conductors and to the impact or shot effect of electrons as they hit the plates of vacuum tubes. It is this noise which is heard when antenna and ground terminals of a high quality receiver are shorted and the gain turned up.**

A spark is accompanied by a sudden current change in the circuit where it originates, the change being transmitted to all parts of the circuit. This sharp current change gives rise to a fundamental audio frequency noise signal whose frequency depends upon the duration of a single disturbance, and a large number of audio and super-audio frequency harmonics of this fundamental. These noise signals may reach the receiver by conductive, magnetic or capacitive coupling, and may either affect the audio stages directly or, more likely, enter a resonant R.F. circuit. The latter is more troublesome, for through shock-excitation it results in the formation of an R.F. current which is modulated with the original noise signal. Because the original noise signal wave form is not destroyed or altered, the expert is usually able to judge, after listening to the noise emitted from the loudspeaker, what the probable source of interference may be.

When a spark occurs in an electric circuit, the current surge is transmitted through the connecting wires, away from the origin of the spark, in both directions * and out of phase. In a power transmission circuit this means that a large area—several blocks—will be affected. This disturbance will continue to travel until it is dissipated by the system. If the circuit contains transformers or other circuit-changing components, part of the disturbance will be reflected back to the origin at the first of these points, be reflected again at the disturbance source, and continue to travel back and forth until the losses in the circuit wipe out the disturbance. The remainder of the surge passes through the first obstacle and out over the line to the next, where it in turn is partially reflected, partially transmitted.

Whenever the surge of current meets an electrical obstacle in the line, be it a transformer, a change in wiring construction, or even a noise-eliminating filter introduced into the line improperly by an untrained radio man, the surge moves back and forth between its origin and this point, creating a standing wave or ultra high frequency oscillation whose frequency is determined by the line length. This wave is radiated through space in much the same way that R.F. currents are radiated by a transmitter antenna.

Sparks in auto ignition systems are typical examples; because the ignition wires are short, the natural wavelength of the radiation is somewhere between 1 and 10 meters. This explains why 5 to 10 meter ultra short-wave reception is so greatly affected by auto ignition disturbance.

*** If you were to drop a stone in a long trough filled with water, the disturbance would likewise travel away from the source to both ends of the trough, and then would be reflected back to the origin of the disturbance.**

Bear in mind that a spark or arc produces a current surge or impulse which is fundamentally of an A.F. or super-audio frequency. Because the circuit in which this impulse is created has reflecting points ultra high frequency radiations are produced. The original A.F. impulse currents, flowing along the transmission lines, also produce strong magnetic and electrostatic lines of force which may travel an appreciable distance through space. Magnetic and electrostatic interference fields of this nature get into the radio receiver through the aerial and ground, over the power supply lines or directly through the chassis. As these impulse fields induce strong impulse voltages in the R.F. or I.F. oscillatory circuits, forced oscillations modulated by the original noise currents are produced.

A study of Fig. *1*, which shows a typical "man-made static" problem, will bring out many of the facts just discussed. An electric motor, located in a house, is sparking at *S*, one of the brushes. Impulse current, therefore, passes out of the feeder line to points marked *1*, where a part divides to flow to points *2* and *4*, and the remainder is reflected back to the motor to produce a radiation whose wavelength is determined by the distance between *S* and *1*. At point *2* the impulse current will again divide, a part going to house *B* before being reflected back. The radio antenna on house *B* picks up noise radiation from all electric wires in the house and from the power line system, and the radio receiver itself receives the impulse current directly through the power line. A radio in house *B*, therefore, picks up more interference than a radio in house *C*, which is unwired and therefore receives noise signals only through space.

It would appear that because of the parallel power leads in this system, out-of-phase impulse currents in the two wires would produce canceling fields. This is not true, because spark *S* is rarely produced in the electrical center of the disturbing device. In this example, where sparking is occurring at one brush, one impulse passes directly into the line while the other passes through the armature and the other brush first. The inductance of the armature thus reduces the strength of one of the impulse current signals and prevents cancellation of the currents. It is safe to say that any line which is connected electrically to a spark source will send out an interfering induction field.

Reflection of the current impulses at points *1*, *2*, *3*, and *4* produces standing waves on the line; radio waves modulated with noise signals are, therefore, radiated by the line to create troublesome interference in all-wave receivers.

REDUCING MAN-MADE INTERFERENCE

In tackling any interference-elimination job, the practical aspects of the problem must be carefully considered, and even human nature itself must not be overlooked. Broadly speaking, however, the interference-eliminating procedure may be divided as follows: *1*, eliminate or reduce the sparking, if possible; *2*, prevent the interfering current impulses from leaving the disturbing device; *3*, prevent the various interfering signals from reaching and affecting the radio receiver. It is generally conceded that elimination of interference at its source is the best procedure, but in cases where this is impractical, filters and other devices which will keep the signal out of the radio receiver must be used.

Reducing the interference at its source is not always the simplest procedure, nor is it always permitted by the owner of the disturbing device. If a customer calls you on an interference job and you can directly trace the trouble to some device in the customer's home, the logical procedure is to kill the interference at its source. On the other hand, where your tests show that the interference is being created outside of the customer's home, you must decide whether to search for the location of the interfering device or prevent the interference from affecting your customer's receiver; remember that once a disturbing device is located you must convince its owner that there is a need for interference-eliminating work, and that this work will make his own receiver more free from interference.

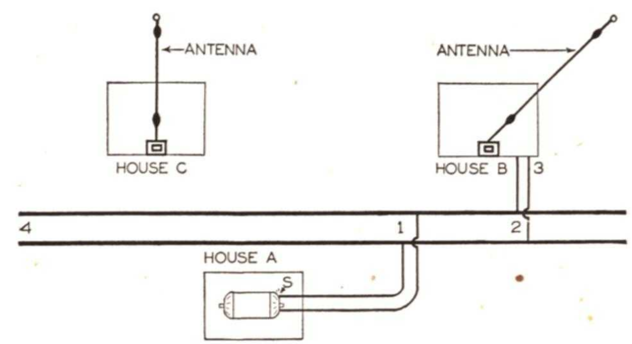


FIG. 1. Diagram illustrating how interference created by sparking brush *S* on motor in house *A* can reach radio sets in vicinity.

After proving to yourself that the chassis of the receiver in question is not picking up noise directly (which of course includes trying a line filter to prove that the interference is not coming in over the power line), your next important move is to install a noise-reducing antenna. You cannot, of course, guarantee that this will entirely eliminate noise interference troubles in the receiver, but you can be sure that it will improve radio reception as well as give a worth-while reduction in interference pick-up. Always make this perfectly clear to a customer who is ordering a noise-reducing antenna. Then, if the antenna fails in its primary purpose, you will not be blamed by the customer for something which is beyond your control, and you will be allowed to tackle the more difficult procedure of locating and eliminating the source of interference.

NOISE-REDUCING ANTENNAS

You are already sufficiently familiar with noise-reducing antennas, so they will not be discussed in detail in this lesson. The type of antenna which you select for a job depends upon the type of receiver encountered, the antenna location, and to some extent upon your personal preferences gained through experience with the products of different manufacturers. An all-wave receiver calls for an all-wave antenna, while a broadcast band antenna should be put up where only American broadcast band stations are to be received. The length of the antenna and lead-in wires will vary according to the space available.

The effectiveness of any noise-reducing antenna depends upon your ability to locate this antenna in a position where it will pick up a minimum of noise interference. You can determine the ideal position with a battery receiver, using a loop or pole antenna and moving the set about until you locate a zone where the least noise is heard, but these three general rules for locating noise-reducing antennas will often allow you to "spot" a good location at a glance: *1,* Place the antenna as high as is reasonably possible, keeping all unshielded vertical wires short; *2,* keep the horizontal or straightaway portion of the antenna at a maximum distance from known sources of interference; *3,* place the horizontal portion at right angles to nearby trolley lines, main power lines or transmission lines. The antenna on house *C* in Fig. *1,* for example, is at right angles to the main power line running from points 2 to 4; the antenna on house *B* is not at right angles to this line, and is, according to the general rule, incorrectly placed. This antenna may actually give better results than an antenna which is perpendicular to the power line, for oftentimes interference radiated from various points will cancel itself in certain regions. If an antenna erected according to general rules fails to reduce the noise sufficiently.

try it in various directions. An antenna located in a noise-free zone, with the shielded or twisted leads correctly balanced and grounded, may be expected to prevent pick-up of noise signals.

In a few instances it may be necessary to locate the exposed portion of the antenna at distances as great as 1,000 feet from the receiver, in order to get the antenna into a noise-free zone. Very little signal strength is lost by a long lead-in such as this, provided that both the antenna and the receiver are correctly impedance-matched to the lead-in, using shielded R.F. transformers for this purpose. Quite often, as in locations near railroad tracks along which run high tension power lines, or in locations near high power cross-country transmission lines, the placing of the antenna at a remote point is the only practical solution to the problem of interference elimination.

SUPPRESSING NOISE AT THE SOURCE

Assuming for the moment that the disturbing device has been located, you will invariably find it to be a spark, an arc or a rubbing condition. (All conductors such as pipes in homes acquire electrical charges; rubbing together of two of these pipes results in current impulses which cause interference.) If the spark or arc is not essential to the operation of the device, it should be eliminated or reduced in intensity. Rubbing parts should either be completely insulated from each other or bonded together with flexible metallic braid or stranded wire.

When the sparking can neither be eliminated nor reduced, the logical procedure is to prevent the current impulses from flowing any distance away from the device. For this purpose filters consisting of condensers alone, or combinations of condensers with choke coils, are available and in general use. The correct sizes for these condensers and choke coils are usually quite difficult to determine in advance: it is necessary to try different values and use the smallest electrical sizes which satisfactorily stop the interference.

The most commonly used coil-and-condenser combinations for filtering or blocking impulse currents are shown in Fig. *2.* That shown at *A,* consisting simply of a condenser connected across the power line as close as possible to the noise source, is often quite effective as a filter. The shunt capacity provides a low impedance path back to the noise source for the high frequency component of the impulse current, lessening the tendency for this current to flow out over the power line. When this condenser is installed on a vacuum cleaner, for example, it should preferably be connected to the terminals of the motor and not across the outlet plug terminals on the wall. If possible, try grounding the metal frame of the offending device; a *short* ground lead oftentimes reduces interference appreciably. All condensers used for filtering purposes on 110- or 220-volt A.C. power lines should have peak voltage ratings of between 600 and 1,000 volts, for these units must withstand high voltage surges caused by impulse currents.

When trying various filter combinations, it is important that some one listen to the receiver to note the effectiveness of each combination when the disturbing device is not within "ear shot" of the receiver. Oftentimes the customer will be only too glad to listen to the receiver for you, but better results can generally be obtained with a trained assistant. If you are working alone, it is wise to set up a portable battery receiver near the location of the disturbing device, using headphones rather than a loudspeaker if the interference noise proves too annoying to those nearby.

With the filter shown at *A* in Fig. *2*, there is no assurance that the impulse currents will pass to ground; the balanced condenser filter, having its center points grounded as shown at *B*, is therefore more effective.

When condensers of a reasonably high capacity, such as 1-mfd. units, fail to give satisfactory noise reduction when used alone, a combination condenser-and-choke filter like that shown at *C* should be tried. This is essentially a brute filter which allows only very low frequency currents to pass through to the power line. The higher the electrical values of the coil and condenser, the better is the filtering action. Always use the smallest commercially available size which gives satisfactory results, for purposes of economy. The condenser may be connected either to the load side of the choke coil (*C*) or to the line side of the choke coil (*D*). As a rule, however, the closer the choke is to the source of interference (*D*), the better is the impulse filtering action. Try the choke coil in one power lead first, then the other, to ascertain which position gives the better reduction in noise.

Two choke coils and one condenser connected either as at *E* or *F* will often give improved results, while the grounded combinations shown at *G, H* and *I* are even better filter combinations. Where several different parts of a device are sparking, such as in commutator type switches for signs or groups of contacts on a relay, then each line which carries impulse currents should be filtered in the manner shown at *J*. A choke coil is inserted in each line, and a suitable condenser connected from the load side of each line to ground.

Improved suppression of interference is often obtained by using a balanced filter having a ground connection which can be electrically varied in the manner shown at *K;* this circuit is otherwise essentially the same as those shown at *G* and *H*. The same balancing scheme can be used with the simple two-condenser filter shown at *B;* a 100-ohm potentiometer, with its variable tap grounded, is connected between the two condensers.

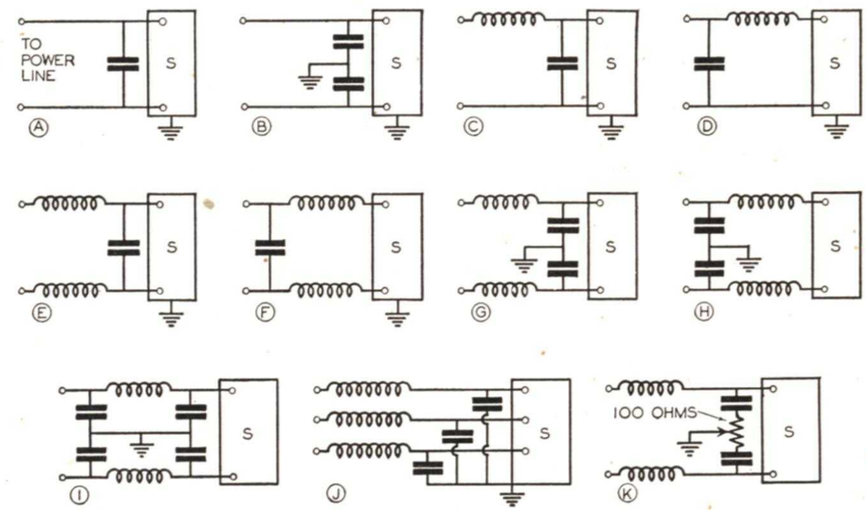


FIG. 2. Condenser filters and condenser-coil filters are here arranged approximately in the order of their effectiveness, the circuit at *I* being the most effective for interference eliminating purposes. Circuit *J* is used with devices which have three make-and-break contacts or with a three-phase load, while circuit *K* is a variation of circuit *G*, which permits adjustment of the ground point. Grounding of *S*, the disturbing device, is optional in circuits *A* through *F*.

A TEST DEVICE FOR DETERMINING THE MOST EFFECTIVE FILTER

Any serviceman, having located an interference-producing device, can almost always secure an effective cure by installing an expensive filter like that shown at *I* in Fig. *2*. But cost to the customer must also be considered in a successful noise elimination job. If noise-free reception costs too much, many people will forego the use of their receivers or endure the noise, rather than pay the price; this is clearly not an encouraging condition for the radio sales and service business. Experience has proven that a satisfactory job done at the lowest possible cost to the customer—a charge which gives a fair profit—is one of the most important requirements for success in radio servicing. This means that the simplest and lowest cost filtering devices should always be tried first, working up gradually to the more complicated and more expensive combinations until the lowest cost unit is found which gives satisfactory filtering.

A variable filter combination system which gives a choice of circuit combination *A, B, C, D, G* or *H* in Fig. *2* simply by changing the setting of a rotary switch and changing connections to the unit is shown schematically in Fig. *3.* All condensers used here should preferably have working voltage ratings of between 600 and 1,000 volts, while the choke coils should be capable of handling at least 5 amperes. Use non-inductive paper type condensers mounted in metal cases which can be grounded. Notice that two outlet receptacles, each having a plug-in cap with insulated alligator clips attached to flexible leads, are used for the input and output connections. A ground connection is made by means of a flexible lead having at one end a prong

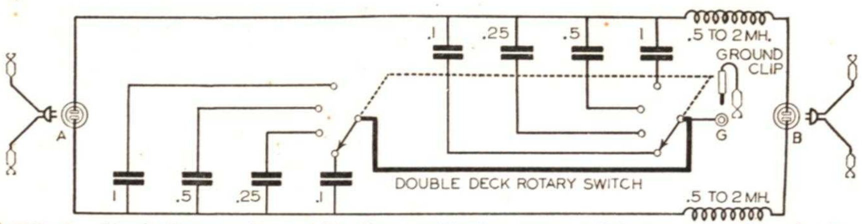


FIG. 3. Circuit diagram of a variable filter combination system which you can easily make for use in determining the most effective filter combination for an interference-creating device. Connections are made by plugging into standard electrical receptacles at *A* and *B*, and by plugging test prong into pup jack *G*. Mount parts in box of convenient size. Be sure power is off before making connections. The filter circuits provided here are those most generally used.

which plugs into a "pup" jack on the unit; at the other end of this lead is an alligator clip which is to be attached to the frame of the interfering device or to a grounded object.

When side *A* of this variable filter circuit is connected to the offending device, the condensers are next to the source of noise; when side *B* is connected to the device, the choke coils are closest to the source of noise. Single condenser connections and single choke and condenser filters are obtained by using one lead at *A,* one at *B* and the ground connection. When using condensers alone, always start with the lowest capacity, increasing the capacity up to 1 mfd. before resorting to choke coils. In making this test filter, be sure to use only those parts which can be readily obtained from radio supply houses at any time, for once the best filter setting is found, you must duplicate the parts used at that setting.

The method just described for using a variable filter combination

system to determine the correct filter for a given job was first introduced by the Sprague Products Company; the interference analyzer which they developed for this purpose is shown in Fig. *4A,* while the circuit diagram of their analyzer appears in Fig. *4B.* This device is used in much the same way as that which was just described. The condensers and choke coils used in the Sprague Analyzer are exactly the same as the units supplied by the Sprague Products Company for use in interference filters; several of these are shown in Fig. *5.* The choke coil is capable of handling currents up to 10 amperes; where larger currents must be filtered, larger capacity chokes can be obtained.

When the condensers and choke coils required for a noise elimina-

COURTESY SPRAGUE PRODUCTS CO.

FIG. 4A. This Sprague Interference Analyzer is one of the serviceman's most effective weapons in the war against man-made radio interference. The knob on top controls the circuit-selecting rotary switch.

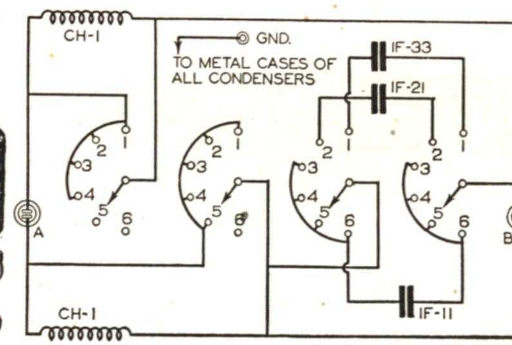
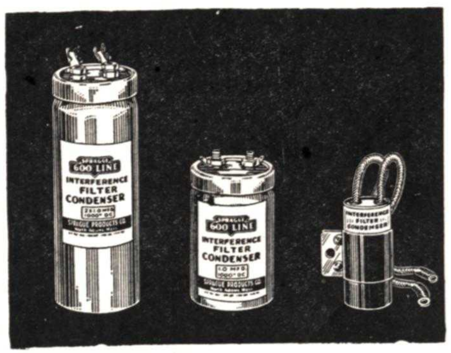


FIG. 4B. Circuit diagram of Sprague Interference Analyzer; numbers alongside condensers and choke coils refer to special interference elimination condensers and chokes sold by the Sprague Products Company, and shown in Fig. 5. A four-deck switch with six contacts per deck gives six different combinations of filtering units. Connections are made by inserting standard connecting plugs into the receptacles at A and B, and by plugging a test prong into the pup jack marked GND. Condenser IF-11 is of the dual-unit type, with the metal case serving as the common grounded connection. Positions 3 to 6 give balanced condenser filters.

tion job cannot be readily installed inside or on the disturbing device, it is wise from the standpoint of eliminating fire hazards, securing a shock-proof installation and improving the general appearance of the installation, to mount the condensers and chokes in a standard electrical cut-out box such as is shown in Fig. *6.* This procedure is compulsory for heavy-duty electrical devices which must pass fire underwriters' specifications and the regulations of local electrical inspectors.

As you already know, a filter unit must be placed as close as possible to the source of sparking if it is to be effective in reducing noise. When a cut-out box is used, the leads connecting it to the source of disturbance should be run through BX conduit or iron pipes, this conduit being permanently clamped at one end to the cut-out box and at the other end to the disturbing device; if necessary, a separate ground wire should be clamped or soldered to the conduit. This shielding procedure will prevent the standing waves, formed on the connecting wires, from radiating modulated disturbance waves of low wavelengths, which might cause interference in ultra high frequency receivers.

As a rule, interference filters have little effect upon the sparking or arcing itself, and serve only to prevent the current impulses from getting into the power line. Quite often the sparking at relay contacts, switch contacts and other make-and-break contacts can be greatly reduced by using a resistor in series with a single filter condenser connected across the spark source. This connection is especially



Courtesy Sprague Products Co.

FIG. 5. Typical interference elimination units. Left to right: Sprague Type IF-11 dual 1 mfd., 600 volt condenser with metal can serving as common terminal; Sprague Type IF-50 single 1 mfd., 1,000 volt condenser unit with two terminals; Sprague Type IF-33, 1,000 volt rating condenser with two flexible leads, available in two capacities; Sprague Type CH-1 special interference eliminating choke coil (above), rated to carry 10 amperes and mounted in a metal case which should always be grounded.

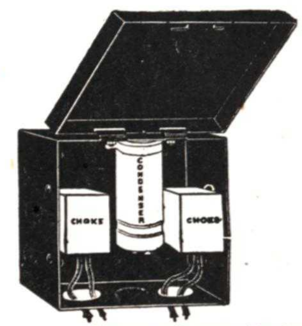
worthwhile if you wish to prevent sparking contacts from pitting badly and producing even more serious disturbances at a later date.

THE NOISE DETECTIVE

You now know what to do once an interference-producing device is located; locating the offending device itself is another problem, however, and one which often calls for systematic thinking and even detective work. A well-trained interference-elimination technician can listen to the noise coming in over a radio receiver, ask a few questions of the customer and from these observations get clues which will permit rapid isolation of the offending device. Just as a detective asks questions when searching for a criminal, so should the Radio-Trician ask questions when on an interference job. When was the noise last heard? At what time of the day or night is it usually heard? Is the noise always the same in character? When was the

noise first heard? These are questions whose answers may give you clues to the solution of the problem. The opinion of the customer as to the source of the trouble is also of value. Ask if the noise began about the time that some one in the neighborhood bought an electric refrigerator, a vacuum cleaner, fruit juice extractor, or other electrical appliance; try to associate the beginning of the interference noise with the arrival of a new neighbor, the installation of traffic lights at the corner, or the installation of a new neon sign in a nearby store. Neighborhood gossip can provide useful tips for the noise detective.

The value of knowing the time when interference noises are heard can easily be demonstrated. For example, interference heard for a



Courtesy Sprague Products Co.

FIG. 6A. The required combination of interference eliminating chokes and condensers should be mounted in a steel cut-out box like this, with all wires to the sparking device being run through BX conduit or pipe to meet fire underwriters' regulations and give a more efficient installation.

FIG. 6B. Another arrangement of filter units in a steel cut-out box. It is a good practice to place a fuse in series with each condenser, as is done here, for breakdown and short-circuiting of a condenser would otherwise place a direct short across the power line.

little while around breakfast time and perhaps occasionally late in the evening at a time when you know that the neighbors are having a party, may be produced by a fruit juice extractor; noise heard at intervals fifteen to thirty minutes apart may be due to an oil burner, a refrigerator, an air compressor in a nearby beer parlor or any other device which is operated only for short periods of time and is automatically controlled. Interference which is heard only when a street car or train is passing near the house gives an obvious clue; interference heard in apartments when the elevator is in operation proves that the trouble is in the elevator motor. Clicking noises heard when lights are turned on in the house tell their story at once. Your questioning of the customer, once you suspect a possible cause of the trouble by listening to the noise yourself, should result in a quick isolation.

If the interference can be picked up by the radio receiver at the time when you call, give special attention to any peculiarities of the sound; note whether the interference is heard with the same intensity at all frequencies. With a little experience you will be able to make very good guesses as to the causes of different types of interference noises. Until you have gained this experience, use the following suggestions which have been prepared by the Tobe Deutschmann Corporation of Canton, Massachusetts, as your guide in recognizing the sources of interference noise which you hear.

Whirring, crackling, buzzing, humming, droning and *whining* sounds are characteristic of motors and generators. When motors start, the pitch of the whine increases until it reaches a steady value. This is especially true of commutator type motors. Repulsion starting single-phase induction motors may have a sputtering, whirring, crackling, buzzing or humming sound. When such sounds are heard, look for such electrically operated equipment as:

Adding Machines	Farm Lighting Plants
Air Conditioning Units	Floor Polishers
Automatic Towel Rollers	Generators
Barber Clippers	Hair Dryers
Beauty Parlor Devices	Humidifiers
Billing Machines	Massage Machines
Cash Registers	Motor-Generators
Dental Engines	Portable Electric Drills
Dishwashers	Printing Presses
Dough Mixers	Sewing Machines
Drink Mixers	Shoe Dryers
Electric Addressing Machines	Small Blowers
Electric Computators	Telephone Magnetos
Electric Elevators	Toy Electric Trains
Electric Refrigerators	Vacuum Cleaners
Electric Vibrators	Valve Grinders
Fans	Washing Machines

Rattles, buzzes and *machine-gun fire* sounds indicate interference from buzzers, telephone dials or doorbells. These noises are usually intermittent, starting and stopping at irregular intervals. Short machine-gun firing sounds indicate telephone dialing interference. Look for such interfering devices as:

Annunciators	Doorbells
Automobile Ignition Systems	Elevator Controls
Buzzers	Sewing Machines
Dental Laboratory Motors	Switchboards
Dial Telephones	Vibrating Rectifiers

Violent heavy buzzing or *rushing* sounds are often heard over a large area or even a whole town, the sounds being at times so loud that they drown out the radio program. They may be louder at one end of the tuning scale of the receiver, indicating high frequency noise-modulated radiation; they may be heard only on certain bands of all-wave receivers. These sounds may be traced to:

Air Purifiers	Neon Signs
Battery Chargers	Ozone Devices
Diathermy Machines	Spark Transmitters
Doctors' Apparatus	Spark Ignition in Oil Burners
Flour Bleaching Machinery	Violet Ray Apparatus
High Frequency Apparatus	X-Ray Machines
Insulation Testers	

Crackling, sputtering, snapping, short buzzes or *scraping* sounds indicate loose connections; if in the house, they will be especially noticeable when walking about; if outside, heavy traffic or street cars may increase the intensity of the sounds. Look for:

Defective Light Sockets	Loose connections in floor lamps and appliance cords; broken heater elements in household appliances. Unbonded rubbing metal contacts in houses, such as adjacent water pipes.
Flimsy Elevator Controls	
High Tension Lines	
Power Lines Grounded to Trees	
Street Cars	
Wet Line Insulators	

Clicking sounds are a definite indication of some sort of make-and-break connection essential to electrically operated industrial equipment, such as:

Elevator Controls	Ovens
Flashing Signs	Percolators
Heaters, Automatic	Shaving Mug Heaters
Heating Pads	Soldering Irons
Incubators	Telegraph Relays
Irons	Thermostats
Mercury Arc Rectifiers	Traffic Signals
Electric Typewriters	Safe Time Clocks

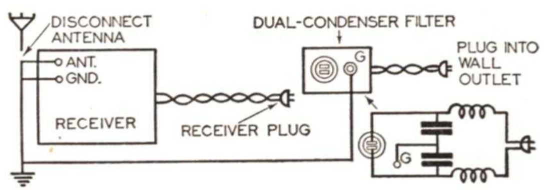
Heavy violent buzzing sounds, usually of short duration, are characteristic of heavy sparking or arcing across a gap. Such sounds are traceable to:

Arc Lights	Motion Picture Projectors
Automobile Ignition	Pole Changer (Telephone Interrupter)
Breaks in Third Rails	Street Car Switches
Electric Car Switches	Street Lights
Electric Elevators	Toy Electric Trains

TRACING THE ORIGIN OF INTERFERENCE

After making a survey of an interference problem, the Radio-Trician is generally able to tell whether the interference noise heard is produced in the customer's house or outside the house; in an apartment building he can readily tell whether devices in the customer's apartment are at fault. When the source of noise can be quickly located, a simple filter will remedy the trouble at minimum expense to the customer.

When, however, locating the offending device involves a search through many apartments in a building or many houses in a neighborhood, by all means give the noise-reducing antenna first considera-



Make this simple test with a condenser-choke filter of the plug-in type to determine whether interference is reaching the receiver directly over the power line. If interfering noises are still heard when the set is connected as shown, with the dual condenser line filter inserted in the power line, you have proved that the receiver itself is creating the noise; if no noise is heard but noises return with full intensity when the filter is removed, the interference is coming in over the power line. The remedy in this case is obvious: Install a line filter. The circuit diagram for the line filter recommended for this test is shown at the lower right.

tion, after you first try a line filter across the power leads of the receiver. Occasionally noise signals get in by this route.

Before actually installing a noise-reducing antenna, make sure that direct chassis pick-up of the noise signal is not involved, either by making the usual test with antenna disconnected and the receiver input terminals shorted, or by operating another receiver in the same location. Direct chassis pick-up is ordinarily encountered only in older types of receivers which have a number of unshielded parts.

Interference Originating in the Customer's Location. A quick test which will rule out the customer's location as the source of interference can be made with a portable battery receiver of the type which uses a loop or fish-pole antenna and no ground connection. The interfering noise should be heard on the battery receiver when it is placed in operation near the customer's receiver; if the noise is not heard, check the customer's antenna and ground system for poor joints and

exposed wires which are rubbing against a tree or building. Assuming that the interference noises are heard on the battery receiver, have some one open the main power switch which controls the entire electrical system in the house or apartment. If the noise disappears or is greatly reduced when this is done, at least one of the offending devices is in the place.

Locating the Noise-Producing Device in the Home. In small homes or in apartments this is easiest done by switching each of the electrical appliances off and on while the customer's receiver is in operation. In large homes this is done more quickly by having an assistant remove the fuses for each electrical circuit in the house in turn, while you note the effects on the customer's receiver. When the noise stops, you have isolated the defective device to one particular circuit; there remains only the checking of each part, device and connection in this circuit. The following procedure has proven very effective for isolating noise-producing sources:

1. Check the antenna, lead-in and ground for loose or poor connections.
2. Be sure that none of the service wires which enter the house are rubbing against the branches of trees or against the building.
3. Make certain that the service conduit containing the supply wires leading into the house is grounded.
4. The wiring in the house should be grounded as provided by the accepted local electrical code. Have a licensed electrician check this if there is any doubt in your mind.
5. Be sure that all switches in the distribution system make firm contact. All line fuses should be firmly in place, with clean contacts. No temporary fuses or fuse shorts should be allowed. Fuses should be checked, as a loose connection between the fusing material and the contact cap will create arcs.
6. Inspect all connections in switch boxes, distribution boxes and fuse boxes for looseness, tightening terminal screws where necessary.
7. Examine all lamp bulbs used in the house and make sure that they are firmly screwed into their sockets. Turn on each lamp and tap it on the side for loose elements and poor base connections. Question the socket.
8. Check all lamp extensions and attachment plugs to every appliance, looking for loose contact. Shake extension cords, listening to the radio for signs of poor internal connections while the device connected to the cord is turned on. Extension cords with knots and kinks, as well as worn cords, are prolific sources of interference.
9. Repair or replace snap switches which do not open quickly.
10. Water and gas pipes or electric conduit pipes rubbing against each other may discharge their electrostatic charges. Bond the pipes together at the rubbing joint or insulate the contact surfaces. Quite often the turning on of a water faucet, walking through the house, use of household appliances or the operation of oil burners or refrigerators will start such electrostatic interference. With experience you will be able to distinguish electrostatic noises from those produced by electrical apparatus.

In checking these items the receiver should be turned on, with your assistant or even the set owner listening to the receiver, while you check various things in the house. A broom handle may be used for probing or knocking against pipes; when the region surrounding the noise source is probed, noise will be clearly heard in the receiver.

Interference Outside the Customer's Home. When your tests show that the noise source is not in the customer's home, and the installation of a noiseless antenna proves inadequate, then the defective device must be isolated by means of an "interference locator." A portable receiver with self-contained batteries may be employed. The receiver should be sensitive, employing three to four R.F. pentode stages if a T.R.F. set; a portable superheterodyne may also be used. If the receiver is not already well shielded, it should be built into a heavy aluminum box. Inexpensive and sensitive portable battery receivers may be purchased from large radio mail order houses. In addition to the headphones used as an output indicator, a copper oxide rectifier type 0-5 volt voltmeter having a 1,000 ohm per volt sensitivity should be permanently connected to the output. Thus both aural and visual output indications are available. Whatever receiver is used, it must *not* have A.V.C., for this would tend to conceal changes in interference intensity.

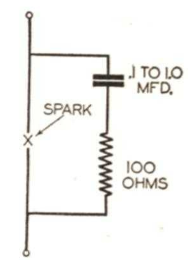
The pick-up system may be a 7-foot collapsible aluminum pole or a loop antenna. In the latter case the antenna coupler in the receiver must be disconnected and the input condenser arranged to tune the loop. For an .00035 mfd. input variable condenser a box type loop containing 24 turns spaced 1/8 inch apart on a 20-inch square form will be needed to cover the broadcast band. Use No. 18 or 20 gauge D.C.C. wire. Both pole and loop antennas may be used by installing a D.P.D.T. change-over switch. The pole antenna is preferred where there are many overhead wires in the vicinity of the home; the loop antenna performs best in open spaces.

In locating a noise source, first listen to the noise signal on the portable receiver, with the tuning dial set to a frequency where broadcasts are not heard. Using the loop antenna, rotate the loop until a maximum output meter reading is obtained. The noise origin will be in the plane of the loop (along a horizontal line parallel to and passing through the top of the loop), but may be either ahead or behind the loop. Walk in the direction which gives increased output readings. Where overhead supply wires exist (we assume that the investigation is started outdoors, as everything in the house has been checked), the greatest noise signal will be evident when the loop is *parallel to* the overhead wires. This does not identify the source, however. Where

overhead wires do not exist, then the direction of interference may be identified from two positions about 200 feet apart and, by following the two directions to their apparent intersections, the approximate location is obtained.

With the pole antenna use the "hot-and-cold" method, walking in the direction which gives increased noise in the phones or an increased output meter reading. Where an overhead power line is involved, follow the line for maximum output. The loop antenna may also be used in the above "hot-and-cold" method. Always point the loop in the direction of greatest output and follow the direction of maximum output indication. Follow overhead lines with the loop parallel to the line.

If some indication of the direction of the interference is secured from the customer, increased output should be obtained when moving



A condenser and resistor in series, connected as shown, will reduce the intensity of a spark at make-and-break contacts.

the interference locator toward the suspected point. For instance, if you are told that noise started when the neighbor installed a new refrigerator, walking to the neighbor's home when the noise commences should show increased noise output.

The independent interference man must realize that in locating a fault he may have to trespass on private property. Where the trouble originates in a home or building, it should not be difficult to obtain permission, once he identifies himself. In case the trouble is traceable to power lines and line equipment, the power service superintendent should be informed; he will without doubt have his engineers cooperate in the matter and make the necessary corrections. Most power companies and public utilities have engineers who specialize in interference work. This text does not consider interference troubles peculiar to public utilities; where the trouble is traced to telephone equipment, street railway lines or other public service equipment, explain the situation to the customer and suggest that he notify the company in question.

Once the noise has been localized to some house or business establishment, first secure permission from the tenant or owner, then proceed to isolate the defective device in the same manner which you would use in the customer's home. If the noise is traced to a point some distance away from the customer's home, it is probably due to a device which draws considerable power; thermostat contacts, electric light switches, and electrostatic sources of interference can generally be ruled out in a case like this.

COMMON INTERFERENCE CONDITIONS

A study of a few common interference-producing conditions which may arise in various types of electrical equipment will help to clarify this important problem of interference elimination.

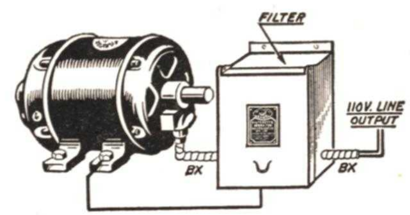
Electric Motors and Generators. Any electric motor, especially the D.C. and universal A.C. motors which employ commutators, should be suspected as a source of noise interference. Probable causes of trouble here include sparking at the commutators due to poor contact with the brushes, and dirty or uneven commutator segments. Sparking causes pitting and burning of the commutator segments, and the interference situation rapidly grows worse; before attempting to clean up the motor, connect the interference analyzer and determine whether a simple filter combination will completely eliminate the present interference. If the combination of filters required proves excessive in cost, repeat the analyzer test after you have remedied the sparking; a less-expensive filter should now prove sufficient. For motors try the filter combination shown at *B* in Fig. *2* first; if this is insufficient, add two choke coils as shown at *G* in Fig. *2*, making sure that the coils used will carry continuously the full load current of the motor. For 110 volt motors figure 10 amperes per horsepower; estimate 5 amperes per horsepower for 220 volt motors.

No interference-remedying job on a motor can be considered complete unless the cause of the trouble is removed or at least rectified. The commutator should first be cleaned and made smooth with fine sandpaper, and the brushes then reshaped if necessary to fit the commutator better. It is common practice to smooth the commutator, where it is not too badly worn, by wrapping or tacking sandpaper to a flat block of wood and applying this while the motor or generator is revolving. Brushes can be reshaped with the motor or generator at rest; slip a piece of sandpaper under a brush, with the cutting surface facing the brush and the sandpaper pressed against the commutator. Rock the commutator back and forth slowly until the brush takes its

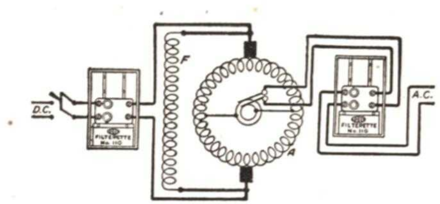
proper curvature. When you have finished, wipe off the brushes and the commutator carefully and apply a very small amount of vaseline over the surface of the commutator.

Oftentimes sparking at brushes can be reduced by shifting the positions of the brushes to get improved commutation. Rock the brushes slowly back and forth a very short distance until minimum sparking is observed; this should be done while the machine is operating at normal load if best results are to be obtained. With generators, moving brushes *in the direction of rotation* ordinarily reduces sparking; with motors the opposite holds true.

Make-and-Break Contacts. With simple make-and-break contacts such as are found in switches, temperature control thermostats, automatic electric irons, electric water heaters and similar devices, a filter consisting of a single condenser or a condenser in series with a



Combination choke-condenser filters mounted in metal cut-out boxes are often necessary to stop interference created by medium and large sized motors. Connections between motor and filter box must be run through flexible BX conduit, as shown here.



Both input and output leads of a rotary converter must be filtered, using choke-condenser units mounted in cut-out boxes and mounted as close as possible to the machine. F represents field coil, A the armature of the converter, which here changes D.C. to A.C.

resistor will usually prove sufficient to eliminate the interference. It is always a good plan to clean and adjust the contacts, in order to prevent a prolonged arc which would prove destructive to the contact points and cause even more severe interference than before.

Oil Burners. Interference produced by oil burners can usually be traced to the high tension ignition circuit, to automatic switching devices, or to the motor. Some burners use a gas pilot light, eliminating ignition systems as a possible source of interference; this you can easily confirm by inspection. If the interference noise is continuous for the period during which the burner is operating, the motor is clearly at fault; if the noise is heard only for a short period when the burner starts, the ignition system, one of the relay devices or the starting mechanism in the motor is at fault. Trouble at the motor can usually be eliminated by installing a filter as close as possible to the brushes.

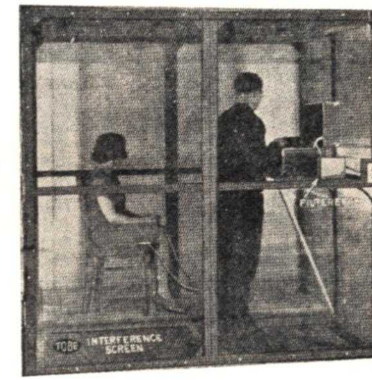
Ignition system troubles are remedied by shielding all high tension wiring either with metal conduit, with flexible metal loom, or with metal braid, the shield being well grounded at each end in all cases. Some servicemen recommend that the frame of the oil burner be bonded to the boiler and to ground with heavy wire or metal braid, to prevent radiation. Try a coil and condenser type filter across the input leads of the ignition transformer; try simple condenser filters across thermostat contacts and relay contacts. Oftentimes it is necessary to place a wire shield around the ignition electrode in gun-feed type oil burners and ground this shield to prevent ultra high frequency radiation.

Here are a few practical suggestions concerning oil burners. If the noise elimination job on a burner appears at first inspection to be a rather involved affair, it is well worth while to contact the local distributor of that burner. Similar interference conditions will have been encountered in other installations, and often the distributor can make suggestions or supply special equipment which will remedy the trouble in short order. Once you prove that you can eliminate interference on that type of burner, the distributor may even refer similar jobs to you. Remember that all filters should be placed in metal housings to conform with underwriters' regulations.

Electric Refrigerators. The motor is the usual source of trouble in electric refrigerators; its treatment has already been taken up. Static charges accumulating on the compressor-motor belt sometimes cause trouble; the remedy here is bonding the motor frame and the compressor frame either to the refrigerator frame, to some large metal mass in the unit or to ground. Refrigerator mechanisms are usually mounted on spring supports; occasionally you will find that a spring has weakened, allowing a make-and-break contact between the refrigerator frame and the part in question; in this case install a new spring. If the interference is traced to a sparking thermostat, it is wise to call in a refrigerator serviceman; adjustments on refrigeration control devices such as this require specialized knowledge.

Electro-medical Apparatus. X-ray machines, violet ray apparatus and diathermy machines can cause a great deal of annoying interference; these may prove the most stubborn cases which you will encounter. Most of the equipment now being marketed is designed to create a minimum of interference, but older models are trouble-makers. Modern vacuum tube type diathermy machines create interference at only one frequency in the short-wave region; this interference can be eliminated only by placing the machine in a screened room.

With medical apparatus in general, the first step involves placing a choke-condenser filter in the supply line to the device. If this is insufficient, the only recourse is to place the apparatus in a screened room. The frame of the room can be either of metal or wood; this is then covered with either iron or copper screening, preferably both inside and outside of the framing, and the screening is well bonded together at all joints. The door must be so constructed that it makes firm electrical contact with the remainder of the screen when closed. Filters should be placed on all power lines which enter or leave this screened room, for otherwise interference would be conducted outside and there radiated; the filters should be placed as close as possible to the exact points where the lines pass through the screen.



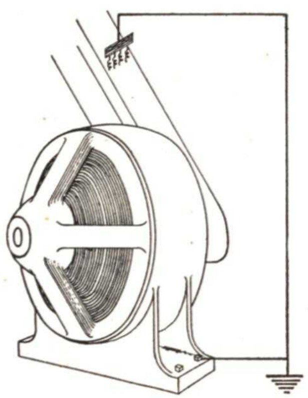
Courtesy Tobe Deutschmann Corp.

When electromedical apparatus is creating noise interference a grounding screen cage like this must often be used. All joints must either be soldered or continuously bonded in some way. Filter units must be attached to all power lines at the points where they enter the cage. All devices and filter units inside the cage should be grounded to the screen; connect the screen to a nearby ground if this gives an additional reduction in interference.

Flashing Signs, Traffic Lights and Neon Lights. In general, interference from these three sources can be spotted by visual inspection and by studying the nature of the sound heard in the receiver. For example, if a steady choppy noise is heard in synchronism with the flashes of a yellow blinker light up the street, the defect is immediately isolated. If a steady rolling or clicking sound is heard, and you note in the vicinity a sign having a continuous change of light, perhaps around the border, that sign is very likely the offender. Whenever there is some question as to the source of trouble, use the portable receiver to localize the trouble. The next step is a study of the device in question to determine the simplest filtering procedure.

Simple flashing signs which have a single make-and-break flasher require only a filter condenser connected directly across the contacts; the closer the condenser is to the contacts, the more effective it will be. Motor-driven contactors are generally used in signs which create the effect of motion; the first step with these is to filter the motor supply leads, then the main supply leads to the electric lights. If this fails, it is then necessary to connect a filter to each contact on the contactor. The condenser should be connected from the contact to the common terminal for all circuits, which is ordinarily easily located. In severe cases of interference it is necessary to place a choke coil in each lead to the lights, the condenser being connected from the contact side of the coil to the common power lead. Short connections are essential here to prevent high frequency radiation.

Flashing traffic lights are treated in much the same manner, using condenser filters across the contacts and line filters where necessary. This work must naturally be done under the supervision of the proper authorities.

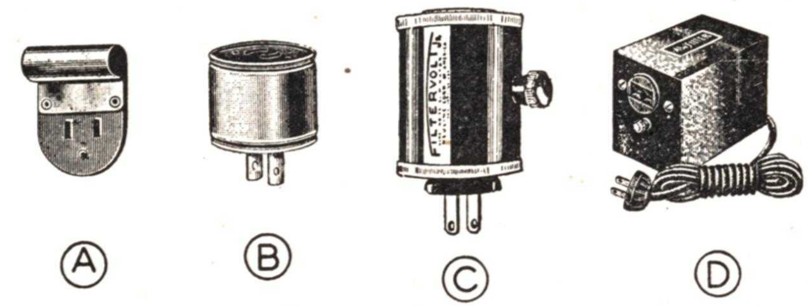


Moving belts and belt conveyers are sources of static discharges, not only creating noise interference but actually endangering the lives of nearby persons and the insulation in the machinery. A grounded metal comb with flat or coil springs rubbing on the belt will discharge this static electricity harmlessly to ground and at the same time stop the radio interference. Use a good ground which is carefully erected. In any industry where static electricity is produced, all fixed and movable parts of machinery should be grounded.

Neon signs of the non-flashing type do not as a rule cause interference troubles; where interference is positively traced to these signs, about the only remedy is the installation in the primary leads of the high tension transformer of a condenser-coil filter of the type shown at *G* and *H* in Fig. *2*. When a rotating contactor is used in the primary circuit of a number of neon transformers to switch from one group of tubes to another, filters must be connected to each contact and to the motor of the contactor. Where the rotating contactor is in the secondary circuit, switching high tension currents from one to another of a number of small sections of neon tubing, condenser filters are out of the question because of the high voltages involved. Try inserting 10,000 to 25,000 ohm spark suppressor resistors in each high tension lead; choke coils inserted in these leads may also reduce the interference. In certain severe cases the only remedy may be a complete change-over of the sign-operating mechanism, which will place

the rotating contactor in the primary circuit and provide a separate transformer for each section of tubing; such an arrangement is more readily treated for noise suppression, but the cost of making the change-over is generally so high that the job of filtering is given up.

Quite often neon tubing will accumulate an electrostatic charge which leaks off to the nearest metal objects or at points of support; try placing mica sheets at these points. The two chains which sometimes support neon signs in show windows often acquire a difference in potential; insulating each chain from the neon tubing or using a non-metallic type of support will effect a remedy. Neon signs should be kept as far away from glass windows as possible, to prevent ac-



Examples of typical commercial filter units for interference-creating electrical appliances. At *A* is a single condenser unit which may be slipped over the prongs of the appliance plug; *B* is a similar unit, but of larger capacity, for insertion between appliance plug and wall outlet; *C* is a dual condenser filter with a midpoint terminal which can be grounded; *D* contains a condenser and coil combination designed for use with larger appliances. These devices are generally carried by those servicemen who do not make a specialty of interference elimination; by trying each device in turn, they can generally find one which will give satisfactory noise reduction where there is only mild interference. Never connect condensers larger than 1 mfd. directly across an A.C. line for filtering purposes; the power losses in larger condenser units are often high enough to cause excessive heating on continuous duty, resulting in failure of the condenser.

cumulations of static charges on the glass. Quite often a general overhauling of the neon sign, done by a sign expert, will greatly reduce the interference and make ordinary filtering procedures effective. This involves cleaning of all insulators and all tubing, to prevent high tension currents from leaking over dust-covered glass surfaces.

Thus you can see that the elimination of interference, once the source has been located, calls for "horse sense" and a certain amount of "trial and error" work, as well as a knowledge of the causes of interference and the technique of filtering.

Radio Noise Survey. Although the results of any survey made of causes of radio interference noises will vary with the locality, the following data taken from one such survey gives a general indication of the frequency with which various noise complaints occur. Out of

9,000 complaints, about 30 per cent were traced to power companies and public utilities, about 30 per cent to apparatus owned by the general public, about 15 per cent to defective radio sets and the remainder to transient or unlocateable conditions. Of the 30 per cent traced to devices owned by the public, motors and motor-operated devices accounted for 10 per cent, defects in wiring of building—6 per cent, switches and interrupter apparatus—5 per cent, electro-medical apparatus and neon signs—3 per cent, and miscellaneous—6 per cent.

SECURING INTERFERENCE ELIMINATION BUSINESS

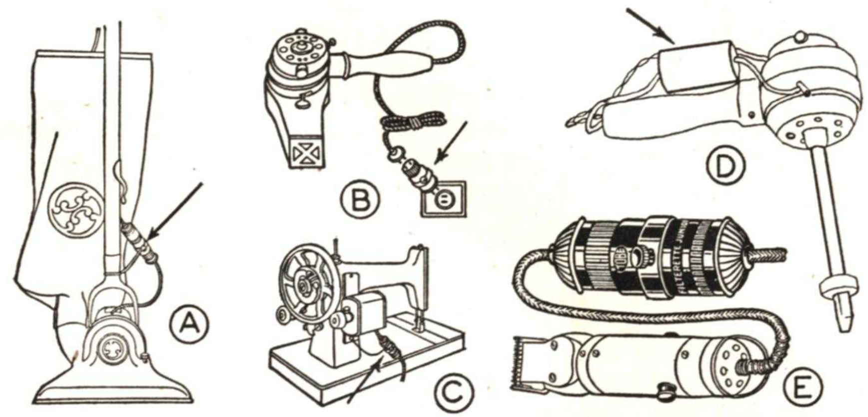
Noise is as old as civilized man, but radio has made the public more noise-conscious today than ever before. Noise ruins the entertainment value of radio programs, changing the radio receiver from a luxury to a nuisance in the customer's mind. Interference elimination is so much a community affair that many towns and cities have passed ordinances which compel those people owning interference-creating devices either to eliminate the noise or to cease using the offending device; as the public demands better and better radio programs, laws become more widespread. With laws such as this in your favor, the securing of interference elimination business is comparatively simple, but even if you must first sell the idea of noise elimination to a customer, there are enticing profits awaiting you in this field. In addition, this side-line of servicing will bring more regular service jobs to your shop.

Always make inquiries about possible interference on each radio receiver service call which you make; bringing noise interference to the attention of the public and stressing the fact that practically all noise can be eliminated, will eventually produce many interference elimination jobs for you. If you plan to become a specialist in noise elimination, it is a wise plan to select a certain section of your town, preferably in the immediate neighborhood of your shop, for complete noise elimination. It may take weeks or months to locate and remedy all noise sources in this section, but once all noise has been eliminated, your reputation will spread throughout the town, and your work in other sections will prove more easy. Then, too, the experience gained will be of great value in solving similar problems elsewhere.

Be sure to contact the trouble-shooting department of your local power company, and the same department in any other nearby public utility. These firms constantly receive complaints of interference; once you have shown that you can handle this work, they will welcome you with "open arms" and even send jobs your way. Whenever

you encounter an interesting or particularly successful job, always call your local newspaper; anything with a little human interest makes a good story for the newspaper and gives profitable publicity to you.

Having selected a six or eight-block square section of your town as a starting point, the best approach is to announce that you are making a "radio interference survey." Visit the homes and business establishments in this section, preferably during your spare time,



Courtesy Tobe Deutschmann Corp.

Examples of filter installations on small electric appliances which are creating interference because of sparking or arcing. *A*—vacuum cleaner motor interference can generally be cured by inserting a dual condenser filter in the connecting cord, not more than six inches away from the motor, and grounding the midpoint terminal to the frame of the appliance; arrow points to filter. *B*—interference created by the blower motor of a small hair dryer can often be satisfactorily reduced by placing a condenser filter of the plug-in type between the wall outlet and the hair dryer plug. *C*—plug-in type dual condenser filter inserted in sewing machine motor cord, as close as possible to motor, gives a neat interference-reducing installation where it is not feasible to make connections directly to motor terminals. *D*—condenser filter connected directly to terminals of a small mixer; this is not an ideal installation, for the filter interferes with the use of the appliance. *E*—plug-in type condenser filter inserted in cord of barber clippers, close to motor, gives satisfactory elimination of interference in most cases. Always try plug-in filters at wall outlet first, to avoid unnecessary cutting of appliance cord. Ground midpoint of filter to frame of appliance or nearby ground wherever possible.

explain what you are doing and ask if they have noticed any radio interference noises. Secure their permission, if possible, to turn on their radio receiver so you can listen for the noise yourself. By starting in a section where you are known, opposition to such a survey will be at a minimum. Keep your eyes open for regular service jobs while making the survey, and put in your bid for the job either at the time of the call or at a later date.

After each call, when making the survey, write your observations on a small card, perhaps of the three by five-inch size. With these cards arranged in geographical order, a study of them should show you where interference is a maximum; your first efforts should be concentrated in this region. Secure permission to check on all suspected devices, and apply the interference-isolating technique which has already been explained.

If you hesitate to make a sales talk in each home in order to explain your purpose, send printed post-cards or letters explaining what you intend to do; this will tend to offset possible objections or the need for lengthy explanations when you make your call. A cartoon or drawing on the card or letter will attract attention to the purpose of your message and thereby give better results for you. Literature like this can also be used to explain why certain devices cause interference and why this interference should be eliminated at its source; this literature, by calling to the attention of customers man-made interference situations which they may not have recognized as such, will make it easier for you to sell filters and interference-elimination services at a later date.

LINE FILTER CONSTRUCTION DATA

Line Filters for Radio Sets. Get two .5 mfd. tubular paper condensers rated at 600 volts D.C. working voltage, one bakelite coil form about 6 inches long and 3 inches in diameter, and a half pound of ordinary No. 18 bell wire. Unwind the wire and cut into two pieces of equal length.

Drill two holes (each about 1/8 inch in diameter) at one end of the coil form, locating them about a half inch in from the edge of the form and about one inch apart. Anchor each wire by looping it once or twice through its hole, leaving about 6 inches projecting for connections. Proceed to wind the two wires side by side on the coil form in a single layer, with turns as close together as possible. When all but about 6 inches of the wire has been wound in this manner, drill two more holes about one inch apart and loop the ends through these holes for anchorage. This will give you two coils of approximately 35 turns each, wound on a single coil form.

Insert this filter choke in the radio set power cord, either at the wall plug or at the radio set. In other words, cut the two wires of the radio set cord at the desired location, connect one pair of cut wires to the leads at one end of the choke, and connect the other pair of cut wires to the two leads at the other end of the choke. Now connect one terminal of each .5 mfd. condenser to one of the leads at the *receiver* end of the choke coil; connect the remaining two condenser leads together and provide a means for grounding this common condenser connection (to a convenient water pipe or to the radio set ground if you know that to be good). Cover all exposed connections with friction tape. This completes the filter itself, but you will probably want to mount it in a wood or metal box so no dangerous 110 volt A.C. terminals will be exposed. The circuit of this filter is like that shown on page *16* (with the receiver connected and plugged into the outlet on the filter), or like that in Fig. *2G* if *S* represents the receiver.

General Filter Construction Hints. The same general filter construction described above will serve for practically any line filter application *if the wire used in winding the choke is the same size as the power cord wire used for the appliance being filtered.* In other words, if you are filtering an electric

motor having No. 14 wire in its line cord, wind the choke with about 35 turns per coil (70 in all) of No. 14 insulated wire; No. 14 tinned solid copper push-back wire will do nicely, or you can use the same size of double cotton-covered wire and apply a coating of insulating varnish to the completed choke. To get this number of turns, you will have to order about 60 feet of wire in whatever size is required. Naturally you will need a longer coil form for heavier wire, since the choke must be in a single layer. The condenser size specified is all right for all cases; in general, the condensers should be connected to that end of the choke which will make the interfering signals go through the *choke* before they reach the condensers.

TEST QUESTIONS

Be sure to number your Answer Sheet with the *number* appearing on the front cover underneath the title of this text.

Place your Student Number on every Answer Sheet.

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

1. What effect does a tone control, which cuts off the high audio frequencies, have on static noises?
2. In locating the best position for the straightaway portion of a noise-reducing antenna, what three rules would you follow?
3. What type of filter would you try if simple condenser filters using 1-mfd. units failed to give satisfactory noise reduction?
4. What should be the peak voltage rating of condensers used on ordinary 110 or 220 volt A.C. power lines for filtering purposes?
5. What are the probable causes of noise interference in D.C. motors?
6. What type of filter would you use on a make-and-break contact?
7. When interference-producing apparatus is located in a completely screened room or cage, where should the line filters (which are placed on all power lines entering the room) be placed?
8. When using a pole antenna with an interference-locating receiver, how can you tell when you are approaching the source of noise?
9. If interference noise traced to an oil burner is continuous for the period of operation of the burner, what is the cause?
10. What should be the current-carrying capacity of a choke coil which is to be used in filtering the power leads to a 220 volt, one horsepower motor?

INITIATIVE

The man who does only the routine tasks, the ordinary jobs in his profession, always waiting for the other fellow to take the lead, can expect only moderate returns for his labors. He who is continually on the alert for new ideas and new uses for his talents—who is alert to grasp each new opportunity—gets the greatest profits. The immediate financial returns from work in a new and specialized branch of your profession may not be great, but the reputation which you gain for progressiveness will soon result in more profitable routine jobs. It all boils down to these simple facts—you must do out-of-the-ordinary things, stand above the crowd in some way, to attract favorable attention. People remember you first for the unusual, then for your ability to do ordinary work well.

J. E. Smith