PHILCO SERVICE

PHILCO Factory-Supervised Service

Shop Practices and Service Techniques

RADIO

AUGUST, 1951

TROUBLE SHOOTING OF INTERMITTANTS

OSCILLATORS — THEIR OPERATION

This is the first in a series dealing with the service problems of intermittants. The intermittant trouble is no respector of time or effort and one difficult job of this nature can upset the shop schedule for a considerable time. These articles are intended to give the serviceman an idea of some of the tests, methods, and shortcuts that will speed the servicing of intermittant radio problems. Inasmuch as the oscillator circuit is one of the most common sources of trouble and that this function is not too well understood, both this and the following article will deal with local oscillator circuits exclusively.

The oscillator circuits employed in present day receivers are usually modified versions of two basic circuits; the tuned grid and the Hartley. However, before discussing the oscillator circuits and their modifications, we had best review a few of the fundamentals. Referring to Figure 1, which is an amplifier circuit using transformer (or tuned circuit) coupling, let us examine an individual tuned circuit such as LC. In principle, the tuned circuit has the property of storing energy in an oscillating or vibrating state, regularly changing from Kinetic form (magnetic field, when current flows through the coil) to potential form (electric field, when the condenser is charged) and back again at a frequency called the natural resonant frequency. Assuming then that the condenser C is charged, it will discharge its energy through the coil (or inductance) L, causing the current to continuously increase until it reaches the maximum when there is no potential across the condenser C. At that instant the energy is all magnetic, and the current continues, fed by the now collapsing magnetic field, to build a voltage of reversed polarity across C. When all the energy has been transferred from L to C, the voltage appearing across

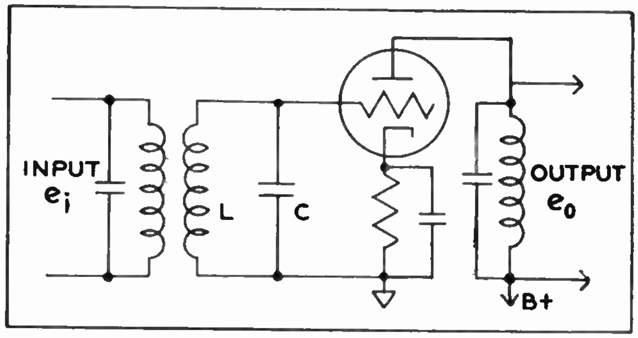

FIGURE 1. A Basic Amplifier

C has its original value (considering an ideal circuit with no resistance in the coil and no loss in the condenser), but is reversed in polarity, and the current is diminished to zero. The process then repeats itself, returning the condenser charge to the original polarity and thus completing a cycle. This is a repetitious process and continues indefinitely.

Were there no loss of energy, each cycle would be identical in amplitude to the preceding one. However, there is always resistance in the coil (wire loss and leakage between turns) and in the condenser (leakage through the dielectric) which absorb power during those portions of the cycle when current it flowing. These power losses act as a damping factor that prevents the oscillatory condition from continuing indefinitely. In practical circuits the amplitude of each successive cycle of oscillation falls so that within several cycles the condition dies out.

The resonant frequency of a parallel tuned circuit is expressed by the formula:

$$F_r = \frac{1}{2\pi\sqrt{LC}}$$

where the above mentioned resistances are neglected.

Referring again to Figure 1, it can be seen that the properties of a parallel resonant circuit are quite helpful when used as the input (grid), and output (plate) loads of an amplifier circuit. When used in this manner, a signal of the resonant frequency fed to the circuit is presented to the grid as a voltage across a high impedance with an apparent gain over the original signal. This is due to the properties of a resonant circuit which, at resonance are: minimum line current, maximum impedance, and high circulating current within the resonant tank. While the resonant frequency is applied to the grid across a high impedance, other frequencies, both above and below the point of resonance are effectively shorted to ground through a relatively low impedance. Thus the entire amplifier is very discriminating frequency-wise as the tuned circuits, of the grid and plate, are providing gain of the resonant frequency and attenuating all others.

Still referring to the amplifier of Figure 1, the action of the tube as an amplifier is possible because a small change of grid potential causes a relatively large change in the plate current and, of course, in the voltage appearing across the plate load. This relation between the grid voltage and the plate voltage is called the amplification factor.

Just as a small voltage at the grid controls a large increment of voltage; so the energy controlled by the amplifier in the output circuit is great compared with the energy consumed by the input circuit. Thus it can be stated that an oscillator is an amplifier that, through some form of feedback, supplies its own input. This is demonstrated in Figures 1 and 2. In Figure 1 there is a coupling circuit from a preceding stage which supplies to the tube grid an input signal e_i. Through the amplification of the tube, this becomes a considerably larger voltage, designated e_o. If through some form of positive feedback or regeneration, such as interelectrode capacity between grid and plate or mutual coupling between grid and plate coils, the amplifier circuit is so arranged that a portion of e_o is fed back to the grid 180° out of phase with e_o it will be in phase with e_i, and add to it to accomplish the same function as e_i. Therefore, as shown in Figure 2, we can remove e_i and the circuit will then be self sustaining; an oscillator. An amplifier operated in this manner will generate oscillations at a frequency that is determined by the electrical constants of the circuit. Furthermore, since the tube operates as an amplifier, the oscillator can be made to supply power to an external circuit in addition to supplying the circuit losses required to sustain oscillations. The tube then acts as a power converter, changing the direct current power supplied to its plate circuit into alternating-current energy in the amplifier output circuit.

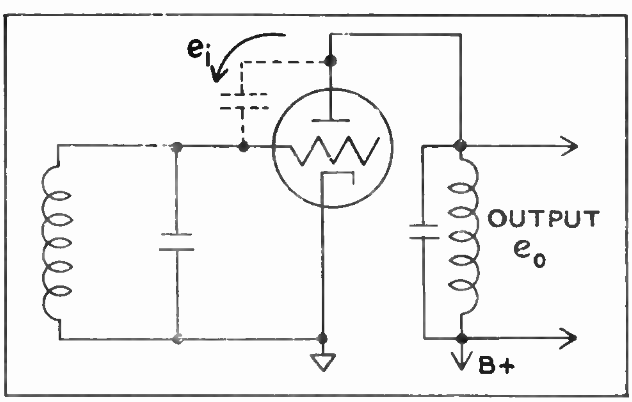

FIGURE 2. Introduction of Feedback in an Amplifier

In the oscillatory circuit of an oscillator, electrical oscillations occur according to the fundamental laws governing capacitor and inductor actions. The oscillatory or alternating flow of electrons in the parallel resonant or tank circuit is caused by the repeated exchange of energy between the capacitor and inductor as explained in the preceding section. Also from the first section, if no energy is supplied to replace the losses caused by the circuit resistances, the magnitude of each oscillation will diminish. It can thus be seen that of itself a simple tank circuit is not a practical means of producing sustained oscillations. The tank circuit of an oscillator is then the frequency determining or controlling factor. In practical oscillator circuits a vacuum tube and a power supply are used to provide the energy required to overcome the losses caused by the resistance of the circuit, thus providing an alternating current of constant magnitude.

The fundamental oscillator circuit, shown in Figure 3, is capable of producing alternating currents of constant magnitude and constant frequency. The operation of this circuit, which is a tuned grid oscillator, is similar to most types of feedback oscillators.

At the instant of closing the switch S (Figure 3), the electrons being emitted from the cathode will be drawn to the plate. This causes a cur-

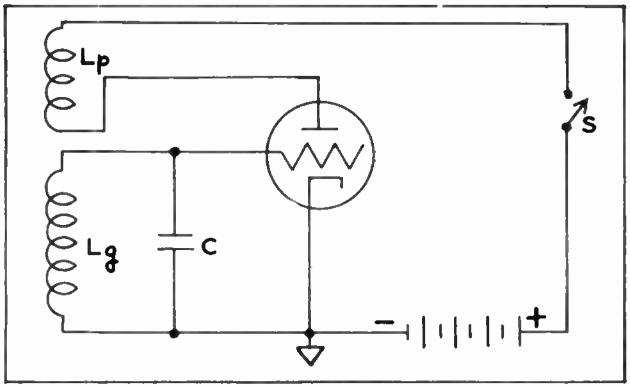

FIGURE 3. A Basic Oscillator (Tuned Grid)

rent to flow from the cathode to the plate, through the plate coil *Lp*, through the B power supply, and back to the cathode. As the current through *Lp* increases, a magnetic field builds up around the plate coil and, by mutual inductance, a voltage of increasing magnitude is induced in the grid coil, *Lg*. The grid and plate coils are connected in their respective circuits so that the voltage induced in the grid coil will have a positive potential at the terminal connected to the grid of the tube when the current in *Lp* is increasing. Two immediate actions result from this positive voltage: (1) the voltage on the grid becomes positive, thereby increasing the amount of plate current flow; (2) the capacitor C in the tank circuit becomes charged. The increasing plate current produces an increase in the strength of the magnetic field about the plate coil, thus causing a greater voltage to be induced in the grid coil. This action makes the grid still more positive, thereby increasing the plate current still further. This action continues until saturation is reached (Figure 4). The point of saturation will depend on the resistance of the circuit, the plate supply voltage, and the characteristics of the tube. As soon as the plate current ceases to increase, the field about the plate coil ceases to expand and no longer induces a voltage in the grid coil. The tank capacitor C, having been charged to its maximum potential, starts to discharge through the grid coil. This decrease in voltage across the capacitor makes the voltage on the grid less positive thus causing the plate current to decrease, which in turn causes the magnetic field about the plate coil to collapse. A voltage will again be induced in the grid coil but will be opposite in direction to that produced by an expanding field. The voltage on the grid thus becomes negative, thereby decreasing the plate current still further. This action continues until the grid voltage is such that zero plate current flows, point C on Figure 4. During the time in which the plate current has decreased from saturation current to cutoff, the tank capacitor has lost its original charge and has again become charged to its maximum potential, the plates now having a polarity opposite to that of the previous charged condition. As the induced voltage in *Lg* is zero when cutoff is reached, the capacitor will now start to discharge through the grid coil. This decrease in voltage across the capacitor makes the voltage on the grid less negative, thus causing the plate current to increase and the magnetic field about the grid coil to expand. The voltage induced in the grid coil will make the grid more positive, thereby increasing the plate current still further until the saturation point is reached in the same manner as explained previously. This cycle of operations repeats itself continuously as long as energy is supplied to overcome the losses in the circuit. The frequency of the oscillations are controlled by the resonant circuit *Lg* C and can be calculated by the use of the following equation;

$$F = \frac{1}{2\pi\sqrt{LC}}$$

where F = frequency in cycles/second, L = inductance in henrys, and C = capacity in farads.

As mentioned above, in the discussion of a basic oscillator, the grid is driven positive during a portion of each cycle of alternating current. In order to prevent the tube from drawing an excessive amount of plate current, and thus cause overheating of the plate or destruction of the cathode, during this portion of the cycle, most all oscillator circuits employ grid-leak bias. Two ways of connecting the grid resistor are shown in Figure 5.

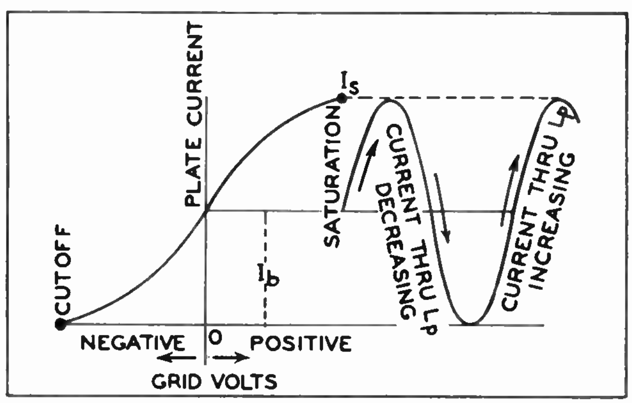

FIGURE 4. Relation of Plate Current to Grid Voltage

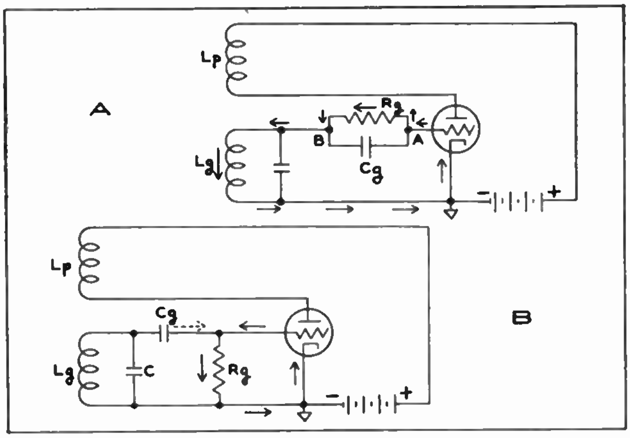

FIGURE 5. Two Methods of Supplying Grid Leak Bias

When the oscillator of Figure 5 is started, the initial bias on the grid is zero. Thus, when positive voltage is applied to the grid, because of the expanding magnetic field about the plate coil, the grid will be driven positive. The flow of electrons in the grid circuit (caused by the positive grid) produces a voltage drop at the resistor R*g* with point A negative and point B positive. The capacitor C*g* will become charged to this polarity. The grid current flowing through the grid resistor thus causes the voltage on the grid to become negative. The plate current will then decrease, thus causing the magnetic field about the plate coil to collapse. The cycle then continues as explained previously. The grid condenser acts as a d.c. blocking condenser so that current drawn during the positive grid position of the cycle will pass through the grid-leak resistor but will still allow the alternating voltage of the tank to appear on the grid. The condenser C*g* also acts to help maintain the bias by preventing direct loss of the electrons on the grid by any means other than leakage through R*g*. This leakage tends to stabilize the grid bias until another cycle is reached at which time the grid current again causes the action to be repeated.

A modified form of the tuned grid oscillator is the Hartley which is shown in Figure 6. The action is very similar to that just described with the following exceptions. Only one coil is used, a portion, L*p* of this coil is in the plate circuit, and the remainder, L*g*, is in the grid circuit. The amount of inductive coupling or feedback between these two sections of the common coil will depend on the ratio of the number of turns in the two sections. Increasing the number of turns in the plate section increases the voltage induced in the grid section, thus increasing the amount of feedback.

The alternating current in the plate section of the coil, L*p*, induces a voltage in the grid section, L*g*. This induced voltage is applied to the grid of the tube, is amplified, and again applied to the plate section. The plate and grid voltages are 180 degrees out of phase with each other as they are taken from opposite ends of the coil with respect to the common lead connected to the cathode.

In the Hartley circuit the tuning condenser is across the entire coil. Therefore, the frequency of oscillation of this circuit is equal to the resonant frequency of the parallel circuit formed by the condenser C and the entire coil, Lg plus L*p*. Having established the operating principles of the basic oscillator circuits, next month's installment will cover practical circuits as used in Philco receivers and the trouble-shooting of difficulties encountered with them.

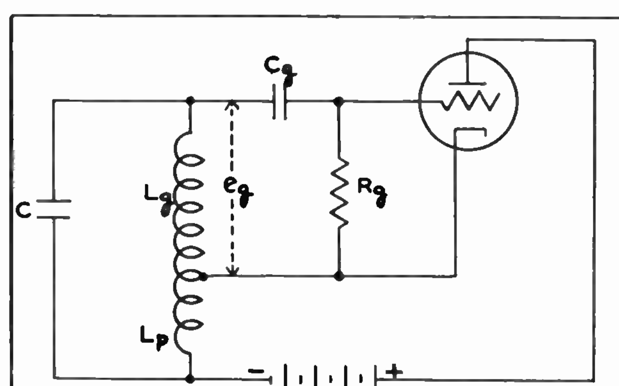

FIGURE 6. A Basic Hartley Oscillator

PHILCO SERVICE

PHILCO Factory-Supervised Service

New Product News

RADIO

ELIMINATING RADIO NOISE INTERFERENCE

KINDS OF NOISE INTERFERENCE:

The class of noise interference with which we are concerned in this booklet is man-made static. This is the type of radio interference which is produced by any kind of electrical apparatus which causes sparking. This might be a motor, a defective light, or faulty electrical wiring, either within the house or on the street. When going after an interference problem, the serviceman must bear in mind the various other types of noises similar to man-made static which can also produce faulty radio reception. Natural static is usually evident, and we need not give detailed consideration to this type of interference. An internal noise within the radio set can often produce interference which is sometimes hard to distinguish from outside man-made static. Such a noise can be readily detected, however, by disconnecting the aerial from the set and shorting the aerial post to the ground post. If the intensity of the noise decreases, it can be safely assumed that the source is external to the radio set. If the noise remains the same, or is still evident, it is being produced in all probability by a faulty part or connection within the chassis. The exact location of the noise within the set must be determined by a process of elimination as follows:

1. Remove the second detector tube or in AC-DC sets kill the detector. If the noise continues it will be known that the trouble is in the audio or speaker circuit. If the noise stops—
2. Disconnect the control grid from the first detector. If the noise continues, it will be known that the trouble is in the first detector or I. F. portion of the chassis. If the noise stops—
3. The source of trouble is in the R. F. end of the chassis.

INTERFERENCE PRODUCING DEVICES:

Most man-made static is produced by small motors or defective electrical wiring. Electrical devices such as vacuum cleaners, electric fans, oil burners, mixers, automatic heaters, and irons are the worst offenders. Defective electrical wiring is often a source of noise, and it is usually possible to locate a loose fuse or a loose wire contact in a socket or plug of some of the household fixtures or switches.

Larger motors often cause interference in those cases where the radio set is located in the neighborhood of a factory or any large building containing heavy electrical equipment.

Electric power lines and equipment, and trolley lines and cars are also bad offenders in many cases.

TRANSMISSION OF INTERFERENCE:

Man-made static is carried from the source of disturbance to the radio receiver in two ways: part of it is radiated in exactly the same way that a radio signal is radiated from a transmitting station; another part is carried along the electrical wiring which is common to the source of interference and to the receiver. In addition to the interference being carried along the line in this manner, the line also acts as a radiating antenna so that interference is radiated from the line which carries the interference, as well as being transmitted directly on the line itself. For example: if an aerial is run parallel to heavy electrical power lines in which interference is present, the interference will be picked up in the aerial. A certain amount of the interference will be carried through the step-down transformer on the pole and along the line into the house on the regular house wiring circuit, but the built-in line filter condenser of the radio set will usually eliminate this incoming noise. When the aerial is run at right angles to the interfering lines, and is placed back as far as possible away from them, the amount of interference picked up will be a minimum.

Since interference is radiated from the electric lines which go to the source of interference, the only correct way to establish complete elimination is to kill the interference at its source. For example: if the interference is being produced by an electric fan, small interference condensers should be connected to the fan at the motor. If the interference eliminating condensers are connected across the two wires at the baseboard plug, interference will be radiated from the power line between the baseboard and the motor itself. For this reason, *we do not recommend the use of interference eliminating devices which for convenience are connected at the baseboard plug instead of immediately at the source of interference. This is one of the most important facts to remember when doing interference elimination work of all kinds.*

NATURE OF INTERFERENCE AND HOW IT IS ELIMINATED

Man-made static is a radio signal which has no particular basic frequency, but is broad over a large portion of the broadcast and short wave bands. Different sources of interference may cover comparatively large bands, but might not cover the entire band. For example, a small motor may be heard louder at the high frequency end of the broadcast band than at the low frequency end. Another small motor may be located sufficiently far away from the receiver so that it does not produce any interference on the broadcast band, but might be heard on a portion of the short wave band. In general, man-made static interference is stronger on the short wave band than on the standard broadcast band.

The noise signal is a complicated radio frequency disturbance made up of R. F. and audio components. Like any high frequency electrical current, it can be carried off from a given point through condensers. The circuits in Figures 1 and 2 show how interference can be corrected. Also, a single condenser may be connected across the terminals of a motor which is producing interference. Interference which would normally be carried out through the lines, finds an easy path through the condenser, and thus circulates around through the condenser and motor windings instead of going out into the lines. This simple filter is often used on small appliances for noise elimination, a .1Mfd tubular condenser such as employed in radio sets can be used.

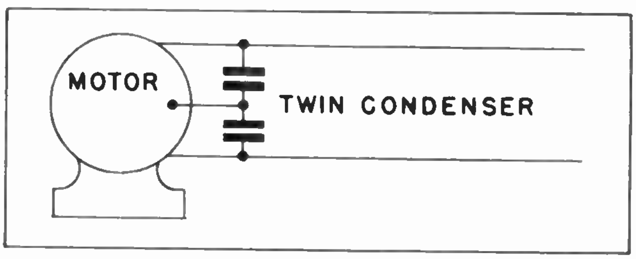

FIGURE 1

In Figure 1, there are two condensers employed with their common center point connected back to the frame of the motor. In this type of circuit, the path of the interference is from one motor terminal through one condenser back to motor frame and from the other motor terminal, through the other condenser and back to frame. This type of interference-eliminating circuit has been found to be more satisfactory than a single condenser, because it has a better effect of confining the interference to the source. The size of the condenser units to be used is dependent upon the intensity of the interference.

An R. F. choke is connected in one side of the line from the motor. Remembering that interference is principally an R. F. signal, it is evident that a choke, which merely impedes the passage of R. F. will tend to stop the interference signal from going out through the line. If this choke is connected immediately at one of the terminals, there will be little radiation from the line. If another choke is connected in the other side of the line, there will likewise be no radiation from this line. It is, therefore, recommended that one of these chokes be used in each side of the line. The size and current rating is dependent upon the type of motor used.

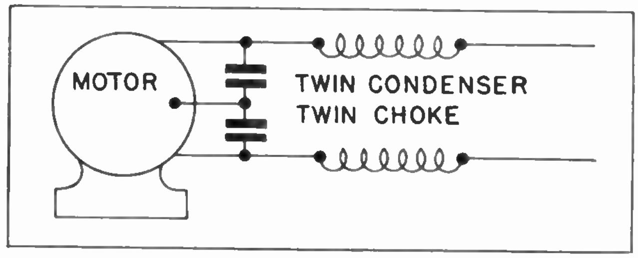

FIGURE 2

In Figure 2, we have a combination of condensers and twin chokes to eliminate interference. The condensers provide an easy path for the interference and make it possible to hold down the signal to the source, which is the motor itself. A certain amount of the interfering noise may still go beyond the condensers however, in which case the effect of the chokes is to block this additional interference, and thus afford more positive noise elimination.

NECESSARY EQUIPMENT FOR NOISE ELIMINATION WORK:

A good assortment of filters and condensers is the first requisite for interference elimination work. As stated above, the exact type of filter to use for any given case of interference must be determined experimentally. In general, the twin condenser arrangement with center point grounded to the frame of the interfering equipment will produce satisfactory interference elimination. In many other cases, however, chokes in addition to the condensers must be employed.

In addition to the filters, it is desirable to have a portable battery operated receiver for locating the interference. A PHILCO portable receiver is highly suitable for this purpose. A receiver of this kind will enable the serviceman to locate practically any kind of radio interference, including that which may be present in public utilities equipment.

A loop aerial having approximately 20 turns of stranded hook-up wire and a cross sectional diameter of 15 inches should be constructed and mounted on the end of a wood pole ½ inch in diameter and 3 feet long. A piece of twisted pair aerial transmission line 8 feet long, inserted within flexible shielding is then connected to the two ends of the loop and the opposite end of the transmission line connected to the loop antenna terminals on the battery receiver. The shielding over the transmission line should be grounded to the chassis.

HOW TO LOCATE NOISE INTERFERENCE:

The interference locating receiver described above can be used to advantage in practically all cases for locating the source of interference. One of the first things to do is to determine if the interference is inside the house or outside. This can be done by placing the interference receiver in operation, and then pulling the main switch at the fuse box. Any interference which is present within the house will immediately stop as soon as all power has been disconnected. If the interference continues, then it is known that the source is external.

Two actions are necessary in determining the source of external interference. The first is to get a general idea from which direction the noise is coming. The second is to locate the apparatus causing the noise after having determined the general location of the offending apparatus. The PHILCO battery operated receiver works out very nicely in both these respects.

A pair of headphones may be connected through two .5 Mfd. Condensers, Part No. 45-3500-10 to the plate of the Output Tube. The Speaker is unnecessary for this type of work.

With the receiver and loop aerial connected in this manner, tune the receiver to the point on the dial that gives maximum interference with a given setting of the volume control. Then rotate the loop aerial until a point of maximum interference is indicated. By drawing an imaginary line horizontally through the loop, this line will point in two directions. Follow this line in one direction for a short distance and observe if the intensity of the interference increases. If it increases, you are proceeding in the right direction. If it decreases, go in the opposite direction.

When the general location of the interference source is reached, the loop aerial will have very little directional effect. It will then be necessary to replace the loop with a small coil. The coil consists of 6 turns of wire wound on a piece of bakelite tubing 2 inches in diameter. This coil may be mounted separately on a 3 foot pole in the same manner as the loop, if desired, having the same type of shielded twisted pair lead-in down the pole. With this arrangement to change from one to the other it would only be necessary to disconnect the one in use, at the set, and connect the other.

After the pick-up coil has been connected to the set, the next action will be to explore around the power apparatus and power wires in the vicinity. If this equipment is radiating interference, the noise will be indicated by a gradual intensity increase when the pick-up coil is brought near the offending apparatus or wiring. The motor or power apparatus may be turned off, noting the change in noise picked up by the receiver. If the noise ceases when the apparatus is turned off, it is evident that the source has been located.

In the case of interference which is traced to electric power wiring on the street, the cooperation of the local electric light and power company should be secured. It will be found in all cases that the public utilities companies will be glad to cooperate. Radio interference makes people shut off their radio sets, and this means that the electric company is not selling power to these consumers, hence, it is to the advantage of the utility company to do everything possible to eliminate interference, from the sales standpoint, and it is also to their advantage from a maintenance economy standpoint. The important thing to bear in mind when going after an electric company or trolley company is to be sure you are right in your deductions that the interference is coming from the utilities equipment.

HOW TO ELIMINATE INTERFERENCE FROM HOUSEHOLD APPLIANCES:

(*a*) SMALL MOTORS, AUTOMATIC ELECTRIC HEATERS AND IRONS: The great majority of interference which originates in household appliances can be eliminated by connecting the twin condenser-type filter across the line to the interfering equipment, and connecting the common center point or case back to the frame of the equipment. The leads from the motor terminals to the condenser should be as short as possible. The condenser interference eliminator should be mounted inside the motor frame, if possible, or at least on the outside of the frame. The center point of the condensers is connected to the case.

The necessary capacity of the condensers will be determined by the strength of interference which is present. In the case of small equipment, a small twin condenser filter will be satisfactory, but for larger equipment, a larger twin filter condenser of greater capacity and power rating should be used. In the case of small Universal motors, which are sparking badly, it may be desirable to first clean the commutator with fine sand-paper in order to reduce the sparking to a minimum. Connection of the filter across the terminals of the motor will then eliminate all of the residual interference. Remember in all cases that the filter leads must be kept as short as possible and *must be connected directly at the motor terminals and not across the line at a distance from the motor.*

In some appliances, it will be found necessary to use the combination of condensers and choke in order to fully eliminate all interference. Included in this general classification of appliances would be such items as electric fans, electric mixers, vacuum cleaners, washing machines, sewing machines.

In some cases it may be desirable to employ an actual ground connection to the motor frame for improved noise elimination or for the sake of removing the A.C. voltage (low current) which is present because of the condenser being connected to the line.

(*b*) ELECTRIC REFRIGERATORS: Most A.C. operated electric refrigerators employ an induction motor which does not ordinarily introduce interference except when starting. In occasional cases, however, it may be found that one side of the line to the motor or inside the motor will be grounded to the frame. In this event, it will be necessary to eliminate the grounded line before this interference can be corrected. This ground may be of comparatively high resistance or it may be a direct ground. Care must be observed not to blow fuses when experimenting. In some cases, induced interference may be present in an electric refrigerator frame, in which case condenser filters should be connected experimentally:

(1) Twin condenser filter across the motor terminals with common point (case) mounted on the frame;

(2) One condenser .5Mfd. from the frame to a water pipe ground;

(3) One condenser .5Mfd. from one side of the line to the frame.

In the case of an electric refrigerator which is operated on 110 volts direct current, the line can be filtered by means of the condenser and choke filter unit connected across the terminals of the motor and mounted on the frame near the motor. In extreme cases, particularly on D.C. motors, the use of the heavy duty filter may be required.

(*c*) DEFECTIVE FIXTURES AND WIRING: Loose wire contacts in a lamp socket or plug will often cause interference. Likewise, a loose contact in a wall switch will cause trouble. The various circuits should be checked by a process of elimination until the particular source of interference is located. This can be done simply by turning on all of the lights, switches and fixtures at one time; then start turning them off until the particular circuit is located where the interference stops as the circuit is turned off. An old electric light bulb which is about ready to burn out will often cause an extremely loud noise.

HOW TO ELIMINATE INTERFERENCE FROM VIOLET RAY MACHINES AND THERAPEUTIC EQUIPMENT:

In most cases, violet ray machine interference can be eliminated at the source by means of small condensers across the power line. In the case of some of the more elaborate therapeutic equipment used by doctors, it may be necessary, in addition to having the various line filters, to use complete shielding of the equipment. Most equipment of this type is large, and the entire wiring as well as the body of the patient becomes a radiating antenna for the interference. The only effective way to eliminate this interference entirely is to provide a completely shielded room made of carefully bonded copper screening grounded at various points.

HOW TO ELIMINATE INTERFERENCE FROM NEON SIGNS AND FLASHING SIGNS:

Neon signs offer the serviceman one of the hardest problems in noise elimination. The elimination of interference from this source is comparatively simple, however, once the cause of this disturbance is understood.

The usual Neon sign installation has a step-up transformer connected to a series of glass tubes that are filled with the Neon gas. The voltage necessary to illuminate the gas in these tubes will vary from 5,000 to 20,000 volts, the exact value depending on the size of the sign. A leakage termed "Corona discharge" usually exists in this high voltage circuit causing the radiation of a continual buzzing noise. This noise is radiated in two ways; through the transformer, out into the power line, and from the high voltage circuit itself. A leakage in the high voltage circuit can exist at either or both of two places, the first being leakage between the high voltage leads coming out of the transformers, and the case; the second, leakage between the tubes of a letter where they cross. For example: If a tube is folded into the letter "O", there will be a crossing of the tubing at the bottom of the letter. The spacing between the tubes at this cross is only about 1/8 inch, which in high voltage circuits would permit a corona leakage to exist. In extreme cases where the spacing between the tubes crossing is this close, the serviceman should contact the neon sign people and have them heat the tubing and separate it at least 1/4 inch.

Care should be taken in the installation of supports for Neon signs since any leakage will result in the terrific noise mentioned above. To prevent the noise from going out into the power lines and radiating from them, it will be necessary to install a twin condenser filter in the 110-volt line circuit as near the transformer as possible.

Interference from flashing type signs can be eliminated by connecting twin condensers across the line with the common center (case) of the filter connected to the frame.

PR 2099-12