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RCA INSTITUTES INC.

A Radio Corporation of America Subsidiary

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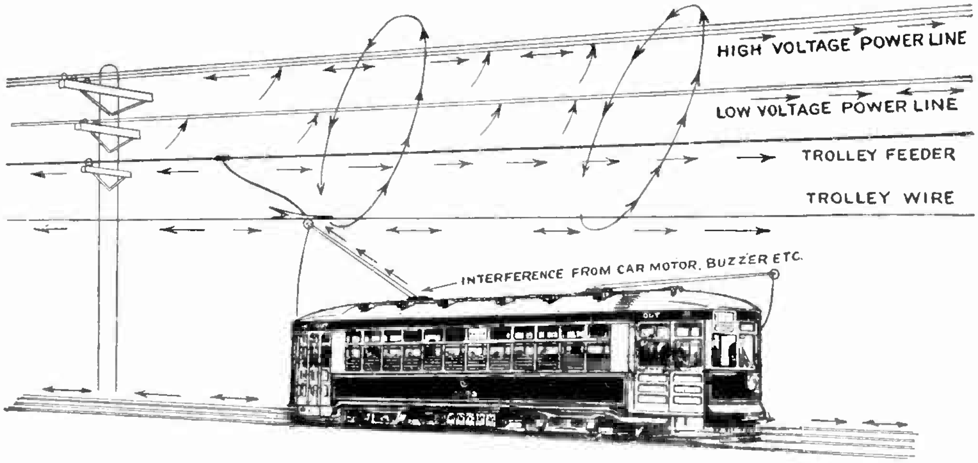

Diagram showing inductive transfer of interference from a street car to the feeder and primary and secondary distribution network.

INTERFERENCE ELIMINATION

Prepared jointly by the Tobe Deutschmann Corp., and the R.C.A. Institutes, Inc.

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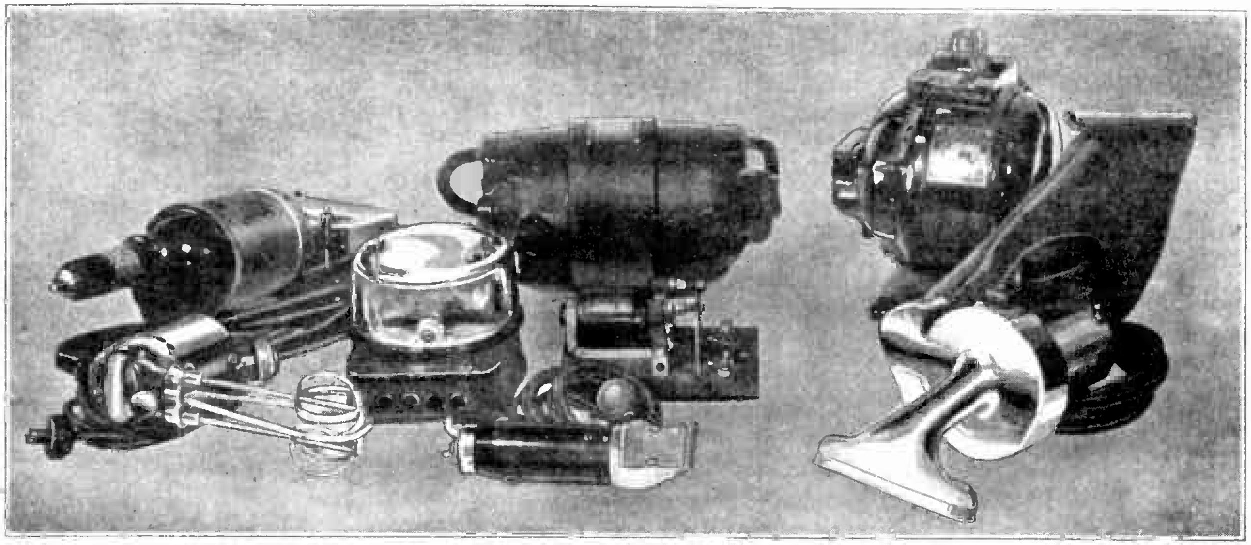

Appliances of the type shown above are responsible for a large percentage of the radio interference in every city.

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INSTITUTES -INC-

INTERFERENCE ELIMINATION

The term "interference" in the broad sense of the word means that when listening to a broadcast program, sounds are heard from the loudspeaker which are not a part of the desired signal. These sounds form a disturbing background to an otherwise enjoyable program and they appear in different forms. They are usually unintelligible sounds which may be described as trifling, fluttering, squealing or queer blurring and buzzing noises. The cause of many of these disturbing sounds which detract from the radio program are readily understood while the cause of others is recognized usually only by the service man who has actually become experienced in this phase of the work.

Radio interference may be classified under six headings as follows:

1. Broadcast transmitters radiating energy on the same or nearly the same wavelength.
2. Nearby powerful broadcasting stations.
3. A neighboring receiver in an oscillating condition will act as a miniature transmitter.
4. Electrical atmospheric disturbances arising in space and commonly known as atmospheric or static cause interference.
5. Faulty parts of a receiver at times will give rise to disturbing noises.
6. Lastly, we have interference which originates from commercial electrical machines, power lines, trolley cars, elevator systems, subways, home electrical appliances and electrical apparatus used in the professional field, such as X-ray and violet ray equipment. This type of radio interference is more commonly referred to as man-made static.

Interference of the nature outlined under the first heading may be due to transmission problems or to lack of selectivity in the receiver. By transmission problems is meant the possible faults in the frequency control devices of the transmitting equipment or where two stations are operating on or about the same frequency at the same time or on frequencies not separated by at least 10 kilocycles.

A shrill whistle which forms a background to the program being received is sometimes caused by broadcasting stations transmitting on adjacent frequencies less than 10 kilocycles apart. When the proper separation of frequencies is not maintained and the receiver is tuned to either of the stations operating under such conditions two currents of different frequency pass simultaneously through the receiving circuit producing an entirely new frequency which is audible. The production of a third frequency or beat note when one frequency is superimposed upon another is called heterodyne. This phenomenon explains the meaning of the expression "the heterodyning of two stations". Such heterodyning not only will cause a shrill whistle, but on occasion when one of the transmitting stations carrier frequency is varying back and forth the resulting heterodyne beat note may be an audible note of varying frequency. Conditions of this kind, however, are rapidly disappearing due to the work of the Radio Commission assisted by the officials of broadcasting stations. Cooperation between officials of broadcasting stations and the Commission results in either a reallocation of wavelengths, a more active watch being maintained on the frequency control devices at the transmitters, or some equally satisfactory plan is put into practice whereby this familiar form of interference is eliminated.

From what has just been said you can readily realize that the serviceman cannot correct troubles of this nature. These difficulties must be removed by the engineers of the stations at fault.

The heterodyne signals resulting when the side band of two transmitters meet are reproduced with greater amplitude on the more modern receivers whose sensitivity is much greater than those of previous years manufacture. This is so because of the increased over-all amplification of the modern receiver as compared to the less modern receiver. Hence a receiver of this design in practically all cases will make an interfering signal audible under certain conditions, where a less sensitive receiver delivering less loudspeaker volume for a given signal on the antenna will not reproduce the interference. This means that the interfering signal may be present in the less sensitive receiver, but it is not amplified to the point of audibility.

The sensitivity of most of the modern receivers is governed by means of a volume control which functions independently of the selectivity control, therefore, the procedure to adopt when interference is experienced with an extremely sensitive receiver is to reduce the sensitivity of the receiver by the volume control. This condition is rapidly disappearing due to the new 50-cycle frequency control regulation of the Federal Radio Commission. Consequently, very little interference of this nature will be experienced in the future.

INTERFERENCE FROM POWERFUL NEARBY BROADCASTING STATIONS

This interference usually results from lack of selectivity of the receiver in question. That is, inability of a receiver to reject signals other than those of a frequency 5 kilocycles below or above that frequency to which the receiving circuits are tuned. Receivers now used for radio broadcast reception may be classified as follows:

1. Those which utilize one stage of tuned radio frequency and variable regeneration.
2. Those which utilize three stages of tuned radio frequency without the effective balancing or coupling between the radio frequency stages, each stage,

however, being heavily damped by what is termed the grid suppressor method which prevents oscillation between the RF circuits.

3. Those which utilize three radio frequency stages, with out the grid damping resistors, and employing more or less complete balancing of interstage coupling between the radio frequency stages; or else employing screen grid tubes as radio frequency amplifiers, with the consequent reducing in the tendency of feed-back, which causes oscillation to take place.
4. Receivers using three or more tuned or untuned radio frequency stages, which stages are preceded by a pre-selector or band-pass filter tuning circuit frequently called a link circuit.
5. Superheterodyne receivers in which both radio frequency and intermediate tuning stages are utilized.

Receivers under classification 1 are more selective than receivers consisting of a detector and an audio frequency amplifier only. Class 2 and 3 have a higher degree of selectivity than class 1 and greater selectivity may be obtained with classes 4 and 5 than either of the preceding types.

Individual receivers, however, may vary relative to the degree of selectivity they are supposed to possess regardless of their design, and especially when located in close proximity to a powerful broadcasting station. The types of receivers subject to interference because of their location to a nearby powerful broadcast transmitter are those mentioned under class 1 and others not classified, such as the single circuit type and some of the home constructed sets. The majority of receivers outlined under 3, 4 and 5 are usually factory products and little or no trouble will be experienced with them unless the gang condensers tuning their tuning circuits are not in proper alignment. This will require that the gang condensers be properly aligned in order that all tuning circuits be resonant to the same frequency at the same time. In the case of superheterodyne receivers this would require a complete realignment of the intermediate frequency, oscillator and radio frequency tuning condensers for maximum output at all points of the dial.

Occasionally, however, any receiver will vary as to its ability of selecting a particular frequency to the exclusion of others especially when located very close to a powerful transmitter, let us say, within a radius of 2 or 3 miles. When this is the case a device known as a wave trap may be employed to overcome the difficulty.

A wave trap is a device designed to reduce or eliminate radio interference when this interference is caused by stations other than the one desired. There are two principle wave traps one of which is known as the absorption and the other the rejector type.

A diagram of the absorption type wave trap appears in Figure 1. The two coils shown are wound on a 3 inch form. The small coil consists of from 5 to 8 turns of double cotton covered wire closely wound. This coil is connected directly in the antenna as shown in the figure.

The large coil is wound with 55 to 60 turns of #28 double cotton covered wire. A .0005 microfarad variable condenser is connected across this coil.

The degree of coupling between these windings offset both the elimination of the interfering signals and the position of the tuning controls of the receiver. To obtain close coupling, wind the coil 1 close to coil 2 thus decreasing the distance between them. This will materially aid in eliminating the interfering signal, but it has a greater effect upon the position of the tuning controls of the receiver.

To secure loose couplings wind coil 1 and coil 2 in such a manner that an open space separates the two windings. The results obtained will now be the reverse of those when close coupling was employed.

The correct spacing to allow between the two coils so that a satisfactory elimination of the interfering signal is secured and at the same time effecting the least change in the receiver controls from their normal tuning position is found by a little experimenting and when once found it can be made permanent.

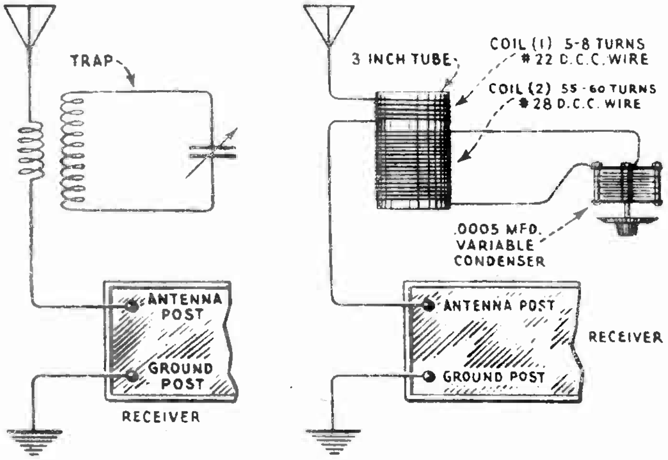


Fig. 1 - View and schematic of an absorption type wave trap.

To use the wave trap set the condenser to zero. Tune the receiver until the interfering signal is received with the maximum voltage. Then rotate the trap condenser until the undesired signal is reduced to minimum strength. Carefully readjust the receiver controls to the interfering signal a second time and readjust the trap condenser until the undesired signal entirely disappears or is reduced to minimum intensity. The wave trap control is now left in this position as long as this particular frequency is to be eliminated. The receiver is operated in the usual way to select the desired signal.

The wave trap functions as a resonant circuit in which alternating current is flowing. By varying the capacity of the variable condenser the capacitive reactance is made equal to the inductive reactance, thus cancelling out these two forms of opposition which oppose current flow at a particular frequency. The circuit is then reduced to one possessing only ohmic resistance and thereby allowing the maximum current to flow. The purpose of the wave trap in Figure 1, the absorption type, is to absorb energy at the particular frequency so that little or none of it will reach the receiver.

A view and schematic diagram of the rejector type wave trap is shown in Figure 2. It is composed of a three-inch tube on which is closely wound 50 to 55 turns of No. 22 double cotton covered wire and a .0005 microfarad variable condenser. The condenser is connected in parallel with the coil.

The operation of this wave trap is identical to the type just described and it has practically the same effect upon the tuning of the receiver as the former type.

The circuit consists of an inductance and capacity connected in parallel. This combination in turn is connected in series with the antenna. By means of the variable condenser it is possible to adjust the trap circuit to resonance with the frequency of the interfering signal. When this condition is obtained the trap circuit offers the least impedance to the interfering signal frequency and bypasses it from the main antenna circuit thereby allowing it to flow back and forth between the condenser and the coil. In this manner it prevents the undesirable frequency from reaching the receiving circuit. This arrangement is most successful when the

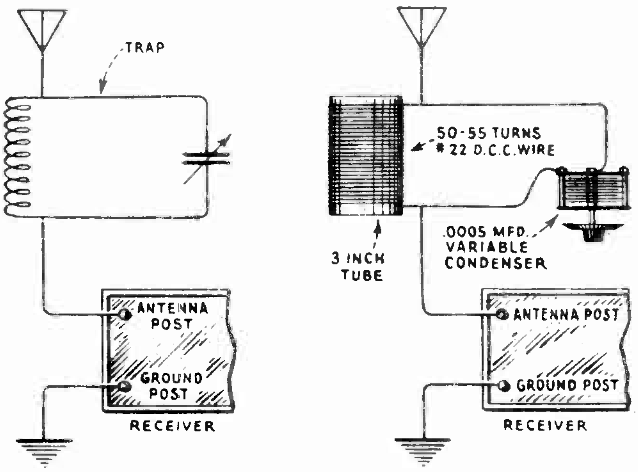


Fig. 2 - View and schematic of Rejector type of wave trap.

antenna is exceptionally long or where the receiver is connected to a poor ground; the wave trap, therefore, can be advantageously used in conjunction with the more or less non-selective types of receivers which are located near broadcasting stations. With the present day modern type of superheterodyne receivers whose degree of selectivity is positively of the order of 10 kilocycles even when very strong signals are present in the antenna system, it will hardly ever be found necessary to use wave traps on these receivers. When a problem of interference under this heading is found to prevail in this type of receiver, the remedy invariably will be to completely realign the receiver tuning circuit.

OSCILLATING RECEIVERS

Regeneration is the process of feeding back energy from the plate to the grid in a vacuum tube circuit. This is permissible, in fact, an asset to a receiver. When, however, carried beyond a certain point, regeneration in the proper sense of the word ceases and the receiving circuit becomes an oscillating circuit. As such it is a generator of high frequency oscillation and in this condition it is really a transmitter.

The power of the radiated energy from an oscillating receiver is weak compared to that of a broadcasting transmitter, yet it radiates sufficient energy to occasionally destroy a broadcast program being received by a neighboring set if the two sets are tuned to the same program. Manufacturers of modern receivers employing a regenerative detector always design the circuit so that oscillations of this nature are prevented from reaching the antenna, but some of the earlier types of receivers were not designed to take care of such a condition. Many of these older sets are still in use, and interference caused as a result of their improper operation should be recognized immediately by the serviceman. If a shrill whistle is heard at times breaking into the program with a violent jerk and at other times gradually rising and falling in pitch when the controls of the receiver are not being manipulated it is a fair indication that someone in the neighborhood is operating a receiver in an oscillating condition.

In the majority of cases the listener-in does not know when he is obtaining the best possible results with the particular receiver he is operating and in an endeavor to get maximum volume he forces the set beyond the best operating point, setting the circuit into oscillation. There is very little that one can do to eliminate this type of interference other than to locate the owner of the offending set and inform him that he is creating interference in his effort to obtain greater volume. Since, however, this type of receiving circuit is giving way to the more modern receiver this type of interference is very rarely met with these days.

ATMOSPHERIC INTERFERENCE

How often we have heard that word! Its tendency to interrupt and in many instances entirely ruin radio broadcast reception is not an uncommon occurrence. "Atmospherics" and "Strays" are synonymous expressions for static. All three of these words refer to the roaming electrical phenomena which are produced by nature. Static is a short way of saying static electricity, and because static electricity concerns us at this time we should know something more about it. The atmosphere of the earth is filled at all times with what is termed "charges of free electricity". This free electricity is static electricity. Where it comes from, no one definitely knows. Many opinions have been expressed in an attempt to arrive at a satisfactory explanation of its exact origin; it still remains, however, one of the secrets of nature.

A most vivid manifestation of the presence of static charges in the air is during thunder storms. The lightning seen at such times is the discharge between the clouds and earth (and between cloud and cloud) of great accumulations of static electricity. A discharge of this nature is immediately made known by a characteristic crashing noise being emitted from the loudspeaker. We say this noise is caused by static.

Fine weather may prevail at the location of the receiver, but the lightning discharges of a distant storm will still have its effect upon the receiver, even though it is thousands of miles away.

Why the receiver is affected by static is because of the discharge of static accumulations which set up an electromagnetic disturbance in the atmosphere. A thunder storm acts as the greatest producer of this form of electrical disturbance.

CARRIERS OF STATIC CHARGES

When listening-in to a program during a rain or snow storm it is not an uncommon occurrence to receive a slight hissing sound. The rain drops and snow flakes are carriers of minute static charges and, as they come in contact with the antenna wire, they impart this charge to the aerial system. Each of these charges set up a minute current which passes through the receiving circuit to earth, producing a slight oscillatory impulse in the tuned circuit which, in turn, is emitted from the speaker as a hiss.

In dry,hot weather the air is filled with small dust particles. These are also carriers of static charges which, on striking the antenna, give up an accumulated charge and produce interfering effects.

Other characteristic noises heard from the reproducing unit of a receiver, because of the effect of charged particles striking the antenna, are irregular "clicking" sounds or crashes resembling that which would be heard by throwing pebbles against a wall.

OTHER SOURCES OF ATMOSPHERIC DISTURBANCE

It is not uncommon, since radio broadcasting became popular, to read accounts of the "Northern Lights" (Aurora Borealis) and its effect upon radio broadcast reception. Why the Aurora Borealis should affect radio reception is not difficult to understand when we accept the scientific reasoning that is set forth as a possible explanation of the phenomenon.

Bodies in space are considered to be one of the sources of electrical phenomena affecting radio reception. This is especially true of the sun which may be thought of as an enormous generator, and which not only radiates heat and light waves, but electrical waves as well. The one particular form of electrical phenomenon in which we are interested, is one which is visible to us on earth; namely, the Northern Lights. Because of the tremendously high temperature of the sun, a continual forming, combining, and decomposing of its elements is in progress, and the atmosphere surrounding this body is considered to be of a gaseous nature. Heated gases originating within the body of the sun rise to great heights and in moving away they expand and cool. In cooling they naturally become heavier than the heated gases below them and they then have a tendency to fall back toward the surface of the sun. An opening may occur at a lower level in the sun's atmosphere, or perhaps at some spot on the surface of the sun into which these cooled gases sink. As they fall back they increase in velocity, rushing toward the openings at tremendous speeds until finally they become stupendous cyclonic storms embracing areas thousands of miles in diameter. This whirling body of gas rushing into the sun is considered to be charged with electricity and, in its downward motion, it sets up a magnetic disturbance of great proportions; so great, in fact, that they extend millions of miles into space. When a magnetic force of this nature emanates from the sun, and the earth is in a line with this force, it may make its presence known by the effect it produces, namely, the Aurora Borealis.

The lights of the Aurora Borealis are considered to be a condition of ionization of the gases in the earth's atmosphere. This does not take place on the surface of the earth, but at high altitudes called the "Auroral" region. This region is perhaps two or three hundred miles in height, at which point the gases of the earth's atmosphere are very low in pressure, i.e., rarefied.

The earth, in moving about its orbit at a speed of over 1,000 miles a minute, passes occasionally through one of these magnetic fields produced by disturbances on the sun. The rarefied gases of the auroral region then perform much like a closed conductor being forced through a magnetic field. An electromotive force is produced and current flows through the gas particles causing it to glow, resulting in a brilliant display of great ribbons of light across the heavens. This glow appears only at the heights in the atmosphere where the pressure is of the value that will cause ionization to take place.

The magnetic force, however, extends to the earth and, as the earth rushes through one of these magnetic storms, current is induced into all conducting mediums, such as antennae, telephone and telegraph lines, and so on. These in turn, produce the characteristic clicks called "Static". The effect of static due to the Northern Lights on telegraph and telephone transmission lines and on receiving antennae is peculiarly more noticeable and particularly annoying on transmission lines or antennae erected in an east to westerly direction. The effect on an individual antenna may not always be so pronounced, but in the case of telephone and telegraph lines, which extend for miles across the country, the induced voltage is often of sufficient magnitude to completely disrupt normal operation for several hours.

From the foregoing paragraphs it is understood that electrical disturbances which affect the reception of radio broadcast programs originate from different sources, and they create interference on all wavelengths.

A tuned radio circuit cannot entirely eliminate these disturbances, but it may greatly reduce them. If the interference is present on the same wavelength as the signal being received, there is no way to prevent it from passing through the circuit and causing audible response in the loudspeaker.

Many devices have been invented in an attempt to eliminate static. but so far the only practical method of reducing its effects is by employing loosely coupled circuits and short antennae. Static eliminators which have produced encouraging results are so elaborate as to prohibit their general use.

There are hundreds of devices on the market which promise to get rid of "Static", but stop and think; the biggest radio manufacturers in the world do not put these devices on their sets. Why? Because they know that they cannot be depended upon to work. The first thing anyone thinks of when he hears about static or interference for the first time is "something to go on the radio set". He doesn't know that the biggest companies in the world have been seeking for years to find such a device. When it is found, if it ever is found, the news will be on the front page of every newspaper in the country. Don't waste money trying "static" eliminators.

NOISE ORIGINATING IN THE RECEIVER

Noises which interfere with a broadcast program are often called static when in reality they originate in parts of the receiver. It is much better to classify this kind of interference as noise because static, strictly speaking, is the result of the antenna system absorbing electrical charges present in the atmosphere. Receiver noises are due to faulty units of the set, its accessories, poor design and careless construction work. It is well at this time to recall that such a thing as corrosion is ever present and frequently causes high resistance or intermittent contact at such points as vacuum tube socket contacts, switches, binding post terminals, sliding spring contactors and Hair Spring connectors to tuning condenser shafts, the junction of interstage shields, vacuum tubes base prongs, poorly soldered junctions and wire splices, etc.

If the on-and-off switch or change-over switch in a receiver becomes worn, the results will be a continual series of scratchy sounds. The worn contacts of the switch are subject to minor vibrations which may often cause circuits which the switch operates to be opened and closed, thereby interrupting current flow. A loss in sound intensity may also result due to poor or dirty contacts in switch parts causing the change of resistance in the circuit which the switch operates.

The rotor plates of variable condensers may become bent because of abuse, and when rotated they will short-circuit the condenser by making contact with the stator plate. When this occurs a click or rasping sound will be heard from the loudspeaker. Flexible leads connecting variable parts frequently become brittle and faulty and will produce crackling noises when the variable part is moved.

All binding post screws or terminal strips should be inspected and when found to be loose they should be tightened so that the wire end or the soldering lug on the cables connected to them will not shift position due to vibration.

Corroded soldered joints are the producers of much undesirable noise. This condition is quite prevalent in receivers several years old. When soldered joints are suspected of causing noise in a receiver, the best procedure is to resolder all of the soldered joints in the receiver by heating each joint allowing the old solder to flow off and replacing it with new solder. In this way an entire receiver can be resoldered in a few minutes and the result in operation of the receiver will more than repay for the time thus taken.

Excessive dirt or dust accumulations about open wiring between condenser plates and on the spring contacts of tube sockets will often be the source of crackling sounds. Such dust is very easily removed either with a strong hand bellows or with the blowing attachment on a modern vacuum cleaner. This will effectively blow off all dirt and eliminate the possibility of bending condenser plates when attempting to clean them by actually rubbing the dust off. The filaments of inferior tubes will often produce noise after they have been in operation for a long time.

A loose tube element shorting intermittently on other tube elements is frequently the cause of receiver noise; poorly designed and cheap grid leaks are very likely to give considerable trouble.

Tapping which occurs at more or less regular intervals may be due to a grid leak of wrong value. Try replacing it with various values until the tapping ceases. Loose control grid caps on screen grid tubes frequently will cause noise when the receiver is set into vibration. Also the control grid leads soldered to the control grid caps which fit on the screen grid tubes frequently are found to be open under the insulation of the wire. Such broken leads must be replaced. Defective resistors are the frequent cause of intermittent noises in a receiver. Such resistors usually open up at some point when they become warm after the receiver has been in operation for some time and since the open end of the wires do not move far enough apart, a continuous arc will take place across the open end. Such resistors must be replaced. Leaking filter condensers which have been in service for some time, particularly electrolytic condensers, tend to break down and the dielectric intermittently punctures.

This is a very common source of noise originating in receiver filter units and can be remedied only by replacing the filter condensers. Rectifier tubes with loose filaments frequently will cause such large variations with their current output as to make it impossible for the filter system to properly smooth out these large ripples. The only remedy in this case is to replace the rectifying tube with a new one. When audio transformer windings become open circuited, particularly secondary windings, they have been known to cause a continuous arc to take place across the open end. Small fixed condensers, used as by-pass and coupling condensers, will frequently function with very little leakage until a strong signal passes through the receiver. This usually results in higher voltages being impressed across these condensers and under this higher voltage they tend to puncture. Such condensers can only be located by unsoldering them from the circuit and applying a very high break-down voltage test to them. They must, of course, be replaced. On battery operated receivers the following conditions will also frequently cause circuit noises. Storage battery terminals often become corroded. The acid sulphate accumulating at these terminals is a source of trouble, sometimes completely preventing the flow of current. The increased resistance to the circuit caused by storage battery terminal corrosion will cause a faint high pitched whistle in some receivers. The remedy, of course, is to remove the corrosion and to treat the battery terminals and battery clips with a coating of grease or vaseline.

Broken plate supply leads in the receiver and in the receiver cables will produce loud clicking noises. Poor "B" battery connections will produce the same effect. When "B" and "C" batteries reach a discharge stage they are invariably noisy, that is, their internal resistance varies radically and this causes a varying current supply to the receiver. Frequently, even new "B" batteries or "C" batteries will be noisy due to poor or broken soldered connections between the primary cells of which they are composed. Corrosion of the wires on variable volume control resistors in any and all receivers result in poor and a high resistance contact between the sliding contactor and the wire. This constantly varying resistance of the circuit when the volume control is moved results in a scraping noise in the loudspeaker. It can be remedied by cleaning the wire at the point of contact and bending the contactor arm so that it makes better contact and coating the wire surface with vaseline to prevent further corrosion.

HOWLING

Howling may occur when the receiver cabinet or any of its controls are touched, or it may even occur when no one is near the receiver. This is caused usually by a microphonic tube. The howl caused by a microphonic tube is principally a problem of mechanical vibration. As you know, "sound" is the result of vibrating air particles and the vibrations of a loudspeaker set the air about the speaker into complex wave motions. If the loudspeaker is resting on a table, vibrations are imparted to the table top. The table top acts as a conductor for these vibrations and transmits them to other objects upon the surface of the table.

The vibrations from the loudspeaker may find their way to the tubes through the air, or by way of the table top. With the speaker isolated from the support holding the receiver, opening the lid of the cabinet will often result in this howl, which will cease when the lid is closed. It is clear in a case of this kind that the vibrations are reaching the microphonic tube by way of the air.

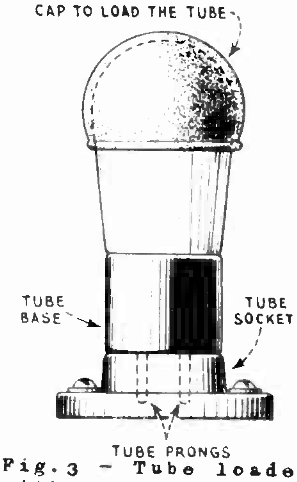


Fig.3 - Tube loaded with rubber cap to prevent vibration.

Consider another case where the loudspeaker is resting upon the same table supporting the receiver. As soon as the set is placed in operation the howl starts; by removing the speaker from the table the howl ceases. This time it is evident that the vibrations were being transmitted from the loudspeaker directly to the tubes by way of the table top, cabinet, and the tube sockets. A remedy which is very often successful in preventing microphonic tube howl is to "load" the tube with a heavy cap. This cap is slipped over the top of the tube as shown in Figure 3. An arrangement of this kind prevents the tube from moving freely. It is still free to swing when vibrations strike it, but not to the same extent. Spring sockets also tend to absorb shocks and vibrations which would otherwise cause the tube elements to vibrate. The vibration period of the tube, when weighted down with a heavy cap, is perhaps only seven or eight times a second. A vibration pitch of this magnitude is far below the audibility range and will not be heard in the loudspeaker.

The new a-c. tubes rarely, if ever, show microphonic tendencies and very little trouble of this nature should be experienced in the new sets.

Vibration is indirectly the cause of this microphonic trouble, but not the actual cause, for why should it occur with one tube and not another? A microphonic tube is simply an ordinary tube in which one or more of the elements are loosely mounted when assembled. It is essential that all of the tube elements (grid, plate, and filament) be so mounted and supported that a rigid fixed position is maintained between them. If any of the elements move, the spacing between them is changed, and, as a result, the normal characteristics of the tube are changed.

For example, a tube designed to have a low voltage amplification factor is so constructed that the grid and plate elements are mounted close together, while in a tube designed to have a high voltage amplification the grid is placed close to the filament and some distance from the plate. If the sound vibrations cause the tube to move, the loose elements will move also. The distance between these elements consequently are changed and the plate current will follow these changes. The plate current changes are then magnified by the amplifying stages following the microphonic tube and reproduced in the loudspeaker as a swinging howl, varying in pitch as the vibration pitch of the tube changes. In some cases, interchanging the tubes in their sockets will eliminate this trouble. A tube having extreme microphonic tendencies should never be used.

MAN-MADE STATIC

If after making the tests described above for natural static, and for defective parts in the set, the same noises as before are heard, the chances are that man-made static is the cause of the trouble.

In the study of radio interference and its elimination, there are a few fundamental principles which must be clearly understood if you are to be successful in your treatment of interference problems. The first thing you need to know is, just what is interference.

Radio interference is an undesired radio signal of such intensity and frequency that it interferes with the reception of desired broadcast signals. This is the broad definition of interference. For the purpose of this course, a more specific definition will be considered.

Radio interference, man-made static,is generally understood to be an undesired radio signal resulting from an electrical disturbance on, or associated with, a wiring circuit. The disturbance may take any one of many forms and the interference may be distributed in many ways, all of which will be studied at the proper time.

Although broadcast listeners have difficulty in realizing that man-made static is not the fault of the receiver, and although there has seemed to be considerable mystery about radio interference, careful consideration of the definition of interference will indicate that the same principles which apply to the generation and transmission of broadcast signals apply to the generation and transmission of the undesired radio signals which are termed "Radio Interference".

It is therefore obvious that in the solution of any interference problem, it is necessary only to consider the interference source as a radio transmitter and to take the steps which are required to prevent the propagation of signals from this transmitter. Figure 4 shows the similarity of an electrical appliance to a fundamental spark transmitter circuit. Just as the transmitter consists of a spark gap coupled to a circuit containing suitable values of inductance, capacity and resistance, so an electrical appliance containing any type of circuit interrupter such as a commutator, thermostat, mercury switch, spark plug or relay, contains what is essentially a spark gap coupled to a circuit embodying inductance, capacity and resistance. As the electrical constants of the transmitter govern the frequency and intensity of the radiated signal, so the electrical constants of the appliance govern the type and intensity of the interference which is produced.

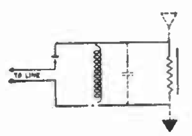


Fig. 4 - Diagram showing similarity of electric circuit to a spark transmitter.

Most types of radio interference have a characteristic sound. Listen carefully to the noise and see which of the following classes it comes under. Opposite each class of noise is a list of the kinds of electrical apparatus which are most likely to cause such a noise.

Whirring, Crackling, Buzzing, Humming, Droning, Whining

Sounds like these generally indicate radio interference which is being caused by an electric motor. Sometimes when the motor starts and stops, the sound will start low and rise in pitch until the motor reaches its full speed when the whine will remain at a certain steady pitch, usually rather high. This is especially true of commutator type motors. Repulsion-starting, induction-running motors may have a sputtering, whirring, crackling, buzzing or humming sound. When such sounds are heard hunt for one of the following:

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

Whistles and Squeals

Sounds of this sort generally indicate radio interference which is being caused by oscillation. Often the whistle or squeal starts high, dips to a low note and mounts again to a high-pitched squeal which may vanish entirely or remain at a steady, high-pitched whistle. Heterodyning broadcast stations have a sort of bubbling whistle, and can be recognized by the fact that they usually occur at the same spot on the dial. Old-fashioned radio sets which tune by the "squeal" of the wave, usually cause the squealing sound to be heard by all radio sets in the vicinity. The addition of a stage of non-oscillating radio frequency amplification will stop this. Whistling or squealing is usually caused by:

- Defective or incorrect value of filter condenser in super-heterodyne.
- Grid and plate leads so paralleled that there is an inductive pick-up between them.
- Grid-leak too high.
- Heterodyning broadcast stations - two stations of almost the same wave length operating at the same time so that the waves combine to form a "beat".
- Inductive pick-up of a loop.
- Intermediate stages of a superheterodyne in oscillation.
- Regenerative sets improperly tuned.
- Set picking up the squeal from a set in the neighborhood.
- Some R.F. stages not neutralized.
- Too much regeneration.

Rattles, Buzzes, Machine-Gun Fire

Sounds of this sort generally indicate radio interference which is being caused by telephone dialing, buzzers, or doorbells. It is not generally steady, but stops and starts. Short rattling sounds like machine-gun fire, varying slightly in length, indicate telephone dialing. Look for:

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

Violent, Heavy, Buzzing or Rushing Sound

Sounds of this sort generally indicate radio interference which is being caused by high-frequency apparatus. Such noises will usually be heard over a large area, a whole town, even, and often are so loud that they drown out the radio program completely. Look for:

- Air Purifiers
- Battery Chargers
- Diathermy Machines
- Doctors' Apparatus
- Dust Precipitators
- Flour Bleaching Machinery
- Violet Ray
- High Frequency Apparatus
- Insulation Testers in Cable Plants
- Ozone Devices
- Rotary Spark Gap of Transmitting Station
- Steady Oil-Burner Spark Ignition
- X-Ray

Crackling, Sputtering, Snapping, Short Buzzes or Scraping

Sounds of this sort generally indicate radio interference which is being caused by one or more loose connections. Sometimes the sounds are especially noticeable when the room is jarred or shaken by footsteps, street cars or traffic. Look for:

- Bad connections
- Burrs on plates of variable condensers
- Corroded or loose connections in radio sets
- Defective light-sockets
- Elevator control
- High tension lines
- Loose connections in floor lamps, appliance cords, broken heating elements, etc.
- Power lines grounded on branches of trees
- Street cars
- Trickle chargers

Clicking

Sounds of this sort generally indicate radio interference which is being caused by some sort of make-and-break connection, such as a thermostat, especially if it comes at fairly regular intervals. Look for:

- Defective Resistors in Eliminators
- Elevator Control
- Flashing Signs
- Heaters
- Heating Pads
- Incubators
- Irons
- Mercury Arc Rectifiers
- Ovens
- Percolators
- Shaving Mug Heaters
- Sign Flashers
- Soldering Irons
- Telegraph Relays
- Traffic Signals
- Typewriters

Heavy, Violent Buzzing, Usually Short

Sounds of this sort generally indicate radio interference which is being caused by arcing across a gap. This may occur as a short noise or a steady one. Look for:

- Arc Light
- Automobile Ignition
- Breaks in Third Rails
- Electric Car Switches
- Electric Cigar Lighters
- Electric Elevators
- Moving Picture Machines
- Pole Changers (Telephone Interrupter)
- Street Car Switches
- Street Lights
- Toy Electric Trains

Steady Humming

Sounds of this sort generally indicate radio interference which is being caused by improperly filtered alternating current. Such humming is often the fault of your set or eliminator. Look for:

- Dynamic speakers improperly filtered
- Faulty construction of set or eliminator
- Filter condenser blown or shorted
- Ground on set poor
- Improper wiring
- Poor tubes
- Wiring parallel with power lines

HOW IS MAN-MADE STATIC DISTRIBUTED?

In order to determine the best method of confining interference to its source it will be well to consider the ways in which man-made static and radio signals are transmitted.

The first and most generally understood method of radio signal transmission involves the radiation of energy from an antenna system and the transmission of this energy through the ether. Another method involves the use of wire channels on which the high frequency currents are impressed. This method of signal transmission is most widely used in what are termed "carrier telephony systems", whereby high voltage power transmission circuits serve as the wire channels for the distribution of high frequency currents.

In the distribution of radio interference, both methods of signal transmission are involved. By far the greater part of the interference is distributed by the carrier or "Wired Wireless" method. Further consideration of fundamental radio transmission principles will show why this is the case.

To obtain maximum radiation of energy, for transmission thru the ether, the antenna system provided must be correctly proportioned to be a part of the oscillatory circuit of the transmitter, at the desired frequency of transmission. Fortunately for radio listeners, the antennae (that is, the length of wiring connected to interference sources) associated with most sources of man-made static are not proportioned to provide maximum radiation of high frequency energy. Consequently, the direct radiation of interference is generally limited to a small area in the immediate vicinity of the interference source. Some energy, however, is radiated from all wiring circuits associated with any source of man-made static, and this possibility of interference radiation must be kept in mind whenever any apparatus is being filterized.

Except in extreme cases, interference radiated from an appliance seldom directly reaches the antenna of a radio receiver. This interference will, however, be transferred both inductively and capacitively to wiring circuits or to metallic objects and, once having been impressed on such circuits, may be distributed over a wide area.

In contrast to the transmission of radio-frequency energy through the ether is the transmission of such energy along wire channels. In order to transmit high frequency energy over a wiring circuit it is necessary only to couple the source of energy and the receiver to the wire line. In the case of a carrier telephone system, used in conjunction with a power transmission line, this coupling is provided by use of special coupling condensers as shown in Figure 5a or by use of a coupling antenna parallel to the power line, Figure 5b.

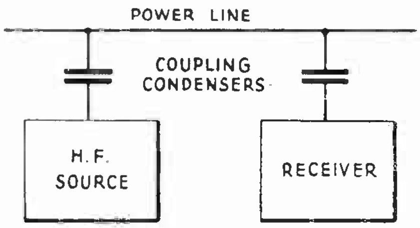


Fig.5a - Showing method of coupling transmitter and receiver to power line in carrier telephone system.

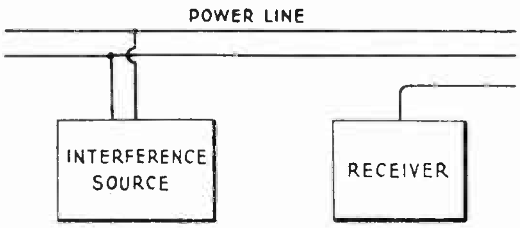


Fig.5b - Showing capacitive coupling between broadcast receiver antenna and power line. Note similarity to Fig. 5a.

It is easy to see the similarity between interference distribution and carrier telephony. The source of high frequency energy is the making or breaking contact; the inductance and capacity which govern the signal frequency are contained in the windings of the apparatus; the distribution channel is the power supply line to the apparatus; and the coupling of signal source to distribution channel is provided both by direct connection of the interfering apparatus to the line and by inductive or capacitive coupling between the wiring of the apparatus and wiring circuits in the building.

Contrary to the accepted belief, the direct wire connection between the radio receiver and the power line seldom serves to introduce man-made static to the receiver. Tests will prove that, in practically every case, interference enters the receiver through its antenna and ground connection. This is due to the fact that there is bound to be considerable coupling between the antenna, the lead-in, the ground wire and all power wiring, telephone wiring, or other wiring circuits. Thus interference impressed on power or lighting circuits is transmitted to the receiver as indicated in Figure 6.

FUNDAMENTALS OF INTERFERENCE SUPPRESSION

It has been shown that the procedure to be followed in suppressing man-made static is the same as that required for suppressing the signals from a radio transmitter whose signals are undesirable. An outline of just what procedure is required should be helpful at this time.

First, take the case of two broadcast transmitters operating at the same frequency. An example of this condition may be found on the 1,230 K.C. channel on which WNAC in Boston, Massachusetts is operating. Listeners to this station experience an annoying interference from Station WFBM in Indianapolis, Indiana which operates on the same channel. Since both stations are operating at the same frequency, any receiver of sufficient sensitivity receives signals from both stations, and these signals are hopelessly intermingled in the loudspeaker.

Obviously, any wave-trap or other device applied to the receiver for the purpose of eliminating the signals from one of these stations would also eliminate the signals from the other. Consequently, the only relief to be obtained by listeners to one station is the suspension of operation of the other, its removal to a different frequency, or the application of equipment to keep its signals off the air.

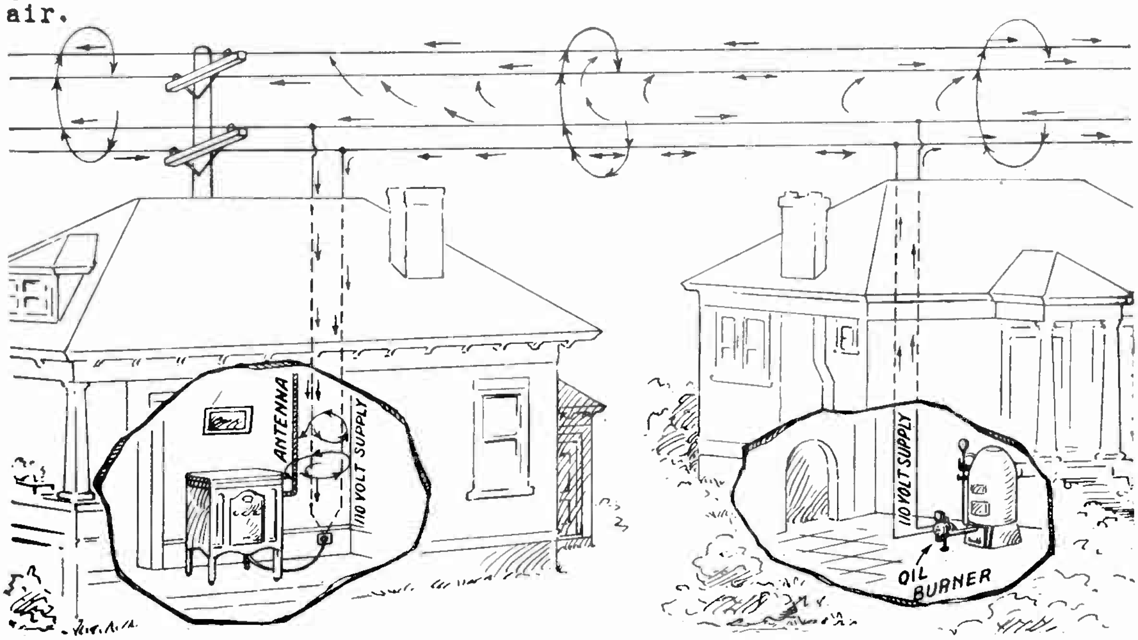


Fig. 6 - Diagram showing inductive transfer of interference from the input wiring of an oil burner to the antenna system of a receiver in a neighboring building.

With this example in mind it is easy to draw a parallel in the case of man-made static. The desired station may be any station, local or distant,operating at any frequency in the broadcast band. The undesired station may be any electrical apparatus, operation of which involves the making and breaking of an electrical circuit. The essential difference between the broadcast station and the interference source is that while the broadcast station has an established frequency, outside the limits of which it does not interfere with program reception, the electrical apparatus broadcasts a disturbance of indeterminate frequency, which mingles with signals from any broadcast transmitter and is inseparable from the desired signals.

It is, therefore, obvious that no device applied to the receiver will separate the broadcast signals from the man-made static. Any device which may appear to reduce interference, when applied to the receiver, will be found to accomplish this result only at the expense of receiver sensitivity and volume output of the receiver.

What, then can be done about interference which enters the receiver at the same frequency as the desired broadcast signal? Obviously it is no more possible to arrange for the suspension of operation of interfering electrical apparatus whenever a broadcast program is to be heard than it is to arrange for the shut down of an interfering broadcast station when this action might appear desirable. And since man-made static seldom has a definite frequency of transmission, but is intermingled with the signals of stations in almost every portion of the broadcast band, the removal of the undesired transmitter to a frequency outside the broadcast band presents a problem far different from that of changing the transmitting frequency of a radio station which interferes at one frequency in the broadcast band.

This brings us to the last mentioned and most generally satisfactory method of obtaining relief from interfering signals, namely, the application of suitable equipment, at the transmitter to keep the undesired signals off the air.

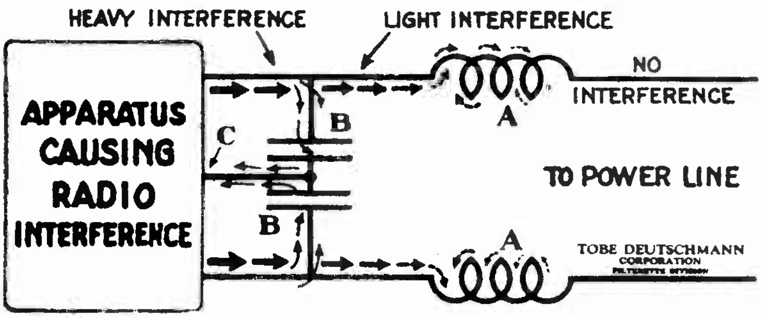


Fig. 7 - Showing how a filter connected between power line and interference creating device suppresses radiation of radio frequency energy.

FUNCTION OF FILTER COMPONENTS

Figures 7 and 8 show the operation of Filters applied to interference-creating electrical apparatus. As shown in these diagrams, the interference is impressed on the power supply line along which it may be carried for great distances and from which it may be radiated to reach the antenna of the receiver. As indicated in Figure 7 the interference, which has a high frequency, tends to flow through the condensers and back to the interference source. This is due to the fact that the impedance of the condensers, at high frequencies, is less than the impedance of the power line and as a result the relatively low interference voltage causes the interference current to flow through the condensers rather than along the power line. Thus a simple capacitive type Filter would be composed of two condensers "B-B" and a return connection "C".

It is important to note that the return connection "C" is not a ground connection. Figure 8 shows what would happen if this connection were grounded. The interference carried along the ground wire would be radiated from this wire to other wires or to the antenna of the receiver with the result that this supposed filter connection would cause an increase rather than a decrease in the interference. The same is true if the Filter is located too far from the apparatus which is causing the interference. Under these conditions a long return connection would be required and as a result interference would be radiated from this long lead as well as from the wiring between the Filter and the interference source.

To suppress this interference it is necessary to use an inductive-capacitive Filter as indicated in Figure 7. As shown in this diagram, the interference which over-rides the capacitive section of the Filter is dissipated in the inductive sections. Inductive-capacitive Filters may consist of sections A, B,B, and C or A,A,B,B, and C, the former combination being used when one side of the power line is well grounded and the latter when the service ground is more than 10 feet from the Filter.

IMPROPER WIRING CAUSES MUCH INTERFERENCE

The condition of wiring circuits in any building has considerable bearing on the results obtained from radio receiving equipment used in the building. Loose connections in wiring circuits, partial or intermittent grounds and high resistance, swinging short circuits may cause serious interference.

As has previously been explained, the voltage of the interference created by electrical apparatus is often so low that it will not

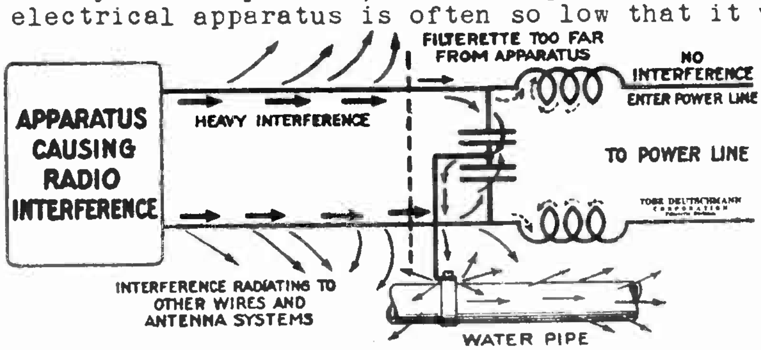


Fig.8 - Showing the effect of connecting Filter a few feet away from the interference source.

overcome the normal R.F. impedance of the power line. In many cases however, the electrical apparatus may create radio interference at sufficient voltage to overcome the impedance of the power line. In such a case only a part of the interference will be bypassed by the condensers of a capacitive type Filter, and the remainder will be carried along the building wiring.

There are two possible ways to consider the effect of loose wiring connections. Considering the way antenna systems are commonly installed, it is obvious that building wiring is a part of the antenna system. When a short indoor antenna is used, the energy received by the receiver is the result not only of pick-up by the short antenna, but of pick-up by all of the building wiring and by every metallic object in the building. The energy thus collected may be transferred either inductively or capacitively to the short antenna actually connected to the receiver. Thus the effect of a much longer antenna is obtained.

If greater signal pickup were the only result of this coupling between the indoor antenna and the building wiring, there could be little said except in its favor. Unfortunately, the additional antenna system thus coupled to the receiver contains many potential loose connections conducive to noisy receiver operation. Every light switch, dial telephone, or home appliance containing a thermostat or commutator may cause a break in the antenna circuit. To appreciate the effect of such a break, it is necessary only to disconnect the antenna from the receiver and attach it intermittently to the antenna binding post. The resulting sound in the speaker shows very clearly the effect of loose connections in the antenna system. It is, therefore, evident when noisy reception is found and when the trouble cannot be traced to any defect in the receiver, that conditions within the building in which the receiver is operated may be responsible to a considerable extent for the noisy reception.

The first step to be taken in assuring clear reception is a careful inspection of all wiring and appliances in the building. This inspection should start at the power service entrance to the building.

The points to be covered at the service entrance are as follows:

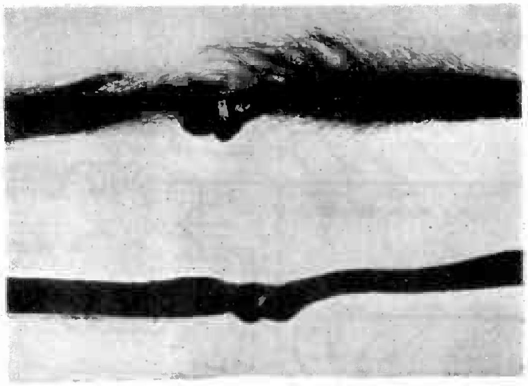


Fig. 9 - Badly worn lamp cords are fire hazards as well as sources of interference. Be sure lamps and appliances have approved cords.

1. Be sure that the service wires from the transformer to the building are not grounded to tree branches.
2. Be sure the service conduit is grounded.
3. Be sure the building wiring is grounded in accordance with the National Electric Code, and the regulations of the local power company.
4. Be sure the contacts of the service switch or switches are sufficiently firm to prevent arcing.
5. Be sure all fuses are firmly in place. This applies to branch circuits as well as mains.
6. Be sure the construction of the fuses is such that there is an uninterrupted flow of current through them. Some fuses have been found in which the connection between the link and the shell was not firm, with the result that arcing, causing radio interference, took place in the fuse.
7. Be sure that all wiring connections to branch cut-outs and mains are firmly made.
8. Be sure all lamps are screwed firmly into their sockets. Tap each lamp on the side to locate possible loose connections within the lamp. If such loose connections are found, the lamp should be discarded.
9. Examine all attachment plugs of floor or desk lamps and appliances, making sure that the prongs make firm contact with the receptacles, and that the terminal screws are holding the cord conductors firmly.
10. Examine all lamp and appliance cords, making sure that they are not worn excessively and that there are no

possible strands from one conductor making a high resistance contact with the opposite conductor.
NOTE: It is particularly important that lamp cords or other portable cords be maintained in the best possible electrical and mechanical condition as defects in such cords may create a serious fire hazard as well as considerable radio interference. Figure 9 shows a condition often found when unapproved lamp cords have been in use for long periods of time.

When all of the building wiring and home appliances have been inspected, and the necessary corrections made, a material decrease in noise level is likely to result, the reason being that many of the possible loose connections have been eliminated.

The second way of looking at this local interference problem is by consideration of the two fundamental sources of radio interference. In the final analysis, it may be shown that interference is the result of an interruption to the flow of current along a conductor, or to the discharge of potentials accumulated on a conductor. These phenomena may occur in the building in which the receiver is located and may thus be coincident with, and indistinguishable from the disturbance due to the loose antenna connections previously discussed.

In other cases, however, they will occur in neighboring buildings or at such distance from the receiver that they cannot be considered as loose antenna connections. Under these circumstances the way interference is distributed must be taken into consideration in deciding upon the best method of obtaining relief from this interference.

Interference due either to the making or breaking of an electrical circuit or to the discharge of a potential from one conductor to ground or to another conductor may be carried along any of the conductors in which the effect takes place and may be radiated from them. This radiated interference may be transferred either inductively or capacitively to other wiring circuits and the interference may thus be spread over a wide area. If any of the circuits on which this interference is traveling, enter a building in which a receiver having a short indoor antenna is located, it is then evident that the antenna system of the receiver in addition to accumulating broadcast energy, is carrying undesired electrical disturbances which are likely to interfere seriously with the reception of the desired signal.

When radiated interference is considered, the first thought is usually to provide shielding for the apparatus thus confining the radiated energy as closely as possible to its point of origin. While with some types of interference this shielding is not only theoretically advisable, but is a practical necessity, it is obviously impossible to shield all wiring on which interference may be carried. Under these circumstances, it appears to be necessary to locate the source of interference and there to take such steps as may be necessary to prevent the distribution of interference along wiring systems.

If the interference is due to the discharge of a potential from one conductor to ground or to another conductor, there are two possible methods of overcoming this interference, both of them involving the prevention of the discharge. The first is by providing suitable insulation between the two conductors and the second is by bonding them together. Two concrete examples of interference due to such a potential discharge as has just been described are as follows:

A broadcast listener found that whenever a certain hot water faucet was used radio reception was impossible. Examination disclosed the fact that a section of armored cable in the wall containing the hot water pipe feeding this faucet was not properly grounded. This cable was so located with relation to the hot water pipe that the slight vibration caused by the flow of water caused an intermittent contact between cable and pipe, allowing the discharge of a low potential from the armor of the cable to the water pipe. Grounding the cable sheath provided relief from the interference.

In another instance it was found that radio reception was out of the question when an electric refrigerator was being used. Examination of the refrigerator showed that the motor and thermostat were in

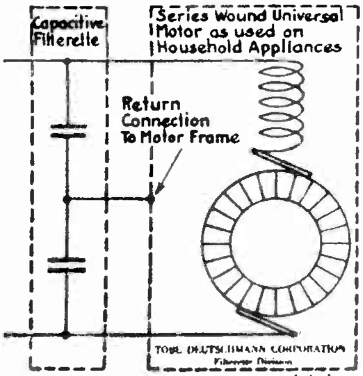


Fig.10 - Showing capacitive filter connected in motor power supply line.

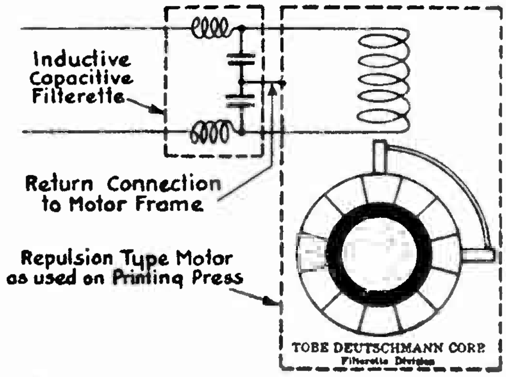


Fig.11 - Showing inductive capacitive filter connected to motor.

perfect condition, so that interference should not have been caused by this installation. In checking, it was found that the interference continued after the refrigerator had been entirely disconnected from the power line, and that this interference was noticeable as long as the compressor motor continued to rotate. Further examination of the refrigerator installation disclosed the fact that although the armored cable connected to the refrigerator was properly grounded, the refrigerator frame was not grounded. The result was that as long as the compressor motor rotated, the spring supports on which the compressor assembly was mounted allowed the mechanism to vibrate and make intermittent contact with the sheath of the armored cable. Bonding the cable to the compressor assembly removed all trace of interference.

It is, therefore, obvious that if freedom from interference is to be obtained, all metal objects likely to accumulate electrical charges should be grounded or should be so installed that there is no possibility of a potential discharge. Of the two methods, grounding is preferred. The broadcast listener or radio dealer may, by examination of the building in which the receiver is located, make sure that the potential discharges just described are not likely to occur.

There then remains the necessity for preventing the distribution of interference caused by interruptions to the flow of current along a conductor. This is accomplished by the application of suitable

Filters to the pieces of electrical apparatus in which these current interruptions occur. The application of a properly designed Filter will not only prevent the distribution of interference along the wiring to which the appliance is connected, but will also reduce, to a great extent, the loose antenna connection effect of the appliance operation.

With the exception of the electric refrigerator and the oil burner, a large majority of the household appliances in common use are operated by series wound or universal motors. Among the household appliances operated by this type of motor are the vacuum cleaner, electric egg beater, humidifier, drink mixer, and fruit juice extractor. By operating each of these appliances while the radio receiver is in use, the effect of the disturbance they create may be clearly observed. This disturbance is generally due to the two effects already described; the first that of a loose antenna connection, and the second the generating of a radio frequency impulse by the household appliance.

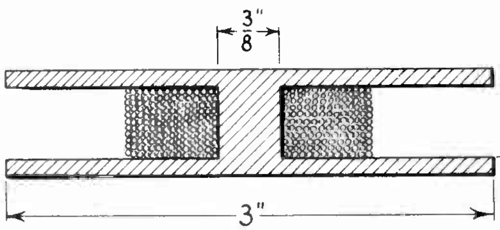


Fig.12 - Showing details of filter inductor construction.

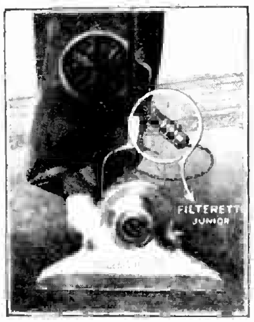


Figure 13

Fig.13 - Application of Filterette Junior to a vacuum cleaner. Note the return wire from the Filterette binding post to the motor frame.

Figures 10 and 11 show the connection of a capacitive and an inductive capacitive filter to such commonly used sparking motor driven devices. The condenser sizes will range from .1 to 2 mfd. and the inductors will range in size from 150 to 300 turns of #18 D.C.C. (for load currents under 3 amperes) wire wound on a spool having the dimensions shown in Figure 12.

Since the radio frequency energy thus developed may be radiated from all wiring to which the appliance is connected, it is obvious that the Filter which is to prevent this disturbance from reaching the receiver must be installed as close as possible to the point at which the interference originates. In the case of a series motor, the interruptions to current flow occur at each brush. The Filter must, therefore, be connected as close as possible to the motor brushes. If the Filter is located at the end of a long attachment cord, it is evident that a considerable length of lead between interference sources and Filter may allow the radiation of much interference. This might be suppressed by shielding the attachment cord, but since this procedure would decrease the flexibility of the attachment cord as well as increasing its cost, it is not to be recommended. A more satisfactory result will be obtained if the Filter is connected in the attachment cord within a few inches of the point where this cord connects to the motor. Many appliances, particularly vacuum cleaners, are provided with a separable connector at the point where the attachment cord connects to the motor.

This renders the application of a **Filter** a simple matter. Figure 13 shows a simple capacitive Filter correctly installed at the motor of a vacuum cleaner. In order to prevent the interference from traveling beyond the Filter and being distributed along the building wiring, a return connection is provided to allow the return of the interference to the point at which it originates. In effect, the use of a Filter in connection with a household appliance provides a low impedance path for the return of the radio frequency current to the frame of the appliance, thus keeping the interference out of the building wiring. The loose antenna connection effect is largely overcome by the bypassing of high frequency currents by the Filter.

DIAGNOSING CAUSE AND APPLYING A REMEDY

We now have a definite idea of the possible sources of radio interference. The next logical step is to determine how the service man may logically determine which of the six different types of radio interference exists in a receiver and how in turn each of these may

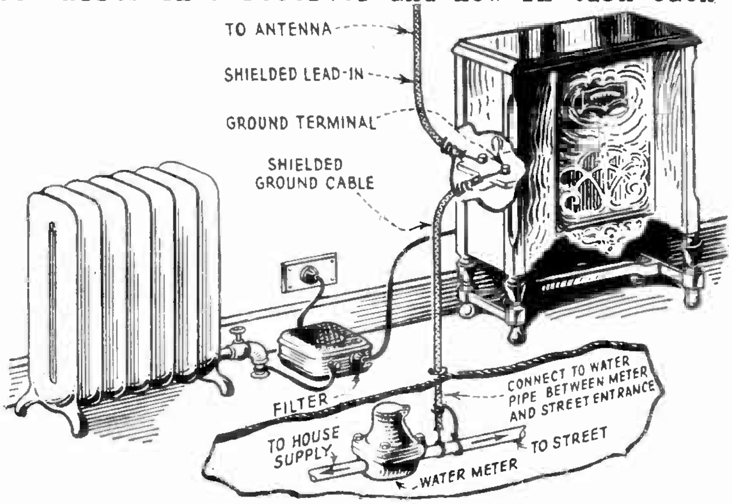
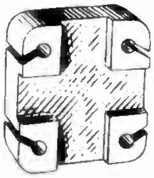


Fig. 14 - Showing details of shielded antenna system installation at a receiver.

be remedied. The first two types which are really the reception of unwanted broadcast signals are usually due to lack of selectivity in the receiver. This in modern receivers can be overcome by proper alignment of the RF tuning stages and the elimination of an unwanted signal from a very nearby powerful broadcasting station can be accomplished by the use of either of the two wave trap circuits discussed in the early part of this lesson. Interference of the type listed under headings 3 and 4 cannot very well be controlled by the serviceman. However, interference originating within the receiver circuits themselves and that type originating in nearby electrical apparatus either entering the receiver via the power lines, the antenna system or the more sensitive unshielded portions of the receiver circuit can be controlled and eliminated by the serviceman who must, however, first determine in which of these three ways the interfering signal is entering the receiver. This is, however, not always so simple to accomplish. A successful method of properly diagnosing this condition is here outlined.

To determine whether the interference is entering the receiver through the antenna system remove the antenna and ground wire. Take a small piece of wire or a nail preferably and connect the antenna and ground posts with it. It is important that if wire is used that the wire be no longer than is necessary to make the connection between the antenna and ground posts. Turn the volume control "full on". The antenna system has now been removed and any noises you still hear are due either to radio interference coming in over the electric light line or second, to a defective part in the receiver circuit or third, the interfering voltage is being induced in some sensitive portion of the receiving circuit. This third condition means that there is a strong interfering field in the immediate vicinity of the receiver. Most modern receivers are sufficiently shielded to prevent interstage coupling. However many of the more modern very sensitive receivers are not so completely shielded as to prevent a strong interfering field in their immediate vicinity from inducing an interfering voltage in their circuits, the proof of this is the fact that many of them will pick up local signals without any connection to their antennae and ground binding posts. A method by which such local pickup may be stopped is to place the entire receiving circuit assembly in a completely enclosed shield with no other openings than those required for tuning controls, antenna and ground connections and power supply. Such a metal shield usually is quite costly to construct. Another quite inexpensive and very satisfactory method is to line the inside of the receiver cabinet with copper screening, insulating the entire receiving chassis from the screening. This includes the building of what is equivalent to a screen door for the back of the receiver cabinet which should be securely fastened to the back of the receiver cabinet in such a manner that the wire mesh on the door frame makes good contact (with no opening) to the wire mesh lining the inside of the cabinet. The only opening that should be left in this complete shield should be the opening required for the power supply cable and the antenna and ground wires, and the tuning controls.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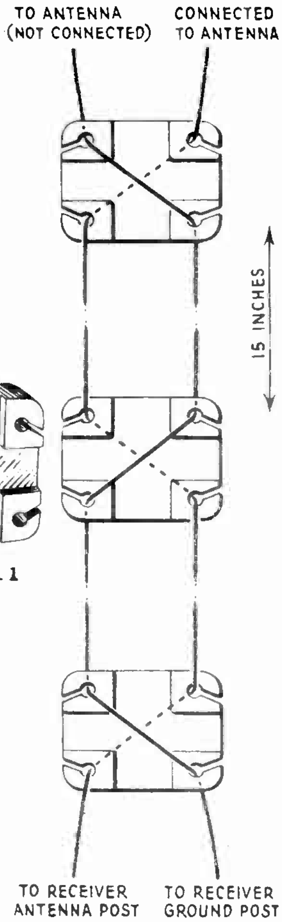


Fig. 15 - Transposed lead-in.

With the receiver thus shielded it is impossible for any local field about the receiver to induce interfering voltages in the vacuum tube circuits themselves. The shielding of the entire receiver as just described should only be attempted after the entire receiver circuit has been checked for possible sources of interference due to any of the conditions described under "Noise Originating in the Receiver", nor should the receiver be so shielded until a filter has been placed between the receiver power input and the power supply line. Thus, if the receiver has been checked for possible noises originating within its own circuit and the power line has been checked by the insertion of the proper filter for noises entering the receiver input, or tuned RF circuits, by means of induction from the field existing about the power line, and the noise or interference still persists, the complete shielding as outlined should be applied. All these tests should be made with the antenna and ground posts shorted.

Should the receiver be quiet when the antenna and ground posts are shorted this indicates that the interference is entering the receiver via the antenna and ground systems.

INSTALLATION OF NON-INTERFERENCE LEAD-IN AND GROUND

The next step in the reduction of the noise level is to decrease the coupling of the interfering field with the lead-in and ground system. Man-made static is generated close to the ground and remains close to the ground, except when it is carried, reflected, or reradiated by wiring, structures, etc., whereas the field of desirable broadcast signals is practically as strong or stronger at considerable distances above the ground. Numerous tests have shown that radio interfering fields seldom extend more than forty or fifty feet from

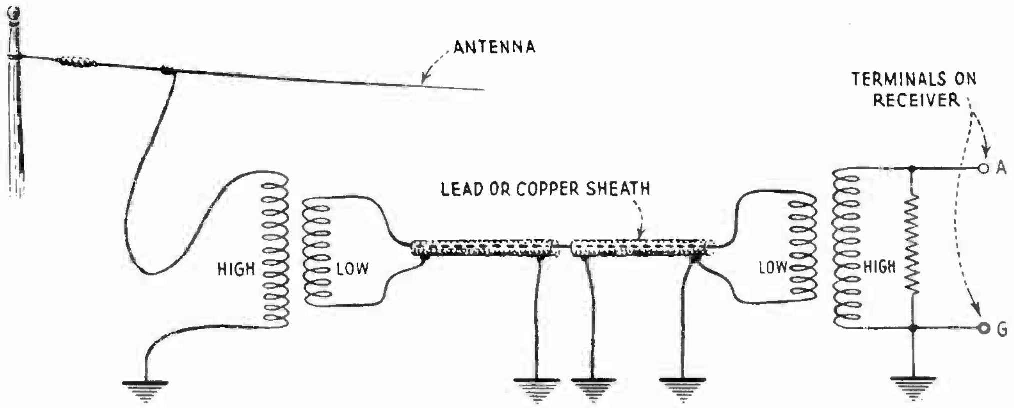


Fig.16 - Schematic equivalent of the transmission line type of antenna system.

the conductor on which they may be carried. It may then be concluded that most of the man-made noise heard in a receiver are picked up by the aerial lead-in, or by those portions of the aerial ground system which are close to grounded objects, pipes, power supply and telephone lines, roofs, walls, etc., which conduct or reradiate undesirable high-frequency electrical or electrostatic noises.

The problem then resolves itself into one of:

1. Locating the horizontal pickup portion of the antennae out of the noise level.
2. Eliminating or greatly minimizing the pickup of the lead-in and ground conductor which must pass through the noise field to the radio receiver.

The location of a well constructed horizontal portion may be accomplished by following these rules:

1. Install as high as possible.
2. Install a horizontal portion of at least 100 feet to 150 feet long.
3. Install as nearly at right angles to other wires as practicable.
4. Install so that a clearance of at least 5 to 10 feet preferably 20 feet from all surrounding objects exists.

5. Use good strain insulators and allow a distance of at least 5 feet between point of support and the insulator.
6. Solder all joints with Resin-core solder only.

The construction of the antennae lead-in and the ground wire so as to decrease their interference pickup may be accomplished in one of three ways:

1. The installation of a shielded conductor for both lead-in and ground wires.
2. The installation of a transposed pair of conductors to serve as antennae and ground wires.
3. (a) The installation of a step-down transformer at the antennae end of the lead-in and (b) a step-up

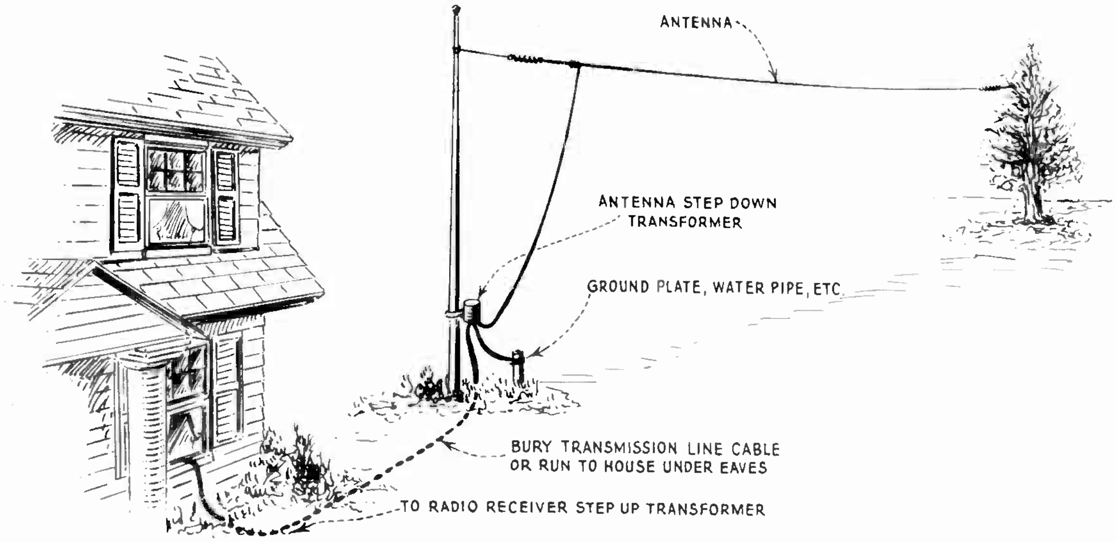


Fig. 17 - Showing the details of the construction of a transmission line antenna.

transformer (of the same turns ratio as the 1st) at the receiver end of the lead-in. The secondary of the first and the primary of the second R.F. transformer to be coupled by means of a pair of conductors either transposed or shielded (in lead or copper sheath). This is known as the R.F. transmission line method.

The details of the construction of these three types of noise reducing lead-in ground systems are shown in diagrams of Figures 14, 15, 16, 17, 18 and 20 respectively. It is important that no window lead-in strips be used with either of these three systems. Where shielded lead-in wire is used, the shielding should be unbroken from the horizontal antennae to receiver antennae post, and should also be unbroken from ground binding post to the ground connection. In shielded systems there is considerable loss of signal to ground between the shield and the wire inside of the shield. This can be remedied by using a shielded lead-in wire, in which the insulating material between wire and shield is very thick. The thicker this insulation or dielectric is, the smaller will be the capacity between shield and inside conductor.

Where a transposed or twisted pair is used the same condition holds true, but not to as great an extent due to the decreased capacity between the two conductors as compared to a single shielded conductor (Figure 19). Even the normal capacity between a pair of #14 twisted lighting conductors can be decreased by transposing them with the aid of separating insulators which are available on the market; thus twisting or transposing the wires, but keeping them separated by means of the special transposing insulators as shown in Figure 15.

STOPPING INTERFERENCE AT ITS SOURCE

In our consideration of the interference problem thus far, we have considered the causes and possible sources of radio interference.

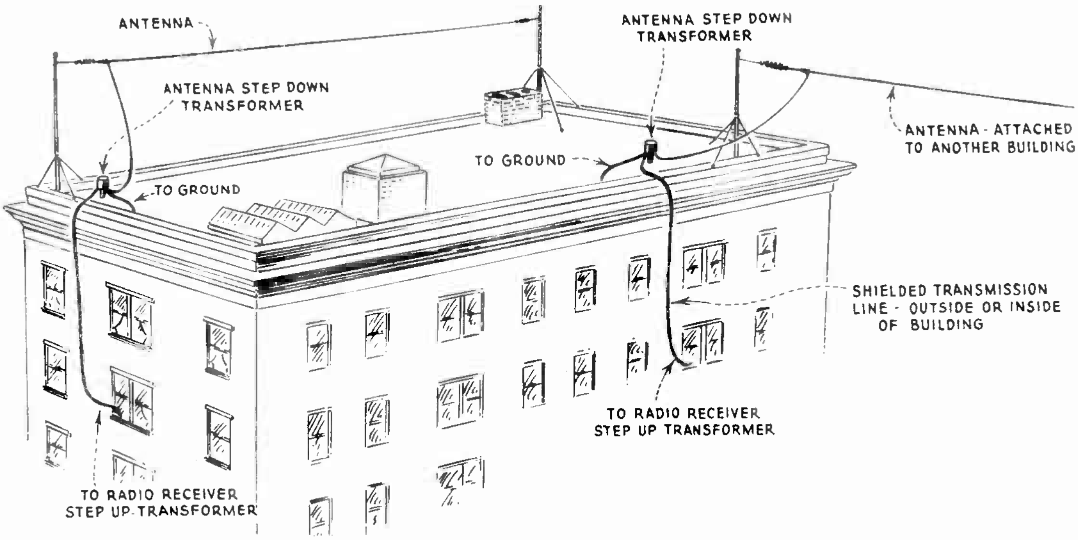


Fig. 18 - Showing the details of construction of a transmission line antenna system for apartment houses.

We have also studied in detail just how the interference enters the receiver and the methods that may be used to keep the interfering field from inducing voltages in its more sensitive circuits.

These methods are the ones which will produce the quickest remedy at the lowest possible cost to the receiver owner. There is however another method in which the problem may be solved and that is by suppressing the interference at its source. This method requires that suitable filters be placed in the power line supplying the interfering device. This will require one of the various types of filters previously described.

These filters should be installed as close to the apparatus generating the interfering signal as possible, and should preferably be mounted directly on it. The coils should be so constructed so that there is no possibility of a breakdown in their insulation to ground at normal operating voltages. Any condensers used should have an operating voltage rating at least twice that of the line voltage on which used.

Fuses should be connected in series with the line and the filter. This is necessary in order to avoid possible overloading of the line should the condenser connected across it break down. See Fi Figure 21.

An additional precaution that is frequently advised is that fuses not larger than 5 amperes be connected in series with the condensers connected across the line. These are indicated as F_2 in Figure 21.

The coils should be wound of wire sufficiently large in order that the I^2R loss in them be low enough to prevent any appreciable rise in their temperature when in continuous use.

The entire filter assembly should be mounted in a metal box with suitable provision made for the connection between power line wiring and the device to be filtered. Filters designed for use on apparatus normally connected to the power line by means of a cord and plug should have a plug receptacle on the output side and a cord and standard plug on the input side. Those designed for use on apparatus having connections to the power line in conduit (piping) or flexible metal sheathed cable should have punched holes in the sides of the box in which the filters are mounted, in order that the cable or conduit may be fastened to the box by standard connectors. Standard knock-out boxes, such as are used in electrical lighting and power wiring systems are suitable for this use. In general filters should be so constructed that they will meet the requirements of the National Board of Fire Underwriters Laboratories and those of the Local Electrical Ordinances.

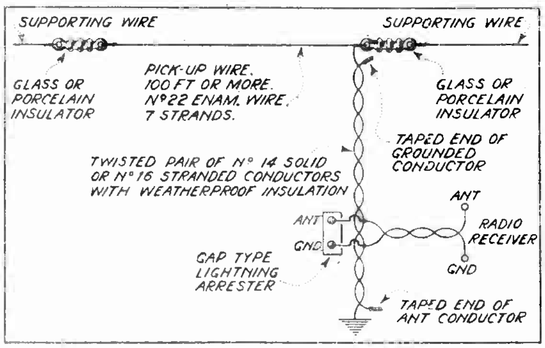


Fig. 19 - Details of the Transposition Aerial installation.

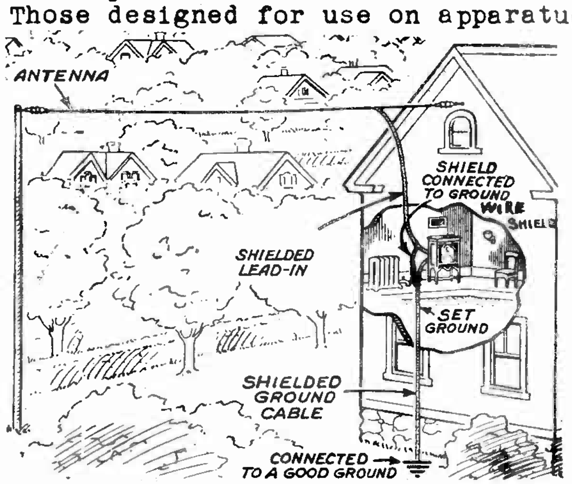


Fig. 20 - Typical antenna installation with shielded lead-in and ground cable.

DETERMINING THE TYPE OF FILTER REQUIRED

Since the intensity and frequency of the interfering signal at its source varies between very wide limits, it is a hopeless task to attempt to design one filter suitable for all purposes. Interference engineers have long realized this as one of their major problems, and in order to simplify the selection of a suitable filter the Tobe-Deutschmann Co. of Canton, Mass., (the largest manufacturer of interference eliminating apparatus and to whom we are indebted for much of the material in this lesson) have designed a Filter Analyzer the operation and application of which is described in the text that follows.

Statistics indicate that more than half of all interference arises in the home. It therefore, behooves every broadcast listener to clear interference from his own home in order that appeals to others in behalf of improved radio reception may be given the attention they deserve. To determine the correct Filterette for application to every household appliance the Filterette Analyzer should be used.

HOW TO USE THE FILTERETTE ANALYZER

The Filterette Analyzer is an electrical instrument designed for use by Authorized Filterette Service Stations. Its purpose is to enable the interference engineer to analyze the interference being created by any electrical appliance connected to the power supply lines by means of an attachment cord and plug. By using the Filterette Analyzer you can determine which of the three plug-in type Filterettes will be required for application to the interfering appliance. The use of the Filterette Analyzer enables you to prescribe the correct Filterette without following the cut and try method of applying Filterettes of various types until the desired interference reduction is obtained.

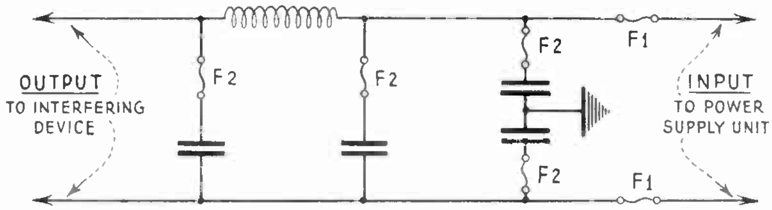


Fig. 21 - Showing location of fuses in filter as safety precaution.

Fig. 22 - Filterette Jr.

In order to understand the operation of the Filterette Analyzer it is necessary that you be familiar with the three most commonly used Filterettes: The Filterette Junior, Filterette Senior and Filterette No. 110-PO. These three Filterettes have been named in the order of their effectiveness. Filterette Junior, shown in Figure 22 is the simplest type of Filterette, consisting of a single capacitive Filterette section contained in a bakelite housing and provided with attachment prongs and a receptacle to facilitate connection of the Filterette to the interfering appliance. The Filterette is provided with a binding post from which a short wire must be connected to the metal frame of the interfering appliance to complete the Filterette installation. The Filterette Junior is suitable for application to most vacuum cleaners, drink mixers, barbers' clippers and other electrical appliances driven by small universal motors.

For application to appliances which create a more intense interference than may be suppressed by use of the Filterette Junior, Filterette Senior is required. This Filterette, shown in Figure 23 consists of the capacitive section used in Filterette Junior plus one inductive section connected in series with one side of the line. Filterette Senior is contained in a cylindrical metal housing and is provided with a receptacle and a short attachment cord and plug to facilitate the connection of the Filterette to the interfering appliance. This Filterette also is provided with a binding post from which a short return connection must be made to the frame of the interfering appliance. This Filterette is designed primarily for application to electrical appliances supplied from a wiring system having one side grounded in accordance with modern wiring practice.

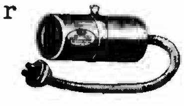


Fig. 23 - Filterette Sr.

It is usually most effective when the inductive section is in the "hot" side of the line

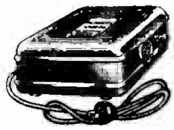


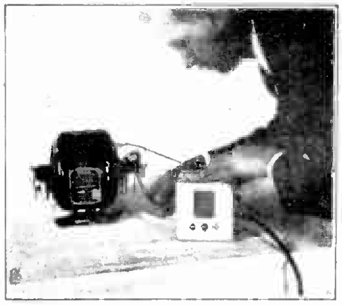
Fig.24 -Filterette 110-PO.

Filterette No. 110-PO, shown in Figure 24 is designed for applications similar to those requiring the Filterette Senior, when the apparatus creating the interference is supplied from an ungrounded line or is located so far from the point at which the wiring circuit is grounded that the ground is not effective as far as interference is concerned. Filterette No. 110-PO contains a somewhat larger capacitive section than is contained in the Filterette Junior and also has an inductive section in each side of the line. See Figure 11. This Filterette also is provided with an attachment cord and plug and a binding post for connection of the return wire.

It is not always possible to tell simply by looking at the appliance, or by hearing the interference which it creates, just which type of Filterette will be required to provide maximum reduction of interference. Consequently, the Filterette Analyzer must be used. This instrument shown in Figure 25, consists of groupings of the fundamental Filterette circuits contained in the three Filterettes which have just been described. By manipulation the effectiveness of each type of Filterette may quickly be determined, and the correct Filterette may be applied to the interfering apparatus.

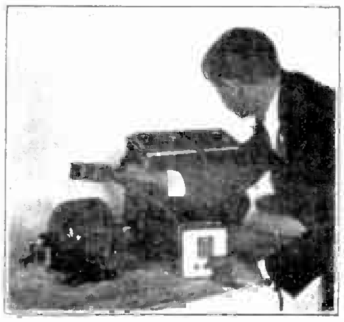
Fig.25 - Tobe Filterette Analyzer. Switch setting shown indicates Filterette Junior.

The use of the Filterette Analyzer is indicated in Figure 26 and as will be seen from these photographs, the attachment plug of the interfering appliance is inserted in the receptacle of the Analyzer. When making the test, the attachment cord of the appliance must be coiled into the smallest possible space in order that there may be no radiation of interference from the attachment cord. A short wire, preferably not more than 6" long is then connected from the binding post on the side of the Analyzer to a clean part of the metal frame of the interfering appliance. This connection should preferably be made



Method of Connecting a Dental Laboratory Motor for Filterette Analysis. Note Return Wire to Motor Frame

Figure 26.



A Tobe Interference Locator gives an Accurate Comparison of the Effectiveness of Various Types of Filterettes to the frame of the motor which is used for operating the appliance. The attachment plug of the Filterette Analyzer is now inserted in the power receptacle to which the appliance was originally connected.

You are now ready to analyze the interference, and to determine the Filterette required for suppressing it. The positions of the three analyzer switches for obtaining standard Filterette combinations are indicated on the name plate of the Analyzer. In using this instrument it is advisable to start with the simplest type of Filterette and gradually to progress to the more effective types. For this reason it is recommended that, before the Analyzer is connected to the power supply line, the switches be set in the Junior position ↑ ↑ ↓. The appliance may then be set in operation and the amount of interference present may be determined.

If, with the Analyzer switches in the Junior position, the appliance may be operated without objectionable interference, it is not necessary to proceed further with the analysis. A Filterette Junior may be applied to the apparatus at once. If, with the Analyzer switches in the Junior position, some interference remains, the switches may then be set in the Senior position, and the result noted.

In analyzing interference to determine whether the Filterette Senior may be used, there are two possible settings for the instrument. The first setting is as indicated on the name plate of the instrument ↓ ↑ ↓ The second position, which is not shown on the name plate, is simply a reversal of the two left-hand switches ↑ ↓ ↓. Reversing these switches transfers the inductance of the Filterette Senior from one side of the line to the other side, thus accomplishing the same thing as would be accomplished if the attachment plug of the Analyzer were reversed in the power receptacle. It is always advisable to try both possible Senior settings because in a great many cases the Filterette Senior will be highly effective when its attachment plug is inserted in the power receptacle in one position, and it may be relatively ineffective when the attachment plug is reversed in the power receptacle. If either Senior setting of the Analyzer provides satisfactory interference reduction, a Filterette Senior may be applied to the interfering apparatus. In applying the Senior it may be necessary to reverse its attachment plug in order that the inductance may be located in the correct side of the line to be most effective.

If neither of the Senior settings of the Analyzer provides the desired reduction of interference. The Analyzer switches should then be set in the No. 110-PO position ↓ ↓ ↑ and the effect noted. In practically all cases, this setting of the Analyzer will provide satisfactory reduction of the interference. If it fails to do so, the indication is that interference is being radiated from wiring of the appliance or from the attachment cord. In order to overcome this interference it is necessary to shorten the attachment cord so that there will be no effective length remaining for interference radiation. When this is done, satisfactory results should be obtained.

The Filterette Analyzer is designed for test purposes only and must not be placed on continuous duty.

EXAMINATION QUESTIONS

1. What is meant by the term "man-made static"?

2. Under what condition would you use a wave trap on a receiver?

3. Name some of the causes of static interference.

4. Why are some receiving circuits more selective than others?

5. How is the interfering signal from radio interfering electrical devices transmitted?

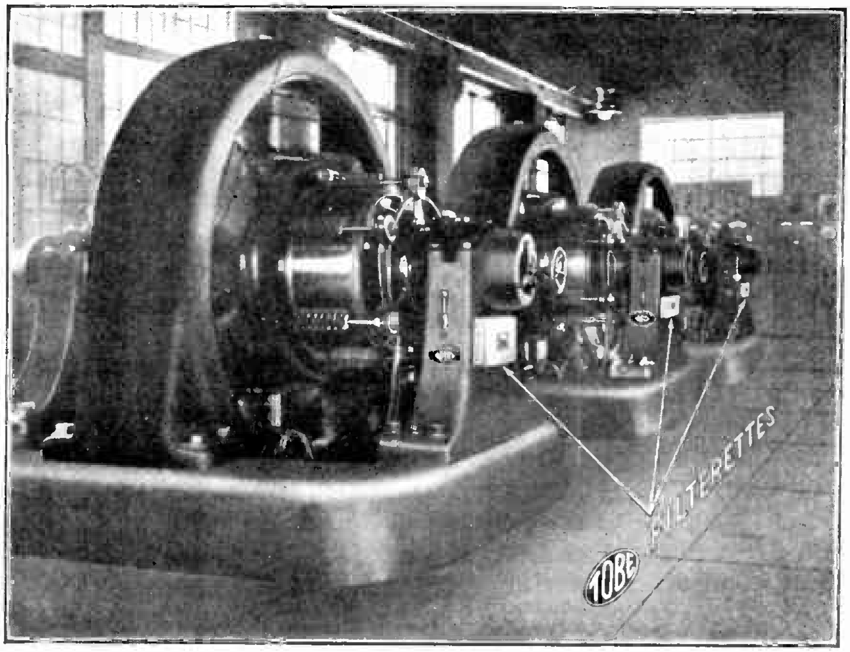
6. How does man-made static enter the receiving circuits?

7. How would you determine whether noise in the receiver originated in the receiver's own circuits, or entered the receiver via the antenna system, or via induction in the sensitive unshielded circuits of the receiver?

8. How would you install a receiver in a location in which man-made static made reception noisy?

9. How would you install an antenna in order to avoid interference signal pickup in the lead-in and horizontal portion?

10. How would you prevent interference created by an electrically operated device from being radiated or transmitted? That is, how would you confine it to the device itself?



Street railway converters filterized by application of Filterette No. 60. The converters shown are 500 K.W. machines.

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