Electrical Interference

In Two Parts

Part I - Causes and Identification

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"INTERFERENCE" is defined as a confusion of received radio signals due to strays and undesired signals. It is also defined as something that causes this confusion. Interference to radio signals occurs whenever an undesired voltage, signal, or disturbance is present in sufficient strength to be heard in the presence of the desired signal. What are the confusions with which the amateur radio operator contends? TVI, BCI, QRN, QRM, XYLI, and RFI or EI. Cures have been found for the first four types, but there is no cure for the XYLI type!

The confusion of electrical interference (RFI or EI) will be discussed in this article. You will be informed of the sources of electrical interference, how it gets into your receiver, and the classifications of this type of interference. Photographs will show the "finger prints" of electrical interference and instructions on the location of interference will be given.

The interference problem of the amateur operator has increased in proportion to the number of hams and the increase in population. The ham has been accused of killing fish in aquariums and taking all the juice out of power lines with his big beam antennas. He has been heard on TV and radio and occasionally seen on his neighbor's TV set. Electrical interference to TV sets has been blamed on the poor ham operator, and he has been accused of breaking thread in a little old lady's sewing machine. This sounds ridiculous? Not so; the aforementioned is just a sampling of complaints received by the writer's company which have been directed against the ham operator.

A comparison of the interference problems of the amateur and the power company indicates a marked similarity. How many of these complaints are justified? The general public feels that all TVI complaints are justified. Ham operators feel that all electrical interference complaints are justified. But the amateur knows that only a small percentage of TVI complaints are justified, and the power companies know that only a small percentage of electrical interference complaints are justified. By far, more noises heard on your receivers are caused by consumer-operated devices.

RFI and the Power Company

It was for this reason that Southern California Edison Company, an investor-owned utility serving over 2,200,000 customers in a service area of 65,000 square miles, appointed an Amateur Radio Representative to work with the high concentration of amateur radio operators in that area relative to the causes of electrical interference. The amateurs are informed that the policy of the company is to do everything within reason, good engineering practice, and sound economy to eliminate or reduce to an acceptable level any interference created by its facilities. Those having interference troubles are requested to locate and correct any of the consumer-created interferences that may be a problem to them; it is pointed out that each one must take a cooperative and patient attitude toward the location and correction of consumer-created interference as well as the location and correction of power-line interference. Finally, amateurs are requested to deal directly with the company on interference problems.

To aid the amateur in identifying sources of electrical interference, tape recordings of the audible characteristics of interference are played at club meetings. These recordings are made by feeding the audio output of a Collins 51S-1, installed as a mobile receiver, directly into the input jack of a stereo tape recorder. In stereo, a comparison is made between consumer-created and power-line interference. Colored slides of the "fingerprints" of interference are used with the recordings.

Appliance QRM

Many feel that the power company should take care of all of interference, even though the company has no jurisdiction over devices used by its customers. It should be looked at from this point of view: An amateur is twice blessed when he locates a source of consumer-created interference; first, he has cleared up a TVI problem that his neighbor is accusing him of creating; second, he has taken care of his own problem, that of interference to his receiver.

Occasionally an amateur will request assist-

> *Radio noise originating in non-radio electrical equipment can make life miserable for the communicating amateur, and becomes more prevalent with increasing use of electricity, both industrially and in the home. There is something you can do about it. This two-part article tells you how.*

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ance in the location of a consumer-created interference. Generally, in these cases he has narrowed the source down to four or five houses and needs help in fixing it in one particular house. The correction is still the responsibility of the amateur since, legally, the power company can do no more towards the correction of consumer-created interference than the amateur. We can only ask the customer to correct the offending device because it is creating interference for himself and his neighbors. This is the same approach that the ham operator can use, and is why we believe that the amateur can do just as well in locating consumer-created interferences as the power companies. We feel that our personnel should not have to confront Mrs. Smith and say, "Ma'am, we believe you have a defective poodle warmer (one was found!) that is causing interference to the ham operator down the street . . ." In the first place, you are better known in your own neighborhood, and secondly, people are more receptive to those they know and have heard. The type of approach to use in this situation will be discussed in Part II of this article.

The company goes one step further in cooperating with the amateur. If an interference complaint is received from one of our customers and the investigation reveals that it is TVI caused by an amateur, no mention of that fact is made to the customer. He will be told that an effort will be made to clear up the problem, and then the complaint is turned over to a TVI committee of a radio club in the area.

Your Noise Background

It is a known fact that every location has a definitely-established ambient noise level, and any attempt to use a radio receiving set for reception of signals which are below the ambient noise level of a given location is doomed to provide unsatisfactory reception. The interference experienced in the operation of a receiver depends on the character of the offending radio frequency or random noise, the coupling between the source and the receiver, the susceptibility of the receiver, and the strength of the desired signal. In other words, what is the signal-to-noise ratio?

For good reception of an a.m. signal, tests reveal that a ratio of 20 to 1 is satisfactory, and intelligence can be extracted at a ratio of 10 to 1. Fifty years ago the signal-to-noise ratio was of little concern to the amateur operator because the bands were uncrowded, and if a signal could be heard over the noise level of the receiver itself the ham was elated. Today the S/N ratio of the receiver is excellent and it is more sensitive, but therefore more susceptible to the noise in the area. And today there are more devices to raise the ambient level.

There is a simple and economical method for improving the S/N ratio if you have a high level of noise — install a 30- to 50-μf. capacitor across the voice coil of your speaker. This is very effective when the desired signal is just slightly above the ambient noise level. Fig. 1A shows the pattern of an interference with the capacitor switched out and Fig. 1B is the same interference with the capacitor across the voice coil of a Motorola mobile speaker rated at 3.2 ohms. Note that the impulse spikes of the interference have been shortened by the use of the capacitor.

The desires of amateurs regarding tolerable level of noise varies from S0 to those who say they can live with an S4 to S6 level. We all know that an S0 level is impossible to obtain without an adjustment of the S meter. Every electric spark, no matter what its source, may provide some power at radio frequencies; therefore there always will be sources such as snap-switches, doorbells, and motors, which will add to the general level of radio noise. Some disturbance from such electrical devices is inevitable and must be regarded, like atmospheric static, as a limitation on reception. We have to be reasonable about our desires, and we have to be satisfied with the lowest level that can be obtained under all conditions. Electricity has been with us since the beginning of time; Adam and Eve undoubtedly wondered about the spark of static electricity they encountered!

In determining the type of amateur operating that you would like to do, an important factor must be taken into consideration — your QTH. Are you going to work for all the DX awards or are you going to be satisfied with local contacts? If you locate close to an industrial or commercial complex your DX contacts are going to be limited by the electrical interference-generating devices. Before you go into hock for a lot of equipment check out the area and govern yourself accordingly. Note the locations of the DXCC award holders; very few interference complaints originate from the serious DX operator.

Interference Paths and Sources

There are three ways by which interference will travel into your receiver. One is by *conduction;* the interference is carried by the power lines through the service wires and house wiring and then into the power supply of the receiver. The second is by *induction;* the interference is carried by the power lines, metal fences and communications circuits and then induced into your antenna system. A long-wire antenna running parallel with and close to any of the preceding will be more susceptible to noise than an antenna perpendicular to the lines. The same holds true for a beam antenna at the same height as any of these interference carriers. The last is by *radiation;* the interference is radiated from the source or lines and picked up by your antenna.

Conduction and induction will affect the receiver more at the lower frequencies, while radiated interference will affect all frequencies. Interference that is conducted and/or induced can travel a considerable distance.

Interference to receivers is a complex subject; however, each interference can be placed in one of three general categories and each category has definite characteristics. These categories are *spark discharge, r.f. oscillation,* and *electrostatic discharge.* Of the three, the spark discharge category accounts for most of the interference heard.

The Spark Discharge

Typical sources of spark-discharge interference are appliances using the brush-type motor, such as the portable mixer, electric shaver, vacuum cleaner, small shop motors, and electric saws; and electrical appliances and devices which are thermostatically controlled by interrupting the supply voltage according to temperature requirements (unless they are of the snap-action type). Thermostats on heating pads, refrigerator butter conditioners, and water heaters for aquariums and brooders are the most troublesome, because of the slow-break contacts; in this type of service the contacts arc for a certain period during each break. Other devices in the home, industry and commercial establishments are neon signs, fluorescent lights and dimmer switches. A source in suburban and rural areas is the electric fence. You may wonder what an electric fence is used for in the suburbs, but recently an interference was found to be originating from an electric fence used to keep the dogs from running loose. One other item, not too common but nevertheless a source of interference which is very difficult to locate, is the carbon-filament light bulb, occasionally found in older homes in the basements and closets. Certain types of power-line interference also fall into the spark discharge category.

The sounds associated with the spark discharge are a buzzing rasping, grinding, frying, or popping sound. Some of the devices mentioned above have a readily identifiable sound; for example, the thermostatically-controlled devices have this characteristic: buzzt — buzzt — buzzt —, on several seconds and off for several seconds. Ninety-nine percent of the time they will have this particular trait and the other one percent of the time will sound like some other source of interference.

The fluorescent light has a 120-cycle sound or roar associated with it. The one peculiarity of the fluorescent light is that it affects certain bands of frequencies. If a continuous-tuning receiver is used you may pick up the noise around 3400 kc. and lose it at 8300 kc. Another interesting fact about the fluorescent light is that the interference is not additive, i.e., if ten lights are radiating you will hear only that light with the highest level of radiation: when this one light is corrected you will hear the next loudest, and so on.

An undulating frying tone with momentary breaks is one of the characteristics of power-line interference. Very rarely will this type of interference begin at a certain time and stop at a certain time — unless, of course, it is caused by a street-light circuit.

Frequencies affected by the spark discharge are variable and depend on the source, distance, and frequency. For example, the fluorescent light will affect 40 and 80 meters and is rarely found any higher in frequency. If you had a noise on these two bands but it could be heard no higher, would you assume that it was a fluorescent light or would you figure that it could be some other type of source a considerable distance from you? Here you are confronted with two possibilities, and this is the reason why the amateur radio operator needs to become familiar with the sounds of interference.

As the sounds of interference differ so do the fingerprints of the interference differ. This is shown in the accompanying photographs. Figs. 2A and 2B show the fingerprints of the electric fence in a.m. and s.s.b. reception (receiver b.f.o. off and on, respectively). Figs. 3A and 3B are power-line interference in a.m. and s.s.b. The fluorescent light is seen in Figs. 4A and 4B, the neon sign in Figs. 5A and 5B, and the typical thermostat fingerprint is seen in Figs. 6A and 6B. Each burst of noise is made up of these pulses.

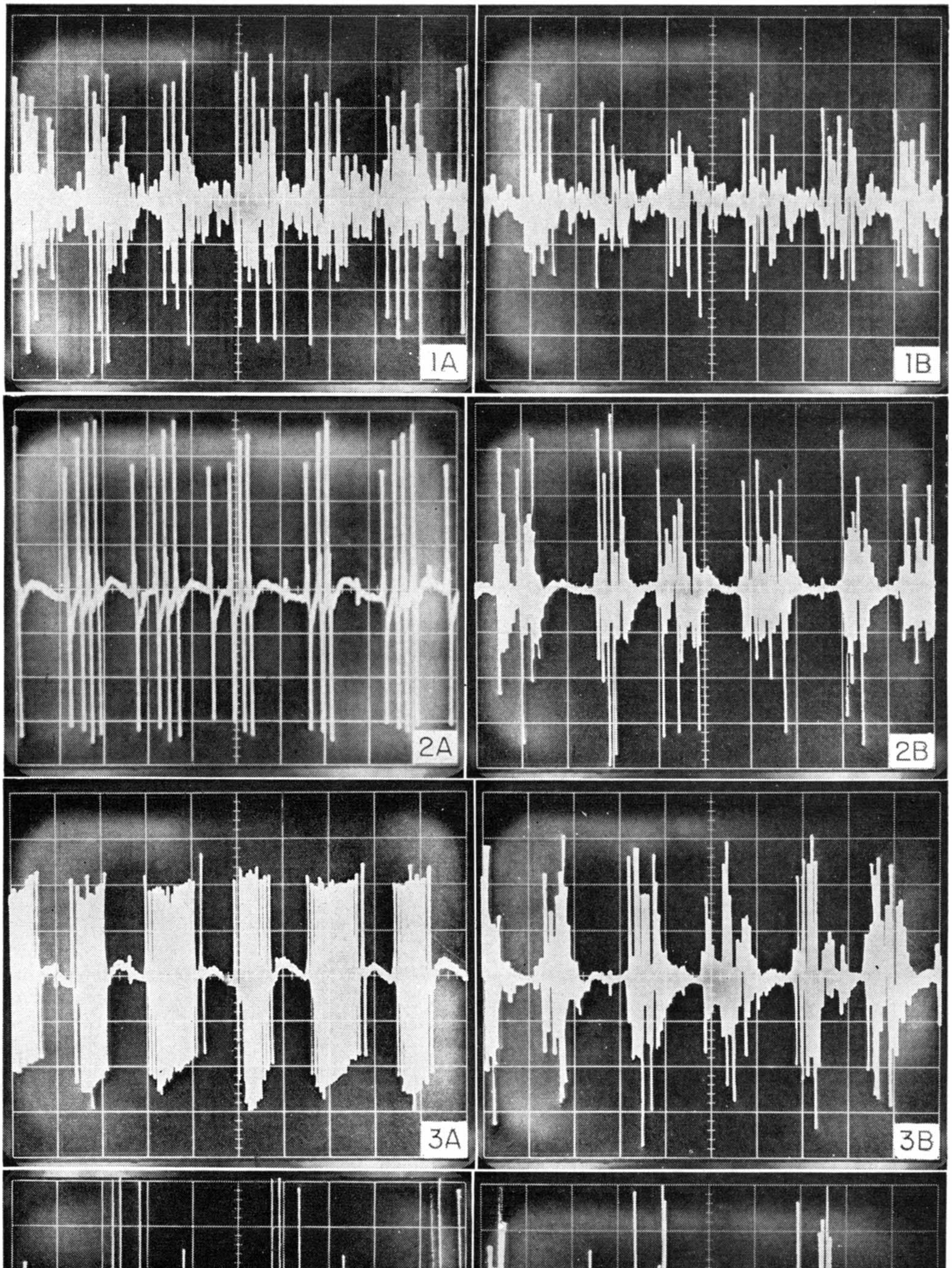
Incidental Radiation

The second category, r.f. oscillation, is interference caused by any device capable of leaking r.f. such as the heliarc welder, induction soldering machines, TV receivers, and diathermy machines; the device most heard on 40 and 80 meters is the heliarc. The sounds associated with this type of interference are whining, buzzing, whistling, or warbling. To become accustomed to these sounds listen on the 11-meter band. Improper shielding of the device causes this type of interference.

Another source of r.f. oscillation is your own receiver. One amateur had an embarrassing experience. He complained of interference to both his receiver and TV set, and although the interference investigator made several trips he was never able to hear the interference outside the ham's QTH. Finally, arrangements were made for the ham to meet with the investigator and an engineer from FCC. When the investigator heard the noise in the receiver he asked the ham to disconnect the receiver, and when this was done the TV picture cleared entirely. Further investigation revealed that a filter condenser had failed. Until the source had been located the power company was being blamed for the amateur's own interference.

Electrostatic Discharge

The third category, the electrostatic discharge, is caused by sources not connected directly to an electrical circuit. It is created by loose contacts between metal objects in an electric field. This type of interference is very difficult to locate because it is intermittent and the region of peak intensity is not readily determined. As a general rule the source is very close to the receiving equipment, such as guy wires touching or rubbing together, antenna lead-in conductor loose, and —most common — a loose pipe strap that holds the antenna mast to the side of a building. A call was received from a ham who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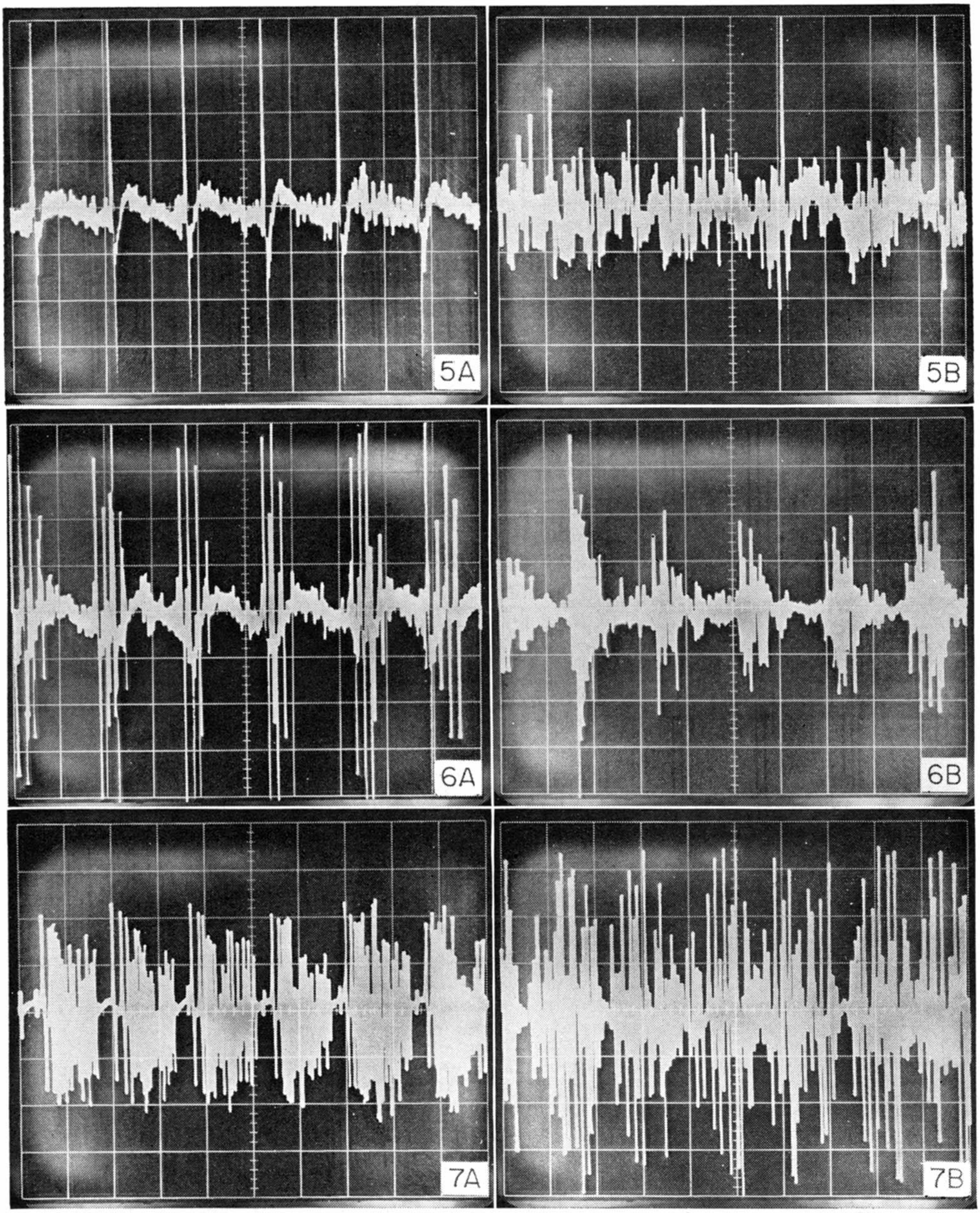

Fig. 1—A—Cathode-ray presentation of a typical spark-discharge interference; B—same noise with speaker voice coil shunted by a large capacitor. Fig. 2—A—Cathode-ray picture of electric-fence noise, a.m. reception; B—Same noise as recorded with the receiver's b.f.o. on (s.s.b. or c.w. reception). Fig. 3—Power-line interference in a.m. reception (A) and s.s.b. reception (B). Fig. 4—Fluorescent-light interference in a.m. reception (A) and s.s.b. reception (B). Fig. 5—Neon-sign interference in a.m. reception (A) and s.s.b. reception (B). Fig. 6—Thermostat interference in a.m. reception (A) and s.s.b. reception (B). Fig. 7—Heliarc interference in a.m. reception (A) and s.s.b. reception (B).

serviced CB rigs and said he had lost several sales because of the "power-line" noise at his shop. Investigation revealed his source of noise to be his antenna guy wires rubbing together.

To summarize, electrical interference is a complex quantity containing unknown factors, but this does not mean that it is an insolvable problem. Some things are known, such as the method interference uses in traveling to your receiver, and the fact that most of the interference is caused by consumer-operated devices. There are three categories of interference, and in each instance many sources. Some of the sources have special characteristics that affect the sound of interference as well as the frequencies. Your location will determine the type of operating you can do. QST

(Part II will appear in an early issue of *QST*.)