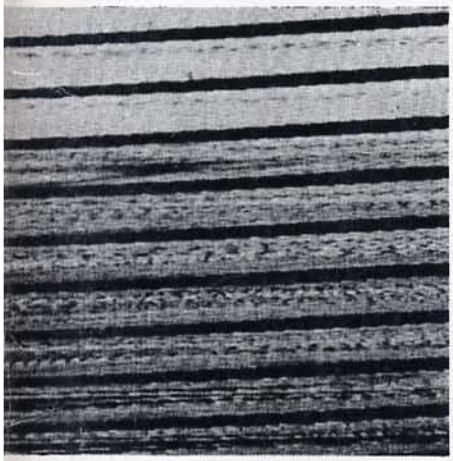
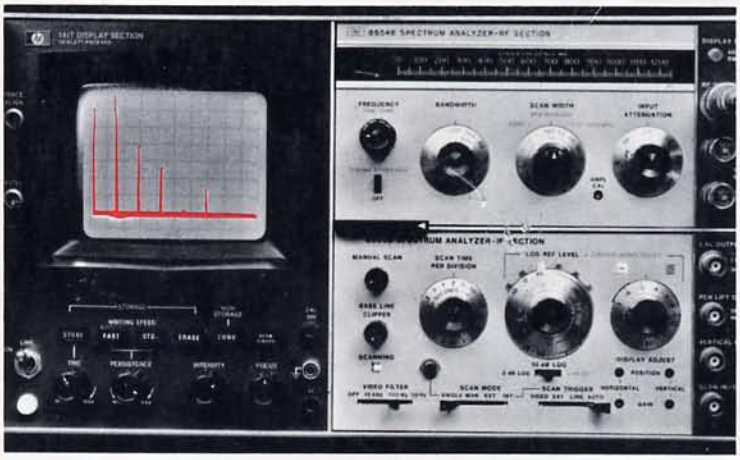
$3.00

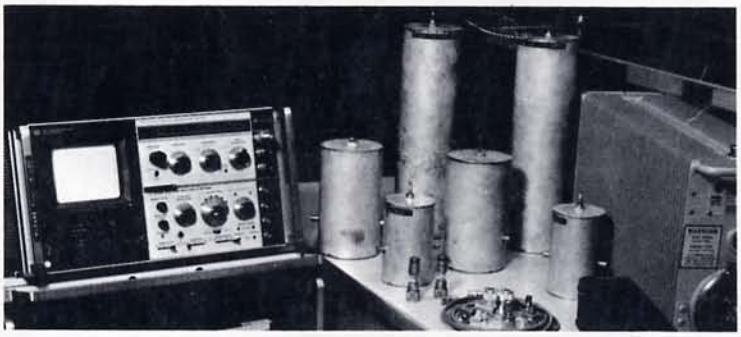
RADIO FREQUENCY INTERFERENCE

HOW TO IDENTIFY IT AND CURE IT:

- IN YOUR TRANSMITTER
- IN YOUR NEIGHBOR'S TV, HI-FI/STEREO, RADIO
- IN CB RADIOS
- IN CABLE TELEVISION







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Radio Frequency Interference

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Foreword

Many changes have occurred since the first edition of this RFI book. Those were the days of the CB boom. Today we face another boom in the electronics industry, an explosion of electronic consumer products and services. Electronic equipment has become increasingly a part of the average person's life. This explosion has fed the multi-headed monster of radio-frequency interference.

This book has been prepared to help you slay the RFI dragon. The tools you need are not shiny armor and a sharp sword. The second edition of the RFI book has been updated to provide you with the benefits of the latest information and techniques for fighting interference problems. Contributing editor Dickinson gives us insight and understanding of cable television in chapter 6. This new material describes a typical CATV system and some of the possibilities of interference both to and from "the cable." He also gives us reason for hope and optimism as we deal with cable system operators.

I would like to thank the ARRL RFI Task Group for their continuing efforts. These dedicated volunteers have done much in the battle against RFI. You can aid in that battle, too, by supporting legislation that would alleviate RFI and by sharing with us how you solved your interference problems. Remember, there is a solution to every RFI problem. Let's fight the battle — and win.

Richard L. Baldwin, W1RU
General Manager

Newington, CT 06111
October 1981

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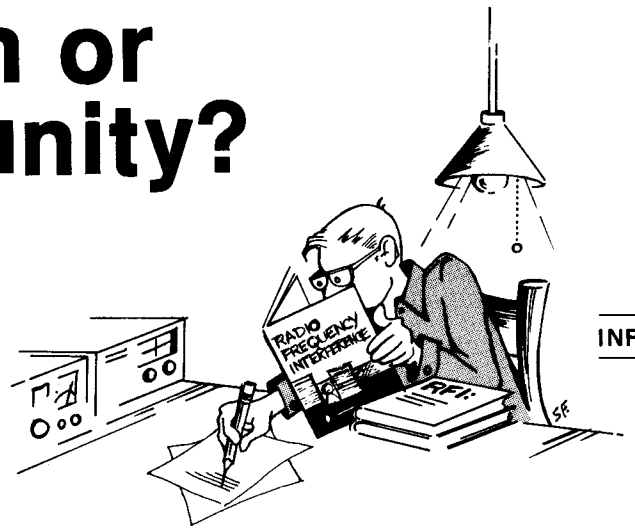
Chapter 1

RFI: Problem or Opportunity?



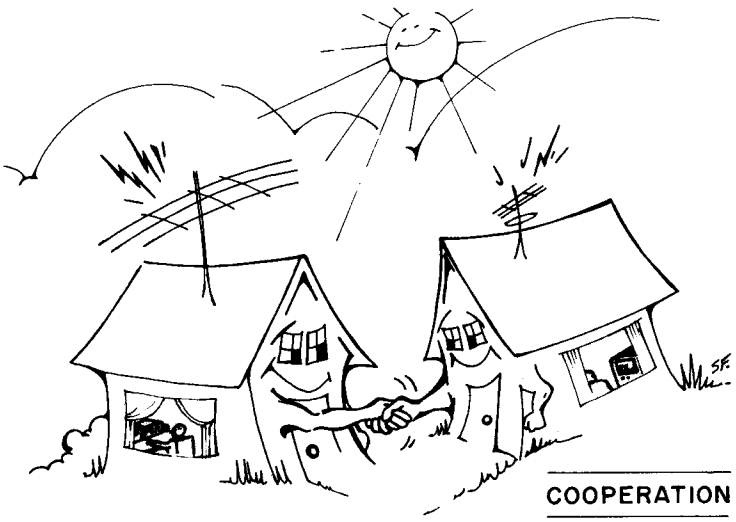
INFORMATION

Mrs. Rafferty has occasionally heard strange sounds on her stereo record player for several months. Today she called her sister in Kansas City but was unable to talk with her because the same strange sounds were on the telephone line. The operator made an adjustment to the charges but could not tell her what had happened.

Sam Peabody is an Amateur Radio operator. One day while pursuing his second favorite hobby — watching the Sunday football game on TV — he received a phone call. It was his neighbor, who asked him to stop "broadcasting" on channel 2, as it interfered with the football game. When Peabody told his neighbor that he was not on the air, but watching the same football game without interference, his neighbor called him a liar and made threats against his life and property.

Jim Sawtooth is a ham who has lived in the same neighborhood for more than 12 years. During that time he has received harassing telephone calls, had his coax cables cut, and had four windows broken.

Annie Martin's handle was "Apple Annie" and she turned as red as an apple the day she discovered her CB banter with the 18-wheelers on the nearby thruway



COOPERATION

ACTION

was being picked up by the instore music system of the local supermarket.

The only short-wave gear George Walton owned was a general-coverage receiver. He became interested in OSCAR 8 through his science class in school. However, every time he tried to tune in the 29.4 MHz signals his mother raised the roof. He was interfering with her television soap operas. She was right; every time George turned off the receiver, the picture cleared up.

Sam Small really liked to make omelets and broil bacon in the microwave oven. The bacon and eggs came out fine, but he really scrambled the morning news on the television receiver.

Hams, CBers, SWLs, TV viewers and amateur chefs — what's going on here? What's going on is that another pollution problem has been created by our exploding technology. This one is called *radio frequency interference* (RFI). In one way or another all of these people are victims. The stories are true; only the names have been changed.

What is RFI?

Radio frequency interference occurs, or has the potential to occur, whenever an electronic device finds itself surrounded by a field of radio frequency (rf) energy.

The originating source of the rf energy might be an amateur, citizens band, police, broadcast or television transmitter, or any other device capable of generating rf energy and causing interference.

The electronic device being interfered with and picking up the unwanted rf energy could be a television set, a hi-fi system, an fm receiver, a garage-door opener or some other piece of sensitive equipment. RFI actually occurs when the electronic device in the midst of the rf field behaves or responds in an undesirable manner due to the presence of the radio frequency field.

What to Do About It

Sometimes the transmitter is at fault, but more often than not, as FCC statistics show, the fault lies with the electronic device itself, due to insufficient shielding or filtering. The purpose of this book is to help you identify and solve those types of problems you can correct. By reading it you will discover how RFI detective work can be an interesting challenge, and at the same time contribute to neighborhood harmony and good will.

Many RFI problems are caused by the lack of compatibility between various electronic systems. The problems requiring investigation generally lie in the following areas:

1) The characteristics of the receiving device. Are system components properly designed and installed? Equipment must not only be able to receive and amplify the desired signal, but must also reject all unwanted signals and noise.

Table 1

Communications Transmitters

Amateur	Marine
Citizens band	Aircraft
A-m broadcast	Taxi
Fm broadcast	Public utility
Television	Military
Fire and police	News services

Table 2

IMS and RC Transmitters

Garage door openers
Microwave ovens
Radio controlled models
Radio receiver oscillators
Television receiver oscillators
Induction heating machinery
Wireless intercom
Diathermy and other medical apparatus

Table 3

RF Noise Transmitters

Power tools
Automobile ignitions
Appliances
Fluorescent and neon lights
Microcomputers
Power transformers

Table 4

Victims of RFI

TV sets
A-m and fm radio receivers
Amateur Radio receivers
Medical equipment
Truck or bus anti-skidding devices
Hi-fi audio systems
Intercom systems
Blasting devices
Smoke detectors
Video cassette recorders
Automobile cruise controls
Many other devices

2) The environment of the receiver. How near is it to the source of unwanted signals?

3) The practices of the person using the receiver. Portable TV with "rabbit-ears" antenna in a fringe area?

4) The characteristics of the rf-generating device. Does it use high power or low power? Is it properly shielded? Filtered? Grounded?

5) The environment of the generating device. Fixed or mobile? In a building or on a tower?

6) The practices of the person using the equipment. Does he operate within FCC regulations? (Even if equipment is operated properly, it is still possible to cause interference.)

Where Does Responsibility Lie?

In many cases, the source of disruption is an amateur or CB transmitter. If so, is the owner of the transmitter responsible for all the RFI that results from its operation? The answer depends on whether the fundamental signal or harmonics (multiples of the fundamental frequency) and parasitic oscillations (another type of unwanted signal) are causing the interference.

If harmonics or parasitics (or both) are the source of difficulty, it is the responsibility of the *owner of the transmitter* to eliminate them. Likewise if the station operator is using too much power. If, however, the transmitter is being operated in a completely legal manner and radiating rf energy only on its fundamental frequency, the interference that results is caused by design deficiencies in the electronic device. Typical deficiencies are insufficient filtering and shielding. If the interference is from a legally operating transmitter, the owner of the home entertainment device has the responsibility for modifying his equipment (if he so desires) to make it immune to unwanted rf energy. In typical RFI situations involving amateurs, FCC statistics show that RFI usually results from design deficiencies in the electronic device experiencing the interference. In each particular case, however, the amateur must determine whether his equipment or his neighbor's is at fault.

Some Sources of RF Energy

The most familiar sources of rf energy are the various types of communications transmitters found in almost every community. You can probably discover about half the types of transmitters in Table 1 within ten miles of your front door. Many of the transmitters are licensed by the FCC to operate on specific frequencies or bands of frequencies.

They can cause interference in different ways. First, the rf energy on the operating frequency can be strong enough to disrupt the operation of nearby electronic equipment. And second, the rf source can produce disruptive signals on other frequencies due to harmonics and parasitic oscillations.

In addition to the public service and entertainment transmitters listed in Table 1, there are other common sources of rf energy which transmit on discrete frequencies. Some of these industrial, medical, scientific and radio control sources are listed in Table 2. As time goes on you may discover more items to add to the table. These devices have been known to radiate their fundamental and harmonic frequencies for considerable distances.

In addition to the equipment designed to generate rf energy as their primary

function, there are devices which produce rf radiation as a by-product of their normal operation. For example, any machine or appliance containing a spark-producing motor with brushes can produce rf energy over a broad spectrum, and often over considerable distances. In the early days of radio, communications were accomplished by sending Morse code by means of spark coils. Some of these rf noise-producing devices are listed in Table 3. And to further complicate matters, passive elements located in a strong rf field can be excited and turned into sources of rf energy.

The Victims of RFI

What kinds of devices experience radio frequency interference? The center of family entertainment, the color television set, immediately comes to mind. Table 4 is a list of electronic equipment that is susceptible to RFI.

The tremendous advances in the fields of communication and home entertainment have created a wide range of problems requiring imaginative solutions. With communications possible from practically any point on earth and beyond, and with personal communications routinely taking place from handheld transmitters as well as those installed in motor vehicles, boats and homes, it is not surprising that there has been such a dramatic increase in RFI complaints.

History of RFI

Actually, radio frequency interference has been with us since the beginning of radio. Back in the days of listening to KDKA, Pittsburgh, on earphones, the old regenerative receivers could transmit a squeal that would life the phones right off your head.

In the early days of amateur radio they called it BCI (broadcast interference) and many articles were published in *QST* regarding its cause and cure. However, BCI was nothing at all compared to the clamor that went up when black and white television first appeared on the 10-inch screen. Naturally it was dubbed TVI (television interference) and a wide range of articles on how to stamp it out began to appear in *QST*.

The June 1947 *QST* carried an editorial by George Grammer, W1DF, calling attention to the problems caused by shortcomings in the broadcast receivers, and pointing out the new problems being created by television.

"There has seldom been reason for being happy about the BCI situation, but through the years we've at least been pretty secure in the knowledge that for the most part the interference has not been our fault. No matter how thoroughly a transmitter is debugged nor how carefully it is operated, it can still cause interference to an inadequately designed receiver.

"But broadcasting (television) is now getting established 'upstairs' (VHF) and that puts a new complexion on things. Not a favorable one, either. The thing we have to face is that some of the interference that is now being caused is not the receiver's fault. It's ours, whether we like it or not. We have in mind harmonics, of course.

"At the present stage the urgent need is for the accumulation of factual information: how much interference is our fault, how much the receiver's. We need to know what it is really possible to do in the way of reducing harmonic fields in the immediate vicinity of the transmitter, what the relative effects of the second, third and higher-order harmonics will be.

"Preventing direct radiation is likely to require a complete change in our phi-

The Interference Muddle

By W. J. Williams*

MOST people wonder why radio should be so noisy. They forget that most of the applications that engineers have recently made of the findings of science to the solution of our everyday problems have produced considerable noise. For instance, most of us can remember in the early days of the automobile industry how noisy the automobiles were.

Similarly with radio, a number of noises we encounter are perfectly natural and show a healthy development.

The "Noise Level"

After we have eliminated the *unnecessary* noises we cannot expect to have a "zero noise level", or in other words, no noise at all. We must always bear in mind that *wherever we have electrical energy there is a possibility of producing an electromagnetic disturbance which will produce noise in a receiving set.*

The interference problem is thus seen to be theoretically simple, whereas practically, it is a very difficult one, owing principally to its size.

Our Problem Explained

A complete solution of the interference problem requires consideration of the social aspect and also the psychological reaction of the individual radio listener. The principal social groups affected are the radio broadcasters, the radio manufacturers and retailers, the radio audience and those government departments which have supervision of radio broadcasting.

The Listener

Before taking up the individual radio listener's reaction to interference we will have to consider some of the characteristics of this interesting person.

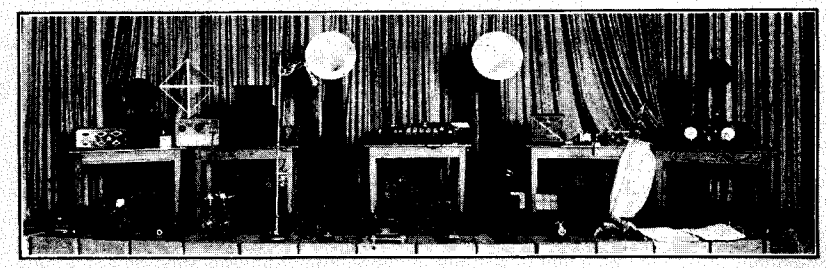
Those of us who were interested in opening broadcasting station WHAZ found that we did not know the psychology of the radio audience. I am going to tell you some of the things we found out.

A large proportion of the working time of most persons is devoted to mere routine and sometimes even to drudgery. This means that in order to be reasonably happy most people have to find outside of their work some means of satisfying those desires which they cannot fully satisfy through their work. The instincts of wonder, admiration and even reverence can be and are satisfied by radio.

The artistic instincts find satisfaction in many different ways in radio, from the construction of a radio set to the artistic enjoyment of the programs received.

The Self-Made Expert

It must be known to all of you that the amateur scientist finds himself in clover when he enters the radio field. This type of radio listener is hard to handle when a



RADIO INTERFERENCE DEMONSTRATION.

Apparatus set up in the Broad Street High School auditorium, Hartford, during a lecture by the author. The tables at the back of the stage carry various well-known receivers, also the control switches for the entire demonstration. A special program was broadcast by station WTIC, the Travelers Insurance Company, received with the Grebe Synchrophase at the left and fed to the large Western Electric loud speakers at the center of the stage. The various electrical devices near the footlight were then turned on to show what made some of the familiar rackets. The audience was absolutely amazed to find that much of the clamor starts right in the home. Even greater was the amazement when it was shown that violent receiver squeals could be set up by the superheterodyne and by a set with fixed tune R.F. transformers.

* Director radio Broadcast station WHAZ, Rensselaer Polytechnic Institute, Troy, New York. Abstracted from a lecture given before the Hartford, Conn., section, A.I.E.E., May 20, 1925, under the title "Causes of Interference In Radio Reception."

By the middle twenties, radio had captured the imagination of the home audience as television was to do some 20 years later. Along with all the excitement, however, came RFI, another new challenge for amateur radio. A reproduction of the first page of an early (August 1925) *QST* article on BCI (broadcast interference) proves that hams have been wrestling with the problem for many decades.

Many more CB and amateur antennas are in close proximity to many more home entertainment devices since the electronics boom began in the 1950s. The result: an RFI problem that shows little sign of disappearing.

losophy of transmitter construction . . . At that, there is no guarantee that the best possible job of reducing harmonic radiation will be good enough to solve the house-next-door problem. . . . There is obviously much we can do to relieve the situation with the means now at our command.

"Not only broadcasting but the many safety services now in the vhf region are going to demand protection from our harmonic excesses — just as we ourselves demand that we be relieved from paying any penalty for the shortcomings of b.c. receivers."

Today we have RFI, and the average home shelters electronic devices that most people never expected to own just a few short years ago. In addition there is a CBer next door, a ham down the street, aircraft overhead, police and taxis cruising by and microprocessors controlling the appliances. Is it any wonder we have a radio frequency interference problem?

Early RFI Was Manageable

The RFI problem was more easily managed until the 1950s. The occasional case of interference was usually solved at the local level. During the late 1940s the FCC was receiving RFI complaints at the rate of only 7000 to 8000 per year. That and the fact that FCC's workload was much smaller than now, allowed the FCC staff to handle individual RFI complaints by visiting the site and offering advice.

This situation deteriorated when commercial television began its boom in the 1950s. During fiscal year 1953, for example, the FCC received more than 21,000 RFI complaints. With that many complaints it became impossible for the FCC to continue its extensive program of on-site investigation of individual cases.

After the creation of the Citizens Radio Service in 1958, the number of interference complaints increased drastically. For this reason the FCC started using correspondence as the chief method of dealing with RFI complaints. Television interference committees were also formed, manned by amateur radio volunteers. On-site FCC investigations were made only as time permitted.

During this era, the FCC discovered that many interference problems were due to deficiencies in the design and installation of the electronic entertainment system subject to the interference. In these cases the complainant's TV, stereo or other electronic equipment simply did not have the capability of rejecting unwanted signals. The solution to the majority of these problems, the FCC found, was to filter or shield the affected device.

A Problem of Huge Proportions

Today we are faced with an interference problem of huge proportions. During the first nine months of fiscal 1981 the FCC received over 62,000 complaints of RFI to home entertainment equipment. Unofficial FCC and amateur sources estimate that for every complaint received at FCC there are up to 100 or more unreported cases. No one knows for sure what the exact numbers are. If you count the mildest cases, we all probably experience some noise on our radios, "snow" on our TV screens, or other minor manifestations of RFI. The magnitude of the RFI problem can be attributed to three factors:

1) With the rapid growth in the electronics industry, the probability of a home entertainment device being located near an rf source has increased markedly. Fig. 1 shows a peak in complaints during 1977. That was caused by the CB boom. Although the boom is now history, CB activity continues. There were 11 million licensed CB operators as of August 1981. In addition to FCC-licensed transmitters, other potential sources of radio frequency energy are power tools, home appliances, lighting equipment and microcomputers. The chances are very great that you have one or more sources of rf near you right now.

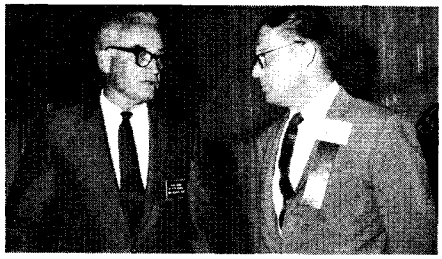
2) Solid-state components have been substituted for vacuum tubes in electronic equipment, because they are less expensive, run cooler, have longer lifetimes and are easier to service when built in modular form. At the same time, solid-state components are more susceptible to stray rf radiation. Too often, the relatively low-cost protective circuitry has been omitted by the manufacturer to pare prices to the minimum.

3) The consumer's use of electronic devices, including TVs, radios, phonographs, games, and audio and video tape equipment, has also grown at a tremendous rate. Thus, a great many more electronic devices may be subject to

Senator Goldwater's Views on RFI

As he introduced RFI legislation into the Senate, Barry Goldwater, W7UGA, discussed the scope of the problem. Portions of his remarks follow:

"In the face of an expanding electronic age, with radio frequency energy fields present everywhere and increasing all the time, home electronic equipment (such as television receivers, burglar alarms and the like) have suffered interference due to inability to reject unwanted signals. The solution to the problem consists of incorporation of inexpensive filtering methods into the design of such equipment. This bill would allow the FCC to require that radio frequency interference suppression techniques be incorporated into electronic home entertainment devices by the manufacturers. In the case of low-cost items which could not profitably incorporate such filtering methods, a simple warning to the consumer as to the susceptibility of that device to radio frequency interference could suffice. Devices manufactured prior to the effective date of the Act would be exempt from this requirement.



Senator Goldwater (l) K7UGA, shown here with then-ARRL General Manager John Huntoon, WIRW, has long championed the cause of RFI legislation.

I am reluctant to take this step to extend FCC jurisdiction over a matter that has been left to the marketplace. But after repeated unsuccessful efforts to obtain the electronics industries' voluntary cooperation, I believe we must rely on the FCC for guidance on a resolution of this issue."

interference (Fig. 2).

RFI Legislation

The first RFI bill was introduced in the 92nd Congress in 1972. Similar RFI bills have been introduced in every Congressional session since. These bills would give the FCC authority to set standards for the susceptibility of home entertainment electronic devices to rf energy. The Communications Act of 1934 grants the FCC the power to make regulations concerning equipment that radiates rf energy. The FCC currently has no power, however, to regulate electronic devices that can experience interference. Even though they do not radiate rf energy, these devices are more often than not responsible for the interference they experience.

Manufacturers of electronic entertainment devices, in a competitive marketplace, are reluctant to take the initiative to RFI-proof their equipment. It is true that factory-installed RFI protection would raise the price of a typical unit, perhaps anywhere from a few cents to as much as five dollars. There is little incentive for one manufacturer to install additional filtering or shielding if it would put him at a competitive disadvantage. But, if the law required it, no particular manufacturer would be hurt.

Others argue that these bills are against consumers' best interests, because the price of electronic entertainment equipment would be raised for everybody. But this reasoning seems unsound when you consider that the bill would improve defective equipment. Also, it is far cheaper to RFI-proof a piece of equipment at the time of manufacture than for the user to do so after he has purchased it.

What to Expect

Simply put, Amateur Radio is often blamed for causing interference, regardless of the type of signal being intercepted — amateur, CB, fire or police department or commercial a-m, fm or TV. The complainant probably believes he is being interfered with by "that ham down the street," when in fact Amateur Radio was probably not involved. Latest FCC figures show that only three percent of RFI complaints can be attributed to amateur operation. It is also true that well over 80 percent of RFI complaints concerning home entertainment devices would never have occurred at all if the manufacturer had included proper shielding or filtering.

But this in no way lets the amateur off the hook. Many people are still confused by the distinction between amateur and CB radio. Furthermore, when a consumer's expensive TV set or stereo is experiencing RFI, he is probably not interested in whether the interference comes from an amateur or a CB station. He simply wants the interference stopped. The amateur may find that his explanations are not welcome. Technical expertise should always be guided by diplomacy and tact in dealing with RFI problems.

There are solutions to even the toughest RFI problems. Cooperation between the parties involved is the most important factor involved in finding a solution. Let's look at what can happen.

We mentioned several hypothetical cases of RFI at the beginning of this chapter. There are several possible outcomes in each instance. In her contact with the telephone company about the disrupted long-distance call, Mrs. Rafferty arranged to have a service representative come to her home. He installed an RFI filter on the line and the problem disappeared. Later she mentioned the problem to a neighbor who told her about a nearby Amateur Radio operator. With the help of the amateur she contacted the manufacturer of her stereo equipment, who told them how to eliminate the strange sounds that came from her record player. Information and cooperation found a solution.

Sam Peabody was unable to talk directly with his angry neighbor. The chairman of the RFI committee at Sam's local radio club contacted the neighbor. Tests proved that a high-pass filter was sufficient to restore peace and uninterrupted football game broadcasts to the neighborhood.

A happy resolution cannot be reported for the problems of Jim Sawtooth. His neighbors were never willing to work with Jim, who has no problem with RFI in his own house. So he continues to operate even though he feels bitter. He sees the irony of his involvement in disaster preparedness while some of the neighbors refuse to let him help. If Jim were a weaker chap he would have given up ham radio a long time ago.

"Apple Annie" is no longer heard on the supermarket music system. It took about an hour and $1.50 worth of capacitors to reduce the rf level on the speaker leads to the point that the amplifier ceased to operate as a receiver.

In *The Radio Amateur's Handbook*, George Walton read, "Effective shielding is perhaps the single most important measure in preventing or curing any RFI problems." A few days later he took his receiver out of the metal cabinet. Carefully he scraped away the paint under the screws and where the cabinet touched the chassis. It took a few tries for him to get a good bond between chassis and cabinet. (He had never done anything like that before.) To top it off he grounded his receiver properly. Now George listens to the OSCAR satellite while his mother watches soap operas on TV.

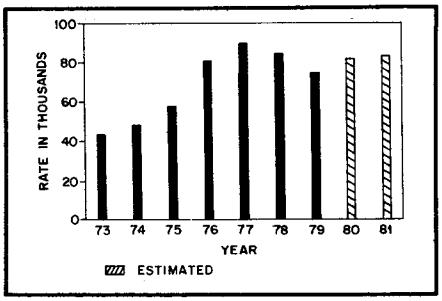


Fig. 1 — Interference complaints received by the FCC, 1973-1981. The peak centered on 1977 was caused by the CB boom.

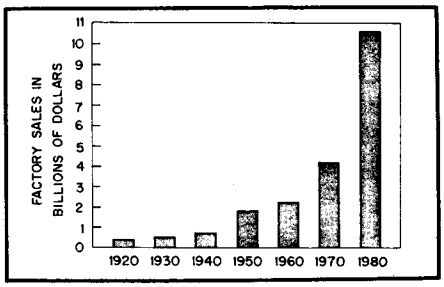


Fig 2. — Consumer electronics decades of growth. The boom that started in the seventies continues as we enter the eighties. (Source: *Consumer Electronics Annual Review, 1981 Edition,* Consumer Electronics Group, Electronic Industries Association, Washington, DC)

Sam Small still scrambles the picture on his TV every time he uses his microwave oven. It bothers him but he has learned to live with it.

The list of case histories goes on. Some have happy endings, and some do not. The outcome depends on the people involved. RFI is a technical problem; it is also a people problem. Turning that problem into an opportunity depends on three factors: information, cooperation and action. Information is needed to know what to do. (This book will help.) The cooperation of the persons involved is essential to resolving the problem. Some kind of action is required to eliminate the RFI. The sooner that happens, the better for everyone involved.

Chapter 2

Coexistence in an RFI-Filled World

For many people, life presents a daily struggle. In addition to the necessity and routine of work, each day has its aggravations. The job itself may be uncertain or insecure. Conflicts can develop, not only with supervisors, but with fellow employees as well. For those who are still young enough to be in school, there is the constant pressure to study and to do well in exams. Those who take care of a house or children have numerous chores and duties that constantly demand attention. Outside of such major daily activities, there are traffic, pollution, crowded supermarkets, and countless other irritations. When the day is over, most people want to relax — to be free, for at least a few blissful hours, from the vexations of the day.

As an Amateur Radio operator, you find escape in your hobby. And your neighbor may find his moments of peace by watching TV or listening to music on his hi-fi set. Unfortunately, your method of relaxation has the potential for disrupting his. As you well know, electronic entertainment equipment, if improperly designed and shielded, can detect and reproduce Amateur Radio signals with very annoying results. If your signals are detected by those around you, your neighbors — who probably know nothing at all about electronics — are painfully aware that their few hours of relaxation are now being destroyed by that irksome ham next door!

We mention all this just to remind you about the other person's point of view. While you have a perfect right to operate an Amateur Radio station and your primary responsibility is to make sure your signal is "clean," your neighbors need their moments of peace and relaxation as much as you do. If you remember that, you may find it easier to maintain cordial relationships with your neighbors as all of you work together to resolve any difficulties that may arise. For, as anyone who has lived through the experience can tell you, your life as an amateur can be unpleasant indeed if you have aroused the anger of your neighbors because of your radio operating. After people identify you as a source of interference to their electronic entertainment sets, there will be a natural tendency to blame all subsequent interference on you, regardless of where it originates. That may not be fair or logical on their part, but is a fact of life.

To make matters worse, you can have a perfectly "clean" signal without any spurious or harmonic output, yet because of design or construction deficiencies in a neighbor's equipment, your signal will be detected and either visually or audibly reproduced, or both. In this case, you will face the very difficult task of convincing the neighbor that his equipment— not yours — is at fault. If the neighbor has spent many hundreds of dollars for his entertainment system, he may not believe you. You can also expect to hear the argument, "But it works perfectly well when you are not on the air, so it must be your fault."

Nevertheless, in the case of television the FCC has found over the years that most TVI problems can be cured only at the television receiver. Certainly, if your own television receiver experiences no interference while you are on the air, it is most likely that interference to a more distant television receiver is not the fault of your transmitter. When it comes to audio equipment (phonographs, hi-fi sets, electronic organs, intercoms, and other similar devices), the only cure for RFI is to treat the audio device experiencing the interference. There is nothing a radio operator can do to his transmitter which will stop a neighbor's phonograph from acting like a shortwave receiver.

It is clear, therefore, that many RFI problems experienced with electronic entertainment equipment result from basic design deficiencies. The few small components or filters that would prevent RFI are often left out by the manufacturers in their attempts to reduce costs and prices on equipment. That policy has not been in the public's interest, because the tremendous growth in radio communications over the past decade has brought increasing numbers of transmitters in close proximity to electronic entertainment equipment. For example, by the end of 1981 there were more than 12 million licensed Citizens Band operators. With the high density of radio transmitters in urban and suburban areas in many parts of the country, the interference potential to unprotected electronic equipment is enormous, and it is growing every day.

What Can You Do?

Given this situation, what can you do to help your neighbor solve any RFI problems he is experiencing, so that both of you can enjoy your forms of relaxation in peace? Basically, you must do your best to ensure that the rf output of your transmitter is on the operating frequency only, and that you are not radiating any spurious rf products, including harmonics, at significant levels. On the hf bands, the FCC requires that any such products leaving the output port of the transmitter be at least 40 dB below the

What to Do If YOU are Accused of Causing RFI

1) Check your log. Were you operating at that time? (A complete log, although no longer required by the FCC, is very useful in interference situations.)

2) Check with *your* nonamateur equipment. If you are not interfering with your own TV set, chances are the problem lies with your neighbor's *receiver* and not your *transmitter.*

3) Solicit the cooperation of your neighbor in testing to determine the exact cause of the interference.

4) Check with your local radio club for a TVI committee or other assistance.

5) Request RFI assistance from the manufacturer of the home-entertainment device. (See Chapter 8.)

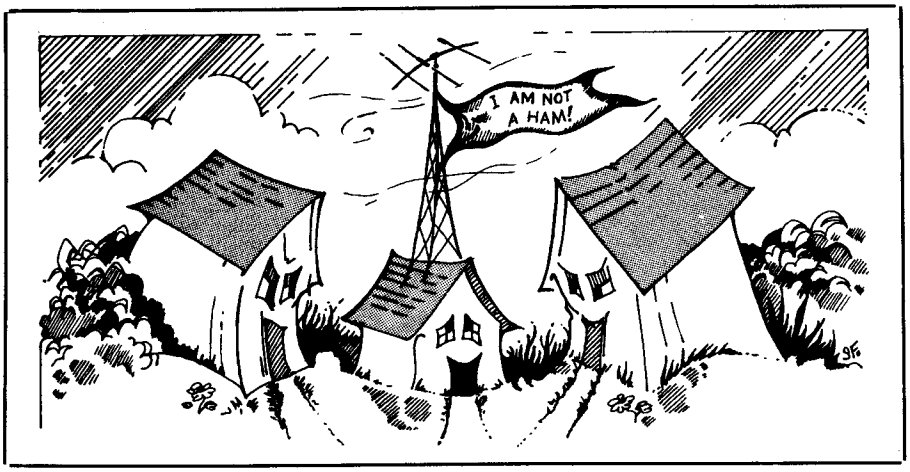
6) Read this book, carefully.

7) Write your Washington representative requesting support of pending RFI legislation.

8) If the fault is in your transmitting equipment, refer to this book, the equipment manufacturer or other technical assistance for advice.

9) Be prompt, courteous and helpful; Amateur Radio's reputation is at stake, as well as your own.

10) For further assistance, write Technical Information Service, ARRL Hq. Include as much detail as you can.



As long as your signal is "clean," it often pays to maintain a low profile in your community. This may be difficult in some cases, however.

peak carrier value of the fundamental signal. On the vhf and uhf bands, this standard is generally −60 dB. Note that the addition of a low-pass filter that effectively cuts off signals over a specific frequency (usually around 40 MHz) at the output port does not change the standard that the transmitter must meet. From a practical point of view, it is very difficult for the average amateur to measure the dB level of radiated harmonics, as very expensive test equipment is needed to make the measurement. Thus, he can determine approximately what spurious rf products he radiates by watching and listening to other equipment, but he can't determine their level. See chapter 4 for a discussion of leakage from amateur transmitters.

Before taking any corrective action, it pays to test thoroughly to see exactly what you are radiating. Pick a time when neighbors are least likely to be listening or viewing their entertainment sets. Transmit on all bands, frequencies and modes you normally use. Employ a dummy load first; then try normal on-the-air operating, avoiding interference with other amateur stations. Listen for harmonic and parasitic output on a separate receiver while you do this. Also observe your own TVs, radios and other electronic equipment. You may be surprised at what you see and hear.

If you are causing interference in your own home, it is important to eliminate it. If you can demonstrate to a neighbor that there is no problem in your own home, it is easier to convince him that his equipment and not yours is at fault. The experience gained in eliminating your own problems is invaluable when advising your neighbors about how to "bulletproof" their sets against your signal.

With luck, your tests may show that you have no problems, or that by simply adding a low-pass filter to your transmitter you may solve any problems that exist. You may find it necessary, however, to shield your rig. You may also have to take corrective action on your own electronic entertainment equipment.

Even if you have no RFI problems, it is a good idea to use low-pass filters on your transmitting equipment. The harmonic output may not bother your own entertainment equipment, but could cause difficulties for a neighbor's. Some sources of low-pass filters are listed in Table 1.

In any case, it is the amateur's responsibility to ensure that his equipment meets FCC standards, regardless of who manufactured it. If low-pass filters are required to prevent interference, this expense must be borne by the amateur, not his neighbor.

Do You Identify Yourself or Not?

After you have made sure your output is "clean" and that you are not radiating any spurious signals, should you advise your neighbors that you operate amateur transmitting equipment? (If you do, you must be prepared to tell them that they may detect your signal on their equipment, and that you are willing to cooperate with them if any difficulties arise; otherwise, why bother to tell them?)

There are two schools of thought on this subject. One follows the philosophy of "let well enough alone," or "maintain a low profile." If you identify yourself, people may become sensitized to possible interference and blame it all on you. So this school believes that if you have proved conclusively that you have a "clean" signal, you should not advertise your presence. Unfortunately, if you are causing interference, by the time people discover you are the source, the situation may be out of control so that future cooperation is impossible. Irritated neighbors have initiated law suits and even vandalized the amateur's property. Town governments may initiate restrictive ordinances that prevent the use of towers. Fighting legal battles can be extremely expensive; an ounce of prevention can be worth a great deal more than a pound of cure.

Because of the foregoing, the other school of thought believes that identifying yourself before you begin extensive operating is the best course of action. Most people are reasonable, and if you show that you want to be as helpful as possible, they will probably cooperate with you. In any case, if your signal is being picked up by your neighbors' equipment, sooner or later they will learn that you are the source. So it is probably best to start off on the right foot while relations are cordial. In any case, if you plan to use a tower topped with big directional antennas, in the average neighborhood it will be impossible to conceal your presence.

What if Your Signal is Detected?

Consider yourself fortunate if none of your neighbors' equipment can detect your signal. But what if you are not that lucky? Even if you have already proved conclusively that your signal is "clean," you still have an obligation to cooperate in resolving the problem. In this case, your goals should be eliminating any RFI problems, keeping peace in the neighborhood and maintaining a friendly, favorable public attitude toward amateur radio.

It is a good idea to encourage the consumer to contact the manufacturers of his equipment, requesting that they provide the components and services necessary to eliminate the RFI that is a source of annoyance to both of you.[1] In addition, make every effort to cooperate in resolving problems. For example, you can run tests and assist in writing letters to

[1]See Chapter 8 for a list of manufacturers.

Sharp Memory Pays Dividends

A California ham discovered that the obvious solutions to an RFI problem may not always work. This "Hint and Kink" item was published in *QST* several years ago.

Recently, while trying to track down the cause of a case of TVI for the neighbor of a local amateur, we had just about exhausted our normal check-off list that included poor antenna configuration, ungrounded circuitry, and missing shields. The amateur involved is a meticulous person when it comes to seeing that his station techniques are all correct. But one neighbor was irate because of the interference caused to his television when the amateur station was transmitting.

In the process of trying to eliminate the problem we tried high-pass filters on the TV set, ran ground wire, and checked that the TV antenna and lead-in wire were good. Still the interference persisted. Luckily, the amateur involved remembered something that he had once heard from a W4: "Wrap the power cord of the television set around a piece of ferrite rod about 20 times and tape." This did the trick and resulted in the elimination of the TVI and produced a satisfied RFI committee chairman.

Uncommon TVI

There are times when the neighborhood's dose of TVI emanates from an unexpected source. This Pennsylvania ham's story holds a message for everyone who stands accused of causing RFI.

"Recently I received a number of TVI complaints from my neighbors up to a block away from my station location. With my big tribander 45 feet up, it was "obvious" that my radio was the culprit. In short order I established that the TVI was present when I was not operating and vice versa. A quick check with another active ham in the neighborhood — who is not so visually obvious since he uses a ground mounted vertical — showed that he too was not operating during the TVI occurrences.

"I could have let the matter drop at that point and protested my innocence when further complaints arose. However, with my beam I felt that I would be blamed no matter what I said. Accordingly, I set out to locate and correct the TVI source. A quick inspection of the neighborhood revealed no obvious CB antennas that could be prime suspects. I found that the high noise level I had recently noticed on 20 meters was directly correlated with the presence of the TVI. Using my beam I was able to determine the bearing of the noise source and prepared to use my low band mobile equipment to locate it.

"By pure coincidence, I was watching the TVI on my own television set when my children began scuffling near the set. Suddenly I realized that the TVI came and went as the kids jarred the floor! Was my own TV set the cause?

"Further investigation verified that my TV set was intermittantly radiating a signal which could be turned on and off by jarring the set. The high voltage supply and the horizontal output circuits were checked as the obvious cause and found to be innocent. Further shaking and jiggling of the set localized the problem to the picture tube. I finally found that the jumper from the outer metal coating of the picture tube was making an intermittant contact with the chassis ground. The inner and outer coatings to the picture tube make up the high voltage filter capacitor with the glass tube envelope being the dielectric. Tightening the ground connection restored the high voltage filter capacitor to full time operation and the television ceased to radiate spurious signals. The TVI in the neighborhood ceased.

"My original beam heading was aimed directly at my TV antenna. I assume that the RF generated by the set was being coupled into the antenna feedline, and the receiving antenna became an inadvertent transmitting antenna."

the various manufacturers involved. Make sure, however, that your neighbor knows it is the manufacturers' responsibility to correct those design deficiencies that lead to the interference being experienced.

Fortunately, many responsible manufacturers are willing to supply filters for reducing television interference when such cases are brought to their attention. A simple letter to the manufacturer involved, stating the relevant facts on the interference problem, is often all that is required to obtain the necessary high-pass filter. For those who wish to purchase their own, a list of manufacturers can be found in Table 2. In the case of interference to other types of equipment, also write to the manufacturer or to the Electronics Industries Association (EIA). Clear presentations of the facts, plus polite requests for help, will be much more effective in obtaining a manufacturer's assistance than will angry letters of complaint. An example of a letter requesting help is shown in Fig. 1. For information about addresses of manufacturers and the EIA, see the section entitled, "Where Can You Get Help?" elsewhere in this chapter.

Regardless of the problem experienced, sending the ARRL the information requested in Fig. 2 will help accumulate statistics on RFI, which will be very useful in our contacts with the FCC, EIA and manufacturers.

Responses to letters sent to manufacturers may be slow in arriving and the RFI will continue in the meantime. Be as helpful as you can during this interim period so that an amicable and mutually satisfactory adjustment of the situation will eventually be reached.

In any event, be very cautious about actually working on the insides of any neighbor's equipment. If it malfunctions after you touch it, you will probably be blamed. Even if your neighbor wants you to work on the equipment, you are well advised not to do so. If internal bypassing or other modification seems in order, it is best performed by a qualified repairman or technician. It may be feasible, however, to make external adjustments, such as changing lengths of leads to loudspeakers, or attaching high-pass filters to the outsides of TV sets. (Unfortunately, filters are more effective if connected inside the TV set, right at the tuner input terminals.)

The neighbor will naturally wonder why he should pay for any of the work. Again, from his point of view, everything works fine if you are not operating. Some of the things you should be prepared to explain:

1) What the FCC requires of you, and your legal responsibilities.

2) The allocations of the various commercial a-m, fm, TV and amateur frequencies. (See Table 1, Chapter 3 and Tables 1 and 2, Chapter 4.)

3) How audio amplifiers, radio and TV sets operate.

4) How your signal, operating on one frequency, can be detected by radio and TV equipment that is tuned to other frequencies, perhaps far removed from yours.

5) How an audio system (including speakers, amplifiers, turntables, tape decks) can act as a radio receiver.

6) How high- and low-pass filters operate.

7) How all types of unwanted signals can enter electronic entertainment equipment via house wiring, antennas, feed lines, and chassis wiring.

Table 1
Manufacturers of Low-Pass Filters

R. L. Drake Co.
540 Richard St.
Miamisburg, OH 45342
The Drake Co. markets a good selection of low-pass filters for every application.

The William N. Nye Co., Inc.
1614 130th Ave. N.E.
Bellevue, WA 98005
Nye's low-pass filter can handle 2 kW of power.

Barker & Williamson, Inc.
10 Canal St.
Bristol, PA 19007
Various B & W filters are available for vhf and hf transmitters. Power capacity is 100 or 1000 watts.

J. W. Miller
19070 Reyes Ave.
P. O. Box 5825
Compton, CA 90224
J.W. Miller markets a filter that is suitable for up to 2 kW ssb.

Low-pass filters are often available through Amateur Radio equipment dealers.

Table 2
Manufacturers of High-Pass Filters

R. L. Drake Co.
540 Richard St.
Miamisburg, OH 45342
This well-respected Amateur Radio manufacturer offers filters for both 300-ohm twin lead and 75-ohm TV coax.

J. W. Miller
19070 Reyes Ave.
P. O. Box 5825
Compton, CA 90224
Three types of filters are offered, with impedances of 75 or 300 ohms.

Radio Shack
Local stores carry inexpensive high-pass filters, or they can be ordered through the catalogue.

Report of Radio Frequency Interference (RFI)
(Please Print or Type)

The purpose of this form is to assist the American Radio Relay League (ARRL) in collecting specific information on cases of radio-frequency interference (RFI). Such information, and the statistics to be derived therefrom, will be of considerable help to the League in its contacts with the Federal Communications Commission, and with various representatives of the electronics industry...contacts which we hope will lead to the elimination of RFI as a source of annoyance to both the consumer and the radio operator.

Type device_____ [television, radio, hi-fi, tape recorder, phonograph, electronic organ, intercom, other (specify)]

Manufacturer_____

Model No._____ Serial No._____

Description of Interference (picture, sound, channels affected, effect of varying volume control, etc.):

Other devices in the same location experiencing interference:

Other devices in the same location which are not experiencing interference:

Approximate distance to radio station's antenna_____

Description of radio station:

Transmitter_____ watts Antenna_____

Frequencies of operation on which interference is observed:

Information submitted by_____

Date_____

Add any remarks you may have on the reverse side of this form.
Mail form to: ARRL RFI Task Group, ARRL, 225 Main St., Newington, CT 06111

(Additional copies of this form are available from the ARRL RFI Task Group, or you may reproduce it locally).

Fig. 2 — Reporting RFI information to ARRL hq. on a form such as this helps the League's RFI Task Group to gather a large body of data on various RFI problems. Working closely on the community level and with the FCC, the RFI Task Group hopes to curtail RFI whenever possible.

8) The necessity of having a properly operating TV antenna with all contacts electronically sound, tight and free of corrosion.

9) The present policy of most manufacturers of electronic entertainment equipment not to bypass and shield their products adequately.

10) The many other sources of interference, both internal and external to the home.

In addition to the above, you should know in advance the names of several well-qualified electronic repair shops and a convenient source of high-pass filters.

Above all else, be tactful. Avoid referring to your neighbor's equipment as "cheap" or "junk" or any other expression that reflects adversely on its quality, price or performance. Most people are easily offended by tactless remarks about their property. *You should be a diplomat at all times.*

Short-Run Solutions

If a neighbor is detecting your signal, it may be diplomatic to curtail your operating until the problem can be corrected. If the signals from one band only are being detected, you may be willing to stop operating temporarily on that band, or to operate on it only when the entertainment equipment is not normally or heavily used. For example, if your signal on 15 meters disrupts TV channel 3, you may avoid 15 meters during the prime TV viewing hours of 6:30 to 10:30 P.M. Tactfully explain, however, that this is a voluntary and temporary restriction on your part, done in the spirit of neighborly cooperation, while they eliminate the problems in their equipment.

Another temporary solution is to reduce power output during critical hours of the day. Interference that may not exist or be barely noticeable and not objectionable at low rf power levels, can become overwhelming when you run a kilowatt.

If you are considering any restrictions on your operating, be aware of the potential difficulties. The neighbor may assume your action is a tacit admission of guilt. Also, temporary solutions sometimes become permanent ones.

Because of these factors, some hams firmly believe that rather than restrict yourself, you should operate a "clean" transmitter as much as possible. This may encourage disgruntled viewers to install filters, and to demand corrective action from manufacturers. But who can predict how people will respond to an unpleasant situation? Because you know your neighbors better than any outsider, you are the best judge of whether temporary restrictions should be used or not.

What if the FCC Intervenes?

You may become involved in an unpleasant situation with a neighbor who becomes angry the very first time he detects your signal. Cooperation with such a person may be impossible, and he may notify the FCC that you are disrupting his enjoyment of electronic entertainment.

The FCC policy regarding complaints is, generally, as follows:

1) The radio amateur is responsible for operating his transmitter in a legal manner, as covered by the amateur regulations promulgated by the FCC, and as discussed above. (The amateur rules and regulations most applicable to RFI are reproduced at the end of this chapter.)

2) The FCC greatly prefers that any problems between an amateur and his neighbors be solved by mutual cooperation.

3) If a neighbor complains to the FCC, he may be sent a booklet entitled, "how to identify & resolve Radio-TV Interference Problems."[2]

The FCC booklet describes a general procedure that the neighbor can follow to eliminate the interference at his end. This includes identifying the type of interference, using home remedies (such as high-pass filters), using qualified local technicians and repairmen, and obtaining assistance from the equipment manufacturer.

[2]This booklet is reproduced in chapter 7. A copy may also be obtained for $1.50 from the Consumer Information Center, Dept. 051F, Pueblo, CO 81009. Make check payable to Superintendent of Documents. Also see "Where Can You Get Help?" elsewhere in this chapter.

My TVI Complaint and the FCC

I live in an apartment in New York City and last October my next door neighbor complained, alleging my interference to his broadcast receiver, television set and record-playing equipment. I showed the neighbor my station, indicated my filtering equipment, attempted to explain its operation and demonstrated that my own broadcast receiver and television were not affected during station operation. He became quite upset and threatened to go to the FCC, which he did.

A few weeks later, I received the FCC's form 762-B advising me of the complaint and requiring a reply. As a member of the Hall of Science Radio Club, I requested assistance from the club TVI committee and Paul, WA2HGG, and Gary, WB2CWK, both Extra Class hams, responded to act as my TVI committee.

My TVI Committee Goes to Work

I use a Yaesu FT-101B, 240-watts PEP-dc input, a Matchbox, model 250-23-3, a Drake TV-42-LP low-pass filter, an end-fed, long-wire antenna, an HQ1 quad for 20 meters and a 40-meter dipole. I use an ac-line bypass filter and ground system.

My TVI committee visited my QTH and while I operated at full power in the ssb mode on the various amateur bands between 80 and 15 meters, they made various tests and observed reception on my own television set and broadcast-band radio. They observed a very mild case of cross-hatching on an unmodified Sylvania CD-63 color receiver equipped with a Drake high-pass filter, model 300-HP-R. The TVI was not noticeable from a distance of several feet from the receiver.

Other observations were made using a Panasonic model RS280S amplifier and receiver. A mild case of audio amplifier rectification was observed. The rectified audio was completely masked when the loudness control was advanced to a reasonable listening level.

The TVI committee then visited the complainant and was allowed to enter the premises for interview and observation purposes. With station WA2VOS in operation, they observed a severe case of audio amplifier rectification on a Harmon Kardon receiver-amplifier when the volume control of the receiver was turned down. A loud buzz was also observed whenever the station carrier of WA2VOS was turned on.

Investigating this problem further, it was found that a 1-watt, 2-meter portable transmitter would cause a similar buzzing problem when it was in the vicinity of the Harmon Kardon receiver amplifier. This indicates an undue sensitivity to rf fields. After these observations were recorded, an attempt was made to explain the causes and cures for the problems related to the complainant's amplifier receiver; however, at this point the complainant became boisterous and agitated, forcing the termination of the interview.

Before submitting a report to the FCC, my TVI committee wanted to be sure we were clean as to harmonics. This required a spectrum analyzer which was not available to us. We asked our local Heathkit outlet manager if we could use his shop unit and he readily agreed. With this we proved that the 2nd and 3rd harmonics were down a minimum of 65 dB.

A few days later we forwarded a report to FCC concluding that the interference problems were not due to station malfunction but that interference to television reception, if it existed, was primarily due to fundamental overload of the front end rather than harmonic radiation, as demonstrated by the lack of TVI and RFI at my location. We also suggested that the major problem of audio amplifier rectification of the complainant's receiver was caused by improper shielding and bypass measures.

Enter FCC

The FCC then assigned an investigator to the case, since we had been unable to placate the

Whether your neighbor is friendly or not, your cooperation will be required at some point in the procedure. For example, a technician may have made adjustments or modifications, or installed filters, and he will want to determine if the changes are effective. It pays to be cooperative. First, the neighbor may be subject to a variety of sources of interference, and the changes made by the technician may have eliminated your signal as a source of difficulty, but not the other sources. Second, FCC policy requires that you cooperate. If you don't, you are inviting official action. Third, your spirit of cooperation may serve to restore harmony with your neighbor. In this case, be willing to forgive and forget.

Several things should be emphasized. You are not required to service or provide filters for your neighbor's equipment, and in any case you cannot take such action without his full cooperation. In other words, any expenditures made to eliminate interference at the neighbor's equipment is his responsibility alone. You can pay for any or all of the work at his equipment if you so desire, but you will be setting a potentially costly precedent in the neighborhood.

On the other hand, any expense made to ensure clean output from your transmitter is your responsibility alone. A neighbor does not have to pay for anything done to your equipment.

The FCC will take no further action if the neighbor's problems are solved, or if he does not communicate with the FCC again. If all approaches to correcting the problem fail, however, the neighbor may seek FCC assistance. The FCC booklet states, "If you have taken all the steps suggested in this bulletin, and the problem still exists, there may be something unique to your interference problem. By furnishing the information requested on page 30 (see Fig. 3) to your nearest FCC

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In requesting assistance from the association, manufacturer, dealer, or FCC district office, the following information will be helpful in analyzing your problem.

_____ Date

1. Your name: _____
   Address: _____
   _____
   Phone Number: _____
2. If known, radio transmitter operator's:
   Name: _____
   Address: _____
   _____
   Call Sign: _____
   Hours of Operation: _____
3. Type of interference identified:
   ☐ Radio Transmitter ☐ Electrical
   ☐ Co-Channel ☐ FM
   ☐ Audio
4. a. TV Channels affected: _____
   _____
   b. AM/FM Frequencies affected: _____
   _____
5. If you are experiencing either FM or Co-Channel interference, estimate the distance of the interfering station from the location of your home: _____(miles).
6. Were suggested home remedies made?
   ☐ Yes ☐ No
   Please explain (be specific): _____
   _____
   _____
   _____
7. a. Was service representative called:
   ☐ Yes ☐ No
   b. If yes, were suggested modifications made? ☐ Yes ☐ No
   Please explain (be specific): _____
   _____
   _____
   _____
8. a. If a radio transmitter is involved, was the operator contacted? ☐ Yes ☐ No
   b. If yes, what was the result of that conversation? _____
   _____
   _____
   _____
   c. Were suggested transmitter modifications made? ☐ Yes ☐ No
   Please explain (be specific): _____
   _____
   _____
9. At what time of day does the interference usually occur and how long does it last?
   _____
10. Give Make, Model Number, and the Year Purchased, of your TV or AM/FM receiver. _____
11. Was the level of interference affected in any way by the modifications suggested in this bulletin? ☐ Yes ☐ No
    Comments: _____
    _____
12. Describe fully the sound or noise made by the interference and, if the TV picture is affected, please provide a drawing of what the interference pattern looks like. (Use separate sheet.)
13. a. Are any of your neighbors experiencing the same type of interference?
    ☐ Yes ☐ No
    If yes, on a separate sheet, indicate their names, addresses, and type equipment receiving the interference; TV, AM/FM radio, electronic organ, etc.
    b. Was the information provided in this bulletin shared with your neighbors?
    ☐ Yes ☐ No
    If yes, please explain what modifications were made to their equipment and if the modifications eliminated or reduced the level of interference. (Use separate sheet if necessary.)
    _____
    _____

Fig. 3 — The information on this page is extremely useful to the FCC district office. Once the form is filled out and sent, FCC engineers will have a means of determining where the problem — and the solution — lies.

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complainant. He visited both my QTH and the complainant's, found my station complying with the rules, gave me a clean bill of health, explained the causes and cures to the complainant and I felt that this was the end of the case and was very appreciative of my TVI committee's aid and for the FCC's efficient handling of the matter — all done in less than three weeks.

Exit FCC

Several months went by when the FCC advised me that the case was being reopened. It seems the complainant had written his congressman suggesting that the FCC people were — shall we say — less than what should be expected. The congressman demanded a recount and he got it in spades but fast.

Re-enter FCC

The local FCC Engineer in Charge became personally involved and assigned two of his best engineers, who incidentally were nonhams, to reinvestigate the complaint. The engineer called me and made an appointment for one week later, advising me to make sure everything was in order for a very intensive test of every piece of gear in the station. During the first inspection, the FCC inspector had given me an FCC diagram showing how to filter TV and audio sets. My TV already had a Drake hi-pass filter grounded to the chassis with a disk capacitor. This seemed to comply with the FCC "cure." My Panasonic stereo receiver was not filtered and I had bypassed it for rf with .001 disk capacitors according to the FCC diagram. I felt I was already as ready as I'd ever be.

The two engineers arrived at my QTH with a load of sophisticated gear, antennas and whatnot that would have put Marconi and Edison in shock. They were all business and no-nonsense and I was sure that if they found anything wrong my license was long gone. Having my TVI committee on the scene really helped my nervous system.

Before any tests began, a complete visual observation of the station was made. I had to explain in detail the function of every piece of equipment and an inventory was made by the engineers of each item. I then had to explain every position on every switch, how I used it, and the purpose and use of each antenna.

Engineer No. 1 then took my receiver and left my QTH. He set up all kinds of gear out on the lawn. Engineer No. 2 by means of a walkie-talkie was in contact with Engineer No. 1 but stayed in my station. I loaded, reloaded, changed frequencies, changed antennas, used every piece of gear and carried out the instructions of Engineer No. 2 for three hours steady on both phone and cw. Talk about a thorough testing. My rig really got it.

The next operation was a check of my station logs and copies of all communications with the FCC. A discussion was held as to our test procedures in preparing the data used in our report to the FCC. Incidentally, our findings, including the spectrum-analyzer tests using the equipment made available by Heath Co., were verified as accurate by FCC.

The engineers then visited the complainant to inform him that WA2VOS was "clean" and operating in accordance with Part 97. I could hear the screams of protest through the walls and even heard the complainant say he would take the matter further. About 11:30 P.M. two very tired FCC engineers, obviously much anguished, packed up their gear.

Re-exit FCC

Most of us have read about Congressman Teague's proposed bill HR 3516 that would require manufacturers to filter TV sets and fm receivers. The last I heard was that it had been put down by the manufacturers' lobby. Proper filtering would have eliminated this whole event.

Anyway, I for one have had more than ample proof that the FCC in New York City is doing its work well and we amateurs are sure glad it is there.

You Can't Win!

As a result of these second tests, the complainant has dropped his lawsuit against me. The complainant was my landlord. He lost his case but maybe, in a way, he won. By the time that this is published, I will be living in my new QTH, my own home, I might add, and doing my hamming in peace. 73, Jim, WA2VOS.

district office, an FCC staff member may be able to determine what additional steps are needed to resolve your interference problem."

4) If the complainant sends that form, the information is evaluated by the FCC. If the complainant has taken the steps outlined in the FCC booklet, then the FCC may direct you (or any other operator involved) to make an investigation and report the results to the FCC. On the other hand, if the FCC believes that enforcement action appears to be the solution, then it will initiate action.

In addition to the above, the FCC may suggest that you maintain "quiet hours," specific times when you avoid certain frequencies, or do not transmit at all. The quiet hours are usually the evening hours when most TV viewing occurs. In an occasional rare case, quiet hours may be ordered rather than suggested, or operating privileges on a particular band may be permanently removed. Many factors influence the course of action followed by the FCC, but the most important are probably the work backlog at the local FCC office and the priority it assigns to the complaint.

It should be obvious that the wisest course of action is to be "clean" at all times. Use low-pass filters on the output of each piece of transmitting equipment, on the output of the exciter as well as on the linear amplifier. Otherwise, any harmonic output of the exciter may be amplified, making it more difficult for the filter on the final amplifier to do its job. It is worth remembering that if harmonics are radiated by your antenna system, undesirable effects may occur at great distances from your home. Keep harmonics out of the antenna system to begin with. And again, if you live in a multifamily dwelling, or have close neighbors, it may be worthwhile to shield the transmitter chassis to eliminate incidental radiation.

Where Can You Get Help?

Manufacturers of electronic entertainment equipment will often assist owners of their equipment who are experiencing RFI difficulties. On request, some manufacturers will provide free high-pass TV filters. Others even have technical representatives who travel in the field to assist their dealers and local technicians.

For assistance in handling RFI problems involving manufacturers who do not appear in the Consumer Products RFI Assistance List in chapter 8, contact the Director of Consumer Affairs, Consumer Electronics Group, Electronic Industries Association, 2001 Eye Street, NW, Washington, DC 20006, Tel. 202-457-4977.

As far as amateur transmitting equipment is concerned, write directly to the manufacturer. He will undoubtedly advise you to use a low-pass filter, and may make other suggestions as well. Chapter 4 also describes several techniques that may be used. For several reasons, however, be very careful about modifying your equipment. A modern ssb transmitter or transceiver is a very complicated piece of equipment. If you manage to misalign some of the circuits, you may lack the technical capability or equipment to realign them, and the rig will have to be sent back to the factory. Determine if modifications will hurt the resale of your equipment. If that is a concern, first try modifications that will have the least effect on resale value.

In any case, keep in mind the potential shock hazard. Make sure the equipment is disconnected from the line voltage. As an added precaution, positively discharge the filter capacitors in the high-voltage power supply.

RFI Committees

You may wish to enlist the advice and support of knowledgeable radio amateurs in your vicinity. If you belong to an ARRL-affiliated radio club, you know where to turn. Otherwise, contact the Club and Training Department at Headquarters for information about a club in your area. If the club does not have an RFI committee, it will probably have one or two members with experience in combatting similar problems. If no RFI committee exists in your area, you may want to start one. Fortunately, the FCC heartily recommends and endorses the private formation of these amateur-sponsored groups. In addition to radio amateurs, such organizations may include representatives from local newspapers, telephone and electric-power companies, TV and radio stations, and any other agencies that are relevant in a particular locality.

RFI committees investigate complaints and aid in determining where responsibility lies by coordinating tests of neighbors' and amateurs' equipment. They provide technical advice to all parties involved in a given complaint, and help establish channels for acquisitions of high-pass filters. RFI committees also maintain educational and publicity programs to keep the community informed about sources and cures for RFI, and the role of the Amateur Radio operator. Some of the problems they have alleviated or eliminated include hams curtailing their activities through fear of causing interference, the public blaming radio amateurs for interference not remotely associated with ham operation, service and repair personnel using the "Amateur Radio alibi," and neighbors not listening to explanations and demanding that the ham purchase high-pass filters for them.

How Does a Committee Get Started

It takes more than one person to start a committee. However, the understanding and enthusiasm of just one amateur can help sell the program to the entire ham community.

A few representatives of all active radio clubs in the area (as well as hams at large) usually meet to discuss ways to begin. In less populated regions, the local radio club often provides assistance through its interference committee. This nucleus of the future interference committee meets to discuss its particular interference problems, which determine those agencies to be contacted for additional representatives on the committee.

Your FCC district engineer-in-charge should be informed about the creation of your committee, so he can furnish suggestions on special phases of your operations. He will want to know your committee contact — the person interference complaints about amateurs should be sent to. He will also want to know what other agencies your committee represents and how they can be reached.

As you will note from the interference committee plan diagram (Fig. 4) the committee represents all the agencies concerned with the different aspects of the interference problem. Although your immediate concern is with the amateur phase, you will need to know who should be contacted at all the other agencies when a problem is their responsibility. The interference committee represents the entire community, but your primary participation and investigations will concern your fellow amateurs.

When your committee nucleus has determined the actual needs of the committee and has contacted the FCC, write to the other agencies — preferably on committee letterhead. Explain your committee objectives, which might include: (1) crusading for a better understanding between all parties concerned with RFI, (2) providing a clearinghouse for coordinating complaints and cooperative corrective action, (3) providing assistance for amateurs who restrict their radio activities because of RFI or fear of it, and (4) investigating RFI complaints where the amateur is known or accused.

Keep your paperwork to a necessary minimum without sacrificing essentials. This will keep processing of forms and records simple and effective. A large number of committees use only letterhead paper, a form to acknowledge receipt of an RFI complaint, and a report form.

If unnecessary paperwork and material is avoided, the operating expenses of the committee can be kept low. Pieces of equipment can be as few or as many as the budget will permit. Some groups make do with a few high-pass and line filters (for test purposes only).

Other committees acquire and use a wide variety of test equipment. The costs of the equipment are often shared between the clubs and other agencies.

How to Coordinate Complaints

Committees usually establish a central

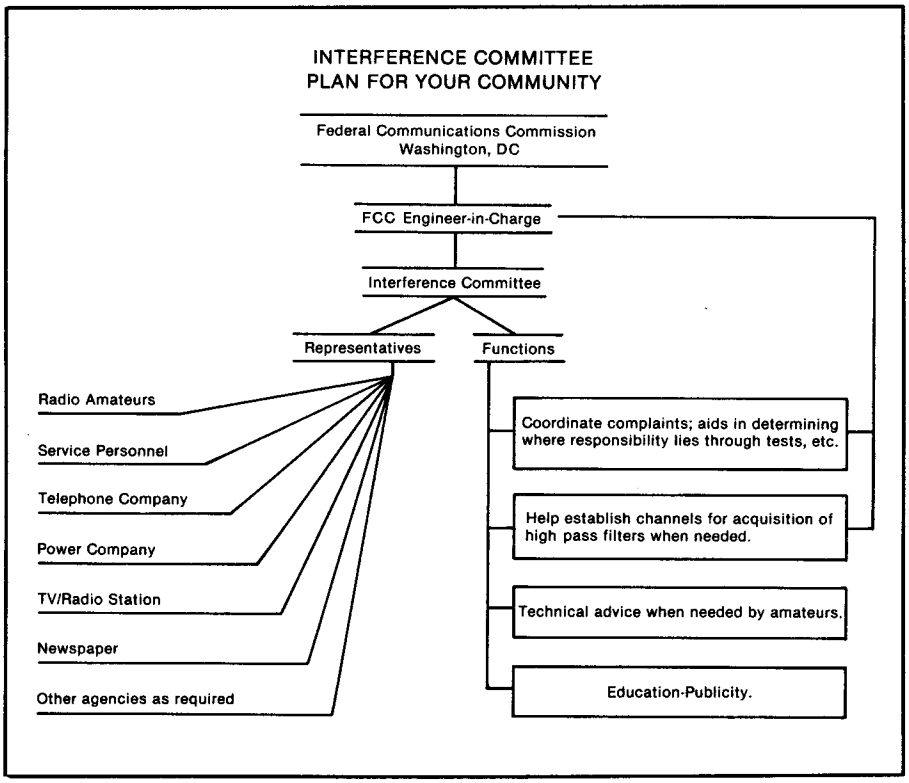


Fig. 4 — A suggested plan for a local RFI committee.

clearinghouse. This is usually the mailing address of a committee representative, or the P. O. Box for the committee itself, and possibly a telephone number. If a complaint concerning a radio amateur is received by the FCC, it is referred to the committee. The committee will often receive complaints directly from the public. In other cases the radio amateur will call on your committee for technical or public relations help.

The acknowledgement of receipt of a complaint regarding interference is usually sent to the person the complaint is received *from*, with copies to the other individuals concerned. If the complaint comes via the FCC, the acknowledgement is sent to the listener, with copies to the FCC, the amateur, and committee files. If the complaint is received directly from the listener, the original acknowledgement should go to him, with copies to the amateur and committee files. If a ham reports he is having difficulties, the original goes to him, with copies to the listener and committee files.

Publicize the Committee!

After the committee is organized, and when you know who should receive complaints about nonamateur RFI problems (your contacts in the other agencies), start publicizing the existence and functions of your committee. The local media can be used to get your story to the public. Many TV and radio stations emphasize items of local interest. Newspapers, shopping guides, civic organizations and bulletin boards are just some of the ways to let the community know about your committee. Don't forget to tell them about your successes. TV service organizations can help by educating local TV repair personnel.

All of the committee contacts, and especially those who have been helped, can be recruited to write to Washington. Representatives and senators should be asked to support legislations that would alleviate the RFI problem.

A Matter of Diplomacy — and Detective Work

Having explored the complex web of legal responsibilities and those actions that merely keep peace in the neighborhood, let's summarize the message behind this chapter.

Even though a large percentage of interference to electronic entertainment devices is caused by the devices themselves, it's a good idea to invest some effort into convincing your neighbor of that fact. It will not only help maintain cordial relations between the other two parties, but will serve to take the burden off of amateurs and place it where it belongs — on manufacturers. If only a small percentage of persons experiencing interference could be persuaded to write the manufacturer of the offending device, a great deal will have been done to ensure that all such devices will be manufactured properly to begin with.

Should tests reveal that you are the source of your neighbor's TVI, you must make certain your signal meets FCC specifications. Specific ways to do this are discussed in Chapter 4. Once your signal is clean, you have the option of getting involved with the neighborhood's RFI difficulties or avoiding them as best you can. If you do choose to get involved, it helps to educate your neighbors about their problem. But be wary of volunteering to pay for high-pass filters or installing them inside a TV set; you might be held responsible for any and all operating difficulties encountered with the equipment forever after, and a precedent will be set.

Should the FCC become involved, be prepared to prove that you are meeting your legal responsibilities, and then to work with your neighbor to find an agreeable solution. (A great majority of RFI difficulties can be solved in this way before the FCC is called in.)

Interference committees were formed soon after the advent of television to handle a community's RFI problems. If your community doesn't have one, you might want to organize it yourself. Amateur Radio — and your neighbors — will benefit.

Rules and Regulations Pertaining to RFI

With the proliferation of various radiocommunication services which share the frequency spectrum, it's no surprise that the FCC closely regulates the types of emissions employed in the Amateur Radio Service. Those rules and regulations applicable to radio frequency interference are reproduced below. Note especially 97.67(b) and 97.73.

The regulations may look forbidding, but the amateur is actually required to do relatively little of a technical nature to meet FCC requirements. A discussion of what to do after determining that your signal meets these requirements appears elsewhere in this chapter.

Subpart C — Technical Standards

§97.61 Authorized frequencies and emissions.

(a) The following frequency bands and associated emissions are available to amateur radio stations for amateur radio operation, other than repeater operation and auxiliary operation, subject to the limitations of §97.65 and paragraph (b) of this section:

Frequency band	Emissions	Limitations (See paragraph (b))
kHz		
1800-1900	A1, A3	
1900-2000	A1, A3	1, 2
3500-4000	A1	
3500-3775	F1	
3775-3890	A5, F5	
3775-4000	A3, F3	4
4383.8	A3J/A3A	13
7000-7300	A1	3, 4
7000-7150	F1	3, 4
7075-7100	A3, F3	11
7150-7225	A5, F5	3, 4
7150-7300	A3, F3	3, 4
14000-14350	A1	
14000-14200	F1	
14200-14275	A5, F5	
14200-14350	A3, F3	
MHz		
21.000-21.450	A1	
21.000-21.250	F1	
21.250-21.350	A5, F5	
21.250-21.450	A3, F3	
28.000-29.700	A1	
28.000-28.500	F1	
28.500-29.700	A3, F3, A5, F5	
50.0-54.0	A1	
50.1-54.0	A2, A3, A4, A5, F1, F2, F3, F5	
51.0-54.0	AØ	
144-148	A1	
144.1-148.0	AØ, A2, A3, A4, A5, FØ, F1, F2, F3, F5	
220-225	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5	5
420-450	AØ, A1, A2, A3, A4, A5 FØ, F1, F2, F3, F4, F5	5, 7
1215-1300	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5	5
2300-2450	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5 P	5, 8
3300-3500	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	5, 12
5650-5925	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	5, 9
GHz		
10.000-10.500	AØ, A1, A2, A3, A4, A5 FØ, F1, F2, F3, F4, F5	5
24.000-24.250	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	5, 10
48.000-50.000	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	
71.000-76.000	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	
165.000-170.000	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	
240.000-250.000	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	
Above 300.000	AØ, A1, A2, A3, A4, A5, FØ, F1, F2, F3, F4, F5, P	

(b) Limitations:

(1) The use of frequencies in this band is on a shared basis with the Loran-A radionavigation system and is subject to cancellation or revision, in whole or in part, by order of the Commission, without hearing, whenever the Commission shall determine such action is necessary in view of the priority of the Loran-A radionavigation system. The use of these frequencies by amateur stations shall not cause harmful interference to the Loran-A system. If an amateur station causes such inteference, operation on the frequencies involved must cease if so directed by the Commission.

(2) Operation shall be limited to:

Maximum dc plate input power in watts

States of:	1900-1925 kHz day/night	1925-1950 kHz day/night	1950-1975 kHz day/night	1975-2000 kHz day/night
ME, MA, NH, RI	100/25	0	0	100/25
CT, DE, MD, NJ, NY, PA, VT	200/50	0	0	200/50
KY, NC, OH, SC, TN, VA, WV	500/100	0	0	500/100
FL, GA, IL, IN, MI, WI	500/100	100/25	100/25	500/100
AL, AR, IA, MN, MS, MO	1000/200	200/50	200/50	1000/200
remainder of states and territories	1000/200	1000/200	1000/200	1000/200

(3) Where, in adjacent regions or subregions, a band of frequencies is allocated to different services of the same category, the basic principle is the equality of right to operate. Accordingly, the stations of each service in one region or subregion must operate so as not to cause harmful interference to services in the other regions or subregions. (No. 117, the Radio Regulations, Geneva, 1959).

(4) 3900-4000 kHz and 7100-7300 kHz are not available in the following U.S. possessions: Baker, Canton, Enderbury, Guam, Howland, Jarvis, the Northern

Mariana Islands, Palmyra, American Samoa, and Wake Islands.

(5) Amateur stations shall not cause interference to the Government radiolocation service.

(6) (Reserved)

(7) In the following areas the d.c. plate input power to the final transmitter stage shall not exceed 50 watts, except when authorized by the appropriate Commission Engineer in Charge and the appropriate Military Area Frequency Coordinator.

(i) Those portions of Texas and New Mexico bounded by latitude 33° 24' N., 31° 53' N., and longitude 105° 40' W. and 106° 40' W.

(ii) The State of Florida, including the Key West area and the areas enclosed within circles of 200-mile radius centered at 28° 21' N., 80° 43' W. and 30° 30' N., 86° 30' W.

(iii) The State of Arizona.

(iv) Those portions of California and Nevada south of latitude 37° 10' N., and the area within a 200-mile radius of 34° 09' N., 119° 11' W.

(v) In the State of Massachusetts within an 80-kilometer (50-mile) radius of 41° 45' N., 70° 32' W.

(vi) In the State of California within an 80-kilometer (50-mile) radius of 39° 08' N, 121° 26' W.

(8) No protection in the band 2400-2500 MHz is afforded from interference due to the operation of industrial, scientific, and medical devices on 2450 MHz.

(9) No protection in the band 5725-5875 MHz is afforded from interference due to the operation of industrial, scientific and medical devices on 5800 MHz.

(10) No protection in the band 24.00-24.25 GHz is afforded from interference due to the operation of industrial, scientific and medical devices on 24.125 GHz.

(11) The use of A3 and F3 in this band is limited to amateur radio stations located outside Region 2.

(12) Amateur stations shall not cause interference to the Fixed-Satellite Service operating in the band 3400-3500 MHz.

(13) The frequency 4383.8 kHz, maximum power 150 watts, may be used by any station authorized under this part to communicate with any other station authorized in the State of Alaska for emergency communications. No airborne operations will be permitted on this frequency. Additionally, all stations operating on this frequency must be located in or within 50 nautical miles of the State of Alaska.

(c) All amateur frequency bands above 29.5 MHz are available for repeater operation, except 50.0-52.0 MHz, 144.0-144.5 MHz, 145.5-146.0 MHz, 220.0-220.5 MHz, 431.0-433.0 MHz, and 435.0-438.0 MHz. Both the input (receiving) and output (transmitting) frequencies of a station in repeater operation shall be frequencies available for repeater operation.

(d) All amateur frequency bands above 220.5 MHz, except 431-433 MHz, and 435-438 MHz, are available for auxiliary operation.

[Editor's Note: The types of emission referred to in the amateur rules are as follows:
Type AØ — Steady, unmodulated pure carrier.
Type A1 — Telegraphy on pure continuous waves.
Type A2 — Amplitude tone-modulated telegraphy.
Type A3 — A-m telephony including single and double sideband, with full, reduced or suppressed carrier.
Type A4 — Facsimile.
Type A5 — Television.
Type FØ — Steady, unmodulated pure carrier.
Type F1 — Carrier-shift telegraphy.
Type F2 — Audio frequency-shift telegraphy.
Type F3 — Frequency- or phase-modulated telephony.
Type F4 — Fm facsimile.
Type F5 — Fm television.
Type P — Pulse emissions.]

§97.63 Selection and Use of Frequencies.

a) An amateur station may transmit on any frequency within any authorized amateur frequency band.

b) Sideband frequencies resulting from keying or modulating a carrier wave shall be confined within the authorized amateur band.

c) The frequencies available for use by a control operator of an amateur station are dependent on the operator license classification of the control operator and are listed in §97.7

§97.65 Emission Limitations.

(a) Type AØ emission, where not specifically designated in the bands listed in §97.61, may be used for short periods of time when required for authorized remote control purposes or for experimental purposes. However, these limitations do not apply where type AØ emission is specifically designated.

(b) Whenever code practice, in accordance with §97.91(d), is conducted in bands authorized for A3 emission, tone modulation of the radiotelephone transmitter may be utilized when interspersed with appropriate voice instructions.

(c) On frequencies below 29.0 MHz, the bandwidth of an F3 emission (frequency or phase modulation) shall not exceed that of an A3 emission having the same audio characteristics.

(d) On frequencies below 50 MHz, the bandwidth of A5 and F5 emissions shall not exceed that of an A3 single sideband emission.

(e) On frequencies between 50 MHz and 225 MHz, single sideband or double sideband, A5 emissions may be used and the bandwidth shall not exceed that of an A3 single sideband or double sideband signal respectively. The bandwidth of F5 emission shall not exceed that of an A3 single sideband emission.

(f) Below 225 MHz, A3 and A5 emissions may be used simultaneously on the same carrier frequency provided the total bandwidth does not exceed that of an A3 double sideband emission.

§97.67 Maximum Authorized Power.

a) Except for power restrictions as set forth in §97.61 and paragraph (d) each amateur transmitter may be operated with a power input not exceeding one kilowatt to the plate circuit of the final amplifier stage of an amplifier oscillator transmitter or to the plate circuit of an oscillator transmitter. An amateur transmitter operating with a power input exceeding 900 watts to the plate circuit shall provide means for accurately measuring the plate power input to the vacuum tube or tubes supplying power to the antenna.

b) Notwithstanding the provisions of paragraph (a) of this section, amateur stations shall use the minimum amount of transmitter power necessary to carry out the desired communications.

c) Within the limitations of paragraphs (a) and (b) of this section, the effective radiated power of an amateur radio station in repeater operation shall not exceed the power specified for the antenna height above average terrain in the table below.

d) In the frequency bands 3700-3750 kHz, 7100-7150 kHz (7050-7075 kHz when the terrestial location of the station is not within Region 2), 21,100-21,200

Authorized Effective Radiated Power for Repeater Stations

Antenna Height Above Average Terrain	*Maximum Effective Radiated Power For Frequency Bands Above:*			
	52 MHz	*146 MHz**	*442 MHz*	*1215 MHz*
below 50 feet	100 watts	800 watts	Paragraphs (a) and (b)	
50 to 90 feet	100 watts	400 watts	Paragraphs (a) and (b)	
100 to 499 feet	50 watts	400 watts	800 watts	Paragraphs (a) and (b)
500 to 999 feet	25 watts	200 watts	800 watts	Paragraphs (a) and (b)
above 1000 feet	25 watts	100 watts	400 watts	Paragraphs (a) and (b)

*Includes frequencies above 222 MHz.

kHz and 28,100-28,200 kHz, the power input to the transmitter final amplifying stage supplying radio frequency energy to the antenna shall not exceed 250 watts, exclusive of power for heating the cathode of a vacuum tube(s).

§97.73 Purity of Emissions.

a) Except for a transmitter or transceiver built before April 15, 1977 or first marketed before January 1, 1978, the mean power of any spurious emission or radiation from an amateur transmitter, transceiver, or external radio frequency power amplifier being operated with a carrier frequency below 30 MHz shall be at least 40 decibels below the mean power of the fundamental without exceeding the power of 50 milliwatts. For equipment of mean power less than five watts, the attenuation shall be at least 30 decibels.

b) Except for a transmitter or tranceiver built before April 15, 1977 or first marketed before January 1, 1978 the mean power of any spurious emission or radiation from an amateur transmitter, transceiver, or external radio frequency power amplifier being operated with a carrier frequency above 30 MHz but below 235 MHz shall be at least 60 decibels below the mean power of the fundamental. For a transmitter having a mean power of 25 watts or less, the mean power of any spurious radiation supplied to the antenna transmission line shall be at least 40 decibels below the mean power of the fundamental without exceeding the power of 25 microwatts, but need not be reduced below the power of 10 microwatts.

c) Paragraphs (a) and (b) of this section notwithstanding, all spurious emissions or radiation from an amateur transmitter, transceiver, or external radio frequency power amplifier shall be reduced or eliminated in accordance with good engineering practice.

d) If any spurious radiation, including chassis or power line radiation, causes harmful interference to the reception of another radio station, the licensee may be required to take steps to eliminate the interference in accordance with good engineering practice.

Note: For the purpose of this section, a spurious emission or radiation means any emission or radiation from a transmitter, transceiver, or external radio frequency power amplifier which is outside of the authorized Amateur Radio Service frequency band being used.

§97.131 Restricted Operations

a) If the operation of an amateur station causes general interference to the reception of transmissions from stations operating in the domestic broadcast service when receivers of good engineering design including adequate selectivity characteristics are used to receive such transmissions and this fact is made known to the amateur station licensee, the amateur station shall not be operated during the hours from 8 P.M. to 10:30 P.M., local time, and on Sunday for the additional period from 10:30 A.M. until 1 P.M., local time, upon the frequency or frequencies used when the interference is created.

b) In general, such steps as may be necessary to minimize interference to stations operating in other services may be required after investigation by the Commission.

§97.133 Second Notice of Same Violation.

In every case where an amateur station licensee is cited within a period of 12 consecutive months for the second violation of the provisions of §97.61, §97.63, §97.65, §97.71 or §97.73, the station licensee, if directed to do so by the Commission, shall not operate the station and shall not permit it to be operated from 6 P.M. to 10:30 P.M., local time, until written notice has been received authorizing the resumption of full-time operation. This notice will not be issued until the licensee has reported on the results of tests which he has conducted with at least two other amateur stations at hours other than 6 P.M. to 10:30 P.M., local time. Such tests are to be made for the specific purpose of aiding the licensee in determining whether the emissions of the station are in accordance with the Commission's rules. The licensee shall report to the Commission the observations made by the cooperating amateur licensees in relation to the reported violations. This report shall include a statement as to the corrective measures taken to insure compliance with the rules.

§97.135 Third Notice of Same Violation.

In every case where an amateur station licensee is cited within a period of 12 consecutive months for the third violation of §97.61, §97.63, §97.65, §97.71 or §97.73, the station licensee, if directed by the Commission, shall not operate the station and shall not permit it to be operated from 8 A.M. to 12 midnight, local time, except for the purposes of transmitting prearranged test to be observed by a monitoring station of the Commission to be designated in each particular case. The station shall not be permitted to resume operation during these hours until the licensee is authorized by the Commission, following the test, to resume full-time operation. The results of the test and the licensee's record shall be considered in determining the advisability of suspending the operator license or revoking the station license, or both.

§97.137 Answers to Notices of Violations.

Any licensee receiving official notice of violation of the terms of the Communications Act of 1934, as amended, any legislative act, Executive order, treaty to which the United States is a party, or the rules and regulations of the Federal Communications Commission, shall, within 10 days from such receipt, send a written answer direct to the office of the Commission originating the official notice: *Provided, however,* that if an answer cannot be sent or an acknowledgement made within such 10-day period by reason of illness or other unavoidable circumstances, acknowledgement and answer shall be made at the earliest practicable date with a satisfactory explanation of the delay. The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answers to other notices. If the notice relates to some violation that may be due to the physical or electrical characteristics of transmitting apparatus, the answer shall state fully what steps, if any, are taken to prevent further violations, and if any new apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and promised date of delivery. If the notice of violation relates to some lack of attention or improper operation of the transmitter, the name of the operator in charge shall be given.

APPENDIX 2

Extracts from Radio Regulations Annexed to the International Telecommunications Convention (Geneva 1959), as revised by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971.

Article 41 — Amateur Stations

Section 5

1) All the general rules of the Convention and of these Regulations shall apply to amateur stations. In particular, the emitted frequency shall be as stable and as free from spurious emissions as the state of technical development for such stations permits.

§15.4 General definitions

(c) *Incidental radiation device.* A device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy.

§15.25 Operating requirements: Incidental radiation device

An incidental radiation device shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interferences.

§76.613 Interference from a cable television system.

(a) Harmful interference is any emis-

sion, radiation or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with this chapter.

(b) The operator of a cable television system that causes harmful interference shall promptly take appropriate measures to eliminate the harmful interference.

(c) If harmful interference to radio communications involving the safety of life and protection of property cannot be promptly eliminated by the application of suitable techniques, operation of the offending cable television system or appropriate elements thereof shall immediately be suspended upon notification by the Engineer in Charge (EIC) of the Commission's local field office, and shall not be resumed until the interference has been eliminated to the satisfaction of the EIC. When authorized by the EIC, short test operations may be made during the period of suspended operation to check the efficiency of remedial measures.

(d) The cable television system operator may be required by the EIC to prepare and submit a report regarding the cause(s) of the interference, corrective measures planned or taken, and the efficiency of the remedial measures.

Chapter 3

Citizens Band Interference

The Citizens Radio Service has a potential to cause RFI that easily eclipses that of Amateur Radio. The number of licensed CB operators is steadily declining from the 1977 high of approximately 15 million. Toward the end of fiscal 1981 there were over 10 million CB licensees. At the same time Amateur Radio licensees totaled less than 1/25th that number.

No one knows for sure just how many Americans use CB radios. Many license holders no longer use or own radios, while many others use CB radios without the required license. It is this latter group that is more prone to disregard the FCC regulations that limit maximum power to 4 watts (a-m) or 12 watts (single sideband). This in turn creates difficulties for amateurs, as their antennas often make them prime RFI suspects in the eyes of their neighbors.

Similar to Amateur RFI

The causes and cures of interference from CB transceivers are similar to those that can plague amateur gear. If operated as the manufacturer intended, however, CB radios are not likely to cause interference. Harmonic radiation into a TV channel may occur when the transmitter or antenna of a legal CB operator is very close to electronic entertainment equipment. Table 1 shows how CB harmonics can interfere with vhf television channels.

The precautions CBers can take closely parallel those recommended for amateurs. Low-pass filters that are specially designed for low-power CB transceivers will often cure an RFI problem. If the CBer's TV set is being interfered with, a properly installed high-pass filter should cure the problem. As a result of field studies, the FCC estimates that if all CB transceivers were equipped with low-pass filters and all TV receivers had high-pass filters, 40% of all CB-caused TVI would be resolved and an additional 30% improved. Several sources of high- and low-pass filters are listed in chapter 2.

Third-harmonic radiation can be reduced by about 16 dB by using a 5/8 wavelength rather than a 1/4 wavelength ground plane antenna. This will alleviate interference problems with TV channels 5 and 6.

An ac line filter for the 27-MHz band is another way of ensuring against unwanted signals. Another is to use good-quality coaxial cable, preferably the larger RG-8/U for applications that run more than 50 feet. Connectors should be soldered carefully. Use only as much coax as needed; the excess will soak up rf energy.

In most transmitters the rf output is taken from a standard coaxial chassis connector — the "UHF" series type SO-239. The mating plug is the PL-259. These are military numbers; in some cases manufacturers have their own type numbers for the same components. There is a rather bewildering variety of rf connectors, each having its advantage, but the VHF series is used on most CB and amateur equipment.

The plugs in this series are designed for assembly with cable approximately 1/2-inch in diameter, such as RG-8/U and RG-11/U (see Fig. 1). An adapter is needed for the smaller and more flexible RG-58/U and RG959/U cables, as shown in Fig. 2. It is important to check *all* connections, at the antenna, as well as at filters and the back of the rig.

Once these steps have been taken, there should be no interference at the CBer's own TV set. With the suppression of unwanted harmonics, he will be in the same position as the "clean" amateur. The choice remains: to become involved in the community's interference difficulties or lie low. The discussion in chapter 2 on this subject applies here as well. Some CBers have become involved in TVI committees and have contributed a great deal toward making their communities interference-free.

CBers and Hams

As more CBers enter the ranks of licensed amateurs, much of the ill-will generated by the deletion of the 11-meter amateur band in favor of the Citizens Radio Service in the late 1950s has faded. The subject of CB interference was first broached editorially in *QST* in April 1961. "As we see it," it said, "the solution is not to damn the CB operators, but to work with them." The editorial ended with the suggestion that working together might

Table 1

TV Channels and Amateur and Citizens Band Harmonics

			Harmonics				
Channel	*Freq. Range*	*Picture Carrier Freq.*	*CB*	*40 meters*	*20 meters*	*15 meters*	*10 meters*
TV I-F	41-47	42	—	—	42-43	42-43	—
2	54-60	55.25	53.9-54.8 (2nd)	56-58.4 (8th)	56-57.3 (4th)	—	56-59.4 (2nd)
3	60-66	61.25	—	63-65.7 (9th)	—	63-64.35 (3rd)	—
4	66-72	67.25	—	70-73 (10th)	70-72 (5th)	—	—
5	76-82	77.25	80.9-82.2 (3rd)	—	—	—	—
6	82-88	83.25	82-82.2 (3rd)	—	84-86.4 (6th)	84-85.8 (4th)	84-89.1 (3rd)

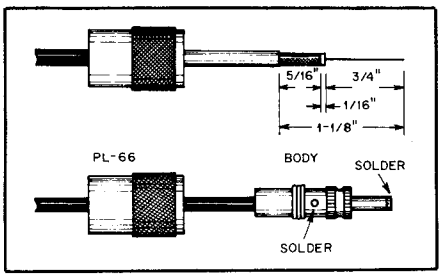


Fig. 1 — To assemble the PL-259 plug to coaxial cable, simply cut back the vinyl jacket 1-1/8 inches, bare the center conductor as shown and tin. Trim the braid, leaving 1/16-inch of polyethylene dielectric protruding, and tin. Screw plug body onto the cable, solder at points indicated and screw the coupling ring on the body.

very well have the effect of making "a few good hams out of the group."

The fact remains, however, that hams are often blamed for interference caused by CBers using faulty — and illegal — external amplifiers that can bring their output up to a kilowatt and more.

A ham accused unjustly of causing interference should prove as quickly as possible that he is not the one causing the problem. This can be done in several ways.

While a detailed operating log is no longer required, it is worthwhile to keep one. If you know you were not on the air when the interference occurred, your problem may be simplified to one of educating your neighbor about the other sources of interference. Also, if any serious problems eventually develop, your log may be used as evidence of what you actually did.

Keeping an accurate log on a consistent basis has many advantages. It can give you a record in writing of time of operation, station worked, mode of operation (cw, fm, ssb or ATV), frequency used, power output, antenna and band conditions. All of this information can be very valuable when the question of RFI is raised.

A log's value in "preventing" RFI is shown in the following true story. A ham recently installed a new set of dipoles on the roof of his apartment building. Within a few days his wife received numerous complaints from neighboring tenants stating that her husband was really "tearing up the TVs." After he demonstrated to his neighbors that the antennas had not been hooked up yet and that there were no recent entries in his log, they quickly calmed down.

On the other hand, when interference does occur, the log can also be of real assistance. If you found that your neighbors experienced RFI every night you operated your low-band rig, a simple check of the log compared to the times noted by your neighbors could not only show whether you in fact had been on the air, but could tell you what band you were on when the interference was occurring. But remember, you must maintain a log on a continuing basis for it to be helpful in RFI problem solving.

If the interference did occur by coincidence when you were on the air, you can conduct tests with the neighbor to show that you are not interfering with him. (Read this book carefully before conducting any tests.) If possible, have another ham operate your equipment while you observe the neighbor's equipment — with his permission, of course.

You are probably the technical expert in the situation, and should be able to distinguish between genuine interference and malfunctioning of the electronic entertainment equipment. To the untrained person, various symptoms may appear to be caused by interference, when the fault lies within the equipment itself. Also, people tend to perceive what they expect to see or hear. After they believe there is interference to their system, they will tend to detect it even when it doesn't exist. For example, when trying to eliminate interference in a TV set, it is often difficult to tell whether the very fine crosshatching that is visible on the screen is always there or is caused by some residual interference from the radio signal.

From that perspective, it is best to avoid putting ideas into your neighbor's mind. When he tells you about interference, let him describe it without any prompting or assistance from you; otherwise his perceptions may quickly become distorted and inaccurate.

What If You Are Not Causing Interference?

If the tests show you are not causing any interference, what should you do, especially if you are strongly suspicious that the interference is caused by a CB operator? (That is most likely the case if audio rectification is occurring, or if a TV set has interference on channels 2 or 5.) In addition, if their antennas are visible, you probably know the location of the CB operators in your neighborhood.

From a legal point of view, you are not required to do anything in this situation. From a public relations viewpoint, however, you may wish to offer some *limited* assistance. We stress the word limited, because it is not wise to become heavily involved in a situation that may develop into a serious neighborhood quarrel. You are almost certain to make enemies if you start publicly blaming local CBers, and you could even get involved with the legal problems that may occur. Nevertheless, you may decide to offer some assistance to a neighbor who is apparently suffering from CB interference. If nothing else, you may be willing to discuss the situation. Many persons do not know the difference between CB and amateur radio, or believe they are about the same. Certainly, if CBers are causing interference, the blame

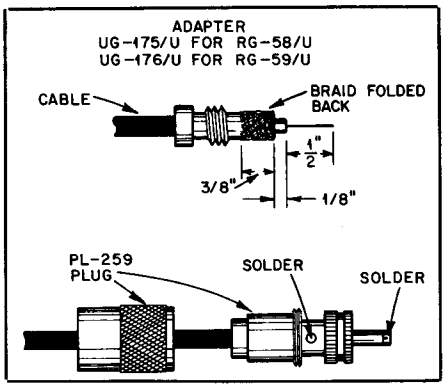


Fig. 2 — To use the adapter and PL-259 plug, slide the coupling ring part of the plug and the adapter onto the cable. Cut off the insulation as shown, leaving about 1/8-inch of polyethylene dielectric protruding, then fold back about 3/8-inch of the braid. Screw the adapter into the body of the plug, solder at the spots indicated, and the job is done.

should fall on them and not you.

You should be prepared to discuss any or all of the following:

1) *Legal CB operation:* The Citizens Radio Service was created to satisfy the legitimate needs of the public for local radio communications. In the regulations covering CB operation, use of the equipment for communications between stations separated by more than 150 miles is specifically excluded. Partly because of this, transmitter power is limited to low levels and antenna heights are restricted. Most CB operators fully abide by the regulations, and operate in a perfectly legal manner.

2) *Illegal CB operation:* Strictly speaking, any CB operation that goes beyond what the regulations permit or require is illegal. Because of the vast numbers of CB stations now in operation, however, the FCC basically concerns itself only with gross violations of the law. Typically those involve operating without a license, failure to identify the station when on the air, and the use of illegal power and antennas that cause so many of the interference problems that draw the attention of the FCC.

3) Differences between amateur and CB radio: While most amateurs derive great satisfaction and enjoyment from their hobby, the Amateur Radio Service was created with a higher purpose: to benefit our country. The basis and purpose of amateur radio in the U.S. are described in Section 97.1 of the FCC Rules and Regulations: The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

a) Recognition and enhancement of the value of the amateur service to the public as a voluntary non-commercial communication service, particularly with respect to providing emergency communications.

b) Continuation and extension of the

amateur's proven ability to contribute to the advancement of the radio art.

c) Encouragement and improvement of the amateur radio service through rules which provide for advancing skills in both the communication and technical phases of the art.

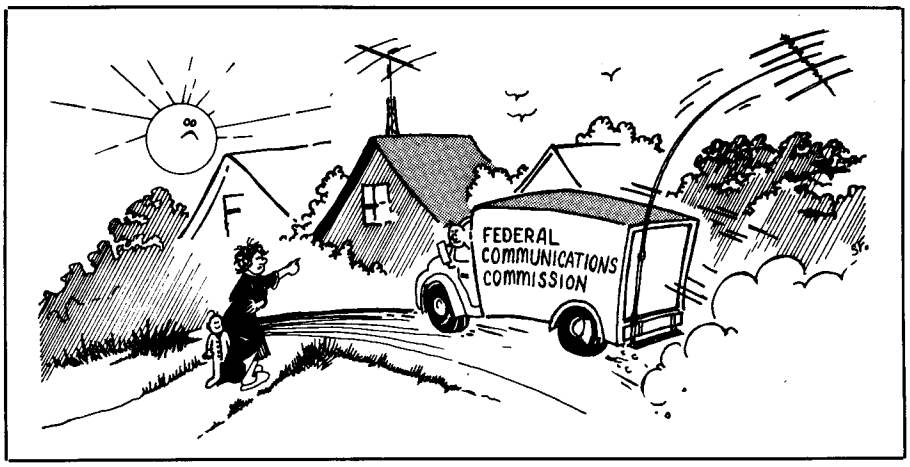
d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.

e) Continuation and extension of the amateur's unique ability to enhance international good will.

4) *Causes of interference:* This is a difficult subject to explain to the average person, who usually lacks knowledge of electronics, but do the best you can. Some of the subjects to cover are spark-generated interference from motors and other electrical devices, fundamental overload, interference from harmonics, audio rectification, the role of the operating condition of electronic-entertainment equipment and antennas, and how high- and low-pass filters work.

Concerning harmonics: TV channel 2 (54 to 60 MHz) is vulnerable to the second harmonic of signals from both the 11 meter (CB) and 10 meter amateur bands. TV channel 5 (76 to 82 MHz) is also vulnerable to the third harmonic of signals from the CB band. If you don't operate on 10 meters and a neighbor has interference on either channel 2 or 5, the most probable source is a CB operator. (See Table 1.) Audio CB interference can be readily differentiated from amateur interference, of course.

5) *What the neighbor can do:* The neighbor may ask you what he should do. Keeping in mind that you should not become unnecessarily involved in neighborhood quarrels, it is a good idea to avoid making a specific recommendation. Probably the best way to handle the situation is to explain the various alternatives. Stress that the final decision is up to the neighbor. Basically, he has three



Whether or not you are responsible, the FCC may become involved in a neighborhood RFI dispute.

choices. First, he can try to identify the CBer and seek his cooperation, although that may be difficult to obtain. Even when he can be identified, if the CBer is operating illegally he may not cooperate to avoid revealing the nature of his actions. Nevertheless, the FCC expects the neighbor to try obtaining cooperation of the CB operator.

Second, the neighbor can complain in writing to the FCC. The FCC may respond initially by sending your neighbor a copy of the booklet, *How to Identify & Resolve Radio-TV Interference Problems.* The neighbor is expected to follow the procedure in the booklet, including attempts to obtain cooperation from the CB operator. If those attempts fail, and the neighbor identifies the CBer and returns page 30 of the booklet to the FCC, the CB operator will receive a letter from the FCC requesting him to correct his deficiencies and to report on the situation within 30 days. If interference still exists after that, what happens next often depends on the workload of the FCC. The Commission does, however, maintain a number of Special Enforcement Facility (SEF) strike forces which visit and investigate areas suffering from CB interference. At that time, serious violators are usually detected and fined. The strike forces are equipped with ultra-sophisticated detection equipment, and can very quickly and accurately pinpoint the location of any illegal CB operation.

Third, the neighbor can try the various technical remedies suggested elsewhere in this book. Some can be tried independently of the CBer. In the case of TV interference, however, a high-pass filter can only cure problems caused by signals and harmonics whose frequencies are lower than the cut-off point of the filter. If a CB harmonic falls in a TV channel, the high-pass filter will not reject the harmonic. (If it did, it would also reject the TV signal!) That problem can only be cured by corrective action at the CB transmitter.

We repeat, the neighbor — not you — should select the course of action to follow. If you have followed the suggestions in this chapter, you have more than fulfilled your duties and responsibilities.

Chapter 4

Interference from Transmitters

The most perplexing form of rf interference originates in a transmitter. The problem is compounded by the proximity of entertainment devices such as TV and fm receivers in densely populated urban areas. Stereos, telephones, garage-door openers, hearing aids, and all manner of small electrical gadgets are also affected adversely by rf energy.

More often than not the fault lies within the equipment being interfered with, although the uninformed complainant often does not realize that it is his apparatus that was designed poorly or installed improperly. Therefore, it is in the interest of good amateur operating practice and neighborhood tranquility that the radio amateur take as many precautions as practical to ensure that his station is not the fundamental cause of an interference problem.

Diplomacy in solving TVI or RFI problems is covered elsewhere in this volume. This chapter details the procedures necessary to suppress harmonic energy radiated directly or by incidental means. Information is also given on measures which can be taken to eliminate the effects of rf at the entertainment equipment.

Cleaning Up Your Transmitter

The first place for any amateur to begin is in his home station. The fact that a piece of amateur equipment is of commercial origin or that it cost several hundred dollars, offers no assurance that it will not be the cause of interference. Regardless of the brand name or cost, certain basic techniques should be followed in preparing the station for service. Notable among the preventive measures is the inclusion of a low-pass filter in the antenna lead, the installation of a brute-force ac line filter and the use of an effective earth ground on the equipment. Other means by which to reduce the interference potential include careful tune up each time the transmitter is placed in service and shielding and bonding of the transmitter enclosure. This will greatly minimize incidental (stray) radiation of harmonic energy. In stubborn interference cases it may be necessary to filter all leads entering and leaving the transmitter. These topics are treated later in this chapter. Careful attention to the prescribed techniques should assure you a clean bill of health if an investigation of your interference problem is conducted.

Low-Pass Filters

There is a substantial amount of harmonic energy present in the output of most transmitters, regardless of the quality of the equipment design. Even though a transmitter may comply with the FCC requirement that all spurious energy must be 40 dB or greater below the peak power of the fundamental signal in the hf bands and 60 dB or greater below the peak level at vhf and higher, the available harmonic currents can be of such magnitude that a TV or fm set may be affected severely. This is especially significant in regions where the received TV or fm signal is quite weak.

In some instances only the radiation of harmonic energy from an antenna will cause TVI or RFI. In more severe instances it is possible to ruin a neighbor's reception of programs by means of incidental radiation from the transmitter cabinet or the control leads entering or leaving the enclosure. So, priority no. 1 is to ensure that the desired signal energy reaches the antenna and the harmonics supplied to the antenna are greatly attenuated. The standard accessory to do this is a low-pass filter, installed directly at the transmitter output jack. The case of the filter should be bonded electrically to the transmitter chassis, and the metalwork of the transmitter connected to an effective earth ground. Fig. 1 clearly illustrates this principle.

Electrical filters are designed to look into a *specific* impedance. Typically, for amateur work, this is 50 or 75 ohms. If the filter is not connected to a load of the design impedance, it does not function as intended. If the mismatch is great enough the filter will not only fail to restrict the flow of harmonic currents, but it can be damaged by excessive rf voltage. For these reasons it is essential to make certain that the antenna is matched to the feed line at all times. Alternatively, a Transmatch can be inserted between the filter and the transmission line to provide a correct termination for the filter. Several companies, including Barker & Williamson, R.L. Drake and J. W. Miller manufacture effective low-pass filters for transmitters (see Table 1, chapter 3). Circuits for homemade ones can be found in the inter-

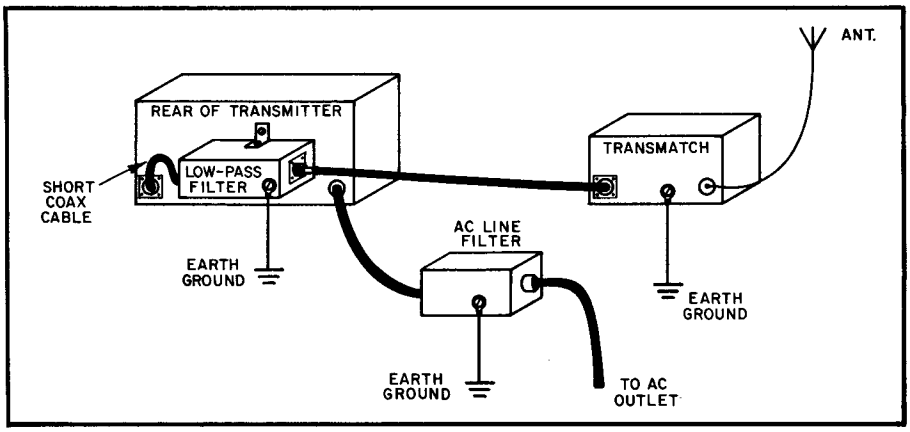


Fig. 1 — Suggested techniques for filtering harmonic energy from the leads of an amateur transmitter.

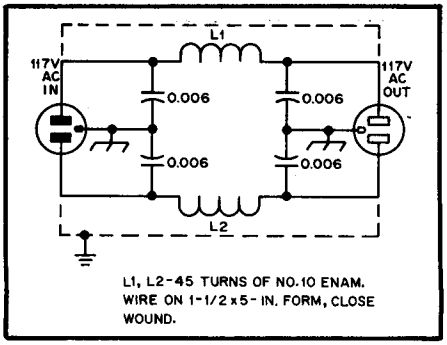


Fig. 2 — Schematic diagram of a brute-force, ac-line filter.

ference chapter of *The Radio Amateur's Handbook*.

AC Line Filters

An ac line filter, referred to earlier as a "brute-force line filter," is another form of low-pass network. That is, it is a pi-network type of filter, with a pi section inserted in each leg of the ac line. The cutoff frequency should be approximately 500 kHz. This will restrict mf and hf amateur energy from entering the ac line and being radiated by power lines near the house. On the other hand, it will not impede the passage of 60-Hz line energy. Although some manufacturers offer line filters for sale, it is an easy matter to fabricate one's own filter from inexpensive components. Fig. 2 shows the circuit of such a device.

Ideally, the line filter should be installed inside the transmitter cabinet, just where the ac line enters the equipment. From a practical point of view this is seldom possible. Thus, the filter is used outside the cabinet, but should be placed as close to it as possible. Furthermore, an effective earth ground is needed on the filter case.

Care must be taken to ensure that the capacitors in the filter will withstand line voltage peaks and spikes which may occur from transients. The conductor used in the filter coils must be large enough in cross section (gauge) to handle the current taken through the filter without heating the wire. Heating could ruin the filter and cause a drop in line voltage to the rig.

Lead Filtering

Now that the ac line and the transmission line of the transmitter have been filtered properly, it is time to add filtering to the leads which plug into the transmitter. A good way to check for incidental radiation from the leads is to "sniff" them by means of a sensitive wavemeter or dip meter. The sensing instrument must be capable of tuning all of the vhf TV and fm frequencies: Harmonics in that part of the spectrum are the ones that cause the most interference (harmonic TVI or RFI). The uhf TV channels are seldom affected by amateur harmonics. Rather, fundamental overloading from strong amateur signals may create an interference problem. Fundamental overloading is treated later in this chapter.

The major source of incidental radiation from equipment leads can be related to the keyer cable, microphone cord, and speaker or headphone conductors. Care must be taken to avoid introducing inductance and capacitance values in the lead filters which will disrupt the performance of the equipment. For example, too much capacitance in the microphone input circuit will greatly attenuate the high-frequency voice energy. The wrong choice of filter components in the keying line will tend to shape the keyed waveform or even affect the keying circuit adversely. The speaker leads are not quite so critical because the impedance of the speaker circuit is very low — 4 to 8 ohms in most instances. Therefore, capacitance values of up to 0.1 μF will have only a minor effect on the audio quality from the speaker.

Filters used in the connecting leads are also of the low-pass variety (pi networks). A loaded Q (Q_L) of 1 is adequate. The filter cutoff frequency can be set for some point just below the lowest operating frequency of the transmitter. For example, if 1.8 MHz is the lowest frequency used, the filter cutoff should be in the region of 1 MHz. However, interference caused by lead radiation is seldom significant in the mf and hf range. It is the radiation of rf in the fm and TV spectrum that needs to be suppressed. Additionally, the leads under discussion are relatively short, which means that they are more effective as radiators above approximately 30 MHz. Since attention is being directed toward restriction of radiation above 30 MHz, the filter components will be sufficiently small in value to have minor effect on the performance of the transmitter. Fig. 3 shows the circuit of a suitable filter network for the leads of a transmitter. Each filter should be installed as close to the associated transmitter jack or plug as possible. Ferrite beads of high initial permeability (950 μ_i) can be used as rf suppressors in the transmitter non-rf leads also. In many instances the beads eliminate the need for coils and capacitors in the filter network. Some amateurs have reported good results when placing several turns of the mic, speaker or keyer cables through a medium-size, high-permeability toroid core and locating the toroid near the transmitter. This places a broadband impedance in the lines, thereby breaking up the radiation path. An Amidon FT-82-43 toroid core would be suitable for the purpose.

Transmatches

Although the primary purpose of a Transmatch (matching network between a transmitter and the feed line) is to provide the transmitter with a proper load impedance, some Transmatches attenuate harmonic energy by as much as 30 dB or more. In the event that a low-pass filter, line filter, and equipment grounding do not solve a harmonic TVI problem, addition of a Transmatch after the low-pass filter may prove to be an effective means to obtain the needed additional harmonic rejection. Bandpass and low-pass types of Transmatches are the most effective in this regard. Fig. 4 shows the two types of circuits.

An SWR indicator is used between the low-pass filter and the Transmatch to enable the operator to set the network controls for an SWR of 1:1 while the indicator is switched to read *reflected*

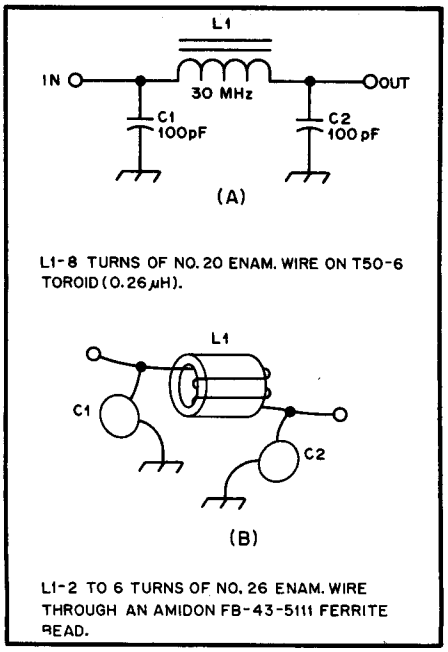


Fig. 3 — A suitable low-pass filter for the leads of an amateur transmitter is shown schematically at A. The pictorial representation at B shows how the filter is constructed.

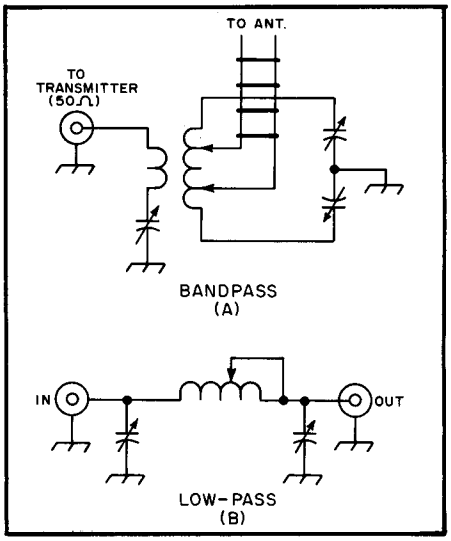


Fig. 4 — Circuits for Transmatches which restrict the passage of harmonics to the antenna.

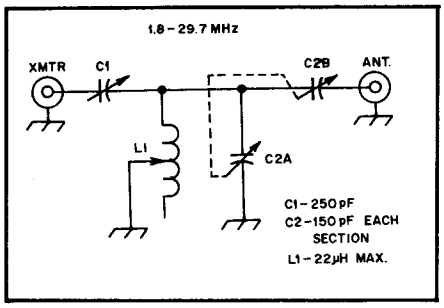


Fig. 5 — Circuit diagram of the SPC Transmatch. The SPC offers good harmonic attenuation and a wide matching range.

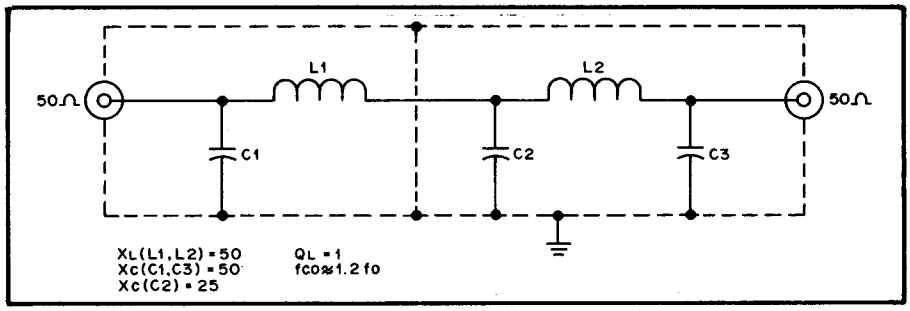


Fig. 6 — Circuit diagram and reactance values for a half-wave harmonic filter. A separate filter must be used for each amateur band.

power. This will provide a proper load for the low-pass filter and will effect maximum power transfer from the transmitter to the antenna system.

Even when the transmission line presents a correct impedance to the low-pass filter and transmitter, adding a Transmatch may be worthwhile in the event harmonic TVI is difficult to cure. This assumes that the harmonic energy being radiated is from the antenna system rather than by incidental means.

The SPC is an improved Transmatch that offers good harmonic attenuation and a wide matching range. See Fig. 5. C2 is a dual-section capacitor, with one section in parallel with L1 at all times. The additional shunt C offers a low-impedance path to harmonic currents, thereby improving the rejection capability.

The SPC circuit has the same number of tuning adjustments as similar Transmatches. C2 is set for the maximum amount of C that will permit obtaining a VSWR of 1:1 with the remaining two controls. Recent editions of *The Radio Amateur's Handbook* present a discussion of the SPC Transmatch.

Half-Wave Harmonic Filters

An excellent low-pass characteristic can be obtained by forming what is called a "half-wave filter." This type of network contains two pi networks in cascade. A loaded Q of 1 is used as a design constant in most instances. Therefore, the X_C and X_L of the filter will be identical to the terminal impedance. The exception is the X_C of the center capactior (C2 of Fig. 6), which will be one-half the reactance of C1 and C2. Thus, for a 50-ohm filter the reactance of C1 and C3 is 50 ohms. C2 has a 25-ohm reactance. L1 and L2 each exhibit an inductive reactance of 50 ohms.

The primary limitation of the half-wave filter is that it is a one-band device. That is, if an amateur wanted to use this type of filter for operation from 160 through 10 meters, six separate filters would be required. They could be contained in a shield box and selected by means of a band switch, or they might be assembled as single-band modules which would attach at the antenna jack of the transmitter or transceiver.

Fig. 7 shows the response curve of a half-wave filter built for use with a 160-meter transmitter. L1 and L2 are pieces of 1-1/2-inch Miniductor stock. The capacitors are large, transmitting-mica types. The characteristic impedance of the filter is 50 ohms. It is designed for a Q of 1. The second harmonic attenuation is 31 dB and the third-harmonic reduction is 53 dB with this filter. When additional attenuation of harmonics is desired it is practical to place two half-wave filters in series.

For maximum filter performance it is necessary to isolate the two halves of the circuit from one another. When air-wound coils are used it is wise to install a shield plate between the coils to reduce unwanted coupling. The input and output terminals should be spaced well apart — at opposite ends of the filter box. When toroidal inductors are used it is not necessary to add a shield divider. This is because toroids have a self-shielding characteristic. However, the toroids should be separated from one another to prevent capacitive coupling. And to ensure that no inductive coupling takes place (however unlikely it will be), the inductors can be mounted at right angles to one another. The same rules for installation, applied to low-pass filters earlier in this chapter, are pertinent to half-wave filters.

Wave Traps

For interference problems which result from a specific harmonic frequency, it is practical to utilize a series- or parallel-tuned wave trap within the transmitter or near the antenna terminal to reduce the harmonic amplitude. This type of circuit is illustrated in Fig. 8 at A and B. The LC combination is resonant at the interference frequency. For example, if a 6-meter transmitter had a second harmonic which fell in the commercial 88-to 108-MHz fm band, at 104 MHz, even though the transmitter met the FCC −60 dB spurious requirement, interference to the fm receiver could result. This would be especially significant if the amateur station was in very close proximity to the fm set and its antenna. The simple addition of a tuned trap could attenuate the harmonic energy sufficiently to eliminate the interference.

With tube-type transmitters it is not uncommon to install a parallel-tuned trap in the plate lead of a final amplifier tube to reduce TVI. The trap is tuned to the frequency of the affected TV channel. The concept is not applied so easily to a

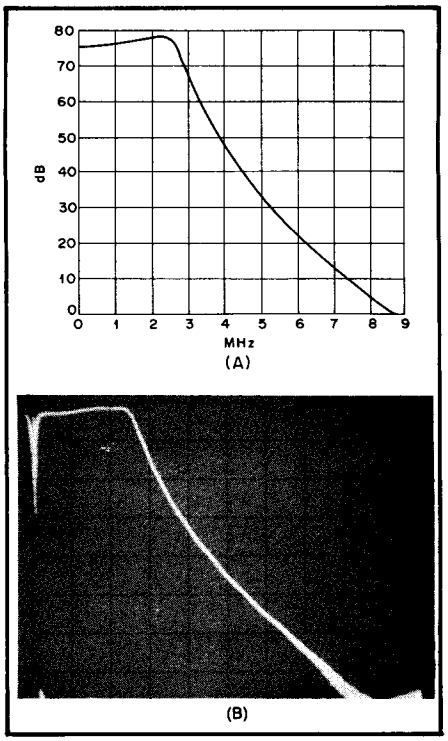


Fig. 7 — The curve at A illustrates the excellent harmonic attenuation provided by a properly designed half-wave filter of the type shown in Fig. 6. This curve was obtained while testing a 160-meter half-wave filter which contained Miniductor stock for the coils and large transmitting capacitors for C1, C2 and C3 of Fig. 6. The oscillograph at B was made by means of a Hewlett-Packard spectrum analyzer. The horizontal scale is 1 MHz per division. There are 10 dB per division on the vertical scale.

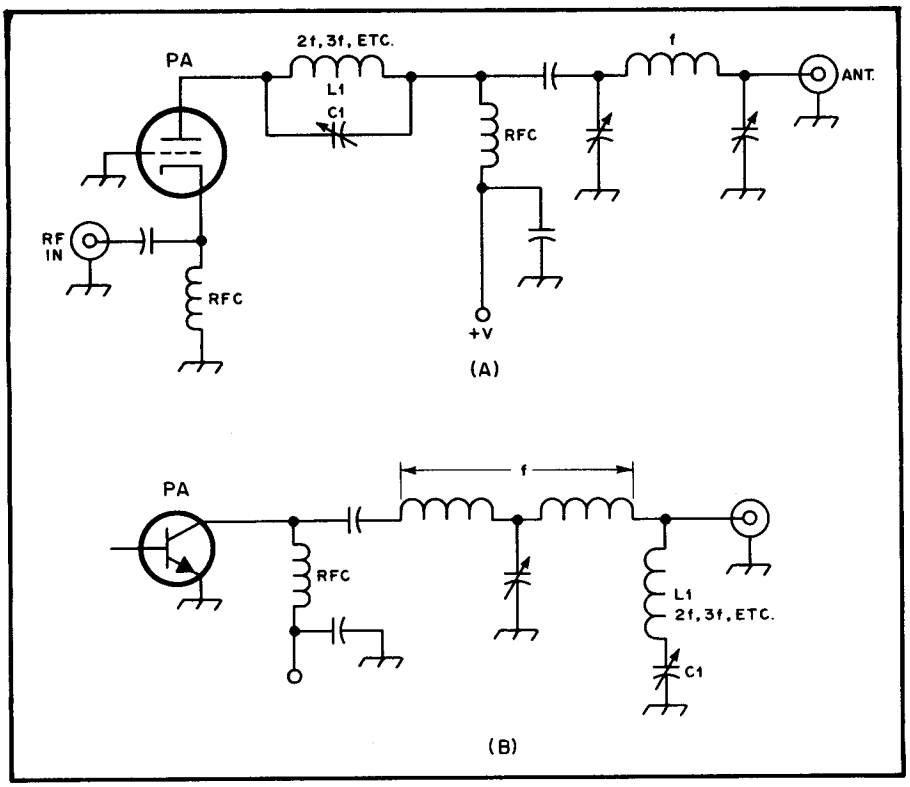


Fig. 8 — A parallel harmonic trap is used at A. The example at B utilizes a series trap.

solid-state rf power stage, as the reactance presented by the trap, however small that value might be, will have a disruptive effect in the collector circuit. This is because the collector impedance is very low — less than 10 ohms in most examples — and even a slight additional reactance (such as that of the trap) becomes a major part of the collector impedance. Vacuum-tube power amplifiers have much higher impedances in the plate circuit — 1000 ohms and higher, usually. Therefore, the reactance of the trap becomes but a small part of the circuit and causes no problems.

VHF and UHF Bandpass Filters

Transmitters operating at 50 MHz and higher may have harmonic output which is strong enough to cause considerable interference to fm and TV receivers. This type of situation is especially prevalent in dense population areas where a neighbor's entertainment receiver is physically close to the vhf or uhf amateur station. Although low-pass filters which use coils and capacitors can be built for the lower part of the vhf spectrum, a stripline or cylindrical bandpass filter will provide better Q and impedance characteristics.

For frequencies from 50 to 420 MHz the 1/4-wavelength type of filter is normally used. A 1/2-wavelength version is more suitable in the 3/4-meter band. This is because the outer conductor (box wall) is likely to form a resonant cavity by itself, with resonance within the tuning range of the filter, when using the 1/4-wavelength format. This condition renders the filter useless except at the resonant frequency of the cavity.

The bandpass characteristics of stripline filters provide attenuation above and below the carrier frequency, thereby offering attenuation to harmonics and multiplier-stage frequencies *below* the carrier frequency. Fig. 9 shows a photograph of the interior of stripline and cylindrical bandpass filters. Circuit diagrams of 1/4- and 1/2-wavelength filters are given in Fig. 10.

These filters have a bilateral impedance characteristic. That is, if one port is terminated in 50 ohms, the remaining port wants to be terminated in 50 ohms. Coupling links are used to feed energy into and out of the filters. The length of the links and their spacing from the center conductor of the filter determines the degree of coupling between the transmitter and the load. The lighter the coupling amount, the higher the filter Q and the narrower the bandwidth. However, the tradeoff for high selectivity is insertion loss through the filter. A reasonable compromise is to set the links for an insertion loss of approximately 0.2 to 0.5 dB. It should be said that the higher the filter Q the greater the rf voltage at the high-impedance end of the strip line. Therefore, the plate spacing of the tuning capacitor should be selected accordingly. The cold end of the strip line should be silver soldered or brazed to the end wall of the box to ensure minimum I^2R losses and attendant heating. The better the bond, the higher the filter Q. Copper or brass (silver plated) is preferred, but aluminum conductors are satisfactory as a second choice, assuming good electrical bonds can be made. Design data for

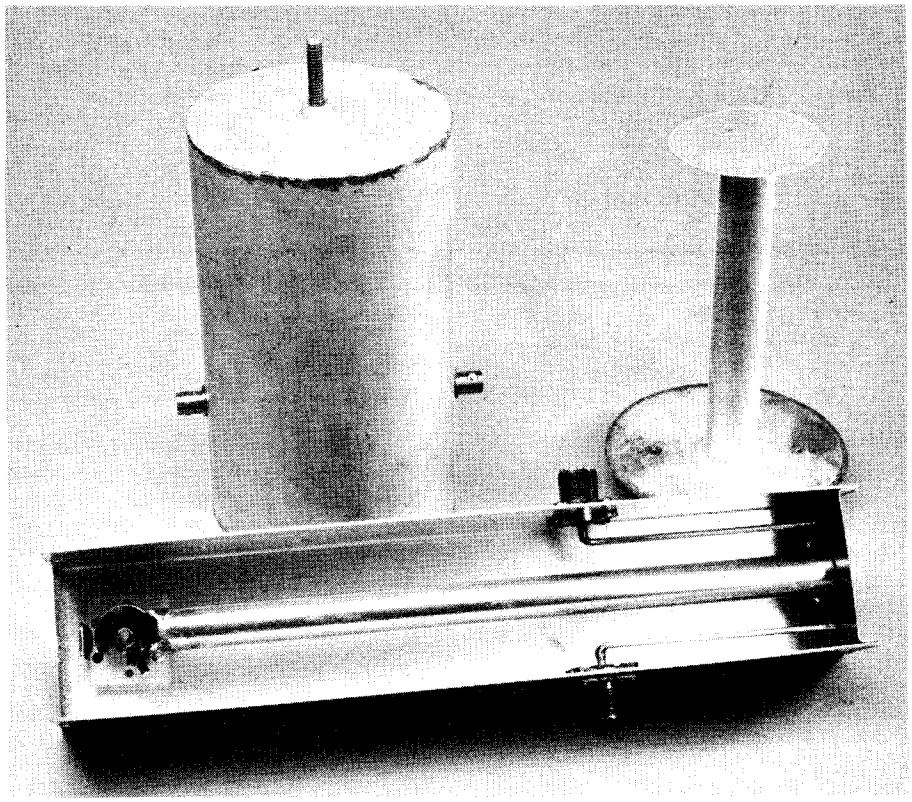


Fig. 9 — A homemade strip-line filter for 144 MHz is seen in the foreground. The innards of a 432-MHz cylindrical filter are displayed at the rear. The outer conductor is at the left.

stripline filters and tuned traps are given in the *ARRL Electronics Data Book*.

The Importance of Transmitter Tuning

A well-designed amateur transmitter contains tuned circuits which are capable of providing sufficient selectivity to reject frequencies above and below the one to which the network is tuned. The rejection capability is determined to a greater extent by the Q of the tuned circuit and the care with which it is adjusted during operation.

Most modern transmitters use bandpass or low-pass networks between stages. The final amplifier section will have a pi or pi-L type of tuned circuit when vacuum tubes are employed (Fig. 11). Solid-state power amplifiers usually contain fixed-tuned, low-pass networks of some type. There is little to be said under this heading about correct tuning of solid-state amplifiers, for they have no tuning controls. Assuming that the load seen by the transmitter is correct for the fixed-tuned network, no problems should arise.

Vacuum-tube power amplifiers seldom contain fixed-tuned tank circuits. Therefore, it is possible to mistune them grossly and ruin the bandpass or low-pass characteristics. This will often permit passage of excessive levels of harmonic current to the antenna system. Furthermore, the loaded Q of the tank circuit will drop if the coupling between the PA stage and the load is excessive. The lower the Q of the tuned circuit, the less effective it will be in rejecting harmonic energy.

A correctly designed pi-network tank is based on a Q of 10 to 15 in most instances. This means that in order for that Q to remain as specified, the input of the network must be terminated in a particular ohmic value (plate impedance) and the output also needs to be terminated in a given load impedance. The latter is usually 50 to 75 ohms. Departures from these impedance values at either end of the pi network will alter the loaded Q. It may increase or decrease, depending upon the matching ratio being dealt with.

A popular misconception among amateurs is that a tunable pi network in a transmitter is intended to provide a wide matching range — 30 to nearly 1000 ohms. In fact, some equipment manufacturers have misled their customers by making such claims in their literature. For best harmonic reduction it is essential that the tank circuit be used to match the tube to a 50- or 75-ohm load, and the tank should be adjusted for the frequency of operation.

Some pi-network tanks have enough tuning range to permit accidental adjustment to the second harmonic of the desired frequency. Evidence of this is seen when Novice cw signals are heard between 14.2 and 14.3 MHz on the 20-meter band. The operator thinks he or she is tuned up for operation between 7100 and 7150 kHz! The usual cause is an improper antenna load. The operator attempts to compensate for the fault by adjusting the pi network beyond the proper settings, causing the PA to *double* rather than function as a straight amplifier.

It is for the foregoing reasons that extreme care should be exercised when adjusting the transmitter. All tunable stages must be tweaked correctly to the operating frequency, and a proper load should be connected to the output of the transmitter. This becomes a major consideration when using transmitters on 15 meters and higher.

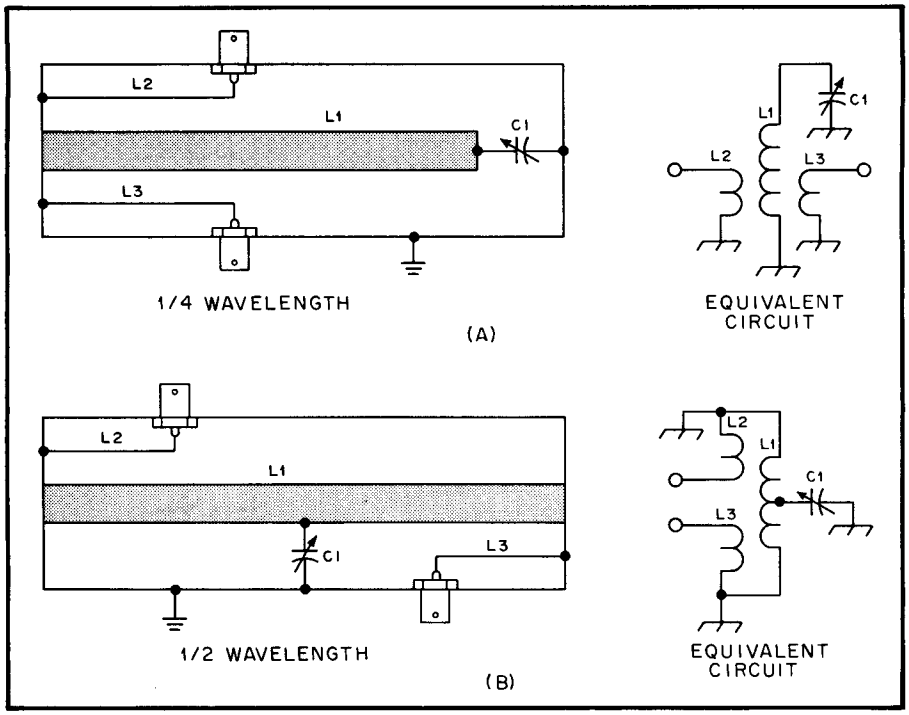


Fig. 10 — Pictorial and schematic presentations of quarter-wavelength (A) and half-wavelength, stripline bandpass filters (B).

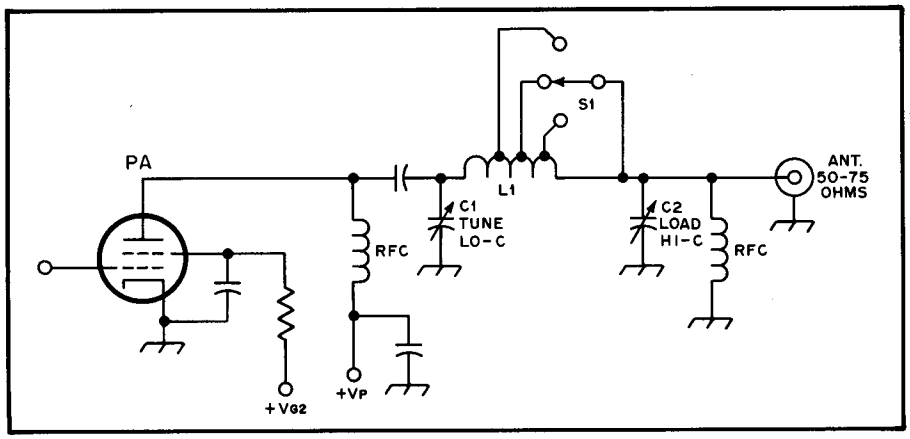


Fig. 11 — Example of a typical pi-network PA tank in an amateur transmitter.

Spurious Oscillations in the Transmitter

Interference to commercial services, TV and fm receivers included, can be traced occasionally to an amateur transmitter which operates in an unstable manner. That is, one or more of the transmitter stages may self-oscillate at hf, vhf or even uhf. There may be no visible signs of the condition as the operator tunes the equipment. The random energy may fall on the frequency of a commercial service and cause serious problems.

Tests for this form of instability can be performed by probing the various tuned circuits of the transmitter by means of a sensitive wavemeter or a dip meter which has been switched to the wavemeter mode. Extreme *caution* must be exercised when using the sampling probe or coil near components which have high voltage

present. *Accidental shock can be lethal!*

Curative measures are routine. Make certain that all bypass capacitors related to the malfunctioning stage are not defective. Add a neutralizing circuit if one is required, or check the adjustment of any existing neutralization capacitors. Install parasitic chokes or decoupling networks as needed. Information on this general subject is contained in *The Radio Amateur's Handbook.*

Nonlinear Devices and Problems

Even though an amateur transmitter may be in perfect operating order, tuned correctly, and in compliance with FCC regulations concerning spurious emissions, harmonic-related interference can occur. This is true even when a low-pass filter and Transmatch are used with the transmitter. The probable cause of interference in such a situation would be brought about by nonlinear electrical elements in the antenna system or its near field. Notable among the causes of this form of harmonic generation and radiation is a poor electrical joint in the antenna (rectification), or a downspout, metal fence, phone line, power line, or similar conductor. The fundamental signal from the transmitter is picked up by such a conductor and the poor joint rectifies the energy, causing harmonic energy to be generated and radiated. A sensitive wavemeter can be used to locate some of the trouble spots outside the house, but the operator should *never* investigate the power lines if they are suspected. Rather, power company personnel should be asked to assist in locating the fault. A loose joint which has corroded will act as a diode and generate harmonics when shock excited.

Another potential source of nonlinearity is ferromagnetic core material that is driven into saturation by the rf power from the transmitter. This cause of harmonic generation has become more prevalent in recent years as toroidal and solenoidal core materials made from ferrite have been used in matching networks and baluns for amateur antennas. If the cross-sectional area of the core material is not adequate for the power level being handled, the core will saturate and cause harmonic energy to be generated.

Transmitter Shielding and Bonding

"Look, Ma, no holes!" That's what the kid who has no TVI might shout at his mother as he pointed to a ham transmitter which was totally "buttoned up" against rf leakage. In reality it is absurd to contemplate a grim-looking metal box with no meters, knobs or dials visible — one which had only an ac-line input cord, a key jack, microphone connector, and an antenna terminal. Although this approach might be part of the ultimate solution to TVI and RFI, not many operators would point with pride to a rig so lacking in aesthetic qualities. The visiting amateur would look at the rig and say, "Hey man, your station ain't got no class!"

The curative measures for incidental radiation (leakage) need not be so severe. The ventilation holes should be as large as necessary to permit free passage of air, allowing the heat to vent freely from the equipment cabinet. Ideally, the diameter of the vent holes should be less than 1/4 inch. All joints in the cabinetry should have good electrical contact between the mating surfaces (lid to cabinet, cabinet to chassis, and so forth.)

Some commercial products have a prohibitive buildup of paint between the mating surfaces of the cabinet, chassis and bottom plates. When this is observed the owner should clean the surfaces thoroughly with sandpaper, then reassemble the metalwork. If only a few retaining screws are used to hold the metal sections together, additional holes can be drilled to accommodate extra screws. A good rule of thumb for tight rf sealing is one screw at least every two inches.

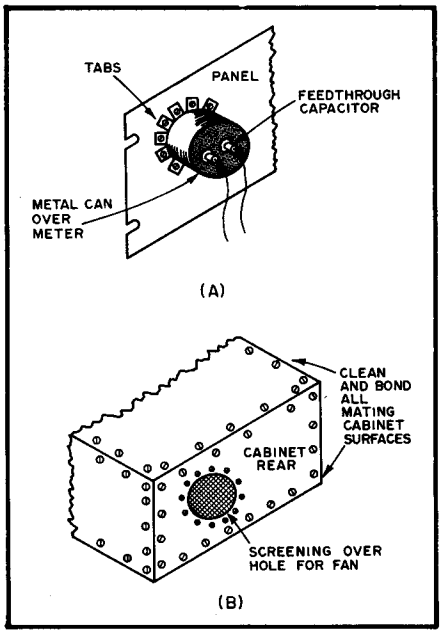


Fig. 12 — Meter shielding is shown at A and screen shielding of cabinet openings is seen at B.

Additional Shielding Measures

If the cabinet has large vent holes or slots, it is recommended that copper window screen be installed inside the cabinet to cover the holes. It can be screwed or soldered to the metal surface of the cabinet wall or top. The mating surfaces should be free of paint and grease to ensure good electrical bonding. It is important that the required amount of air flow not be restricted by the addition of screening. This is especially significant when treating equipment which uses forced-air cooling (Fig. 12B).

Screening should be placed over the entrance or exit holes for cooling fans. Similarly, shields should be installed over the backs of meters (Fig. 12A), bonding the shielding material securely to the inside surface of the equipment front panel. Copper window screen can be formed and soldered in place for this application, or a metal food container of the proper diameter can be cut down in size to fit over the back side of the meters. Feedthrough capacitors can be installed on the meter shields to allow the wiring to be routed to the meters. Needless to say, the front panel of the equipment must be mated well to the chassis and cabinet to provide good electrical contact.

Double Shielding

Two poor shields around an rf source are more effective than one good shield. For this reason it is wise, when the equipment format permits, to actually build an inner screen cage to enclose the transmitter "works," then install the complete assembly inside the regular transmitter cabinet. Alternatively, some modern transmitters and transceivers which are not built to permit this technique can be enclosed in a screen type of housing, exclusive of the regular cabinet. The composite screened equipment can then be installed in a larger homemade metal box to dress up the appearance and provide a mechanically strong enclosure. Although it may not look as sharp as the production-line version, TVI and RFI can be reduced significantly by this means in stubborn cases. It can mean the difference between being able to operate or having to observe "quiet hours"! The regular factory cabinet can be stored until the owner is ready to sell the rig, at which time it can be reinstated — scratch free!

The effectiveness of cabinet shielding is dependent upon having the leads entering and leaving the cabinet filtered, as discussed earlier in this chapter. It is necessary to assume, also, that the antenna lead contains a suitable low-pass filter.

The Point of Interference

Most TVI and RFI is not caused by amateur station equipment. Rather, the entertainment device itself is the culprit, being susceptible to radio-frequency energy because of inadequate preventive measures during its design period. Specifically, hi-fi equipment often acts as a broadband receiver even though the amplifiers and preamplifiers are intended to *amplify — not detect* — rf energy. This usually results from the manufacturer's effort to economize by using as few components as possible in a given design. A second cause of susceptibility is a naive outlook by the designer: He or she may assume that the interference potential is minimal, and therefore the proper preventive steps are not taken to protect the hi-fi or TV apparatus from RFI and TVI.

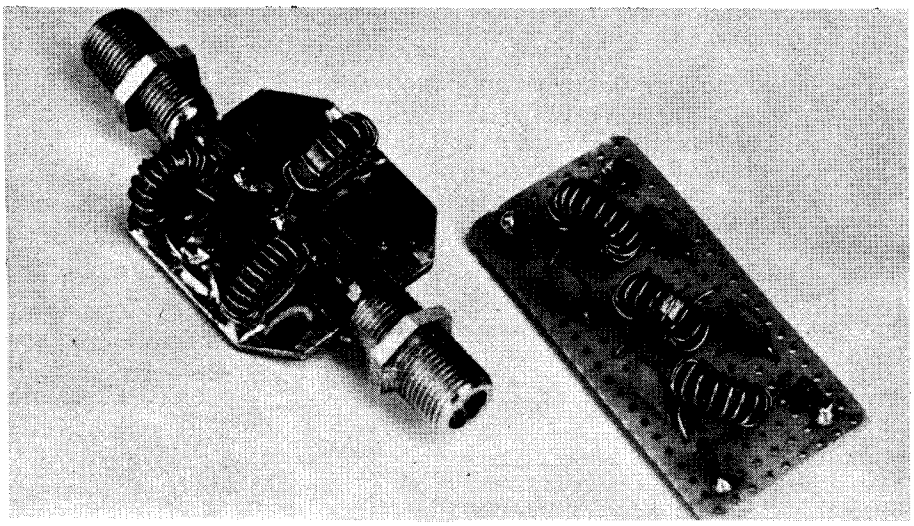


Fig. 13 — Modern high-pass filters can be simple and effective. The units pictured represent modern filter design technology. Diagrams are found in Fig. 14.

It is unfortunate that corrective measures are not implemented when the circuits are first conceived, for the cost of producing a reasonably "tight" entertainment device is not monumental. All that is needed to ensure immunity to most forms of RFI and TVI is adequate shielding and input-output lead filtering. The filters need not be complex or expensive.

The notable exception to the entertainment device being the "guilty party" is when the amateur station "socks it to the TV set" with harmonic energy. But, fundamental overloading of a TV or fm receiver strongly illustrates poor front-end design in the TV or fm receiver. Similarly, a hi-fi amplifier that is "crunched" by an amateur signal is lacking in isolation (at rf) where the leads enter and leave the equipment cabinet. This is especially true of solid-state hi-fi gear. The input stages (usually preamplifiers) act as rf detectors by virtue of the diode junctions in the transistors or ICs, and the rectified rf is amplified by the succeeding audio stages.

This section deals with solutions to RFI and TVI at the entertainment devices. The advantages and disadvantages of entering a neighbor's house to do repair work are treated in chapter 2. The amateur may wish to apply the suggestions that follow to his own television set, should it be susceptible to TVI.

TV-Set Interference

Fundamental overloading of the TV set front end is the most common cause of TVI when the neighbor's house is in close proximity to the amateur station. This type of interference can happen no matter what ham band the operator is using. The visual signs are complete wipeout of the video on the TV screen when the amateur transmitter is keyed. The TV screen may go black or it might just become light with traces of color. The aural portion of the TV signal will probably be blotted out also. Although fundamental overloading from hf-band transmitters seldom affects the uhf TV channels, they can be blanked out also in severe TVI cases. More often than not, channels 2 through 13 are affected by this form of TVI.

The objective in curing fundamental overloading (which can also affect fm receivers) is to prevent the amateur signal from entering the front end of the entertainment receiver: The remedies are simple and well established. A high-pass filter should be installed at the TV or fm receiver input, preferably at the point where the feed line enters the tuner of the set. Best results will be obtained when the filter is contained in a shield box, and the box and filter ground bus are connected to a high-quality earth ground and to the TV or fm set chassis. *Beware of receivers which have a so-called ac-dc circuit.* They could have a chassis which is common to one side of the ac line, thereby providing a shock-hazard potential! When in doubt, make the earth-ground connection to the TV or fm receiver chassis and filter case through a 0.001-μF, disk-ceramic capacitor. The capacitor voltage rating should be 500 or greater. More than one high-pass filter may be needed in obstinate cases.

Figs. 13 and 14 contain photos and diagrams of inexpensive, modern design, high-pass filters that are suitable for use at the inputs of TV or fm receivers for rejecting energy below approximately 56 MHz. The filters were designed using network-synthesis techniques by Ed Wetherhold, W3NQN. They exhibit improved performance over earlier designs. Because of the toroidal inductors, shield boxes are not necessary, although an enclosure would provide physical protection.

Some amateurs have reported good results in curing mild cases of fun-

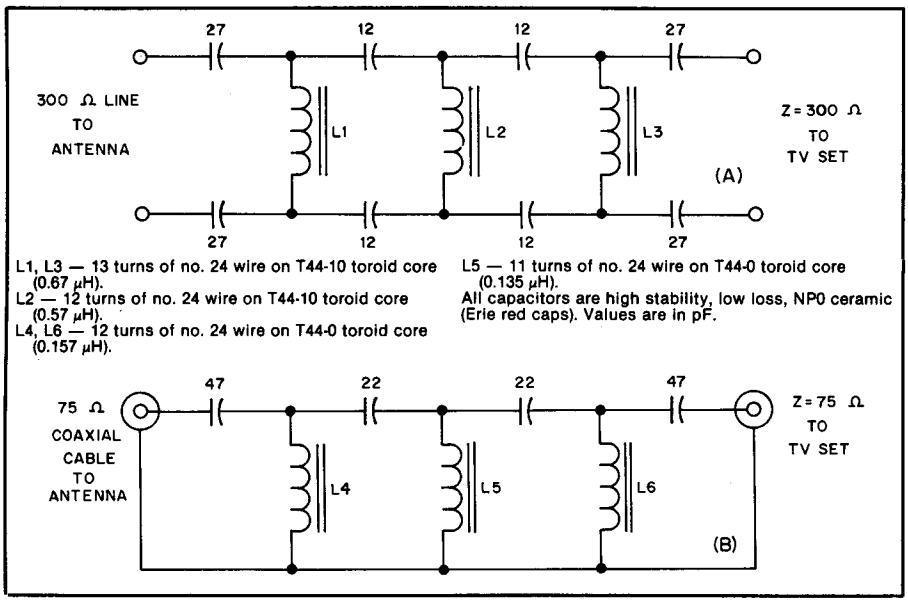


Fig. 14 — A balanced high-pass filter for 300-ohm line is shown at A. The version at B is for use in 75-ohm coaxial lines. Both were designed using network synthesis techniques by Ed Wetherhold, W3NQN.

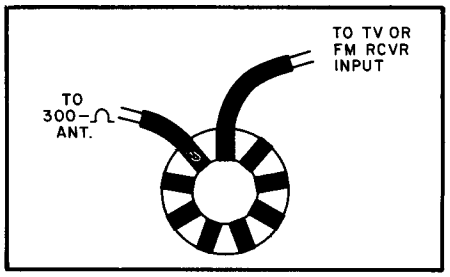


Fig. 15 — The TV ribbon can be wrapped around a toroid core as shown to reduce fundamental overloading of a TV set.

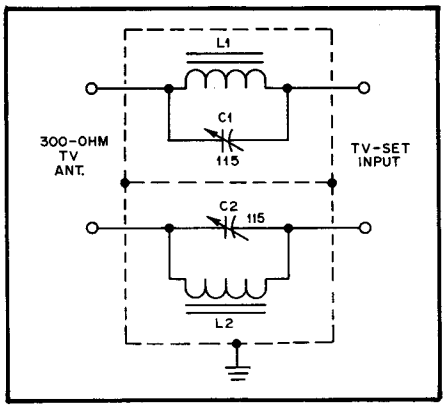


Fig. 16 — A wave trap can be inserted in each leg of the TV-set 300-ohm line and tuned to the interfering amateur frequency. This circuit is effective for that purpose.

damental overloading by winding several turns of the TV ribbon line around a toroid core as shown in Fig. 15. The core should be large enough physically to accommodate several wraps of the 300-ohm line, as illustrated. A high-permeability ferrite core ($950\mu_i$) is suggested. This will provide ample reactance from 80 through 10 meters to choke back the amateur signals on the TV line while permitting the TV or fm signal energy to pass. At vhf and higher the core material tends to "disappear" electrically and only the ribbon line constitutes an inductance. This action provides a high-pass type of response through the toroidal choke.

There are times when only one amateur band is involved in a case of fundamental overloading. The 75- and 80-meter bands seem to be particularly bad in this regard. A series trap that is tuned to the 80-meter band (Fig. 16) can be installed at the TV or fm receiver input to block the passage of 80-meter energy, while allowing the TV or fm signals to pass through it. A typical circuit for use at 3.5 MHz is seen in Fig. 16. Similar filters for other amateur bands can be built. C1 and C2 are tweaked for minimum TV or fm receiver interference when the amateur transmitter is operating in the chosen part of the 75- or 80-meter band.

Harmonic interference to the TV or fm set must be cured at the amateur station as outlined earlier in this chapter. This type of interference, when seen on a TV screen, shows up as crosshatch or a herringbone pattern. It seldom affects all of the channels. Rather, it may bother the one channel that is frequency-related to the harmonics of the ham transmitter.

Table 1 lists the visual and aural frequencies of the vhf and uhf TV channels. From this it is a simple matter to relate the amateur-band harmonics to the TV-channel frequencies. The fm frequency assignment covers 88 to 108 MHz.

Fig. 17 illustrates the potential harmonic interference of amateur signals below 30 MHz with respect to specific TV channels. Generally, the low TV channels (54 to 88 MHz) are most affected by harmonics from amateur transmitters operated below 30 MHz.

Table 2 relates harmonics from amateur 144-, 220- and 420-MHz transmitters to TVI in the uhf TV channel spread. As is true of harmonic suppression related to hf-band transmitters, the harmonic energy from vhf and uhf transmitters must be attenuated at the amateur transmitter.

Loose or corroded TV and fm antenna connections can generate harmonic energy, even though the amateur transmitter may be "clean." Similarly, loose gutter connections and the like may be the underlying cause of harmonic-type interference.

It is wise to install a brute-force, ac-line filter on a TV or fm receiver which is prone to amateur interference. The circuit of Fig. 2 is suggested for this application. As a somewhat severe measure against amateur interference, the fm or TV receiver can be shielded by means of copper screening (inside the equipment cabinet). This kind of shielding will help prevent rf energy from being picked up in critical areas of the receiver circuitry, such as the i-f strip or video amplifiers.

Hi-Fi Interference

Under this heading it is practical to include all devices which amplify audio or generate it. Therefore, the solutions to RFI apply to such items as turntables, burglar alarms, smoke detectors, hi-fi amplifiers, electronic organs, and even hearing aids. The objective is to prevent unwanted rf from getting into critical circuits of these devices and disrupting the performance. Although the applied cures are not the responsibility of the amateur, he or she should be willing to show this material to the set owner or service technician who may be called upon to effect a cure.

Household devices that employ loudspeakers are especially subject to RFI because the speaker leads serve as receiving antennas for the unwanted rf energy. If the speaker leads are of sufficient length to be resonant in one or more amateur bands, the RFI problem is compounded significantly. Fortunately, the cure for speaker-lead pickup is usually quite simple. The least complicated of the cures is seen in Fig. 18 where a 0.01-μF disk-ceramic capacitor is connected from each speaker terminal to the equipment chassis. An earth ground is attached to the amplifier chassis. Shielded speaker wires are helpful in reducing rf pickup. The wire should be the three-conductor type, with the shield braid serving as the third conductor. It should be grounded at both ends.

A slightly more aggressive approach to speaker-lead filtering can be carried out by installing a filter of the type shown in Fig. 19 at each speaker terminal (rear of hi-fi cabinet). This low-pass filter will pass audio with but minor attenuation to the audio "highs," but will impede the passage of hf and vhf rf energy.

The hi-fi amplifier should be equipped with a brute-force ac-line filter, Fig. 2. This will prevent rf energy from migrating into the hi-fi amplifier via the ac cord.

Certain precautions are in order when filtering the audio signal leads when entering a hi-fi or similar amplifier. The impedance of the various input ports is relatively high as compared to the typical 8- or 16-ohm speaker lines. Therefore, too high an inductive or capacitive reactance inserted in the input lines will restrict the high-frequency audio response of the system. From this emerges a basic rule of thumb which indicates that only enough inductance and capacitance be used in the

Table 1
U.S. Television Channels

Channel (No.)	Frequency (MHz)	Visual Carrier (MHz)	Aural Carrier (MHz)
1		(Not assigned)	
2	54-60	55.25	59.75
3	60-66	61.25	65.75
4	66-72	67.25	71.75
5	76-82	77.25	81.75
6	82-88	83.25	87.75
7	174-180	175.25	179.75
8	180-186	181.25	185.75
9	186-192	187.25	191.75
10	192-198	193.25	197.75
11	198-204	199.25	203.75
12	204-210	205.25	209.75
13	210-216	211.25	215.75
14	470-476	471.25	475.75
15	476-482	477.25	481.75
16	482-488	483.25	487.75
17	488-494	489.25	493.75
18	494-500	495.25	499.75
19	500-506	501.25	505.75
20	506-512	507.25	511.75
21	512-518	513.25	517.75
22	518-524	519.25	523.75
23	524-530	525.25	529.75
24	530-536	531.25	535.75
25	536-542	537.25	541.75
26	542-548	543.25	547.75
27	548-554	549.25	553.75
28	554-560	555.25	559.75
29	560-566	561.25	565.75
30	566-572	567.25	571.75
31	572-578	573.25	577.75
32	578-584	579.25	583.75
33	584-590	585.25	589.75
34	590-596	591.25	595.75
35	596-602	597.25	601.75
36	602-608	603.25	607.75
37	608-614	609.25	613.75
38	614-620	615.25	619.75
39	620-626	621.25	625.75
40	626-632	627.25	631.75
41	632-638	633.25	637.75
42	638-644	639.25	643.75
43	644-650	645.25	649.75
44	650-656	651.25	655.75
45	656-662	657.25	661.75
46	662-668	663.25	667.75
47	668-674	669.25	673.75
48	674-680	675.25	679.75
49	680-686	681.25	685.75
50	686-692	687.25	691.75

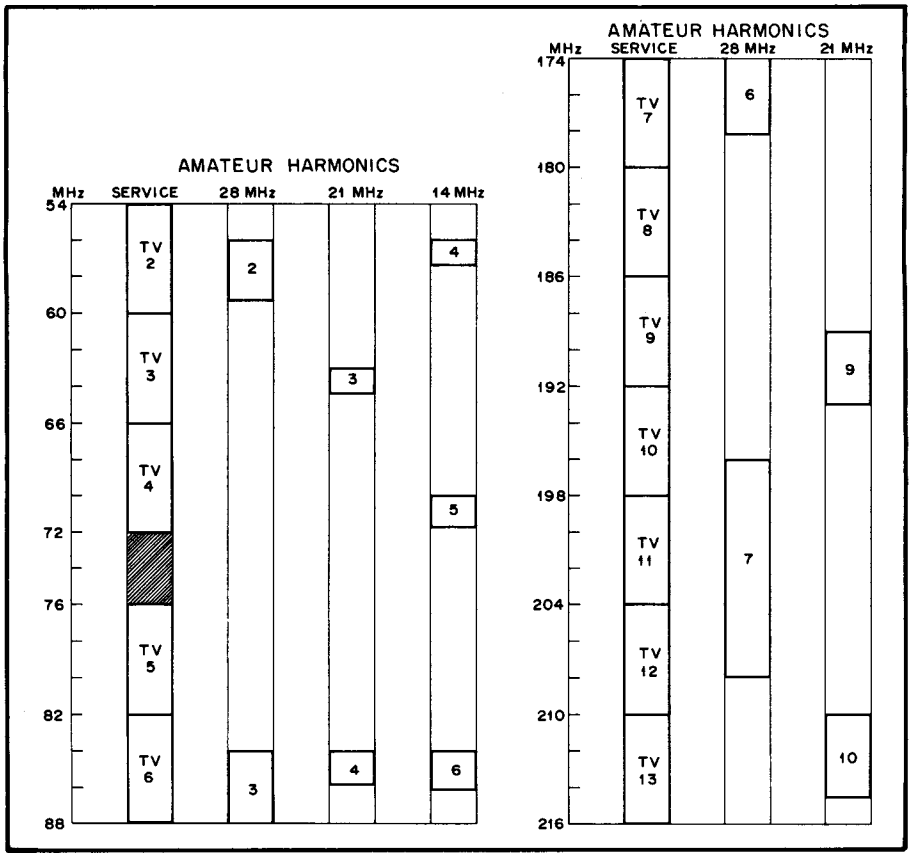


Fig. 17 — The relationship of amateur-band harmonics to the vhf TV channels.

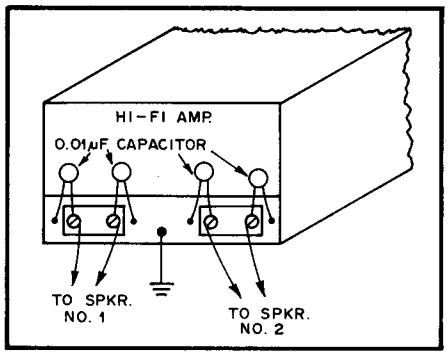


Fig. 18 — Most hi-fi interference can be cured by installing a bypass capacitor from each speaker connection to ground as shown here. Capacitor leads should be kept as short as possible.

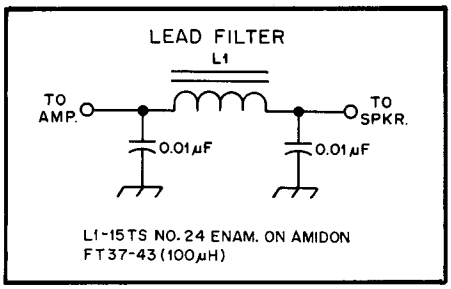


Fig. 19 — A speaker-lead, low-pass type of filter for keeping rf out of the hi-fi amplifier.

lead filters to cure the RFI problem. Unfortunately, the acceptable L and C values must be arrived at by experimentation.

In many instances a simple solution to RFI is realized by slipping from one to four high-mu ferrite beads over the input lead to the first amplifier stage or stages of the amplifier. A permeability of 950 or 2000 will suffice. The beads should be installed as close to the related transistor or IC as possible. The circuit configuration of Fig. 19 is more suitable for stubborn cases of RFI. Two or three high-mu beads are used at L1 and the signal lead is passed through them. The end capacitors are fairly low in value. Generally, they are less than 100 pF each. The lower the impedance of the input port being filtered, the greater the amount of capacitance before audio "highs" are rolled off. Again, the filter must be located as close to the amplifying device it protects as is practical.

Hi-fi cabinet shielding and bonding is as important as it is with an amateur transmitter. The same rules given for transmitters are applicable to entertainment devices.

The tone arm of turntables is a known point of unwanted rf pickup. Unfortunately, if filtering is added within the tone arm it may be impossible to compensate for the added weight, and records may be damaged. Shielded wire should be used between the phonograph cartridge and the input to the amplifier. Also, the technique shown in Fig. 20 can be applied as a deterrent to the passage of rf energy from the turntable to the hi-fi amplifier. A high-mu ferrite toroid core (μ_i of 950 or 2000) contains several turns of the shielded audio connecting cable and is used between two units of a hi-fi system. This method will break up rf paths while permitting the desired audio signal to reach the amplifier.

These solutions for curing TVI and RFI are quite effective. If they are carried out as described here, the majority of interference problems can be cleaned up quickly and inexpensively. If all else fails, the ultimate solution may be to place the hi-fi equipment, the amateur gear, or both, under a steamroller and take up scuba diving for a hobby. At least with the latter it is unlikely that rf energy could travel underwater to spoil the performance of the scuba equipment!

Table 2
Harmonic Relationship — Amateur VHF Bands and UHF TV Channels

Amateur Band	*Harmonic*	*Fundamental Freq. Range*	*Channel Affected*
144 MHz	4th	144.0-144.5	31
		144.5-146.0	32
		146.0-147.5	33
		147.5-148.0	34
	5th	144.0-144.4	55
		144.4-145.6	56
		145.6-146.8	57
		146.8-148.0	58
	6th	144.00-144.33	79
		144.33-145.33	80
		145.33-147.33	81
		147.33-148.00	82
220 MHz	3rd	220.00-220.67	45
		220.67-222.67	46
		222.67-224.67	47
		224.67-225.00	48
	4th	220-221	82
		221.0-222.5	83
420 MHz	2nd	420-421	75
		421-424	76
		424-427	77
		427-430	78
		430-433	79
		433-436	80

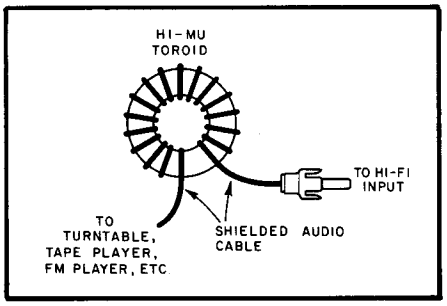


Fig. 20 — The connecting cables between modules of a hi-fi system can be treated with rf chokes by wrapping the shielded audio cable around a high-mu toroid core as shown here.

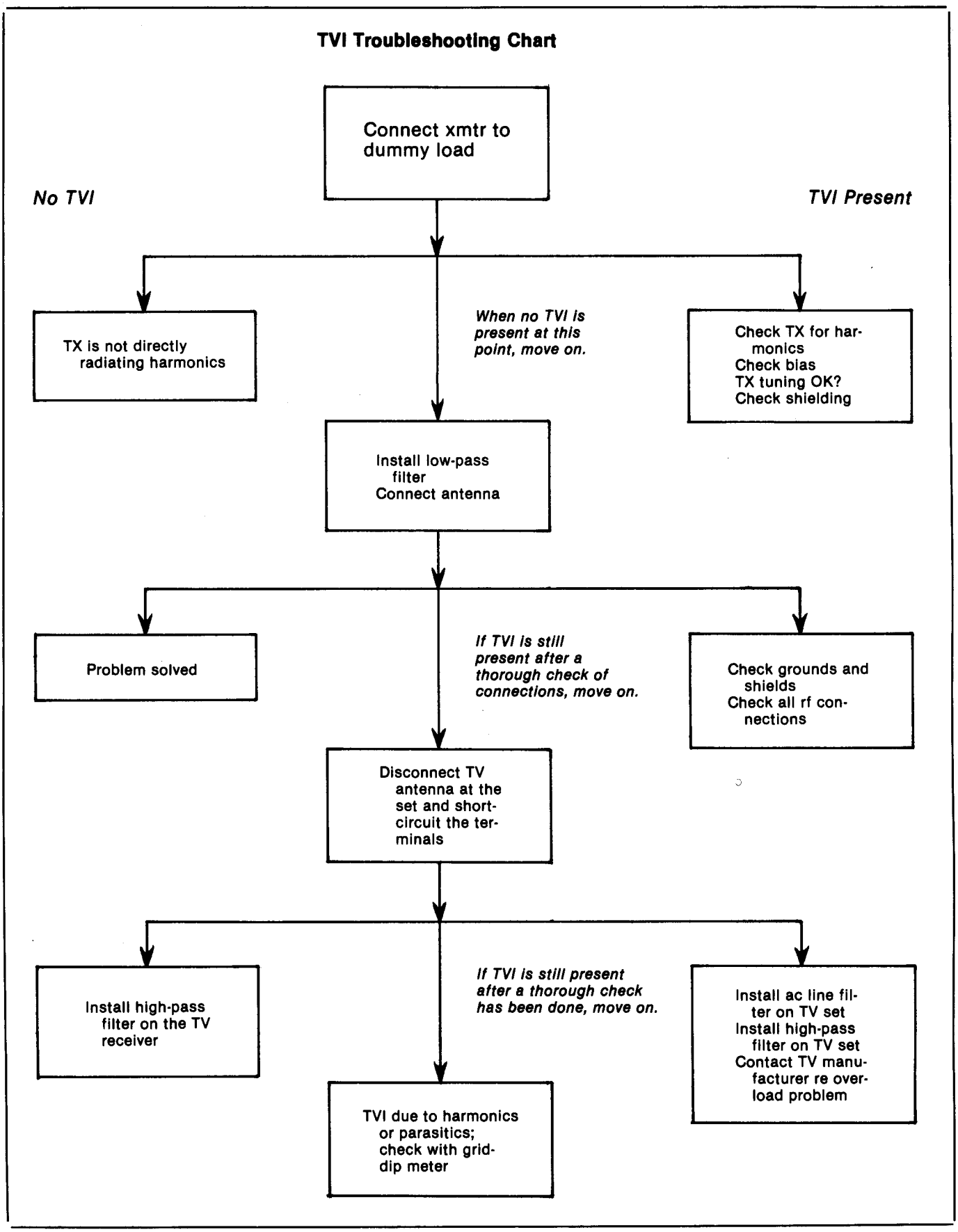


Fig. 21 — The steps to take if you're a victim — or a cause — of RFI. As explained in the text, do not make modifications to neighbors' home entertainment devices without weighing the consequences.

Chapter 5

Interference from Electrical Devices and Power Lines

In this seemingly all-electric world it is not uncommon for a communications receiver (a-m, fm and TV included) to be rendered partially or totally unusable by a somewhat different type of interference — that caused by the multitude of home and commercial pieces of electrical and electronic equipment.[1] Although not normally considered sources of RFI or EMI, sewing machines, electric blankets, fish-tank heaters and the like can emit large amounts of rf energy across the radio spectrum. In the strict sense, these devices are sources of RFI/EMI and must be treated as such. As we will see, each source of so-called "man-made" interference has its own characteristics and therefore its own cure.

This chapter will provide a working knowledge of how the interference is generated, as well as effective measures for reducing it to an acceptable level. Some of the more common "offenders" and appropriate cures are explained. However, this section is not meant to be all-inclusive. With a good understanding of how the interference is created and an idea of where to look, the amateur should be able to locate the source.

Since many RFI complaints alleged to be caused by a neighborhood amateur's transmitter are unfounded, this chapter should be worthwhile reading for most amateurs. Unfortunately, some nonhams will blame any interference to their radios or television sets on a local amateur. Should you receive such a complaint and your transmitter is not at fault, it might be wise to make a quick check of the neighbor's interference problem. This may (1) prove to the complainant that your equipment is not at fault, since you cannot be at their house and operating the transmitter at the same time, (2) show that amateurs are concerned about their reputations and are willing to help track down the interference, and (3) eliminate a possible cause of interference to your receiving equipment, as the offending appliance may actually be in the complainant's house.

[1]Interference of this type is often called EMI, electromagnetic interference. It can be thought of as "RFI in reverse."

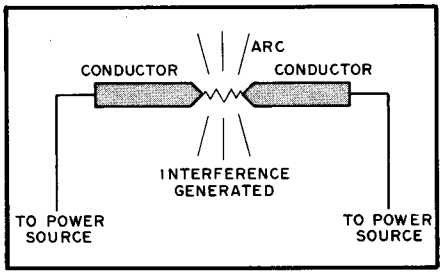


Fig. 1 — Representation of an electrical arc.

What is Interference?

Interference, as it pertains to radio reception, is the reduction of intelligence to a desired signal caused by an unwanted (interfering) signal. This interference may be as simple as natural static, a lightning storm, or other atmospherics. There is little we can do to prevent this natural type of interference. On the other hand, the unwanted signals may come from a light dimmer, an electric fence, the ac mains, or a refrigerator. These forms of interference are quite common and fall under the broad category of "man-made." Luckily, interference of this type can often be eliminated or greatly reduced.

Man-made interference can be divided into two basic areas. The first, which at present is responsible for most interference problems of this type, is caused by an electrical arc. Depending on the equipment and circumstances involved, the arc may or may not be a desired end product. For example, an arc in the utility's power distribution system (ac mains) is certainly not part of the design. However, electronic welding machinery makes use of the arc for bonding pieces of metal.

The second area of man-made interference centers around equipment that makes use of fixed- and variable-frequency oscillators. TV receivers, scanning communications receivers, microprocessors and microcomputers are thus capable of causing severe interference problems.

Electrical-Arc Interference

As mentioned above, a large percentage of man-made interference can be attributed to an electrical arc (Fig. 1). An electrical arc generates varying amounts of rf energy across the radio spectrum. These rf signals are completely random, and appear as "hash" in a communications receiver.

When an electric current jumps a gap, an arc is produced as the current travels through the air instead of through a conductor. For an arc to occur there must be sufficient voltage to ionize or break down the air between the gap. Once an ionized path is established, current can flow. The flow of electrons is highly

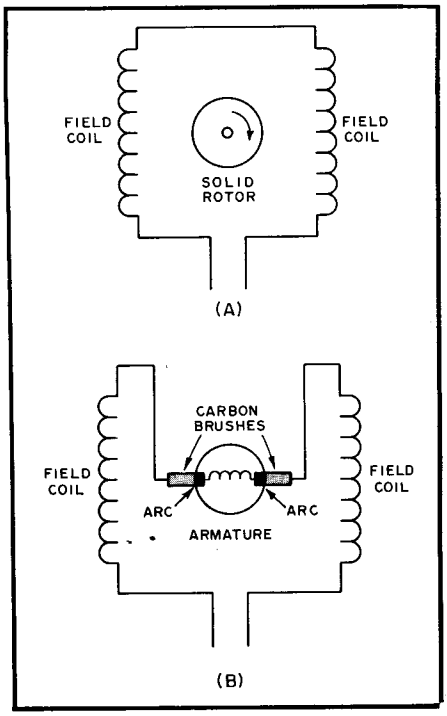


Fig. 2 — A: Diagram of an induction-type motor. B: Diagram of a brush-type motor.

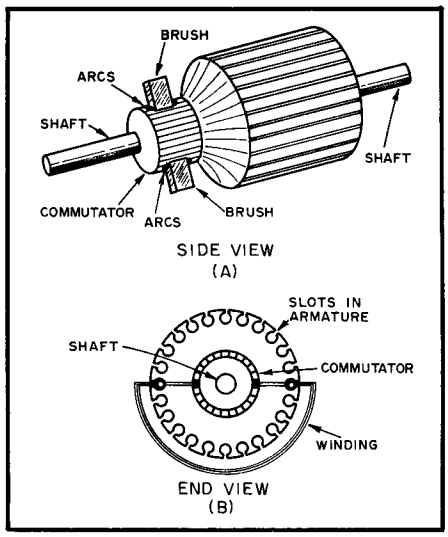


Fig. 3 — A: A side view of a typical motor armature. The arcing occurs between the commutator and each brush. B: An end view of a motor armature, depicting how the individual armature windings are connected.

irregular through this path compared to the rather smooth flow through a good conductor. Since the resistance of the ionized air is constantly changing, so is the instantaneous current. Rapid variations of this sort are set up not only in the arc itself, but also in the power lines connecting the device to the supply. As we might expect, there is a definite relationship between the length of the arc, the voltage needed to sustain it, and the amount of interference it will produce. In short, the longer in length the arc, the higher the voltage and the greater the interference.

Arcs are created in a variety of everyday appliances, especially those using brush-type motors. Electric shavers, vacuum cleaners, sewing machines, and air conditioners are just a few. Induction types of motors, as found in record players, clocks and refrigerators, do not normally cause interference. Fig. 2 illustrates the difference between the two. The induction type motors do not use a brush/commutator system. Since no arcs are produced, there is no interference.

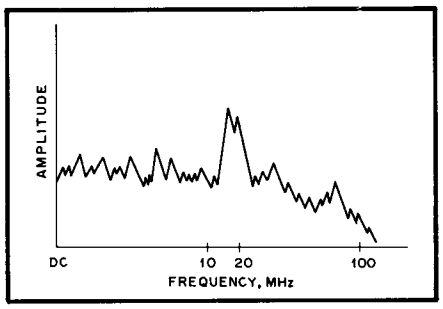


Fig. 5 — In this drawing, the normal frequency/amplitude curve has been modified by a resonant line connected to the interference source.

Figs. 3A and B show a typical brush-type motor armature. For clarity, only one winding is shown. The coil is wound in a slot in the armature with the ends of the coil attached to commutator contacts 180 degrees apart, as shown. The number of windings will vary from motor to motor, with 10 to 15 separate windings most common. Since there are two commutator connections per coil, there will be twice as many contacts as windings. Contact between the field coils and the armature windings are made through soft carbon brushes. The brushes are held in place by holders that are usually equipped with brush-tensioning springs. These springs press the brushes against the commutator with just the right amount of pressure. If the brushes are worn, fit loosely, or if the commutator is uneven or dirty, the brush is apt to bounce as the armature turns and create excessive noise (interference). Since there is a constant making and breaking of contacts, arcing is inevitable. However, with properly fitting brushes and a clean commutator the arcing should be at a minimum, and so should the interference.

Most small motors of this sort can be disassembled with ease and checked for proper operation should they be suspected of generating interference. While you have the motor apart check the brushes for a correct fit and clean the commutator. There is apt to be a black carbon buildup on the copper bars. Emery cloth, steel wool, or an ordinary pencil eraser will remove the deposit.

Arcs are also common in a number of thermostatically controlled heating systems. Some use a heat-sensing, bimetallic strip to open and close a set of contacts. As the contacts age they become pitted and more prone to arcing. Arcs can also occur in light switches, circuit breakers, or a loosely fitting wall plug. The possibility for an arc exists in almost any piece of electrical or electronic equipment.

An amplitude-versus-frequency graph for a hypothetical arc is shown in Fig. 4. Notice that the amplitude of the noise (interference) decreases as the frequency increases. This can be verified by listening to a communications receiver affected by noise. Start out by listening to the lowest frequency band covered by the receiver and switch to the next highest band. Note the S-meter reading and switch to the next highest band, and so on. Each time the receiver is switched to a higher band the noise interference should decrease. We say "should" decrease because there is a possible exception. Should the lines connected to the source of interference be a resonant length at a particular frequency covered by the receiver, the interference may very well be strongest at that frequency. This phenomenon is illustrated in Fig. 5. As can be seen, the noise has a definite peak around 20 MHz. This should be kept in mind when searching for

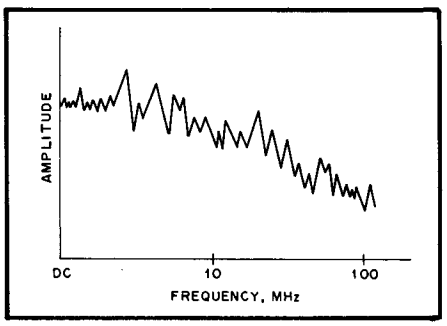


Fig. 4 — A graphical representation of an electrical arc showing how the amplitude varies as a function of frequency.

sources of interference. Knowing the frequency of maximum noise intensity may help lead to the source, saving considerable time.

An oscilloscope representation of a pure 60-Hz sine wave, the type we would expect from the ac mains, is shown in Fig. 6A. Fig. 6B shows the same basic waveform with the addition of noise caused by an arc. Since the noise contains a multitude of different frequencies it will make the original sine wave look fuzzy.

Oscillator Interference

Many pieces of electronic equipment use one, or more, fixed or variable-frequency oscillators. Some of the oscillators are rich in harmonic energy, adding to the problem. Not only can the fundamental of each oscillator be a problem, but so can each of the harmonics and each mixing product should more than one oscillator be running at the same time. Notable among such devices is the television receiver.

The horizontal repetition rate of a TV receiver is very close to 15.75 kHz. Unfortunately, this signal is rich in harmonic energy. It is not uncommon to

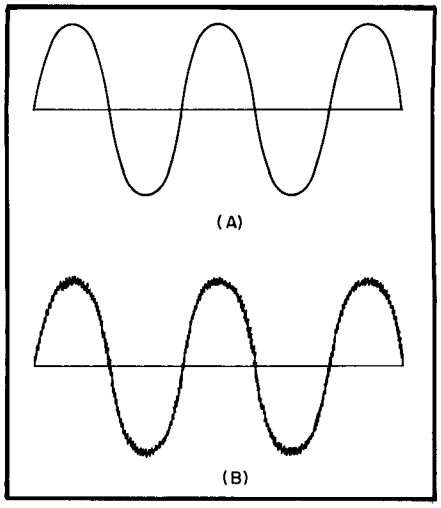


Fig. 6 — A: A pure sine wave of the type we would expect from the ac mains. B: Noise interference can be seen as fuzziness of the waveform.

hear harmonics (which occur every 15.75 kHz) well up into the lower hf spectrum. These signals are heard as continuous running ac notes (rough sounding) every 15.75 kHz across the receiver dial. It is possible for a TV set located some distance away to cause sufficient interference to blot out weak and even medium-strength signals on a good-quality communications receiver.

Color television receivers make use of a color-subcarrier (color-burst) oscillator that operates on 3.579545 MHz. This frequency and several of its harmonics fall within amateur bands: A quick computation shows that the second harmonic is at 7.15909 MHz, the fourth harmonic is at 14.31818 MHz and the eighth is at 28.63636 MHz. Since the relative amplitude of harmonics decreases as the order increases, the chance for interference is less at the higher frequencies. It still exists, however.

In recent years scanning-type receivers have become quite popular. These receivers can be set to check a number of frequencies and lock onto those in use. Quite often a number of different police or commercial frequencies are monitored. Some of the more sophisticated receivers are frequency synthesized so that the receiver can be programmed to virtually any frequency in a given band or bands. It is common for two or more oscillators to be running at the same time — one of which may be varied for the scanning action. Any time two or more oscillators are operational in the same piece of equipment undesired mixing may result. The correct combination of frequencies can often cause interference anywhere in the hf or vhf spectrum.

Even more recent is the trend toward microprocessor and microcomputer control of various appliances. Processor-equipped sewing machines, microwave ovens, ranges, blenders and other appliances are capable of generating large amounts of RFI/EMI. A crystal operating in the vicinity of 1 MHz is used as the clock. This reference is divided down any number of times for additional frequencies. Square waves are used throughout; these signals are thus rich in harmonic content. This fact, along with the multitude of gates being switched on and off at any given moment, add up to wideband interference across the radio spectrum.

Tracking Down Interference

There are two ways in which noise interference can find its way into a communications or television receiver. If the source of interference is located in the same building as the receiver, it is likely that the noise will flow along the house wiring from room to room. For example, if an oil-burner motor is at fault, the interference will ride the ac line from the basement to wherever the receiver is located. This is also true for electric razors, hair dryers, electric knives, and a host of other small appliances.

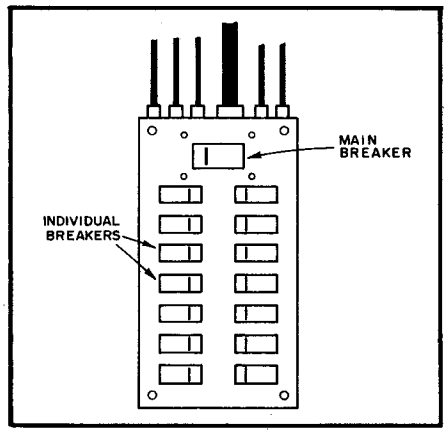


Fig. 7 — A typical home circuit-breaker box. The main circuit breaker is at the top center with the individual ones below.

Since communications equipment often makes use of an outdoor antenna/feedline system, it is possible for the interference to be radiated and picked up by the antenna or feedline. This signal is coupled directly to the receiver.

The first step in tracking down the interference is to determine if it is being generated by an appliance in your own house. This can be checked by pulling the main fuse or circuit breaker. See Fig. 7. You will need a battery-equipped receiver for this test since the power will be off! A simple, battery-powered a-m receiver should work fine for this application since most forms of interference will raise havoc with the broadcast band. Tune the receiver to a clear channel somewhere near the low end of the band (525 kHz). Flip the main breaker off so that the entire house is without electricity. If the interference disappears chances are good that it is being generated in your house.

Use Process of Elimination

Once it has been determined that the source is in your house, the next step should be obvious: Use the process of elimination to locate the offending device. Unplug each electronic or electrical device one at a time while monitoring the receiver. Access to the fuse or circuit-breaker box can help speed up the process. It is an easy matter to shut off portions or individual rooms of a house by turning the breakers off one at a time. Once the offending room or area of the house has been found it should be a simple matter to zero in on the culprit.

If the interference is not being produced in your house, the search will become a bit more difficult. The problem may be an arc in the utility power distribution system, a neighbor's appliance, a street light, or any number of other items powered by the ac mains.

As mentioned earlier, it is possible that the interference is being generated by an arc in the power distribution system. Since most connections are exposed to the weather, the possibilities for corrosion are excellent. Loose and corroded connections, a faulty transformer and rubbing guy wires are possible sources.

Also, it is quite likely that the interference is originating from a source located in a neighbor's house. Most modern households contain many of the devices capable of causing problems — washing machines, dryers, television sets, hot-water heaters, electric blankets, and all manner of convenience items.

Whether the interference is from an arcing power line or from an appliance in a neighbor's home, the method used to hunt down the source is basically the same. If the bulk of the interference is reaching your receiver through the antenna/lead-in system and you have a rotatable directional antenna, it is sometimes possible to get a bearing on the source. This method is not a sure-fire way to pinpoint exactly where the interference source is located; it is possible to get a false reading since the energy is distributed in many directions once the noise reaches the power lines. Although this method is not entirely accurate, it is a reasonable way in which to start your search.

For the next step use a battery powered a-m or short-wave receiver. Start by "sniffing" the power lines in front of your house. Follow the lines in each direction looking for stronger interference. Should the source emit a strong signal, it may ride the lines for several miles. In a case where such strong noise is present, it will be possible to use an a-m car radio.

If you should find that the problem lies in the power distribution system (if there is an arc you'll probably hear it when you get close) do not tackle the problem yourself. Contact the local power company office and inform the head of the engineering department of what you have found. Give the pole number, affixed by a plate. It will usually help to tell him you are a radio amateur and have used portable receiving equipment to track down the source of the problem. If you are unable to pinpoint the exact spot it is often helpful for them to know what frequency bands are affected, whether it is intermittent, and if so when the problem starts and stops. Provide as much information as you can as the more they have to go on the easier their job will be. They may ask to stop at your house and listen to your receiving equipment to get an idea of what type of problem they should look for. Chances are, they will have a collection of test equipment to help track down the problem.

You will more than likely find the power company representatives quite helpful. An arcing problem in the system will mean work for them later should a

connection burn through. Above all, be polite and do not demand their immediate service. It may take them several days to get to your complaint — you're not their only customer.

Should the search lead to a neighbor's house, things can turn out one of two ways — good or bad. If you are friendly with them, chances are they will let you look around, especially after you explain the interference problem in detail. Do not be surprised to find that they are also experiencing severe interference with a television or a-m/fm receiver and will be more than happy to have the source cleaned up.

On the other hand, your search may lead you to a house owned by a neighbor who you do not know. There is no harm in explaining the situation to see how far you get. If you meet with a welcome response, fine. If you do not, contact the local power company. Again, provide as much information as you can. Tell them that you think the interference is coming from a particular house and the manner in which you were received. It is possible that the power company has had other complaints of power-line noise in that area, especially if the source of the interference is strong. Power company personnel will no doubt be able to gain access to the house to try to locate the noise source.

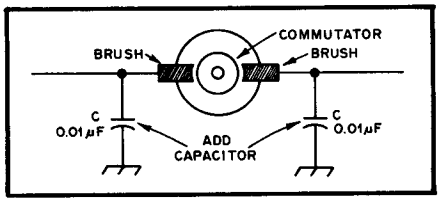


Fig. 8 — Where to install bypass capacitors inside a brush-type motor.

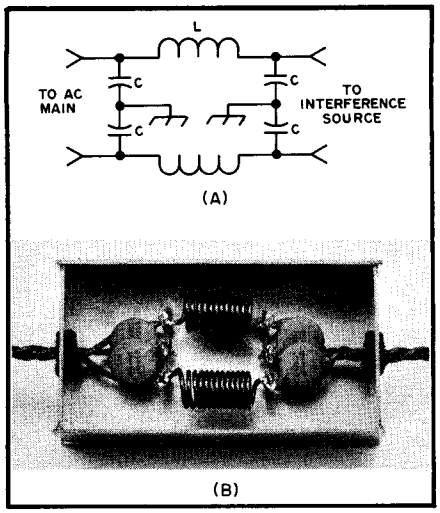


Fig. 9 — A homemade line filter. The capacitors are 0.01-μF, 600-volt types and the coils are made from no. 18-gauge wire wound on a 1/4-inch form (not critical).

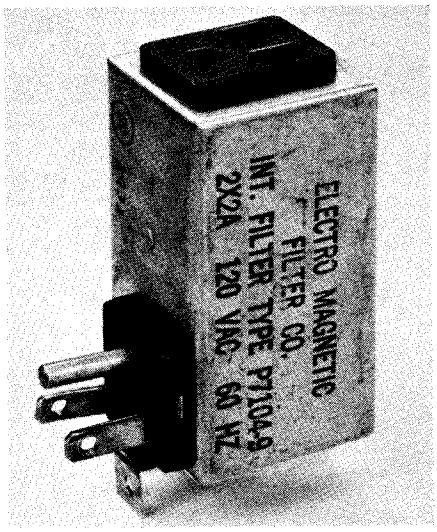


Fig. 10 — Commercial plug-in type line filter.

Eliminating the Interference at the Source

Once the source of interference has been found, the next step is to reduce the interference to an acceptable level. Has the source always caused interference or is it doing so because of a malfunction? Example: Suppose that you have been operating the 40-meter band most every day for several years. One day there is an interference problem and the source turns out to be a light dimmer. It is obvious that something has gone wrong with the dimmer since it never caused a problem before. Alternatively, you may have recently become interested in operating on the 40-meter band after being a ham several years. Since you had not operated that band before you had no way of knowing that the light dimmer caused severe noise problems on that band. Has the dimmer been causing interference all along or did it just start recently? In this case it is hard to say.

The main point here is to try deciding whether the device is malfunctioning or if the interference is inherent in the design. Another example: Suppose your oil-furnace motor suddenly starts causing interference after years of trouble-free service. Rather than apply an interference cure, it may be better to actually find the cause of the problem. Perhaps the brushes are badly worn and need replacement. Maybe the motor needs a good cleaning. A little common sense goes a long way when it comes to solving interference problems.

Some Common Interference Problems and Cures

If a brush type of motor is the source of interference, and it is in proper working order, the use of capacitors from each brush to the motor frame should help. The capacitor will bypass rf currents to ground that would normally ride the power lines. Bypass capacitors should be installed as close to each brush as possible (Fig. 8). There is apt to be little room inside the motor housing so use physically small capacitors. A capacitance of 0.01μF (or greater) at a voltage rating of 600 should be sufficient. Disk-ceramic or mylar capacitors are the best choices. Although tantalum capacitors are physically small, they are not designed for ac applications such as this.

Should it not be possible to install capacitors inside the motor, it is practical to add them, or a line filter, at the point where the power cord enters the frame. Special filters for this application are available from several manufacturers, e.g., CDE, Erie, Corcom and J. W. Miller. It is also possible to build your own filters with the information given in Fig. 9A and B. The filter should be enclosed in a metal container with the case directly connected to the frame of the motor.

If for some reason it is not feasible to mount a filter directly at the motor, a plug-in type of line filter can be used. A commercial unit is shown in Fig. 10. The filter plugs into the wall outlet and the offending appliance is simply plugged into the filter. These filters are rated for a certain maximum safe current, so pay particular attention to this when buying a ready-made unit. A filter installed at the wall outlet will be the least effective method for reducing interference, since the cord connecting the appliance to the wall outlet will radiate.

Sewing-Machine Motors

The likelihood that interference will derive from a sewing-machine motor depends on the age of the motor. Because sewing machines are fairly rugged, there are quite a few older models still around.

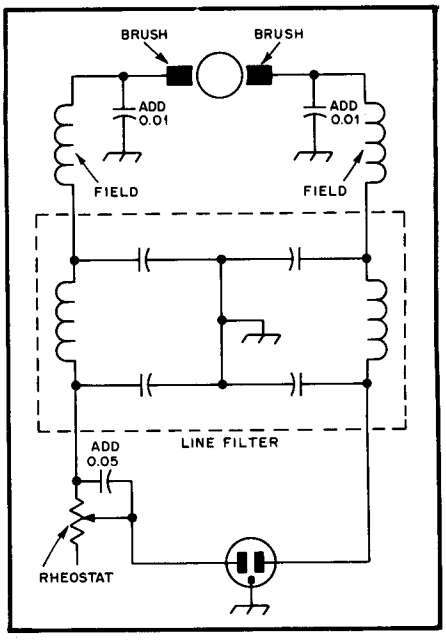


Fig. 11 — Schematic diagram for a typical sewing machine. Bypass the rheostat and brushes and add a line filter in series with the power cord.

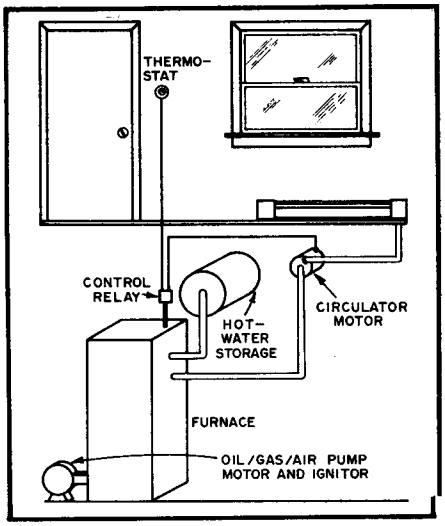


Fig. 12 — A typical home heating system.

Most new machines have been treated for RFI/EMI, however.

Many models use a rheostat to control the motor speed. Start by connecting a 0.05-μF, 600-volt capacitor across this control. If space permits, use two bypass capacitors, one from each brush to the frame, inside the motor. Should there not be room for such an installation, mount a line filter as close to the motor body as possible. See Fig. 11.

Electric Lawnmowers

The motors used on electric lawnmowers are of the high-torque/high-current variety. Since the mower is usually powered with a lengthy extension cord (antenna!) severe interference is possible. These motors are quite compact so bypass capacitors can not be installed directly at the brushes. Use of a line filter mounted directly at the motor is the next best solution. Place the filter as close as possible to the point where the wires enter the housing, and make sure there is a good bond between the lawnmower chassis and the case of the filter.

Vacuum Cleaners

Most modern vacuum cleaners are fairly well protected against RFI/EMI. However, the inside of the motor will become fairly dirty since not all of the dust will be stopped by the collector bag. This can lead to excessive arcing. The first step in eliminating noise from a vacuum cleaner is to check the commutator and brushes and clean or replace them if necessary. There should be ample room inside most units to install 0.01-μF capacitors at the brushes. If there is not sufficient room a line filter is the next best alternative.

Many vacuum cleaners come equipped with a rug-beater attachment, used in place of the usual floor-cleaning nozzle. Most have a small motor in the attachment to turn a roller that uses a system of bars and brushes. The same method of RFI/EMI suppression should be used with this motor as with the main one.

Electric Shavers

Most currently manufactured electric shavers have built in RFI/EMI suppression capacitors. If the shaver is thought to be causing more-than-normal interference, check the capacitors.

It is likely that there will be some residual interference even though the capacitors may be in good shape. This can be reduced to an acceptable level through the use of an external line filter. A plug in type of filter will work nicely.

Electric Knives, Mixers, Hairdryers, etc.

Most small household appliances use compact, brush-type motors. Since many of these items are operated for a short period at a time, only a fanatic would tackle all of them. However, if one is interested in an RFI/EMI-proof environment these items can be treated. Use bypass capacitors from each brush to the frame, or across the two brushes. Should there not be a motor frame (as is common in small appliances), use a line filter at the motor or a plug-in type of line filter.

Office Machines

Some older office machines are capable of producing a fair amount of interference. Most new models are well shielded against RFI/EMI. When necessary, use bypass capacitors, a line filter at the motor, or a plug-in line filter at the wall outlet.

Electric How-Water Heaters

The typical electric hot-water heater has two heating coils controlled by two separate thermostats. Since the coils draw large amounts of current, the thermostat switch contacts may become pitted over a period of time. When this happens the chances are good for excessive arcing. If the contacts are pitted they should be replaced. In some cases it might be necessary to replace the entire thermostat/switch assembly. These assemblies are not very expensive and can be easily replaced. If the contacts are in good shape, the addition of a capacitor across the contact may cure the problem. A 0.01-μF, 600-volt capacitor should be sufficient.

Gas-Oil-Heat Burners and Thermostats

There are several places for interference to be generated in an oil- or gas-heating system (Fig. 12). Two or more motors are used in many systems. One pumps the air/fuel mixture into the combustion chamber, and one or more additional motors circulates hot water or air, depending on the number of zones in the house. Each of these motors should be checked for RFI/EMI. Use bypass capacitors and line filters where necessary.

An ignition system is used to light the air/fuel mixture. This is nothing more than an arc drawn across a spark gap. The gap is fed with a high voltage from a step-up transformer that is run from an ac line. If the leads on the primary side of the transformer are not properly bypassed or filtered, interference can find its way into the house wiring. In situations of high interference levels, resistors may be required in each of the high-voltage leads, as shown in Fig. 13. Note: The ignition system normally is on for a few seconds to fire the oil. If the arc stays on continuously the ignition control is defective and should be replaced.

A thermostat is used to sense the temperature in the house and automatically start and stop the furnace. Most older thermostats use a set of contacts attached to a bimetallic strip. Since the bimetallic strip moves slowly the contacts are brought together and pulled apart at a slow speed. The chances for pitting and arcing are great. A new type of thermostat that uses a mercury switch is shown in Fig. 14. These types should not cause interference. If an older type thermostat is found to be the source of interference, the contacts should be cleaned and a bypass capacitor installed across them. The alternative is to replace the old type with a mercury-switch system.

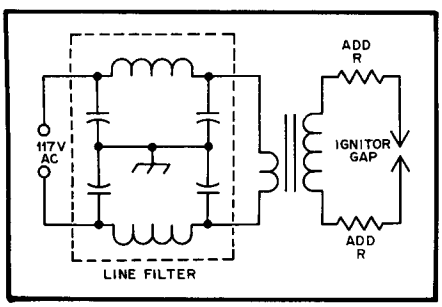
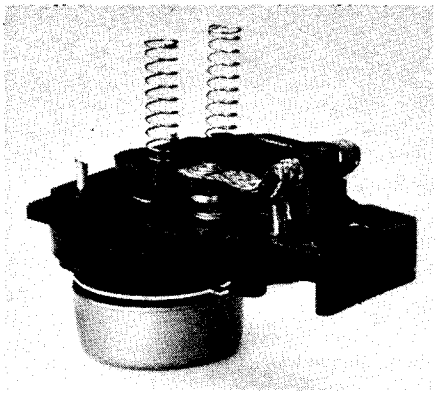
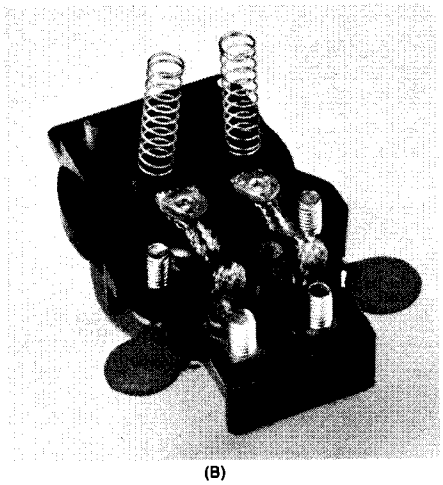


Fig. 13 — A method for reducing interference from the ignition system used in most furnaces.

Fig. 14 — Modern-type mercury thermostat.



(A)



(B)

Fig. 15 — A: Typical electric heat thermostat/switch assembly. If necessary, add capacitors as shown at B.

Most heating systems use several relays to control the different zones. Since these relays open and close many, many times they are apt to become dirty and pitted. Replace them as needed and install a 0.01 μF, 600-volt capacitor across each contact.

Electric-Heat Thermostats

Most electric heating systems use a combination thermostat/switch assembly for control of the radiators. Houses equipped with electric heat often have a separate system for each room; every room has its own thermostat. A typical thermostat/switch assembly is shown in Fig. 15A. Since the contacts are required to switch high currents there is a good chance that they will become pitted. When the contact is opened it is possible for an arc to develop. Some heating systems utilize single-pole switching; others use double. Make sure to bypass each set of contacts in the switch assembly as shown in Fig. 15B.

Door-Bell Transformers

Some doorbell systems are equipped with transformers that have a temperature-sensing, shut-down mechanism. Should there be a malfunction in the system the voltage to the transformer is open circuited to prevent further damage. If this contact becomes intermittent, interference can be generated. The solution is to find the problem in the system or replace the transformer should it be at fault.

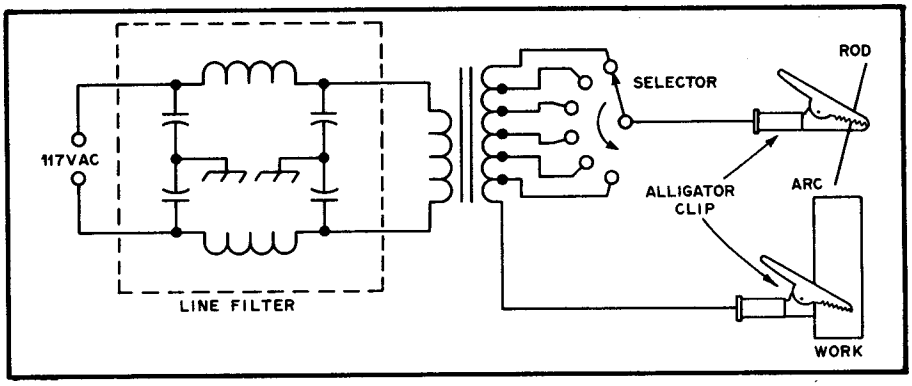


Fig. 16 — Arc welding setup with line filter (heavy-duty type) installed.

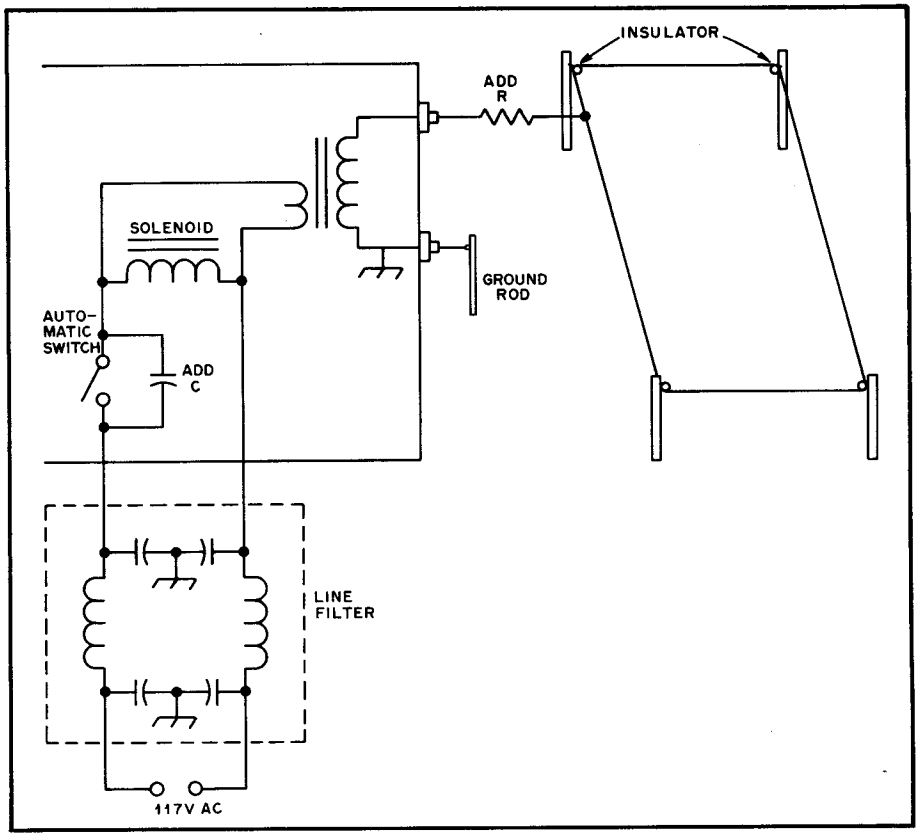


Fig. 17 — Electric fence. A capacitor is used across the automatic switch, a resistor is in series with the high-voltage lead, and a line filter is in the ac line.

Arc Welders

Arc welders are capable of causing severe interference. Of course, there is no way to suppress the arc and leave the machine functional. A heavy-duty line filter should be used directly at the transformer primary as shown in Fig. 16. The filter must be capable of handling the current drawn from the line. Capacitors of the 0.01 μF variety should be adequate. However, the coil should be wound from wire of at least no. 8 gauge.

Fish-Tank Heaters

Fish-tank heaters are used to keep the water inside a tank at a certain temperature. The heating unit and thermostat are in a self-contained, water-tight tube. Bypassing the thermostat contact is usually impractical. Either replace the heater or install a line filter as close as possible to the device.

Pipe Heaters

Pipe heaters are used to prevent water pipes from freezing during cold weather. Normally, a wire is wrapped along the entire length of the pipe to be protected with the ends connected to a wall outlet.

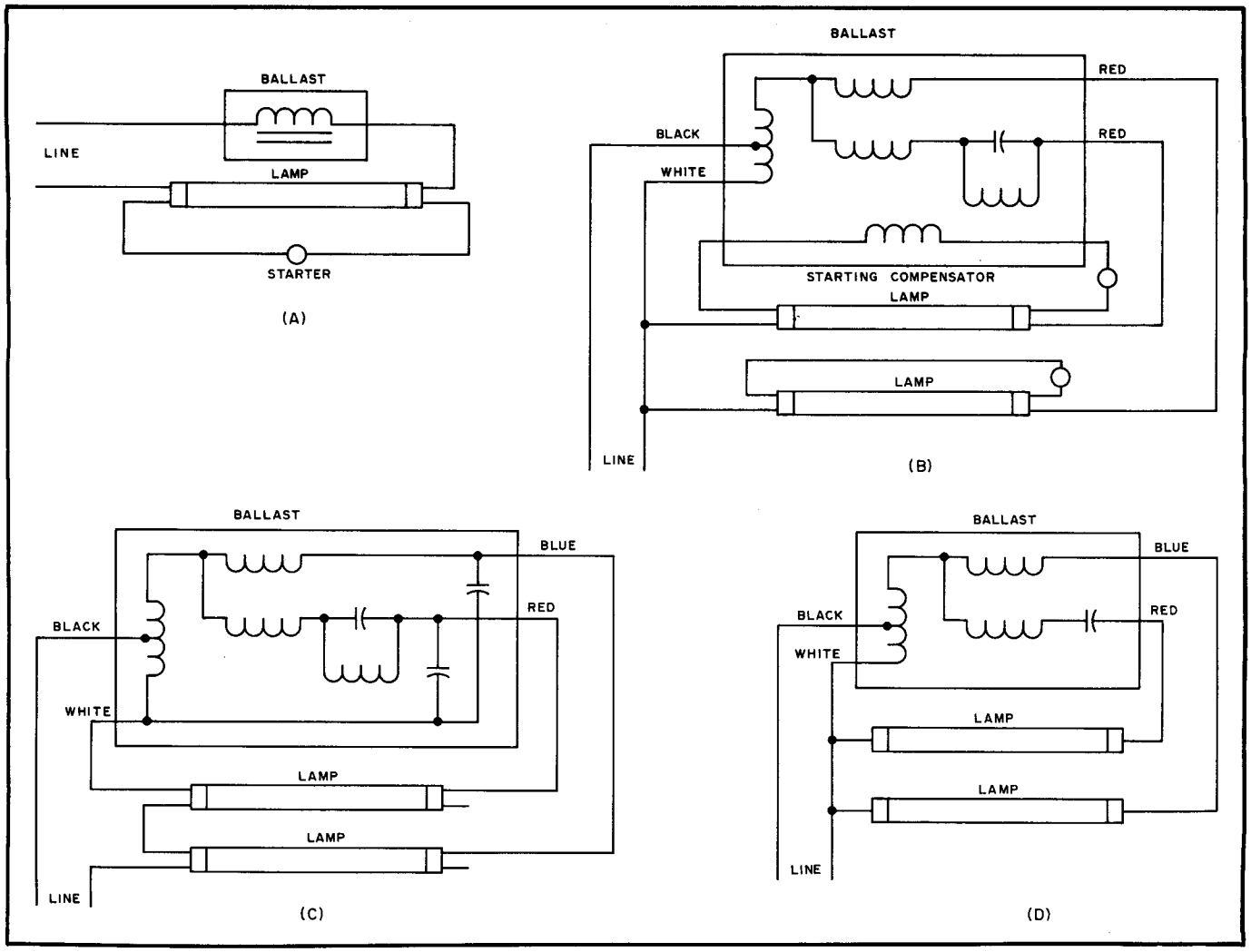


Fig. 18 — A: Single-lamp ballast for 4- to 40-watt, hot-cathode fluorescent lamp.B: Two-lamp ballast circuit for instant-starting, hot-cathode fluorescent lamps. D: Two-lamp ballast circuit for multiple operation of cold-cathode fluorescent lamps.

Some units use thermostats but most do not. If a thermostat is used treat it for RFI/EMI in the manner already described. Replace if necessary.

Electric Blankets

The cause of interference from an electric blanket can most often be traced to a defective thermostat. Since the blanket contains many coils of wire it can act as a good antenna. Use a 0.01 μF capacitor at the thermostat contacts.

Electric Fences

The electric fence is still quite common in rural areas. A transformer steps up the line voltage and an automatic switch sends a pulse down the fence once every few seconds. The voltage is pulsed so it will not be a serious shock hazard to humans. A single conductor is used for the fence and is connected directly to the switch mechanism. The basic system is shown in Fig. 17. Since the wire used for the fence can be very long, it acts as a good antenna. A resistor placed in series with the fence wire will help to damp the pulse. A capacitor across the switch mechanism and a line filter in the ac line should finish the job. Also, look for broken or dirty insulators. Clean or replace them as required.

Fluorescent Lights

Noise from a fluorescent light is caused by the arc that excites the gas in the tube. There are several systems in common use. Most of the recently developed types do not use starters, which are the source of many interference problems. Some of the different variations of fluorescent lighting are shown in Fig. 18. The cure is basically the same for each one: Add a capacitor or line filter inside the fixture. In cases of extreme interference it may be necessary to replace the ballast and/or the fluorescent tubes.

Neon Signs

The basic circuit of a neon sign is shown in Fig. 19. It is very similar to the fluorescent light in that a long arc is drawn through the tubing to excite the gas. A transformer is used to step up the line voltage to a level suitable for excitation of the gas. Relatively large amounts of voltage, approximately 1000 volts/foot of tubing, are required for proper excitation.

The cure for neon-sign interference is a line filter mounted directly at the transformer and resistors in series with each high-voltage lead. Resistors of the 10-k Ω 1-watt variety should work fine. If these measures do not reduce the interference to an acceptable value, try winding thin magnet wire around the tubing for the entire length. Six or seven turns of wire per foot should be sufficient. Ground each end of the wire. Also, make sure that the transformer case is attached to a good ground.

Light Dimmers

Light dimmers can be the source of severe interference problems at lf and the lower hf frequencies. These dimmers use SCRs or triacs to control the brightness of incandescent lamps. The triac or SCR is continually switching from a high-impedance state to low impedance, usually in less than a microsecond. A rapid rise in load current produces the interference that can extend to several megahertz.

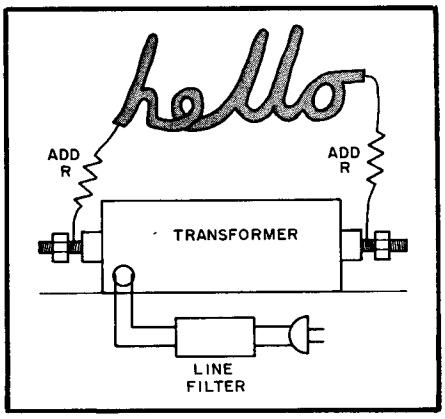


Fig. 19 — Typical setup for a neon sign. Add a 10-kΩ resistor in series with each high-voltage lead, plus a line filter at the transformer.

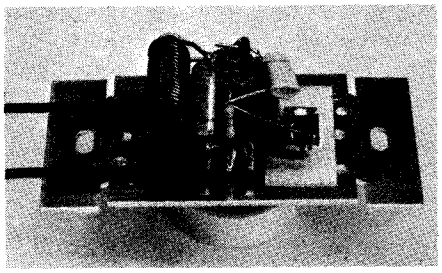


Fig. 20 — Internal workings of an inexpensive light dimmer. The choke coil and capacitors are for RFI/EMI reduction.

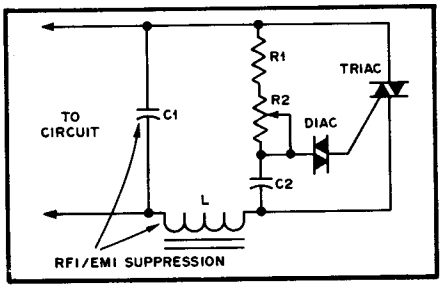


Fig. 21 — Schematic diagram of a typical incandescent light dimmer.

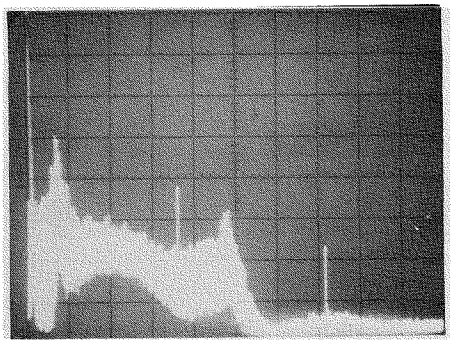


Fig. 22 — Spectral display of a TV receiver output as measured at the antenna terminals. Each horizontal division corresponds to 1 MHz and each vertical division is 10 dB. The top line represents -30 dBm (7000 μV).

Most recently manufactured light dimmers have been treated for RFI/EMI. A typical unit is shown in Fig. 20, with the schematic at Fig. 21. Should a dimmer be found to be the cause of interference check the choke and bypass capacitors for defects. It is not uncommon to find that some brands of dimmers cause more noise than others.

TV Booster Amplifiers

In fringe TV-reception areas it is common to employ a booster amplifier mounted at the antenna. These amplifiers may malfunction and oscillate in the upper hf or vhf frequencies. This can be caused by corroded contacts, poor alignment or a defective component.

Television Sets

As mentioned earlier in this chapter, a television set is capable of causing interference. The horizontal and color-burst oscillators are usually the cause. Fig. 22 shows the spectral output as measured at the antenna terminals of a currently manufactured set. Each horizontal division is equal to 1 MHz with the "pip" at the far left representing zero frequency. Each vertical division is 10 dB with the top line equal to −30 dBm (7000 μV). Each pip on the display can be read in dBm referenced to the top line. This energy rides the antenna lead-in to the antenna and is radiated. Since these levels are by no means weak, the chances for interference is good.

The cure for this interference is to add a high-pass filter to the antenna terminals of the set. A commercial unit designed for a 75-ohm system is pictured in Fig. 23. The response of the filter is such that frequencies below 40 MHz are attenuated by at least 60 dB. The spectrum analyzer photograph at Fig. 24 shows the difference after the filter was added. Note the absence of the interfering signals.

It is also possible that interference caused by the oscillators can be conducted along the ac line. Most sets come equipped with built-in line filters. Their effectiveness is questionable, however, since the addition of an external line filter has been known to eliminate the interference.

Microprocessors and Microcomputers

The use of microprocessor control of various appliances is relatively new. Sewing machines, blenders and microwave ovens are only a few of the everyday items controlled in this way. Microcomputers, of the type used for problem solving, can be particularly bad offenders. The spectrum-analyzer photograph (Fig. 25) is of a currently manufactured microcomputer available from a worldwide electronics firm. A sense antenna placed one meter away from the machine resulted in the photograph shown. Indeed, while listening to a receiver in the same room as the microcomputer a multitude of signals were heard across each of the hf amateur bands.

The main problem is that the unit is mounted in a plastic case with no regard for rf shielding. If such a unit is found to be causing interference, the only cure that will likely be effective is to completely shield the unit and use line and lead filtering throughout.

Summary

Tracking down the various sources of interference can be a time-consuming and tedious task. Practically every electronic or electrical device is capable of causing interference to communications receiving equipment. Since the method used for finding the source is apt to be an elimination process, do not overlook even the simplest electronic device. You'll probably be surprised more than once!

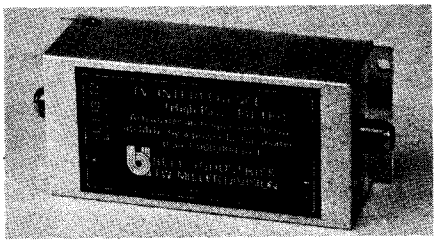


Fig. 23 — A commercially available TV high-pass filter.

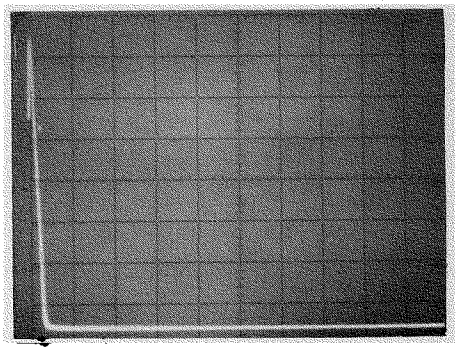


Fig. 24 — Spectral display at the filter output, with the input connected to the TV antenna terminals. The interference-causing signals are virtually gone.

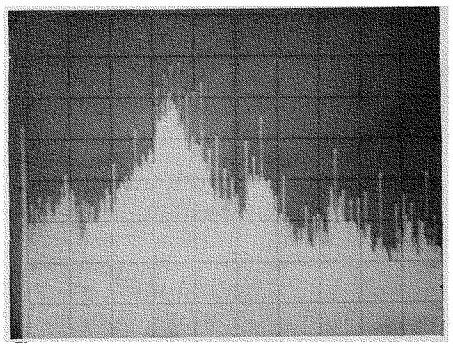


Fig. 25 — Spectrum analyzer display of signals radiated from a poorly shielded microcomputer. Each horizontal division is 10 MHz.

Chapter 6

Cable Television: Friend or Foe?

Cable television (CATV) was known originally as "community antenna television." Today it represents the broad area of entertainment and other services carried over coaxial cable networks to various subscribers. As implied by the name, the original purpose of CATV was to serve communities with entertainment television service where TV reception was poor. The idea was to find one good receiving site, pick up signals from local and distant TV transmitters, and relay these signals by way of coaxial cable to residents of the community. This concept was applied widely, and many people enjoyed satisfactory TV reception through these systems.

In the early days a few channels were distributed within the vhf band. The limit was generally the channel capacity of the standard vhf television receiver, which is 12 channels. Many 12-channel cable systems are still in operation. Cable television has not always been an economic success. Therefore, in recent years, systems have been enlarged to carry many more channels with particular emphasis on premium entertainment services such as Home Box Office and Show Time.

Today's sophisticated CATV installations offer high capacity and quality in essentially closed communication systems. A wide variety of quality equipment is available from a number of manufacturers to construct the systems and implement the services. CATV systems serve mainly residential subscribers; they are installed on a franchise basis in each community. There are nearly 20 million cable homes across the United States. Cable TV systems have also proved popular in Canada. Large CATV installations can be found in various other countries around the world.

Many of the recent franchise requirements have called for increasingly sophisticated systems with high capacity and interactive services. In order to better understand the relationship of the amateur operator to CATV, we will look at a typical system. We will then look at the possibilities of interference to and from Amateur Radio.

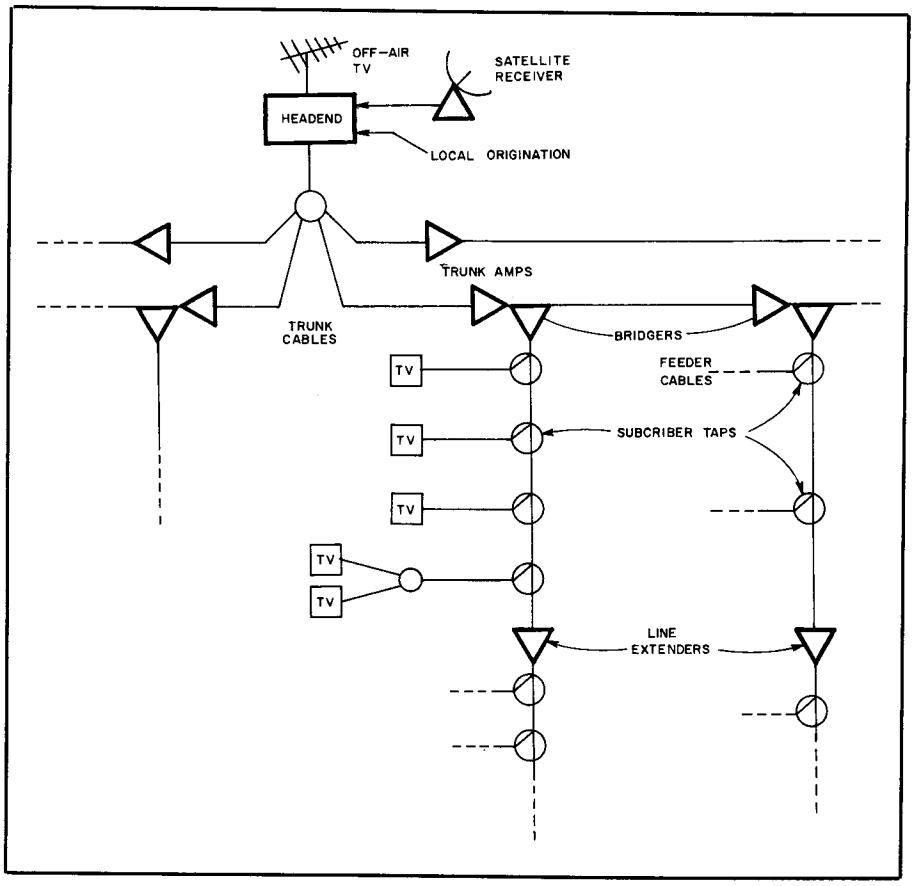


Fig. 1 — A typical CATV installation consists of the headend, trunk and distribution systems. Cable signals originate at the headend. The trunk system carries the signals to the various parts of the service area. Individual subscribers receive their signals from the distribution system.

Typical CATV System

A typical cable television network is illustrated in Fig. 1. This simplified draw-

ing illustrates the principles of CATV. At the headend, off-air television signals are received and processed. The processing involves filtering to eliminate out-of-band signals, adjustment of the sound carrier level (which is regulated by the FCC to be 15 ±2 dB below the video carrier), and frequency translations as required to carry a uhf signal in the vhf band. In addition to the off-air signals, satellite receiving stations are often used to pick up the satellite premium entertainment packages. More than 30 of these packages are now available. Additional program material may include local originations plus information channels using alphanumeric, graphics and the like.

At the headend the signals are properly processed and formatted, all signals are then combined and broadcast throughout the CATV system to the subscribers. From the humble beginning of 12 channels, CATV formats have gone to 20, 26, 30, 36 and now as high as 55 channels. CATV systems with more than 12 channels employ "converters" to expand the capacity of the subscriber TV set. These converters are merely tuners that can select any channel in the system and convert it to a channel on the TV set. Converter output is usually on channel 3 or 4. Fm broadcasts may also be carried, often in the standard 88- to 108-MHz fm band.

Once inside the coaxial cable, the signals are routed throughout the community. Obviously, there are losses where the signals are split in power dividers as well as losses in the cable itself. The cable losses are greater at higher frequencies. Tilt equalizers are used to attenuate the low-frequency end, restoring a flat response; amplifiers then restore the operating levels.

The main distribution path of the cable network is known as the trunk system. A trunk system carries the signals to the various areas of the community but does not feed subscribers directly. Trunk amplifiers are appropriately placed to make up for cable or system losses and to maintain the signal quality. Normally, signals for distribution to subscribers are extracted by power division and reamplification. This is accomplished by bridger amplifiers that are located inside the same housing as the trunk amplifiers.

The bridgers feed the distribution system, which is tapped with passive directional couplers to supply the subscriber drops. At the point where the losses in a distribution leg reduce the signal to a predetermined level, distribution amplifiers commonly known as line extenders are added. The CATV trunk system may extend for many miles and employ dozens of amplifiers. The distribution system, on the other hand, seldom uses more than two or three line extenders in any leg. The line extenders are operated at levels 10 to 20 dB above the trunk amplifiers. Transmission of analog signals, such as television, requires that signal levels be run as high as possible to obtain the best carrier-to-noise ratio. The limiting factor on the level is the distortion in the broadband amplifiers. There is a noise contribution by each amplifier so that the noise floor increases as the number of cascaded amplifiers increases. The levels of operation along the trunk system are such that the distortion buildup and the noise buildup both become objectionable with about the same number of amplifiers in series. This obviously is the maximum useful system length. In the distribution system, high-quality signals are delivered by the trunk. The line extenders can be run at higher levels than the trunk since very few series line extenders are employed. Higher levels allow feeding more customers per amplifier and hence have economic advantages.

There are many different cables available for CATV, all having a 75-ohm characteristic impedance. The trunk and distribution cables have solid aluminum outer conductors; they range from less than 1/2 inch (13 mm) to approximately 1 inch (25 mm) in diameter. This choice allows the system designer to optimize performance and cost. The final feed to the subscriber generally uses RG-59/U or RG-6/U flexible cable, supplied usually with several layers of shielding. The shielding may be braid or foil, or various combinations of the two.

One of the greatest achievements of cable television technology is the ability to amplify a broad band of frequencies. A 36-channel system generally occupies the frequency range of 54 to 300 MHz; 55-channel systems range from roughly 54 to 440 MHz. CATV amplifiers are able to amplify this spectrum with very low ripple in the response. Many semiconductor developments have contributed to this. The most important is probably the development of hybrid amplifier modules.

It is important to be aware of the levels at which signals are carried on the cable system. In CATV a new unit of measure has been established. This is the *dBmV*, which is the voltage level in decibels referenced to 1 millivolt across 75 ohms. (Since the impedance is fixed, this also represents a reference power level.) The signal arriving at the subscriber TV set is required by the FCC to be equal to or greater than 0 dBmV. This equals -48.75 dBm, where 0 dBm is equal to 1 mW. The TV signal carrier level arriving at the customer set, therefore, is in the range of 0.013 microwatt to a little less than 1 microwatt — not very much power. It is possible to see in a TV picture interfering signals that are as much as 65 dB below the visual carrier level. Minus 65 dBmV is approximately 4×10^{-15} watts or 4×10^{-9} microwatts — an exceedingly small power level. The level of a TV signal at the output of a bridger amplifier or line extender is in the range of +38 dBmV to perhaps +50 dBmV, and that at the output of a trunk amplifier in the order of +30 dBmV. The point of this is that CATV works on low power levels, particularly when compared with transmitters running 1000 watts (+60 dBm or +108.75 dBmV). Gain antennas concentrate power and can further compound the situation.

CATV Channels

When off-air signals are carried on the broadcast frequencies, interference from or to an amateur station is generally not experienced. The frequency relationship of amateur signals to the CATV channels are the same as those to the off-air channels so that any disturbances are generally caused by harmonics or overloads. Because of the shielded system this does not usually occur. When the CATV coverage is virtually continuous from 50 to 300 or 450 MHz, a number of amateur frequencies are utilized inside the cable. It is helpful to know the frequency locations used on the cable system. Table 1 shows three commonly used channelization plans. A channelization plan is selected by the cable operator.

The plan of channelization designated as "standard" is based on the standard broadcast frequencies of the low and high vhf channels and is very commonly used. Even the small amount of harmonic and intermodulation distortion in a CATV amplifier causes products to occur at the sum and difference frequencies of the various signals. In the standard plan these distortion products often fall at frequencies which cause visible interference to the TV picture. In the harmonically related carrier system (HRC) all of the visual carriers are related harmonically (normally with a 6-MHz separation). The major distortion products fall on the carrier frequencies and are, therefore, less visible. The HRC system is being used increasingly in systems with 36 or more channels. The IRC or incrementally related carriers system performs somewhat better than the standard system, but is not as effective in reducing beats as the HRC system. In Table 1 the "Channel Name" column gives only one of the various designation systems that are used. When you are dealing with a CATV interference complaint it may be hard to know which cable channels are involved, much less the actual frequencies. For instance, it is not unusual for a cable system to take an off-air channel from uhf and put it on some midband vhf channel (120 to 174 MHz) so that channel 58 might now be called channel G. As you can see, things could become extremely frustrating without some knowledge of the facts.

Interference

CATV-related interference is a two-edged sword. As with normal TV interference the amateur can be the cause of

Table 1
Common Channelization Plans

Channel Name		Visual Carrier Frequency		
		Standard	*HRC*	*IRC*
2		55.25	54.0	55.25
3	Low	61.25	60.0	61.25
4	VHF	67.25	66.0	67.25
5		77.25	78.0	79.25
6		83.25	84.0	85.25
A-2		109.25	108.0	109.25
A-1		115.25	114.0	115.25
A		121.25	120.0	121.25
B	Mid	127.25	126.0	127.25
C	Band	133.25	132.0	133.25
D		139.25	138.0	139.25
E		145.25	144.0	145.25
F		151.25	150.0	151.25
G		157.25	156.0	157.25
H		163.25	162.0	163.25
I		169.25	168.0	169.25
7		175.25	174.0	175.25
8		181.25	180.0	181.25
9	High	187.25	186.0	189.25
10	VHF	193.25	192.0	193.25
11		199.25	198.0	199.25
12		205.25	204.0	205.25
13		211.25	210.0	211.25
J		217.25	216.0	217.25
K		223.25	222.0	223.25
L		229.25	228.0	229.25
M		235.25	234.0	235.25
N	Super	241.25	240.0	241.25
O	Band	247.25	246.0	247.25
P		253.25	252.0	253.25
Q		259.25	258.0	259.25
R		265.25	264.0	265.25
S		271.25	270.0	271.25
T		277.25	276.0	277.25
U		283.25	282.0	283.25
V		289.25	288.0	289.25
W		295.25	294.0	295.25
AA		301.25	300.0	301.25
BB		307.25	306.0	307.25
CC	Hyper	313.25	312.0	313.75
DD	Band	319.25	318.0	319.25
EE		325.25	324.0	325.25
.		.	.	.
.		.	.	.
.		.	.	.
UU		421.25	420	421.25
VV		427.25	426	427.25
WW		433.25	432	433.25
XX		439.25	438	439.25
YY		445.25	444	445.25
ZZ		451.25	450	451.25

picture disturbances experienced by CATV subscribers. It is also possible that leaks from the CATV system will produce interference signals in the amateur bands such as channel E in 2 meters, channel J and K in the 220-225 MHz band, or channels UU, VV, WW, XX, YY in the 432-450 MHz band. There are yet more possibilities, as we will see later.

As was said before, the cable system is, or at least should be, a closed system. Interference is usually caused by a leak in the CATV system that allows signals to escape from the system or to get in from the outside. The biggest offender is generally the flexible drop cable from the pole to the home. The shielding is less effective than the solid aluminum cable on the pole. The drop cable encounters more mechanical motion since it is flexible and moves in the wind. The F connectors used in CATV are low-cost items (about 10 cents each), and are subject to certain difficulties. These difficulties are usually caused by poor installation rather than a connector fault. They may be the result of physical damage, such as caused by pulling sharply on the coaxial line and thus separating the shield from the connector body. A recent survey by the Federal Communications Commission found that a high percentage of the leakage in cable systems occurs on customer drops. (Some have run a piece of 300-ohm twin-lead to their neighbor's house. Othel "modifications" may result in the same kind of leakage.) Self-made taps and extensions on the cable drop should never be made. Not only are they morally wrong, they also open the door to interference problems.

Other problems result from poor connections arising from corrosion. The subscriber drop leaving the line normally comes to a hanger under the eave of the house, down the side of the house through a grounding block. Two types of grounding blocks are shown in Fig. 2. The shield is connected through a heavy copper wire to a ground in the electrical system, the cold water system, or some other ground point accepted by utilities or the state regulatory agency. Rules and codes vary widely throughout the United States. Corrosion of the fittings on either side of the grounding block or poor ground connections often cause leakage or rectification of strong local signals.

The distribution and trunk sections of the CATV system are usually much tighter than the subscriber drops. There are, however, two major areas of leakage. The first is related to the use of old-style connectors that provide no clamping support for the sheath of the aluminum cable. This is true for both splices and connectors where the cable enters the housing of amplifiers or passive components (power dividers, directional couplers, and so forth). Mechanical motion caused by the wind will often cause cold flow in the aluminum and hence a poor or intermittent connection. Leakage may also arise from cracks in the outer shield of the cable. This condition is less frequent in newer systems because improved installation techniques are used.

A subscriber drop cable leaves the distribution line from a housing that includes passive directional couplers. The latter are used to tap off the proper amount of power to feed the subscriber's TV set. Usually there are four drops from each housing, which is called a "four tap." When an amateur experiences interference from pickup of his high-power radiation, it is possible that one or more of these taps is unused but not terminated.

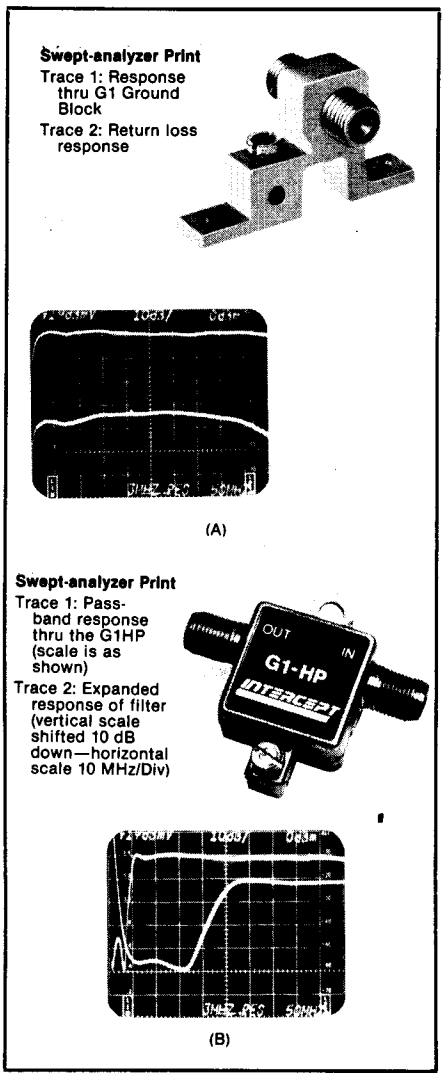


Fig. 2 — Grounding blocks are used at the subscriber drops. A typical unit is shown at A. The version at B contains a high-pass filter. *(Photos courtesy of Intercept Corporation)*

Tap terminations cost but a few cents since they are merely an F fitting with a 75-ohm resistor soldered inside. Resistors sometimes have their leads shaped and are plugged in without the use of an F fitting or solder. This procedure is suspect. The addition of the F connector (for 10 cents) by maintenance personnel is recommended.

The ultimate problem of amateur interference to CATV probably occurs when an amateur runs high power into a beam antenna directed at a portion of the cable system. In this case connectors and housings for amplifiers and taps may not have enough shielding. Since the power differential can be over 150 dB, it may be too much to ask that the cable system shield against this enormous differential. The potential for interference seems to be largely in the vhf region where amateur power may be somewhat lower, and where it is a lot easier to get antennas up higher (over the CATV system).

In some cases amateur interference is picked up on the connecting cable between the converter and the TV set. The viewer then sees the interference on all channels. The solution to this problem generally follows standard TVI elimination procedures. It is not directly related to the CATV system.

Two-Way Cable

The newest CATV systems provide bidirectional capability. If the description of a typical system did not excite your interest, notice that we are now adding an upstream path from every subscriber to the headend. All kinds of two-way services may now be implemented. Currently these include home security, power company load control, meter reading, traffic control, point-to-point communications, surveillance camera control, and a host of others including the broad scope of interactive services to the home. These services will include banking, shopping, graphics, home computer services, catalog displays and services that have not yet been conceived.

To provide bidirectional transmission, the cable is fitted with reverse amplifiers, usually covering the range of 5 to 30 MHz. The configuration of 50 to 300 MHz or more downstream (from the headend) plus 5 to 30 MHz upstream is referred to as a "subsplit" CATV system. In cases where there are numerous industrial users or multiple residential cables, the "midsplit" system is often employed. Typical frequencies for a midsplit system are 5 to 120 MHz upstream and 174 to 300 MHz or more downstream.

Perhaps you begin to sense a potential problem. Some CATV systems are now operating in all of the amateur frequencies from 7 to 28 MHz where high power and large antennas are generally employed. One of the worst problems that operators of two-way cable systems have had to date is with Citizens Band transmissions. There are many CB transmitters, mostly mobile, making it difficult to locate the source of the interference. The matter of leakage from the cable system to the amateur on the upstream frequencies so far has been almost nonexistent because of limited use of two-way operation to date.

Interference entering the cable system on upstream frequencies results in an interesting problem. In the earlier description a typical system was shown to resemble a tree whose root is the headend. The system branches to feed different areas until finally it reaches the subscriber, which you might liken to the end of the twig on a branch. Consider signals being transmitted from subscribers to the headend. There is a situation where there can be thousands and thousands of "twigs" generating signals that all come together at the headend. Should an interfering signal enter the system, it is impossible to tell where it originated. This means that curing the interference may take a long time. In that time it can do a lot of damage since an intruding signal in an upstream data channel can totally obliterate the service. Cable operators are becoming aware of this problem and are taking steps to avoid it. The most flexible solution utilizes remotely controlled switches to selectively divide the system into areas. This technique can be used to locate the vicinity of interference entry. This section is then shut off, allowing the rest of the system to function while corrective action is taken.

Responsibility and Assistance

The responsibility of the cable system operator is defined directly and indirectly by FCC regulations. There has been a great deal of attention given to leakage from cable systems that might cause disruption of aircraft navigation and communications channels. These include the frequencies of 73.5, 108 to 136, and 225 to 440 MHz. Part 76 of the FCC regulations defines the leakage allowed. This is presently 15 microvolts per meter at 100 feet at frequencies up to 54 MHz, 20 microvolts per meter at 10 feet from 54 to 216 MHz, and 15 microvolts per meter at 100 feet above 216 MHz. The extra attention given to the FAA services had led to numerous other regulations and will doubtlessly lead to change (possible loosening) of the limits cited. A leak of 20 microvolts per meter at 10 feet can certainly be received by nearby amateur equipment, although this amount of leakage from a single point is not significant at relatively long distances. A leak of this magnitude will permit significant signal entry from a nearby high-power amateur transmitter.

The legal responsibility of the amateur in regard to cable television is no different than that of any other service. FCC regulations do not preclude all interference from amateurs to CATV viewers nor all interference to the amateur service from minor CATV system leaks. The amateur's role should be that of a diplomat and an ambassador for a fine and highly respected technical fraternity.

There is one major difference in dealing with CATV problems rather than complaints from neighbors. When the cable TV viewer has a complaint he will go to his cable system operator. When the amateur has a complaint he will go to the same operator. The cable-system operator is at least one, if not many, technical levels above the average neighbor. He runs a sophisticated communications network and can be expected to understand much of what the amateur has to say. As a matter of fact, there are many Amateur Radio operators in the CATV business. All in all, amateurs are at least one leg up when dealing in this environment. The CATV operator may also have a good deal of sophisticated equipment and personnel who know how to operate it. They generally have convenient devices such as portable field-strength meters and spectrum analyzers. Perhaps most important, they have legal, economic and moral incentives to recognize in satisfying their viewers. It is quite likely that one of your best friends in the community could be the chief technician of the cable company. You can help him make his service better and he can help make your hamming more enjoyable.

There are industry groups in the cable business that can be helpful in providing technical information and even specific assistance in knotty cases. These include the National Cable Television Association, 1724 Massachusetts Ave., N.W., Washington, DC 20036; The Society of Cable Television Engineers, P.O. Box 2665, Arlington, VA 22202; and Community Antenna Television Association, 1100 17th St., N.W., Washington, DC 20036. All of these groups have strong ties with both the cable industry and the Federal Communications Commission.

It is also well to note that the local cable operator has some responsibility to represent the community and often to produce programming for his network. By working with the CATV operator in your community you may be able to do much for Amateur Radio (in terms of public relations).

In summary, we can say that cable television does bring a potential new set of problems for the amateur operator in this world of congested communications. On the other hand, location and elimination of these problems may well be more easily handled than those of normal RFI because of the opportunity to work with a technically oriented group that has a vested interest in getting to the bottom of the problem.

Chapter 7

how to identify & resolve Radio-TV Interference Problems

Prepared by the staff of the
Field Operations Bureau
Federal Communications Commission

First Edition
May, 1977

Readers are invited to submit comments and suggestions to:

Federal Communications Commission
File 1410-C
1919 M Street, N.W.
Washington, D.C. 20554

Note: A similar publication, with the same title, is available to Canadians. A copy may be obtained at any Department of Communications district office. DOC office addresses can be found on page 7-14

Introduction

During the past few years tremendous advances have been made in the field of radio and television communications. Communications by radio and television from any point on the earth, and sometimes from points beyond the earth, have now become commonplace. In recent years, the growth of two-way radio, permitting personal communications from motor vehicles and homes, has been explosive.

These advances in communication technology are not without problems. The radio frequency spectrum is becoming crowded and interference problems, due to lack of compatibility between the different radio systems, are becoming widespread. This is evidenced by the thousands of complaints of interference to home electronic entertainment equipment (television, stereo, electronic organ, telephone, tape recorder and other audio equipment) received by the Federal Communications Commission (FCC) each year.

Most of these interference problems can be traced to one or more of the following factors:

1. Characteristics of the receiving system, e.g., television receiver or antenna systems design and installation.
2. Environment of the receiving system, e.g., distance from television transmitter and intervening terrain or presence of nearby radio transmitter.
3. Characteristics of radio frequency generating devices, e.g., Citizens Band (CB) radio transmitter or other radio transmitters.
4. Practices of radio transmitter operator, e.g., CB user operating an illegal overpower transmitter or amplifier.

The control of some of the above factors is within the jurisdiction of the Federal Communications Commission. For example, the Commission has technical standards for radio transmitting devices such as CB transmitters; these technical standards were strengthened by the Commission, effective January 1, 1977. Also, the Commission has rules concerning the way in which radio transmitters are operated.

Obviously, control of some of the above factors is *not* within the jurisdiction of the Commission. The quality of the television signal received at your home is one such factor, because such quality is most often influenced by the distance you live from the television station and the intervening terrain. Also, the Commission has no standards for the design and installation of television receivers and associated antenna systems. As you will find in this bulletin, many interference problems can be corrected by modification and improvement of the television receiving systems.

The purpose of this bulletin is to help you identify and resolve interference problems which you can correct. By reading this bulletin, you will discover that identifying and resolving interference can be an interesting challenge. You will not only be doing your own detective work in locating the source, but you also will be resolving the problem by following the suggestions contained in the "Home Remedies" section.

Because most interference complaints concern television reception, you will find the first section of this bulletin devoted to television interference. If the interference is to your audio equipment (stereo, telephone, AM/FM radio), simply skip to the section of this bulletin which deals with audio interference.

As you begin to identify the type of interference you are experiencing, keep in mind that not only must your equipment be able to receive and amplify the desired signal, but it also must reject all unwanted signals and noise. This means that, even if the equipment allegedly causing the interference is being properly operated, it is still possible to experience interference.

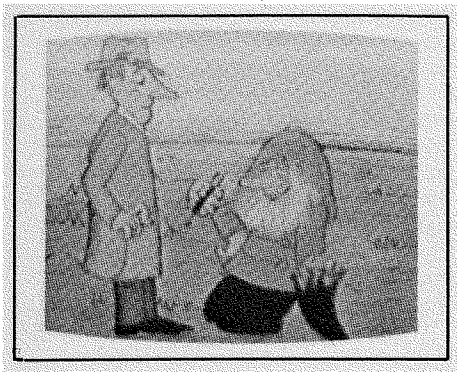
If you have followed the home remedies suggested, and the interference continues, you may want to contact your service representative for assistance. When you contact your service representative, we suggest that you provide that person with a copy of the Service Representative Section of this bulletin. This section has been designed specifically for a technician's use. There is also a section directed to the radio operator which you may wish to show to the operator of the radio transmitter that is allegedly causing you interference.

If you find, after following the guidelines for resolving interference that are provided in this bulletin, that you still are experiencing interference problems, you may want to contact one of the Sources for Assistance listed in Appendix B.

We hope this bulletin will serve as a useful tool in helping you to resolve your interference problem.

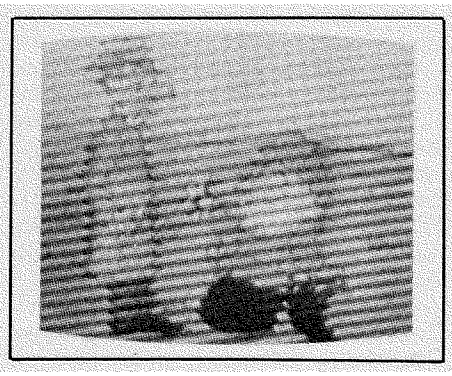
Caution: To avoid the possibility of a shock hazard, fire, or violation of your equipment warranty, any INTERNAL modifications of your equipment should be done ONLY by a qualified service representative.

Identifying Interference to Television



NORMAL PICTURE

Use this normal picture for comparison with the other pictures shown on this page.

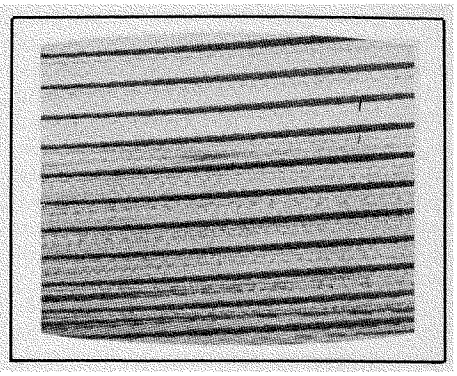


RADIO TRANSMITTER INTERFERENCE

This is what your picture looks like when it is picking up the transmission of CB, Amateur, Police or other radio transmitters. It will normally affect VHF channels only. You may notice that the interference pattern changes or moves as the radio transmitter operator talks.

Steps you or the service representative can take to eliminate the interference begin on page 50. Refer to that page if you have identified this as being the type of interference you are receiving.

Do not confuse this interference with Horizontal Control Problem.



HORIZONTAL CONTROL PROBLEM

When your set requires adjustment of the horizontal hold control or replacement of a bad tube or component, the above pattern will appear on your TV picture. The sound, if affected, may contain a high pitch tone.

To eliminate, simply adjust your horizontal hold control or call your service representative to replace the bad tube or component.

NORMAL PICTURE

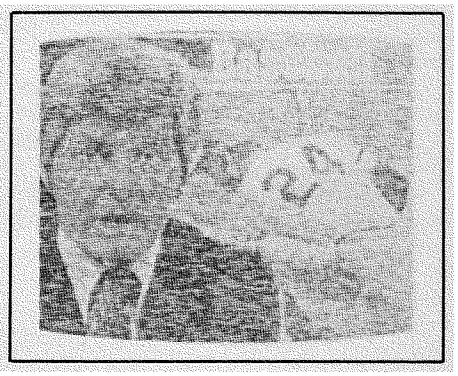
Use this normal picture for comparison with other pictures shown on this page.

ELECTRICAL INTERFERENCE

This is what your television picture looks like when your set is reacting to any of the following devices operated in or near your home. *Hair dryers — electric shavers — mixers — blenders — power saws — vehicle ignition systems — and other similar devices.* When this type of interference is occurring, you may also hear a sizzling or buzzing sound along with the sound of the TV program.

Methods used to locate the offending device, and ways to correct the problem begin on page 50. Refer to that page if you have identified this as being the type of interference you are receiving.

Do not confuse this interference with Poor TV Signal.



POOR TV SIGNAL

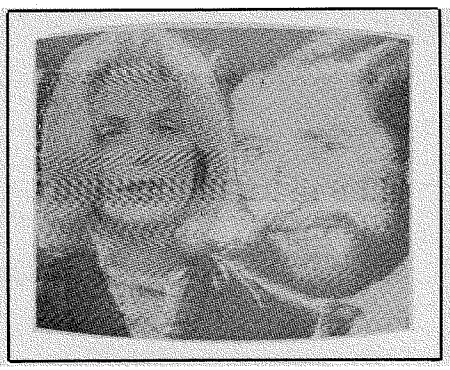
This is the type of television picture you will be receiving if you are far away from the TV transmitter site or if there is a building or mountain between you and the TV station. Defective antenna, improper antenna orientation, or disconnected or broken lead-in wire may also cause this problem. The sound of your TV usually will not be affected unless the TV signal is extremely weak.

You can improve the quality of the signal by installing a higher antenna; using a directional antenna; a signal amplifier; or repairing the lead-in wire.

Check with your TV sales and service representative on antenna systems available.

NORMAL PICTURE

Use this normal picture for comparison with the other pictures shown on this page.



FM INTERFERENCE

Interference from a nearby FM broadcast station will cause this type pattern to appear on your TV screen. Although it normally will affect TV Channel 6 only, one additional channel in the Channel 2-13 series may occasionally be affected. It sometimes affects both the picture and sound of your set.

Note that the interference pattern may change or vary with the sound of the FM broadcast station program, NOT the sound of the TV program.

Techniques to eliminate this interference are discussed on page 51. Please refer to that page if you have identified this as being the type of interference you are receiving.

Do not confuse this interference with Fine Tuning Problem.

FINE TUNING PROBLEM

This is the type of pattern which will appear on your screen if the fine tuner of the TV set is not properly adjusted. Although it looks similar to FM interference, you will note that the pattern changes with the sound of the TV program.

Readjust the fine tuning control of the TV set to eliminate the problem.

NORMAL PICTURE

Use this normal picture for comparison with the other pictures shown on this page.

CO-CHANNEL INTERFERENCE

This is the type of pattern which will appear on your screen when your set is simultaneously receiving two TV signals. Note that the two images are different, as though one picture has been placed on top of the other.

Co-Channel interference is due to either atmospheric conditions or the location of your home in relation to the location of the TV stations. If the problem is from atmospheric conditions, little can be done to correct the problem. However, the problem is usually temporary. If it is caused by the location of your home in relation to the location of the TV stations, use of a highly directional antenna may help to eliminate the problem.

Do not confuse this interference with Ghosting.

GHOSTING

This is the type of picture you will see when (1) the TV signal is reflected, or (2) the TV antenna or antenna lead-in wire are in poor condition.

When "Ghosting" occurs, it means the TV signal is being reflected off a mountain, building or other man-made structure, with the signals being sent over different paths to your TV set and arriving at slightly different times. With "Ghosting," note that the two images are the same.

Rotation of your TV antenna to a new position, or installation of shielded lead-in wire may resolve this problem. If rotation of the antenna does not resolve the problem, have a service representative check the condition and/or placement of the antenna and antenna lead-in wire.

Home Remedies for TV Interference

Installing A High-Pass Filter

There are no set procedures for eliminating television interference — it is a matter of eliminating the most likely sources of interference a step at a time. The first step is to install an inexpensive high-pass filter on the back of your TV set. In making this installation, follow these procedures:

1. Determine the type of antenna wire that is connected to your TV set. There are two possibilities:

Coaxial Cable — a round lead-in wire which requires a filter "impedance" of 75 ohms. (See Figure 1a).

Twin Lead Wire — a flat wire which requires a filter "impedance" of 300 ohms. (See Figure 1b.)

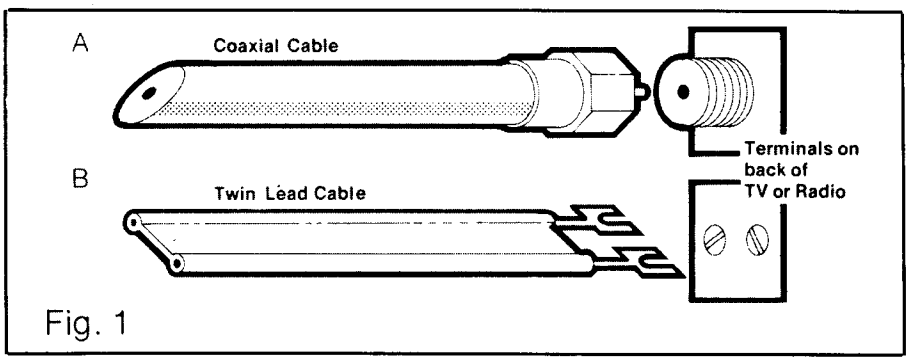


Fig. 1

2. Purchase the filter which matches the type of antenna wire coming from your set. The "impedance" information mentioned above will be on the filter label. DO NOT use a combination of twin-lead and coaxial cable without proper matching transformers (often called baluns). Filters are available in most stores that sell or repair television sets. Figure 2 provides a small example of what high-pass filters look like.

3. Carefully read the instructions that are provided with the filter. You will be installing the filter on the back of your TV set, as near to the antenna terminal as possible. The antenna terminal and the filter terminal will look like either Figure 1a or 1b depending upon the type of wire you are using — coaxial or twin lead.

4. If you are on a cable system, you may still install the filter at the antenna terminal. However, if the interference continues, contact the cable company repair service for assistance. DO NOT attempt to modify the cable system yourself.

5. The following information on installing the filter should answer any additional questions you may have.

a. Disconnect the antenna wire (twin-lead or coaxial) from the television set antenna terminals.

b. Connect the wire from the antenna to the input terminals of the filter.

c. For twin-lead wire, connect a very short (1" to 2") "jumper" wire from the antenna input terminals of the set to the filter (see Figure 3). For coaxial cable, it will be necessary to obtain a jumper cable that has the proper connectors already installed. (This can be purchased at the time you buy the coaxial filter.)

d. Be sure that in the case of *twin-lead wire,* the actual wires are making contact with the terminals. For *coaxial cable,* be sure the connector plugs are properly installed on the coaxial cable.

e. If you have an amplifier in your antenna system, you should have a filter installed ahead of the amplifier and another filter ahead of the TV receiver input terminals (see Figure 4). If the amplifier is located close to the receiver, then install the filter before the amplifier only.

Note: BOOSTER amplifiers usually are located near the back of the TV set; MAST MOUNTED (Outdoor) amplifiers are usually located on the antenna; and DISTRIBUTION amplifiers are usually located somewhere in the distribution system. If a distribution amplifier is in your antenna system, then be sure to trace the entire length of the antenna system, because amplifiers are usually in out-of-the-way places (for example — clothes closets, basements, etc).

f. The connecting wires between the filter and amplifier, and between the amplifier and antenna terminal, should be as short as possible.

g. The instructions provided with the filter you bought may call for a ground connection. The wire should be as short as possible and connected between the high-pass filter ground terminal and a metallic cold water pipe or a ground rod. Use bell wire for this connection (see Figure 3). Bell wire can be obtained from most variety stores.

h. If installations of the filter at the TV antenna terminals does not entirely eliminate the interference, you should then contact your service representative to install a high-pass filter inside the TV set at the tuner input terminals. INTERNAL modifications to your set should be done ONLY by a service representative. Information to assist your service representative is contained in the Technical Information for Service Representatives section.

Home Remedies for Resolving Electrical Interference

Electrical interference is caused by two sources:

1. Vehicle ignition systems,
2. Electrical devices.

The first step in attempting to resolve electrical interference problems is to locate the source of interference.

Interference from Vehicle Ignition System

1. Ignition interference sounds like a "popping" noise in the sound system of your TV that rises in intensity; the "pops" occur closer and closer together as the speed of the engine speeds up. This can be caused by any vehicle ignition system, such as gasoline operated lawn mowers, snowmobiles, automobiles, etc.

2. If the interference is to television receivers, you may hear the same popping noise in the sound and also see "dancing dots" in the picture of the set. You may only see the interference, and not hear the "popping" noise in the sound.

3. If your own vehicle is causing interference, you may wish to install a commercially manufactured kit in your vehicle to reduce the ignition noise. Other

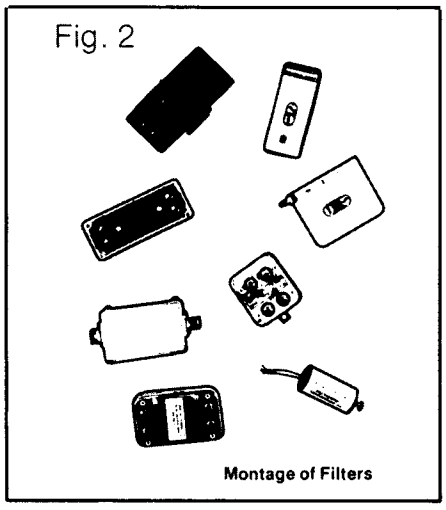


Fig. 2
Montage of Filters

remedial measures include relocating your antenna, raising the antenna, and using shielded lead-in antenna wire.

Interference from Electrical Devices

1. Any one or more of the following electrical devices may be causing the interference you are experiencing on your television set or AM/FM radio:

Electric razor, Vacuum cleaner, Fan, Drill, Electric blankets, Bake ovens, Fluorescent lights, Arc lights, Light dimmer controls, Relays, Static from machinery, Lightning arrestors, Adding machine, Cash register, Circuit breakers, Ultra-violet lamps, Germicidal lamps, Defective wiring, Loose fuse, Arc welder, Switch contacts (such as on dishwashers and other home appliances), Refrigerator, Water pump, Sewing machine, Light blinkers (including Christmas tree light blinker), Electric heating pads, Aquarium warmers, Neon signs, Door bell circuits/transformers, Toys (such as electric trains), Sign flashers, Antifriction bearings, Printing press static eliminators, Calculator, Insulators, Incandescent lamp (new or old), Sun lamps, Electrical pole (ground wire cut or poor contact), Loose electrical connection, Electric fence unit, Furnace controls, Power company transformers, Smoke precipitators.

2. In attempting to locate the specific device causing the interference, consider the following suggestions:

a. If you have a portable radio that is affected by the interference, use the radio as a detection device to assist in locating the source of interference. With the portable radio, move from room to room and determine in which room the interference appears to be the loudest. Then look for one of the devices listed above and unplug it to see if the interference disappears. If several devices listed above are in the room, unplug them, one at a time, until the interference disappears.

b. If a portable radio is not affected, you can go to the main fuse or circuit breaker box in your home, remove one fuse at a time, or shut off one breaker at a time, and see if the interference goes away.

c. If it does not go away when the first fuse or circuit breaker is off, replace the fuse or turn the circuit breaker back on and continue on until the interference does disappear. When the circuit that supplies the power to the TV or radio is turned off, it will be necessary to plug that device into some other circuit to determine if the interference is being generated by a device in the same room as your TV or radio.

d. When the interference disappears with a fuse removed or circuit breaker off, you should go to the room supplied by that circuit and look for any of the devices listed above. If any of the listed devices are found in the room, replace the fuse or turn the circuit breaker back on. Then unplug the device suspected of causing the interference. If several devices are in the room, unplug them, one at a time.

3. If you are unable to locate within your own home the device that is causing the problem, the interference may be coming from a device located in your neighbor's home. With the cooperation of your neighbor, follow the same procedures described above.

4. If your investigation leads you to suspect that a power line or power company equipment is the source of interference, you should contact the power company to assist you in resolving the problem.

5. Short duration interference, such as that from electric drills and saws, may be very costly to attempt to eliminate; you may just want to "live with it."

6. To *resolve* electrical interference, modifications must be made to the interfering device. This should only be done by a qualified service representative. Information for your service representative is contained in the Technical Information for Service Representatives section.

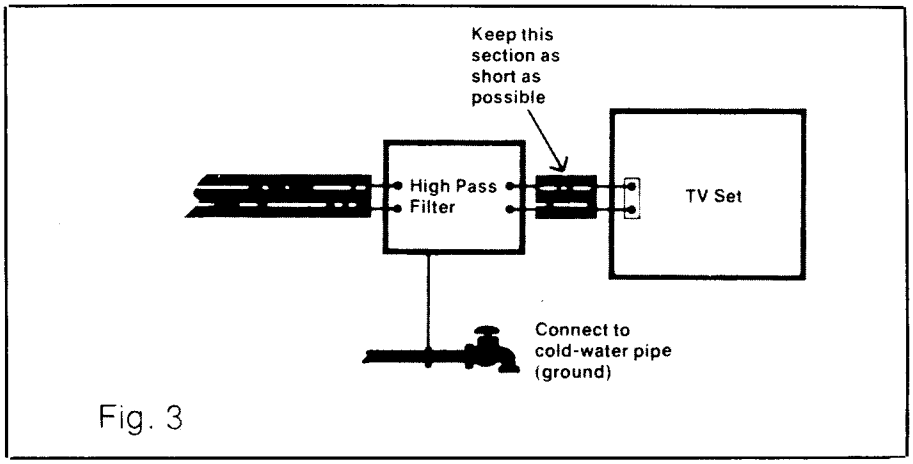


Fig. 3

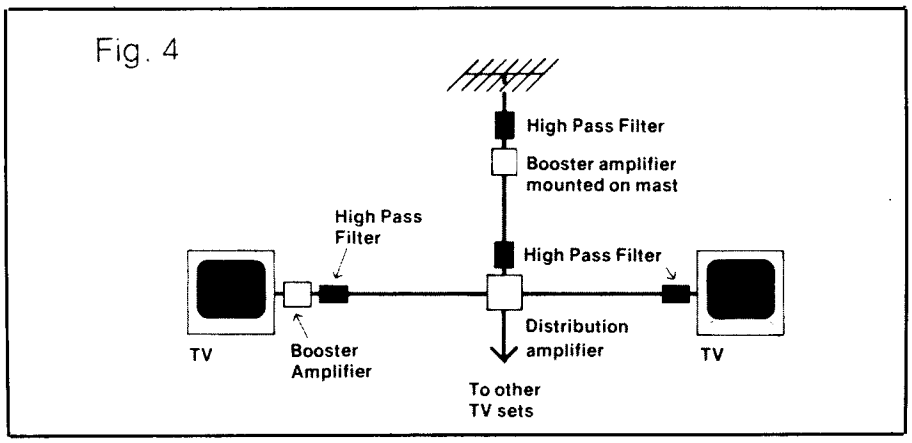


Fig. 4

Home Remedies for Resolving FM Interference

The installation of an inexpensive FM band rejection filter is the first step to take in resolving FM interference. In making this installation, follow these procedures:

1. Determine the type of antenna wire you have connected to your TV set. There are two possibilities:

Coaxial Cable — a round lead-in wire which requires a filter "impedance" of 75 ohms (see Figure 1a).

Twin Lead Wire — a flat wire which requires a filter "impedance" of 300 ohms (see Figure 1b).

2. Purchase the appropriate filter, according to the type of antenna wire you have. The "impedance" information mentioned above will be on the filter label. DO NOT use a combination of twin-lead and coaxial cable without proper matching transformers (often called baluns). Filters are available in most stores that sell or repair television sets.

3. Carefully read the instructions that are provided with the filter. You will be installing the filter on the back of your TV set, as near to the antenna terminal as possible. The antenna terminal and the filter terminal will look like either Figure 1a or 1b depending upon the type of wire you are using — coaxial cable or twin-lead wire.

4. If you are on a cable system, you may still install the same FM band rejection filter at the antenna terminal. However, if the interference continues, contact the cable company repair service for assistance. DO NOT attempt to modify the cable system yourself.

5. The following information on installing the filter should answer any additional questions you may have.

a. Disconnect the antenna wire (twin-lead or coaxial) from the television set antenna terminals.

b. Connect the wire from the antenna to the input terminals of the filter.

c. For twin-lead wire, connect a very short (1" to 2") "Jumper" wire from the antenna input terminals of the set to the filter (see Figure 3). For coaxial cable, it will be necessary to obtain a jumper cable that has the proper connectors already installed.

d. Be sure that in the case of TWIN LEAD WIRE, the actual wires are making contact with the terminals. For COAXIAL CABLE, be sure the connector plugs are properly installed on the coaxial cable.

e. If you have an amplifier in your antenna system, you should have a filter installed before the amplifier and another filter ahead of the TV receiver input terminals (see Figure 4). If the amplifier is located close to the receiver, then install the filter before the amplifier only.

Note: BOOSTER amplifiers usually are located near the back of the TV set; MAST MOUNTED outdoor amplifiers are usually located on the antenna; and DISTRIBUTION amplifiers are usually located somewhere in the distribution system. If a distribution amplifier is in your antenna system, then be sure to trace the entire length of the antenna system, because amplifiers are usually in out-of-the-way places (for example — clothes closets, basements, etc).

f. The connecting wires between the filter and amplifier, and between the amplifier and antenna terminal, should be as short as possible.

g. The instructions provided with the filter you bought may call for a ground connection. The wire should be as short as possible and connected between the FM band rejection filter ground terminal and a metallic cold water pipe or a ground rod. Use bell wire for this connection (see Figure 3). Bell wire can be obtained from most variety stores.

h. If the filter does not entirely eliminate the interference, you should call your service representative. The Technical Information for Service Representatives Section is provided to assist the service representative.

Audio Interference

Identification of Audio Interference

Interference to audio devices, such as tape recorders, record players, electronic organs, telephones, hi-fi amplifiers, etc., is caused when the equipment responds to the transmission of a nearby radio transmitter.

Audio interference (often called audio rectification) may also affect the sound (audio) portion of your TV and AM/FM radio.

When this type of interference is occurring, you will hear the voice transmissions of the radio transmitter and/or the volume level of the audio device you are using may decrease.

If you have determined that this is the type of interference you are receiving, refer to the following Home Remedies section for suggested methods for eliminating audio interference.

Home Remedies for Resolving Audio Interference

Audio interference is a condition that usually requires internal modification of your equipment. For safety reasons, it is recommended that any modifications be made by a qualified service representative.

Due to the complexity of resolving interference to an electronic organ, again, servicing should be done only by an experienced service representative. More detailed information should be obtained from the equipment manufacturer.

For telephone interference, contact your local telephone company. They can install a 1542A or similar inductor in the telephone instrument to resolve the problem. The information provided in this bulletin applies primarily to privately-owned equipment and should not be applied to equipment owned by the telephone company. Bell System personnel can obtain additional data in Section 500-150-100 of the "Bell System Practices — Plant Series" manual.

For all other audio devices, you may wish to take the following steps before calling your service representative.

1. Replace UNSHIELDED wire between the amplifier and speakers with SHIELDED wire.

2. Ground the affected equipment to a metallic cold water pipe or ground rod. A ground connection can be made with a short piece of "bell wire" which can be obtained at most variety stores. DO NOT ground "AC-DC" type devices. Normally devices which may safely be grounded will provide a grounding terminal. If no terminal is provided, then you should consult a qualified service representative for advice.

3. If the interference is not eliminated after taking these steps you must call a qualified service representative. The Technical Information for Service Representatives section is provided to assist your service representative in resolving the problem. You may also wish to discuss the matter with the operator of the radio transmitter, sharing the information in the Radio Operator Guidelines section of this bulletin.

Resolving Radio Transmitter Interference

There are no set procedures for eliminating television interference — it is a matter of eliminating the most likely sources of interference a step at a time. You may be required to take several steps before the interference problem is resolved. Once you have installed the filter called for, or made the adjustment that you were instructed to do, leave the modifications in place and proceed to the next step. To begin, check to see if a high-pass filter has been installed on the TV set at the antenna terminals. If not, read the Home Remedy information beginning on page 50. If the interference is still present after the installation of a high-pass filter proceed with the following steps.

Check Radio Transmitter

1. Contact the operator of the radio transmitter identified as the source and, with his/her cooperation, determine if the transmitter is operating properly. You may also wish to share the Radio Operator Guidelines section of this bulletin with the operator. Areas of concern should be:

a. Is the transmitter properly grounded? (This means a good radio frequency [RF] ground. A single piece of wire to a ground rod may be an open circuit to RF).

b. Are harmonics and/or spurious emissions present?

c. Is the transmitter cabinet radiating energy?

2. If the transmitter is not grounded, connect the chassis to a good earth ground with large diameter wire or copper strap. This should assist in eliminating radiation of energy from the cabinet.

3. Next, install a low-pass filter on the transmitter antenna circuit to see if any difference occurs in the interference pattern. If a change occurs, the interference is probably caused by harmonics and/or spurious emissions from the transmitter. If no change occurs in the interference pattern, it is probably being generated at some point in the TV reception system.

Check TV Reception System

1. Conduct a visual inspection of the TV antenna, lead-in wire, and lightning arrestors. This may reveal a source of trouble. Corroded connections or deteriorated lead-in wire could be at fault and should be repaired.

2. Assuming no faulty conditions are found, or if found, they are corrected, and the interference is still present, look for an amplifier in the line. Amplifiers are highly susceptible to radio frequency (RF) energy.

Note: BOOSTER amplifiers usually are located near the back of the TV set; MAST MOUNTED (outdoor) amplifiers are usually located on the antenna; and DISTRIBUTION amplifiers are usually located somewhere in the distribution system. If a distribution amplifier is in the antenna system, then be sure to trace the entire length of the antenna system, because amplifiers are usually in out-of-the-way places (for example — clothes closets, basements, etc.).

3. If an amplifier is in the system, remove it from the circuit. If you find that this eliminates the interference, reconnect the amplifier, but protect the amplifier by a) grounding, b) enclosing it in a metallic rf-proof housing and grounding the housing, or c) installing a high-pass filter at the input to the amplifier. If one filter improves the condition, but does not entirely eliminate the interference, install two filters in series.

4. If no amplifier is utilized, or the interference still persists after following one or all of the above steps, check the TV receiver system.

Check TV Receiver System

1. An AC power line RF filter should be installed to determine if the RF from the transmitter is entering the TV via the power cord. (A line filter may be either purchased or one may be constructed by following the schematic in Figure 5.).

2. If no change is found with the power line filter installed, and the antenna disconnected, then the set itself is responding to the RF energy.

3. The most likely internal circuit in the set to be affected by a radio transmitter is the tuner. Disconnect the antenna input lead inside the set directly at the tuner. If the interference is eliminated, then install a high-pass filter at the tuner.

4. If the interference is still present after installing the filter at the tuner, it will be necessary to refer to service data for the set and check each stage of the set for undesired response.

CB Interference to TV Channel 2

1. Second harmonic interference from a CB transmitter to Channel 2 television may exist even though the transmitter meets FCC specifications for harmonic radiation. In such cases, a tuned filter across the antenna terminals of the television should help. The filter may be an inductor and capacitor in series as in Figure 6. The filter should be tuned for minimum interference.

2. A second method is to put an open circuit, quarter-wave, tuned stub across the antenna terminals. The stub should be made of the same type of wire as the antenna input terminals of the television. The initial stub length should be 37" for RG-59/U coax; and 48" for 300 ohm twin lead.

3. After connecting the stub, cut the unterminated end of the stub off in 1/8"

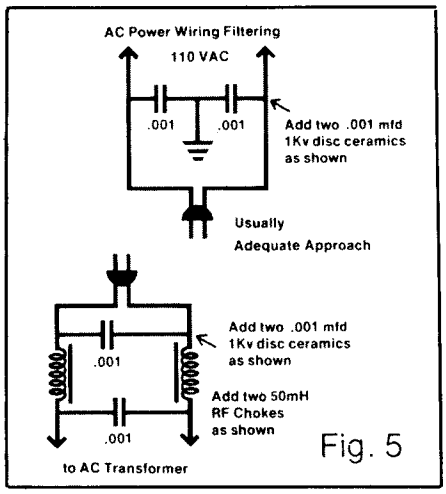


Fig. 5

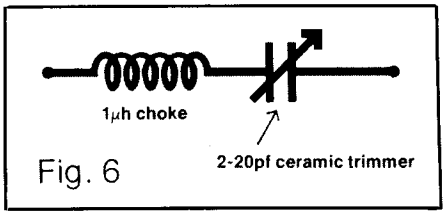


Fig. 6

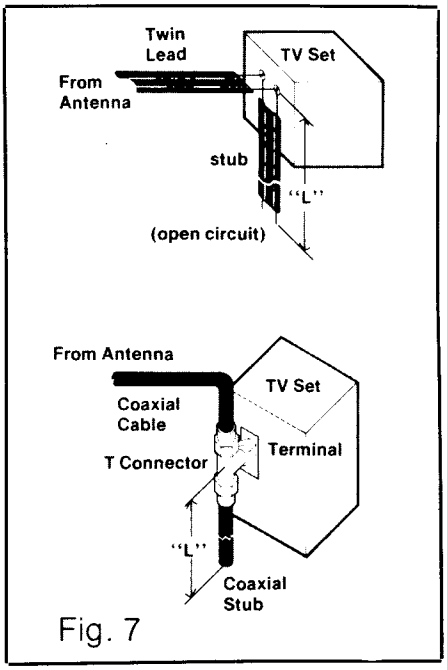


Fig. 7

to 1/4" sections until the interference is eliminated. Refer to Figure 7. For harmonics falling on other TV channels, such as channel 5, 6, or 9, the length of the stub may be approximately shortened according to the following formula.

$$\text{Length in inches} = \frac{2952V}{f}$$

where **V** = Velocity factor of line
and **f** = frequency in megahertz

Amateur Interference to TV Channel 2

1. One additional type of interference from a nearby transmitter is unique to the amateur 6 meter band — 50-54 MHz. Since 6 meters is immediately adjacent to Channel 2 television (54-60 MHz), interference to Channel 2 may occur.

2. In most cases, installation of an open circuit, quarterwave, tuned stub at the antenna terminals of the television set should be effective. It should be connected as shown in Figure 7.

3. If RG-59/U is used as the TV lead-in wire, the initial length of the stub should be 42". If 300 ohm twin lead is used, the initial length should be 53".

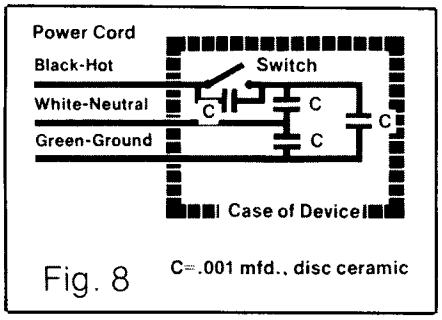


Fig. 8 C=.001 mfd., disc ceramic

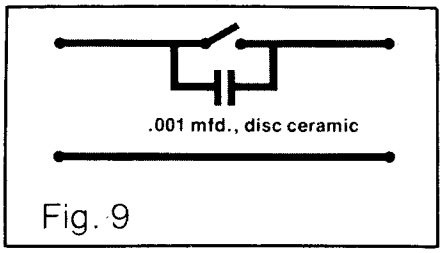


Fig. 9

4. After the stub is attached to the television, begin cutting off the unterminated end of the stub 1/8" to 1/4" at a time until the interference is eliminated. If the interference is reduced, but not eliminated by this method, add a second stub directly to the input terminals of the tuner. The theoretical final length of the stub should be:

$$\text{Length in inches} = \frac{2952V}{f}$$

where **V** = Velocity factor of line
and **f** = frequency in megahertz

5. If the interference continues, share the information in the Radio Operator Guidelines section with the operator of the radio transmitter.

Resolving Electrical Interferences

1. Please read through the procedures outlined in the Home Remedies section, beginning on page 50, before proceeding. If the steps in the previous section have been taken, you should now know the source of the interference.

2. Before proceeding with the following steps to modify the device located as the source of interference, you should check the local electrical codes to determine if the device may be modified, and whether a licensed electrician must modify the device.

Caution: All bypassing of devices with capacitors should be done with extreme care to insure that the capacitors do not short out the AC line. Dangerous voltages exist which can cause electrocution if mishandled. Also, avoid power wiring which can cause the full AC line voltage to appear on the case of the device.

3. Since interference from an electric drill or saw may be of short duration, we suggest no modifications be made to the device. Mainly because it may be very difficult and time-consuming to modify the device. If, however, interference is of long duration, and you wish to take on this task, proceed as follows:

a. Interference from a drill or saw is actually caused by arcing between the brushes and commutator. The interference then is transmitted through the power cord. Bypassing each side of the line to ground with a capacitor, and each side to the other may be helpful. Also bypass the switch. Figure 8 shows the schematic involved. The bypassing should be internal to the device in question.

4. Electric blankets, fish tank heaters, and other thermostatically controlled appliances, with worn and pitted contacts, cause interference because of contact arcing of the breaker points. This can be eliminated by bypassing the contacts with a .001 mfd capacitor or replacing the worn or pitted contacts. (See Figure 9.).

5. Defective devices such as doorbell transformers should be replaced.

6. Dimmer switches that utilize an SCR or triac can produce tremendous interference and it is very difficult to eliminate. This is due to the approximate square wave output that is produced by the switching at the SCR or triac. However, bypassing in a manner shown in Figure 10 may be helpful.

7. Since resolving electrical interference has to proceed on a case-by-case basis, you should always consider adequately bypassing any component of the circuit that arcs or distorts the AC sine wave with ceramic condensers.

Resolving FM Interference

Tbere are no set procedures for eliminating FM interference — it is a matter of eliminating the most likely sources of interference a step at a time. You may be required to take several steps before the interference problem is resolved. Once you have installed the filter called for, or made the adjustment that you were instructed to do, leave the modifications in place and proceed to the next step.

1. To begin, check to see if an FM band rejection filter has been installed on the TV set at the antenna terminals. If not, read the Home Remedies section of this bulletin, beginning on page 50.

2. If the installation of an FM band rejection filter is not effective, then a tuned stub trap should be constructed (see example in Figure 11). The trap should be placed on and parallel to the lead-in and tuned for minimum interference. Then slide the trap along the line to further reduce interference. Finally, tape the trap to the lead-in in the most effective position.

3. Another type of stub, called an open circuit quarter-wave type, can be made from the same type of wire as the antenna lead-in wire (see Figure 12). The initial

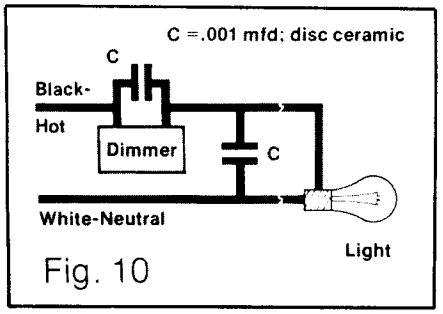


Fig. 10

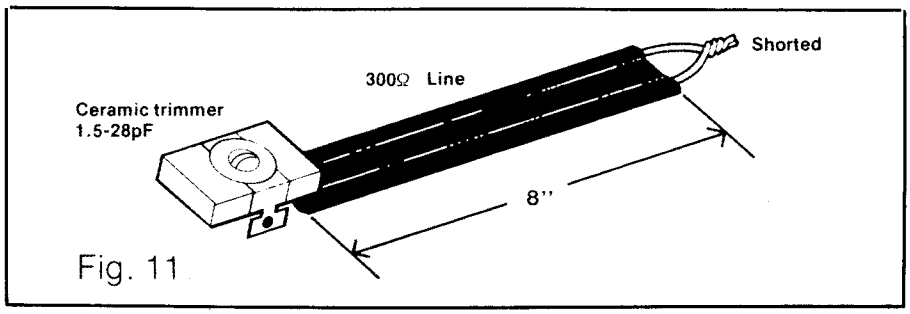


Fig. 11

length of the stub should be 24" for RG-59/U coaxial cable or 29" for 300 ohm twin-lead wire. For other cables, the initial length can be determined by the general formula:
Length in inches = (35) (Velocity factor of line)

Note: If "f" type tee connectors are not available, you may use BNC type connectors.

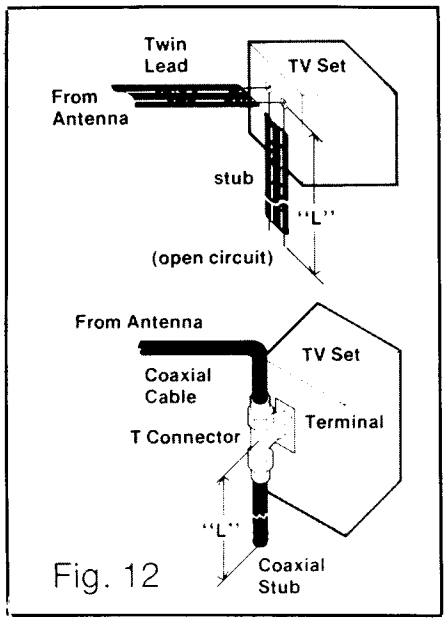


Fig. 12

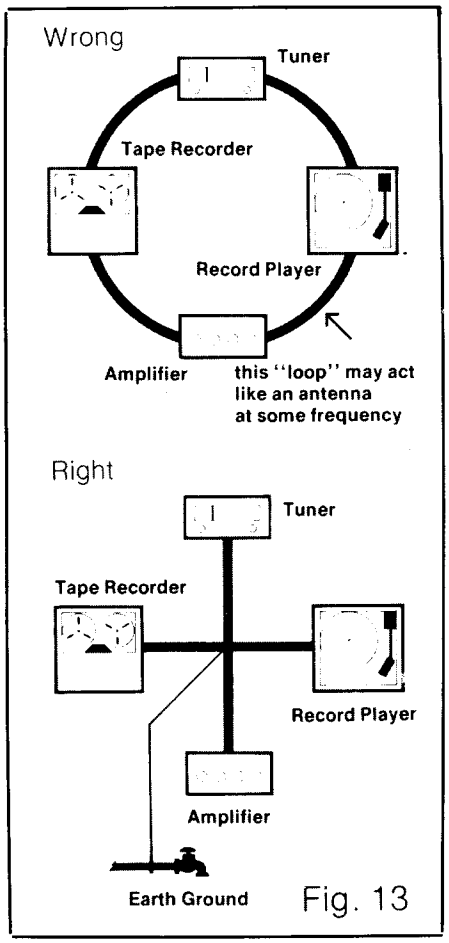


Fig. 13

4. If connecting the stub to the antenna terminals is not completely effective, connect a second stub of the same length directly to the input terminals of the tuner, inside the television set. This should eliminate the interference.

Resolving Audio Interference

1. Audio interference is defined as reception of radio frequency (RF) energy by an audio amplifier. The RF energy is then rectified, or more properly "detected," by an electron tube, transistor, diode, poor solder joint or ground, or integrated circuit. The detected signal is then treated identically as a normal audio signal appearing at the amplifier input terminals. The effects of audio interference vary with the type of modulation employed by the transmitter. The following chart shows expected effects:

AM — The voice or music will be heard as any normal audio signal applied to the amplifier. The voice or music may be extremely loud and slightly distorted.

SSB — Single Sideband — The voice will sound practically unintelligible and garbled.

FM — Usually no sound will be heard; however, a decrease in the volume of the amplifier will be noted when the radio transmitter is on. Clicks may be heard when a two-way radio transmitter is keyed and unkeyed. A "frying" noise (such as bacon sizzling) may also be heard.

TV — Audio rectification of a TV signal will sound like a buzz. The buzz will change its sound as the television picture changes.

2. In attempting to isolate where in the audio chain the rectification is taking place, check to determine if the volume control has any effect on the interference. If the volume of the interfering signal changes with a change in the volume control, then the rectification is occurring BEFORE the volume control. If the volume control has minimal or no effect, the rectification is occurring AFTER the volume control. You should next proceed to the appropriate set of solutions. If the solutions described below do not resolve the audio interference problem, contact the manufacturer of the audio device for further assistance.

Rectification Before the Volume Control

1. A multiple input audio amplifier may be susceptible to audio interference on only one or some of the available inputs. Generally, low-level, high-impedance inputs, such as those in turntables, cartridges, tape heads, or microphones, are the most susceptible. If, for example, the only input affected is from a turntable, then disconnect the turntable cartridge from the amplifier at the input terminals of the amplifier.

2. If the interference is eliminated, then the cartridge, or wire between the cartridge and amplifier, is sensing the RF. Proper grounding, connections, shielding, and RF bypassing are the keys to solving audio rectification. Often, a "process of elimination" approach must be used.

Grounding

1. All grounding should be to a good earth ground such as a metallic cold water pipe or 8' ground rod. Ground leads should be as short as possible. Remember, a DC ground may appear as an open circuit to RF energy. Ground leads should be of as large a diameter wire as practicable. Finally, grounding of the chassis, shields of speakers leads, and other external connections should be made to a common point to avoid ground loops. (Ground loops are circuits that form a DC ground, but contain RF circulating currents.) Figure 15 shows the correct and incorrect methods of grounding components.

Caution: Some equipment chassis are at line voltage potential and cannot be connected directly to ground. In these circumstances, a ceramic capacitor of 0.001 mfd at 1Kv should be placed in the ground lead. This capacitor appears as a short to RF, but an open circuit to AC.

Shielding

1. All speaker leads from audio equipment should be made of two conductor shielded wires. The shield should be grounded only at the amplifier end, and should not be used as an audio

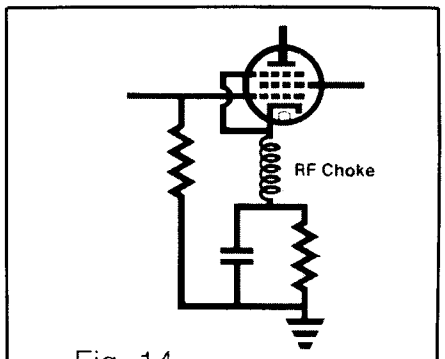


Fig. 14

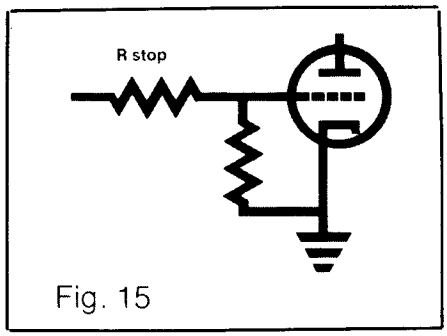
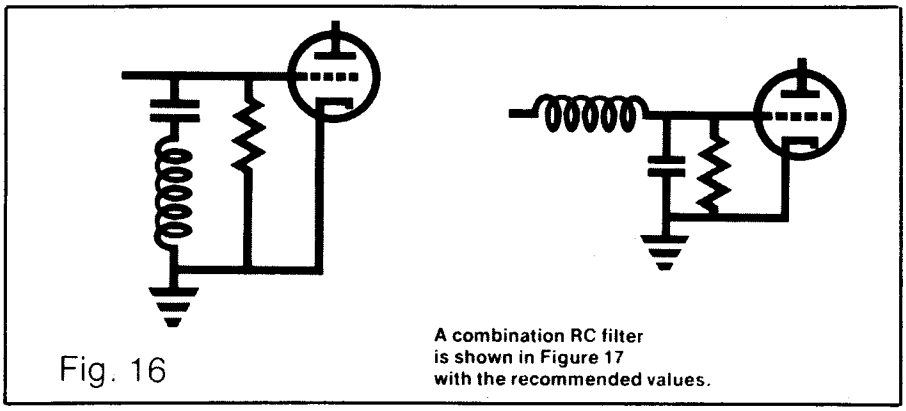


Fig. 15



A combination RC filter is shown in Figure 17 with the recommended values.

Fig. 16

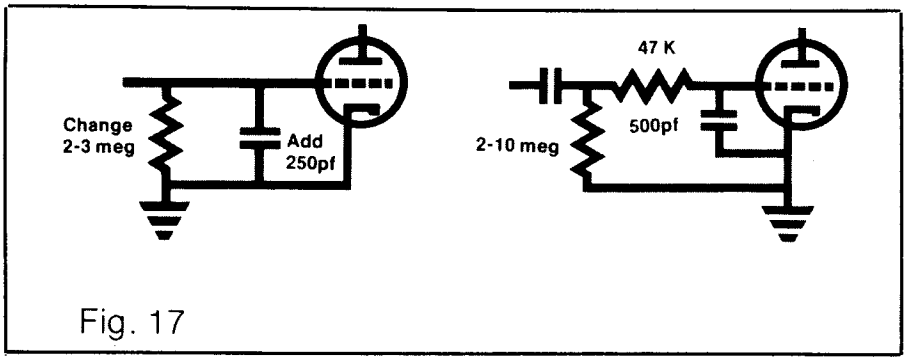


Fig. 17

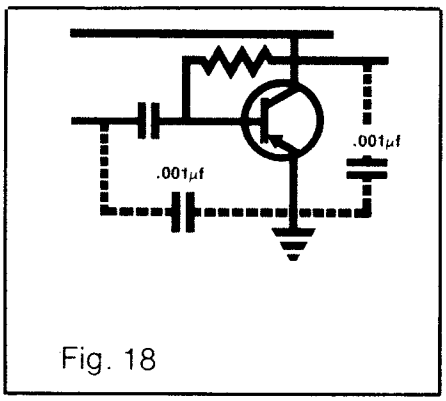


Fig. 18

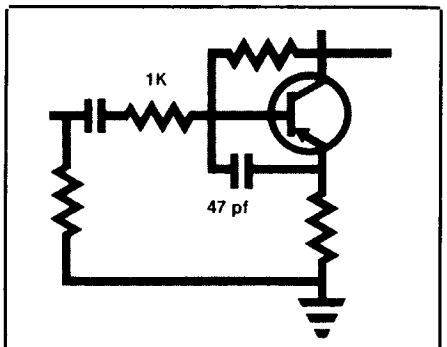


Fig. 19

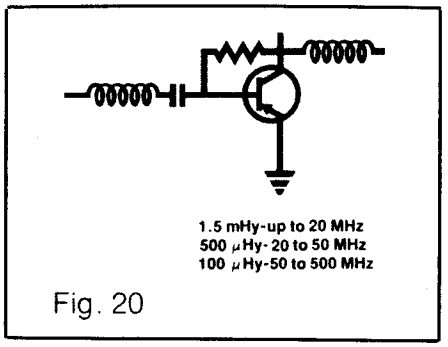


Fig. 20

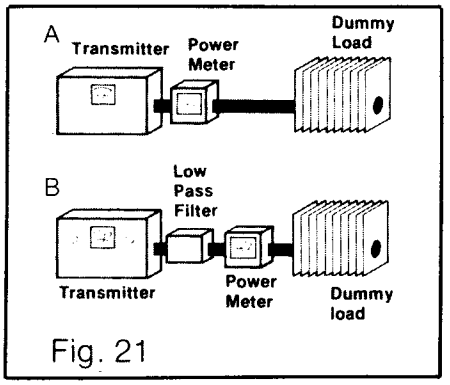


Fig. 21

conductor. The two internal wires should be connected to the speaker.

Power Line Filter

1. RF may be entering the audio device through the AC power line. Several power line filters are commercially available. If necessary, a power line filter like the one shown in Figure 5 may be constructed, placing the filter as close as possible to the point where the AC cord enters the amplifier.

Poor Electrical Connection

1. Occasionally, poor solder connections or old electrolytic capacitors may be the cause of the audio rectification problem. If tests to this point have failed, try resoldering all connections in the amplifier and replacing electrolytic capacitors. Before actually replacing the electrolytic capacitor, try paralleling the capacitor with another one of like value. This should reveal the presence of a bad capacitor.

Rectification After the Volume Control

1. When the volume control is in its minimum position, and the interference is still heard, then an RF filter is required in the audio amplifier. It is extremely important that the filter does not affect the audio response of the amplifier.

Tube Type Equipment

1. Interference in tube type equipment can be avoided by connecting an RF choke (ranging in value for 2 milihenry to 5 milihenry) in the upper end of the cathode circuit as shown in Figure 14.

2. The choke coil must NOT be bypassed by a capacitor because the DC resistance of such coil is generally quite low and the bias voltage is not greatly affected. However, if the DC resistance does affect the bias voltage, the value of the bias resistor may be decreased to compensate for the DC resistance of the choke.

3. A grid-stopping or "swamping" resistor can also be employed. A resistor, ranging in value from 1 k to 75 k ohms, can be connected in series with the grid as shown in Figure 15.

4. Capacitors, RF chokes and resistors can be used in combinations to make filters to eliminate the interference. For circuits such as those shown in Figure 16, use a choke of 2 to 6 microhenries and a capacitor of about 10 picofarads. A combination RF filter is shown in Figure 17 with the recommended values.

Transistor Equipment

1. Interference in transistor equipment can usually be eliminated with the use of a shunt capacitor as shown in Figure 18. A resistor/capacitor combination can be used as shown in Figure 19. It is important that the filter network does not affect the biasing of the transistor of the frequency response of the amplifier.

2. The values of the capacitors used are not critical, but there are some pitfalls to look out for in using capacitors. For example, ceramic caps are best, whereas paper caps do not work at radio frequencies.

3. Leads should be kept as short as possible. Grounds should be made directly to the emitter and not to the chassis or other grounds, since they may have more RF than the signal lead. If the signal increases, then a ground loop has been created, and the inductor method should be tried.

4. In areas of high RF energy, the inductor approach is more effective than the shunt capacitor. An RF choke can be

used in series with the input and output leads of the amplifier stage since the RF can enter a stage through either. This method and the values are shown in Figure 20.

Electronic Organs

1. Organ circuits can be isolated by the use of the Swell Pedal, band box volume, or tabs (draw bars). By adjusting each one of these different controls, the effect on the interference can be noted. If the volume of the interference changes, the RF is being detected by the amplifier at a point before that particular control. If the volume of the interference does not change, then the interference is being detected after that control.

2. Using this method, the point at which the RF is entering the organ can be determined, and the appropriate filter, as described above, can be inserted into the circuit.

Telephones

1. Telephone RF interference can be eliminated by the use of a 1542A or similar inductor. This inductor must be installed inside the phone and not at the baseboard. To install the inductor inside the phone, the corners of the plastic container will have to be removed. If the phone is too small for the inductor, such as the "Princess" telephone, then a pair of 2.5 mH chokes (75 ma or higher) must be installed inside the phone, one on each side of the line and as close to the 211A equalizing network as possible.

Note: The information provided here applies primarily to privately owned equipment and should not be applied to equipment owned by the telephone company. Telephone company owned equipment should be modified only by telephone company personnel. Bell System personnel can obtain additional data in Section 500-150-100 of the "Bell System Practices — Plant Series" manual.

References

1. *The Audio Cyclopedia* by Howard M. Tremline, Howard W. Sams and Co., Inc.
2. *Radio Handbook* by William I. Orr, Editors and Engineers, Ltd.
3. *The Radio Amateur's Handbook* by American Radio Relay League.
4. *Thomas Tech-Flash,* Thomas Organ Co., Sepulveda, California.
5. "Filtering RF Interference in Audio Equipment," by R.S. MacCollister from Journal of the Audio Engineering Society, April 1968, Pages 210, 212, 214.
6. *Stopping Telephone Interference* by Irvin M. Hoff, *QST*, March 1968, pages 46-47.

Radio Transmitter Operator Guidelines

Resolution of Interference for Radio Transmitter Operators

Although some interference problems can be attributed to television receivers, such problems can also be traced to CB radio transmitters. Therefore, upon receipt of an interference complaint from your neighbor(s), you should take all steps possible to insure that your radio transmitter is not causing the interference. Voluntary installation of a low-pass filter, or other steps as outlined below, may eliminate the interference, and may prevent you from receiving an order from the Commission to implement these measures. You are not, however, required to service or add filtering to the complainant's television, and should not take any such action without the full cooperation of your neighbors.

You are cautioned that the use of an amateur transceiver on the Citizens Band is illegal. Further, the use of external RF power amplifiers with CB transceivers is illegal. Both actions may subject you to Commission actions or criminal penalties.

Generally, transmitter equipment that is commercially manufactured and type-accepted by the Commission has precautions built into the set to reduce harmonic radiation. Harmonics are radiations that are multiples of the operating frequency. However, you should follow the steps outlined below to insure that your radio equipment is operating properly.

1. If television interference is occurring, note which channels are affected.

a. Lower harmonics of CB generally affect TV Channels 2, 5, 6, and 9. Therefore, if one or more of these channels are affected, your transmitter is probably radiating harmonics.

b. If all TV channels are affected, the problem is more likely to be in the TV receiver.

2. If the interference is caused by harmonics, a spectrum analyzer, a calibrated field intensity meter, or frequency selective voltmeter, can be used to accurately measure harmonic and spurious radiations from your transmitter. If any lead-in devices, such as standing wave ratio (SWR) meters are used, measurements should be made with the inline device both installed and removed. This may help identify the interference and lead you to the source. These are complex measurements and should normally be made only by experienced technicians.

3. If it appears that your transmitter is at fault, you should first make sure the chassis of the set is secured to the metal case of the radio by tightening the screws holding the chassis and case together. Then assure that the case of the transmitter is grounded to a good earth ground (metallic cold water pipe or 8 foot ground rod). Solid conductor wire of at least No. 10 gauge or copper ribbon should be used as a ground lead. The lead should be as short as possible.

4. By installing one or more low-pass filters in the transmitter antenna lead, you will reduce the chances of unnecessary harmonic radiation. A low-pass filter allows frequencies up to 30 or 50 megahertz (MHz), depending on brand, to pass through unattenuated to the antenna while effectively shorting out harmonic radiation. To make this test, connect the equipment as in Figure 21 and take a power reading. If only an SWR Bridge is available, calibrate it in the forward direction to the calibrate line in the meter. Then insert the low-pass filter and make another power measurement. DO NOT retune the transmitter.

5. If you notice a decrease in output power on a power meter, operating to a properly matched load, with the low-pass filter installed, this is an indication that harmonic content may be present. Even though the meter reading may be lower with the filter installed, it does not mean that the transmitter absolutely has harmonic radiation. Slight detuning of the transmitter by the filter may cause a lower indication.

6. At amateur power levels, corroded metal connections in the area of the transmitting antenna may act like diodes and generate harmonics which may radiate. This type of problem can be found by vibrating suspected offenders such as galvanized downspouts, metal fences, clothes lines, etc., while viewing the affected television set. Sudden changes in the interference pattern which correspond to the vibration should be noted. This test requires an observer at the TV receiver, someone to "shake" suspicious metal objects in the area, and another person to key (but NOT modulate) the transmitter involved.

7. Finally, some transmitters may actually be radiating harmonic and spurious energy from their cabinet or through the power lines. Try operating the transmitter into a shielded dummy load. If the interference is still present, then cabinet or power line radiation is indicated. A power line filter should be installed. Several types are commercially available. For low power transmitters, the filter in Figure 5 may be used.

8. Continued interference with the power line filter installed points toward cabinet radiation. An earth ground should eliminate cabinet radiation.

9. Local Television Interference (TVI) Committees dedicated to resolving CB-TVI problems are now being established.

For assistance in locating a TVI Committee in your area, contact: International CB Radio Operators Association (CBA), P.O. Box 1020, Roanoke, VA 24005.

Resolution of Interference for Amateur Transmitter Operators

1. If you have a linear amplifier on your amateur transmitting equipment, use two low-pass filters. One filter should be installed between the actual transmitter (exciter) and the input to the linear amplifier. (This prevents harmonics generated in the exciter from reaching the linear amplifier.) The second filter should be installed at the output of the linear amplifier to reduce harmonic and spurious content.

2. One unique interference problem to TV Channel 2 is from an amateur transmitter operating on the 6 meter band. This is due to the close proximity of the frequencies involved. You may wish to follow the procedures outlined in the Technical Information for Service Representatives section, page 53, to eliminate this type interference. You are not, however, required to service or add filtering to the complainant's television, and should not take any such action without the full cooperation of your neighbor.

3. Local Television Interference (TVI) Committees are available to assist you in resolving interference problems. Contact the nearest FCC district office (see addresses below) or the American Radio Relay League, Newington, Connecticut, for assistance in locating a TVI committee in your area.

Radio Transmitter Operator Guidelines for Resolving Audio Interference

Although audio interference (often called audio rectification) is usually resolved by modification of the affected device, you as a radio operator can take certain steps to reduce the possibility of audio rectification by eliminating circulating radio frequency (RF) currents in grounds and metal objects in the area.

1. Your radio transmitting equipment should be effectively grounded to a metallic cold water pipe or a ground rod driven into the ground at least 8 feet. The ground lead must be at least No. 10 wire or copper ribbon. The greater the surface area of the ground lead, the more effective it will be. Also, the ground lead should be as short as possible.

2. You are reminded that you are licensed to use only the amount of power necessary to establish communications. Operating with excessive power is likely to cause audio interference problems.

3. If you need assistance in performing the above modifications to your equipment, you can contact the dealer or manufacturer representatives. Also, an FCC-licensed service representative may be able to assist you.

Addresses of FCC District Offices

Listed below are the addresses and telephone numbers of the FCC district offices. This list is alphabetical by state, and also includes offices in Puerto Rico and the District of Columbia (Washington, DC).

You are reminded that the information requested in the FCC bulletin reproduced on page 19 will be required in order that a staff member may analyze your interference problem. Please forward this information by mail.

ALASKA, Anchorage
1011 E. Tudor Road, Room 240
P.O. Box 2955
Anchorage, Alaska 99510
Phone: Area Code 907 276-7455

CALIFORNIA, Los Angeles
3711 Long Beach Blvd.
Suite 501
Long Beach, California 90807
Phone: Area Code 213 426-4451

CALIFORNIA, San Francisco
423A Customhouse
555 Battery Street
San Francisco, California 94111
Phone: Area Code 415 556-7700

COLORADO, Denver
12477 West Cedar Drive
Denver, Colorado 80228
Phone: Area Code 303 234-6977

FLORIDA, Miami
919 Federal Building
51 S.W. First Avenue
Miami, Florida 33130
Phone: Area Code 305 350-5542

GEORGIA, Atlanta
Room 440, Massell Building
1365 Peachtree Street, N.E.
Atlanta, Georgia 30309
Phone: Area Code 404 881-3084

HAWAII, Honolulu
300 Ala Moana Blvd., Room 7304
P.O. Box 50023
Honolulu, Hawaii 96850
Phone: Area Code 808 546-5640

ILLINOIS, Chicago
3940 Federal Building
230 South Dearborn Street
Chicago, Illinois 60604
Phone: Area Code 312 353-0195

LOUISIANA, New Orleans
1007 F. Edward Hebert Federal Bldg.
600 South Street
New Orleans, Louisiana 70130
Phone: Area Code 504 589-2095

MARYLAND, Baltimore
George M. Fallon Federal Building
Room 1017, 31 Hopkins Plaza
Baltimore, Maryland 21201
Phone: Area Code 301 962-2728

MASSACHUSETTS, Boston
1600 Customhouse
165 State Street
Boston, Massachusetts 02109
Phone: Area Code 617 223-6609

MICHIGAN, Detroit
1054 Federal Building
231 W. Lafayette Street
Detroit, Michigan 48226
Phone: Area Code 313 226-6078

MINNESOTA, St. Paul
691 Federal Building
316 N. Robert Street
St. Paul, Minnesota 55101
Phone: Area Code 612 725-7810

MISSOURI, Kansas City
8800 East 63rd Street
Room 320
Kansas City, Missouri 64133
Phone: Area Code 816 926-5111

NEW YORK, Buffalo
1307 Federal Building
111 W. Huron Street at Delaware Ave.
Buffalo, New York 14202
Phone: Area Code 716 846-4511

NEW YORK, New York
201 Varick Street
New York, New York 10014
Phone: Area Code 212 620-3437

OREGON, Portland
1782 Federal Office Building
1220 S.W. 3rd Avenue
Portland, Oregon 97204
Phone: Area Code 503 221-4114

PENNSYLVANIA, Philadelphia
Oxford Valley Office Bldg., Room 404
2300 East Lincoln Highway
Langhorne, Pennsylvania 19047
Phone: Area Code 215-752-1324

PUERTO RICO, San Juan
747 Federal Building
Hato Rey, Puerto Rico 00918
Phone: Area Code 809 753-4008

TEXAS, Dallas
Earle Cabell Federal Building
Room 13E7, 1100 Commerce Street
Dallas, Texas 75242
Phone: Area Code 214 767-0761

TEXAS, Houston
5636 Federal Building
515 Rusk Avenue
Houston, Texas 77002
Phone: Area Code 713 226-5624

VIRGINIA, Norfolk
Military Circle
870 North Military Highway
Norfolk, Virginia 23502
Phone: Area Code 804 441-6472

WASHINGTON, Seattle
3256 Federal Building
915 Second Avenue
Seattle, Washington 98174
Phone: Area Code 206 442-7653

Addresses of DOC Offices

NEWFOUNDLAND: Department of Communications, P.O. Box 811, Corner Brook, NF A2H 6H6; Department of Communications, Sir Humphrey Gilbert Bldg., Room 612, Duckworth St., St. John's, NF A1C 5W1.

PRINCE EDWARD ISLAND: Department of Communications, 180 Kent St., Charlottetown, PE C1A 1N7.

NOVIA SCOTIA: Department of Communications, 6009 Quinpool Rd., Halifax, NS B3K 5J7; Department of Communications, 500 King's Rd., Sydney, NS B1S 1B2.

NEW BRUNSWICK: Department of Communications, 159 Main St., Bathurst, NB E2A 3Z1; Department of Communcations, 77 Vaughn Harvey Blvd., Moncton, NB E1C 8P9; Department of Communications, P.O. Box 7285, Station A, Saint John, NB E2L 4G7.

QUEBEC: Department of Communications, 942 Chabanel St., Chicoutimi, PQ G7H 5W2; Department of Communications, 19th Floor, 2085 Union St., Montreal, PQ H3A 2C3; Department of Communications, 32 Frederic Hebert Ave., Noranda, PQ J9X 1V2; Department of Communications, Suite 436, 2 Place Quebec, Quebec, PQ G1R 2B5; Department of Communications, 701 Laure Blvd., Sept Iles, PQ G4R 1X8; Department of Communications, 1650 King St., West, Sherbrooke, PQ J1J 2C3; Department of Communications, 86 Edifice Publique, P.O. Box 67, Trois Rivieres, PQ G9A 5E3.

ONTARIO: Department of Communcations, Alexandra Square, 135 James St. South, Hamilton, ON L8P 2Z6; Department of Communications, Federal Building, Room 154, Kenora, ON P9N 2X9; Department of Communications, Federal Building, Room 273, Clarence St., P.O. Box 633, Kingston, ON K7L 4X1; Department of Communications, 30 Duke St. West, Kitchener, ON N2H 3W5; Department of Communications, Government of Canada Bldg., 451 Talbot St., London, ON N6A 5C9; Department of Communications, Trebla Building, 473 Albert Street, Ottawa, ON K1R 5B4; Department of Communications, Suite 301, 222 McIntyre St. West, North Bay, ON P1B 8J5; Department of Communications, 421 Bay St., Sault Ste. Marie, ON P6A 5N3; Department of Communications, Dominion Public Bldg., 33 Court St., South, Thunder Bay, ON P7B 2W6; Department of Communications, 55 St. Clair Ave., East, Toronto, ON M4T 1M2; Department of Communications, 880 Ouellette St., Windsor, ON N9A 1C7.

MANITOBA: Department of Comunications, 436 Thompson Dr., Thompson, MB R8N 0C6; Department of Communications, 2300-One Lombard Pl., Winnipeg, MB R3B 2Z8.

SASKATCHEWAN: Department of Communications, 2101 Scarth St., Regina, SK S4P 2H9; Department of Communications, 206 Circle Drive East, Saskatoon, SK S7K 0T5.

ALBERTA: Department of Communications, 205-8th Ave. S.E., Calgary, AB T2G 0K9; Department of Communications, Financial Building, Room 300, 10025-106 St., Edmonton, AB T5J 1G6; Department of Communications, 202-11117-100 St., Grand Prairie, AB T8V 2N2.

BRITISH COLUMBIA: Department of Communications, 11-14th St. South, Cranbrook, BC V1C 2W9; Department of Communications, 471 Queensway, Kelowna, BC V1Y 6S5; Department of Communications, 3884-192-2nd St., P.O. Box 3396, Langley, BC V3A 3R7; Department of Communications, 1294-3rd Ave., Prince George, BC V2L 3E7; Department of Communications, Federal Building, Room 227, Prince Rupert, BC V8J 1G8; Department of Communications, 816 Government St., Victoria, BC V8W 1W9; Department of Communications, Room 300, 325 Granville St., Vancouver, BC V6C 1S5.

NORTHWEST TERRITORIES: Department of Communications, Post Office Building, P.O. Box 540, Fort Smith, NWT X0E 0P0; Department of Communications, Bellanca Bldg., P.O. Box 2700, Yellowknife, NWT H0E 1H0.

YUKON TERRITORY: Department of Communications, 201-4133, 4th Ave., Whitehorse, YT Y1A 1H8.

Chapter 8

Additional Sources of Assistance and Information

Does turning to this chapter mean than you are having trouble tracking down an elusive RFI problem? Don't panic! Don't despair! You are the great detective and must use all your clues. Take time to review all you know about your case. Are there still unanswered questions? Have you done all you can to isolate the cause or source of the interference? What happens when the TV antenna is disconnected? Does the interference persist in the headphones when the stereo speakers are unhooked? Most RFI problems can be cured with fairly simple and direct corrective measures. Other cases will require that more than one step be taken before the situation is resolved.

In chapter one, three factors were introduced that are essential to the resolution of an RFI problem: information, cooperation and action. While you are seeking information that will lead to the appropriate action, don't forget cooperation. You don't have to be a door mat to be cooperative. It is much easier to walk through the open gates of your neighbor's castle than to attempt to enter by force once the gates are closed and locked. Honesty, tact and diplomacy will serve you well as you deal with other people.

The remainder of this chapter consists of two lists. The first will help you make the appropriate contact if you have an RFI problem with a consumer product. The second is a bibliography of RFI-related material.

Consumer Products RFI Assistance List

If you are experiencing an RFI or TVI problem, contact the manufacturer at the address listed below. The companies listed have volunteered the information and should be willing to help. This list was developed by the ARRL RFI Tast Group. Special thanks to Hal Richman, W4CIZ.

Admiral

No longer in business. For parts, tel. 800-447-8361.

Akai American

Akai products include audio tape recorders, video tape recorders, a-m/fm receivers, speaker systems and related accessory products. Inquiries related to RFI should be addressed to the Customer Service Department, 800 W. Artesia Blvd., Compton, CA 90220, or to P. O. Box 6010, Compton, CA 90224, tel. 213-537-3880. "Upon receipt of these inquiries, we will investigate the situation and, to our utmost, try to resolve the customer's problems."

Allen Organ Company

When a complaint is received via a dealer, Allen Organ Co. sends the dealer an informational service bulletin on RFI and sufficient components to cover all amplifiers in the affected instrument. This service is offered at no cost to the customer. Refer RFI problems to the local Allen dealer. Inquiries may be made to Mr. David L. George, National Service Manager, Macungie, PA 18062, tel. 215-966-2200.

Altec Lansing International

Customer RFI problems are referred to the authorized Altec warranty stations located nationwide and denoted by an information card furnished with each piece of equipment. Unusual situations are, at the option of the warranty station, referred to Altec Customer Service, 1515 W. Katella Ave., Anaheim, CA 92803, tel. 714-774-2900, or to the Engineering Department, 1515 S. Manchester Ave., Anaheim, CA 92803, Attention: Chief Engineer, Electronics.

Apple Computer, Inc.

Apple products include business, professional, educational, scientific, industrial and home computers, peripheral devices, and software. These products are designed to be compliant with the FCC guidelines covering Class A and Class B computer devices. Inquiries related to RFI should be addressed to any of our more than 800 dealer-operated Level One service centers. If the service technicians there are unable to solve the situation, they will contact the Corporate Engineering Services Group.

Arvin Industries, Inc., Consumer Electronics Division

Customer problems involving RFI should be referred to Mr. John Currey, Manager Engineering Support Group, E. 15th St., Columbus, IN 47201, tel.

812-372-7271.

Audio Research Corporation

In the event of an RFI problem, the customer may write to Mr. Richard Larson, Chief Engineer, 6801 Shingle Creek Pkwy., Minneapolis, MN 55430, tel. 612-566-7570.

Baldwin Piano and Organ Company

RFI complaints are usually handled by the local Baldwin service technician. Factory personnel are available to assist a technician when needed. Baldwin maintains its own staff of technical representatives who travel in the field and may be called upon to assist a dealer technician with difficult problems, including RFI. Several Baldwin Technical Manual Supplements are available with specific instructions for RFI suppression on specific models. This information is readily available upon request. Inquiries may be directed to Mr. Gilbert C. Carney, Manager Organ Technical Service, Baldwin Piano and Organ Co., 1801 Gilbert Ave., Cincinnati, OH 45202, tel. 513-852-7838.

Bogen Division of Lear Siegler, Inc.

Bogen Division manufactures professional, commercial and industrial sound equipment. In the event of an RFI problem with any Bogen unit, write for the division's free Field Service Bulletin No. 59 about RFI signal interference, or contact Allen Guthman, Service Manager, Bogen Division/LSI, Box 500, Paramus, NJ 07652, tel. 201-343-5700.

Carver Corporation, Inc.

Carver Corporation manufactures high-fidelity components. Problems pertaining to RFI should be directed to the service manager, Mr. Philip Fenner, P. O. Box 664, 14304 N.E. 193rd Pl., Woodinville, WA 98072, tel. 206-487-3483.

Conn Keyboards, Inc.

RFI complaints should be referred to the local Conn dealer, whether instrument is in or out of warranty. Factory assistance is available to the dealers who are unable to correct the RFI. RFI problems encountered within the term of instrument warranty are usually corrected by the selling dealer without cost to the organ owner. Contact Mr. Thomas A. Umbaugh, National Service Manager, 350 Randy Rd. Carol Stream, IL 60187, tel. 312-653-4330.

Crown International

Crown International is the manufacturer of high-end audio products. RFI suppression is incorporated in the design of the product. If a customer should encounter an RFI problem, he may contact the Technical Services Department of Crown International, 1718 W. Mishawaka Rd., Elkhart, IN 46517.

Curtis Mathes

Curthis Mathes products include color TVs and stereos (100% solid state) in portable, console and combination configurations. Customer complaints involving RFI should first be resolved at the retail-dealer level. If not satisfied, then the complaint should be made in writing to the Consumer Relations Department giving all details of the problem, along with the model information, serial number, date of sale, dealer and service history. Each complaint will be handled individually. Write to Curtis Mathes Manufacturing Co., Curtis Mathes Pkwy., Athens, TX 75751, tel. 800-527-7646, Texas only tel. 800-492-9543.

Delco Electronics, Division of GM Corporation (see GM Corp.)

Dumont (see Emerson Quiet/Cool Corp.)

Electra Company, Division of Masco Corporation of Indiana

Electra Co. asks that RFI problems with "Bearcat," its automatic scanning radio, be referred to its service department at 300 E. County Line Rd., Cumberland, IN 46229, tel. 317-844-1440.

Emerson Quiet/Kool Company

Mr. Jerome Roth reports that his company has not made TVs or audio devices since 1972. As a continuing gesture of goodwill, however, Mr Roth suggests that customers may refer RFI problems with equipment previously marketed by Emerson Quiet/Kool Co. to him for recommendations, at the mailing address below. *Do not confuse* this company with Emerson Radio Corp., which is an entirely different, publicly owned corporation. Contact Emerson Quiet/Kool Co., P. O. Box 300, Woodbridge, NJ 07095, tel. 201-381-7000.

Emerson Radio Corporation

Customers may refer RFI inquiries related to Emerson Radio Corp. TV and radio problems to Mr. Dave Buda. Emerson Radio does not supply filters. The new address is: Emerson Radio Corp., One Emerson Way, Secaucus, NJ 07094, tel. 201-865-4343.

Epicure Products, formerly Elpa Marketing Industries, Inc.

Complaints are handled with respect to parts and labor on an individual basis. Necessary modifications for RFI are made on a no-charge basis for parts and labor during the term of instrument warranty. Beyond warranty, modification parts are available free of charge. The customer then pays for labor involved in the installation of the parts, Refer RFI problems to Mr. John F. King, National Service Manager, 25 Hale St., Newburyport, MA 01950, tel. 800-225-7932.

Fannon Courier Corporation

If any RFI problems are encountered with units in the Fannon Courier product line, individuals should contact Mr. Mike Santana, Vice President of Engineering, 15300 San Fernando Mission Blvd., Mission Hill, CA 91345, tel. 213-365-2531.

Fisher Corporation

Fisher Corporation asks that RFI problems involving a Fisher product be handled as follows: request assistance from the local selling dealer or request assistance from the local Fisher authorized service station (a list is packed with every Fisher unit). Contact with local Fisher agencies is the preferred method of handling. Fisher's service coordination group maintains close communications with Fisher authorized service stations and Fisher's Engineering Department, and works under the supervision of the office of the National Service Manager. If the problem cannot be solved at the first two service levels, contact Service Coordination, 21314 Lassen St., Chatsworth, CA 91311, tel. 213-998-7322.

Garrard/Plessey Consumer Products

Garrard advises the customer on methods that may eliminate RFI. In unusual cases where the suggestions are ineffectual, customers should refer the RFI problem to Mr. Al Pranckevicus, National Service Manager, 85 Sherwood Ave., Farmingdale, NY 11735, tel. 516-293-2400.

General Electric Company

RFI problems involving G.E. television receivers should be referred to the nearest General Electric Customer Care Service Operation. If G.E. Customer Care Service is unable to correct the RFI, the customer should refer the problem to General Electric Co., Mr. J. F. Hopwood, Manager of Consumer Affairs, Appliance Park, Louisville, KY 40225, tel. 502-452-3754. All RFI problems involving G.E. radios, record players and other audio products should be referred to Manager of Consumer Counseling, Mrs. Patricia C. Cleary, Electronics Park, Bldg. 5, Syracuse, NY 13221, tel. 315-456-3388.

General Motors Corporation

From time to time you may have questions concerning the electromagnetic compatibility of mobile transmitters when installed on General Motors vehicles. To help avoid such questions from arising, it is urged that care be taken to follow any applicable GM service procedures. The local GM Service Manager for the Car or Truck Division whose vehicle is involved should be contacted for information about such service procedures. If you are unable to obtain such assistance locally or if questions nevertheless arise, GM has

established a central contact point for all such inquiries. Accordingly, you should direct your inquiries to: Mr. Henry J. Lambertz, GM Service Research (GMSR), Service Development Center, 30501 Van Dyke, Warren, MI 48090, tel. 313-492-8448. He will direct your inquiries to the appropriate division or staff within GM and follow up to see that appropriate action is taken.

Gulbransen, Division of CBS Musical Instruments, Inc.

Gulbransen cooperates with dealers and customers in offering suggested solutions to RFI. Gulbransen does not reimburse the consumer for servicing. When extreme cases are encountered because of the proximity of the transmitter and relative power, however, the dealer may sometimes absorb the cost of servicing RFI problems. Customers should refer RFI problems to the local dealer. Inquiries may be directed to Mr. J. A. Iacono, Consumer Service Supervisor, 100 Wilmot Rd., Deerfield, IL 60015, tel. 800-323-1814.

Hammond Organ Company

RFI difficulties are usually handled by the local Hammond dealer service technician. Hammond maintains a staff of technical service representatives who travel in the field and may be called upon to assist local dealer technicians with difficult or unusual service problems, including RFI. Hammond states that the services of the Engineering and Technical Field Service Department under its control are provided to consumer and dealer without charge. RFI problems should be referred to the local Hammond dealer, Inquiries may be directed to the Hammond Technical Service Department, 4200 W. Diversey Ave., Chicago, IL 60639, Attention: Jerry J. Welch.

Harman/Kardon, Inc.

RFI problems should be directed to Harman/Jardon at 240 Crossways Park West, Woodbury, NY 11797, tel. 516-496-3406. Attention: Customer Relations Dept.

Heath Company

Heath Co. suggests that, for fastest service on matters related to RFI regardless of the product line involved, customers may now reach the Technical Consultation Department by either writing directly to that department at Heath Co., Benton Harbor, MI 49022, or by using a new direct-line telephone system to the department by calling 616-982-3302. Do not write to an individual.

Hitachi Sales Corporation of America

Hitachi's primary products are TVs, radios, tape recorders, hi-fi components and video tape recorders. Hitachi Sales Corp. of America attempts to cure each RFI problem on an individual basis. Customers should provide model number and information concerning the nature of the problem. RFI problems should be referred to the nearest Hitachi Regional Office. *Eastern Regional Office,* 1200 Wall St. West, Lyndhurst, NJ 07011. tel. 201-935-8980. Attention: Service Dept. *Mid-Western Regional Office,* 1400 Morse Ave., Elk Grove Village, IL 60007, tel. 312-593-1550, Attention: Service Dept. *Western Regional Office,* 612 Walnut, Compton, CA 90220, tel. 213-537-8383, Attention: Service Dept. *Southern Regional Office,* 510 Plaza Dr., College Park, GA 30349, tel. 404-763-0360, Attention: Service Dept.

J. C. Penney Company, Inc.

J. C. Penney Company asks that customers with RFI problems contact their nearest J. C. Penney store for personal assistance. J. C. Penney Company, Inc., 1301 Avenue of the Americas, New York, NY 10019.

Kenwood Electronics, Inc.

Kenwood asks that customers with RFI problems take the affected unit to an authorized service center where an adjustment will be made at no cost to the customer if the product is properly registered with Kenwood and is within warranty. It is suggested that prior authorization for the return be obtained from Mr. Toshi Furutsuki, 1315 E. Watsoncenter Rd., Carson, CA 90745, tel. 213-518-1700.

Lafayette Radio Electronics Corporation

Customers should refer RFI problems involving Lafayette products to the local dealer. If the dealer cannot alleviate the problem, the customer may contact Mr. Charles Tanner, Vice President Administration, 111 Jericho Tpk., Syosset, NY 11791, tel. 516-921-7700.

Lowrey Division of Norlin Music, Inc.

Lowrey customers should refer RFI problems to the local Lowrey dealer or certified Lowrey technician. Lowrey provides all technicians with technical literature regarding RFI and will provide assistance to local service organizations through its staff of field technical representatives when needed. Inquiries may be directed to Mr. Larry R. Thomas, Director of Product Service, 707 Lake Cook Rd., Deerfield, IL 60015.

Magnavox Consumer Electronics Company

RFI problems are usually handled by the local Magnavox Authorized Service Center. Technical assistance in resolving such problems is provided by the Magnavox Field Service Staff through four Area Service Offices. Technicians or customers may refer unusual RFI problems involving Magnavox products to their nearest Area Service Center. In the *New York area* contact Magnavox Consumer Electronic Co., 161 E. Union Ave., East Rutherford, NJ 07073. In the *Chicago area* contact Magnavox Consumer Electronics Co., 7510 Frontage Rd., Skokie, IL 60077. In the *Atlanta area* contact Magnavox Consumer Electronics Co., 1898 Leland Dr., Marietta, GA 30067. In the *Los Angeles area* contact Magnavox Consumer Electronics Co., 2645 Maricopa St., Torrance, CA 90503.

Marantz (see Superscope)

McIntosh Laboratory, Inc.

McIntosh has a number of authorized service agencies located throughout the country. Customers will be assisted to receive prompt help. RFI and other service-related problems can be directed to Mr. John Behory, Customer Service Manager, 2 Chambers St., Binghamton, NY 13903, tel. 607-723-3512.

MGA Mitsubishi Electric Sales America, Inc.

MGA is the new sales and service representative for the Mitsubishi Electric Corp. RFI reports from the field, beyond the dealer's capability to resolve and in which MGA becomes involved, are handled on a individual basis. All attempts will be made to give customer satisfaction. MGA suggests that requests for assistance be addressed to 3030 E. Victoria St., Compton, CA 90221, or the Service Department may be contacted by telephone, toll free, at 800-421-1132. Mr. Ken Kratka is the new National Service Manager.

Midland International Corporation

Midland policy remains the same. If any RFI problems are encountered with Midland portable black-and-white and color TVs or audio and radio products, individuals should contact Mr. Dennis Oyer, Vice President Customer Service, P.O. Box 1903, Kansas City, MO 64141, or at 1690 N. Topping, Kansas City, MO 64120, tel. 816-241-8500.

Montgomery Ward

Service for RFI should be obtained from the nearest Montgomery Ward location. If service is not obtainable locally, the customer may write to: Customer Service Product Manager, Corporate Offices, Montgomery Ward Plaza 4-N, Chicago, IL 60671. The Montgomery Ward field service organization can call upon factory and corporate engineering talent for assistance in handling difficult RFI problems.

Morse Electro Products Corporation

RFI complaints related to Morse entertainment products may be referred to Mr. Phillip Ferrara, Service and Parts Dept., 3444 Morse Dr., Dallas, TX 75221, tel.

214-337-4711 or 800-527-6422.

Nikko Audio

Nikko's line of products includes stereo receivers, tuners, amplifiers, combination pre-amp and main-amp pairs, tape decks and signal processors. For information and assistance with any Nikko products, inquiries should be made to Mr. Robert Fontana, National Service Manager, Service Dept., 320 Oser Ave., Hauppauge, NY 11787, tel. 516-231-8181.

North American Phillips Corporation

This corporation no longer manufactures its own RFI-prone products. (See Sylvania.)

Nutone Division

Refer RFI problems to Mr. Norman W. Aims, Field Service, Scovil Housing Products Group, Madison and Red Bank Rds., Cincinnati, OH 45227, tel. 513-527-5415.

Panasonic Company

When instances of RFI occur, the customer should contact Panasonic at the following address: Panasonic Co., Division of Matsushita Electric Corp. of America, One Panasonic Way, Secaucus, NJ 07094, Attention: Supervisor of Quality Assurance Group, tel. 201-348-7000. The customer should provide model number, serial number and information concerning the problem. Upon review of the problem, the customer will be contacted and advised where to return the unit for corrective repair. Panasonic will absorb both parts and labor costs in these instances.

Phase Linear Corporation

RFI problems should be directed to Phase Linear Service Dept., Rick Bernard, Service Manager, 20121 48th Ave. West, Lynnwood, WA 98036, tel. 206-774-8848. In-house articles regarding RFI cures are available upon request at no charge.

Quasar Company (Matsushita Corporation of America)

For a high-pass filter, the consumer should contact Quasar Co., Consumer Relations Manager, Mr. George Datillo, 9401 W. Grand Ave., Franklin Park, IL 60131, tel. 312-451-1200. Model and serial number of the receiver and frequency of the interfering signal, if known, should be included with the written request, as well as whether sound or picture or both are affected. The Quasar distributor serving the local area should be contacted relative to any other interference problem that is unique to Quasar products.

Radio Shack

Customers who encounter unique interference problems involving Radio Shack audio products may write to Mr. Dave Garner or Mr. Al Zuckerman, Product Development Engineers, National Headquarters, 1100 One Tandy Center, Fort Worth, TX 76102, tel. 817-390-3205.

RCA Consumer Electronics

RFI problems involving both TV and audio products may be referred to Mr. J. J. Sanchez, 600 N. Sherman Dr., Indianapolis, IN 46201, tel. 317-267-6448. Requests for filters should include model number and serial number of the RCA television receiver. Filter installing charges will be the customer's responsibility.

Regency Electronics, Inc.

Regency Electronics asks that RFI problems involving their scanner or marine products be referred to Customer Service Manager, Regency Electronics, Inc., 7707 Records St., Indianapolis, IN 46226, tel. 317-545-4281.

Rodgers Organ Company, Division of CBS Musical Instruments, Inc.

RFI problems involving the Rodgers Organ may be referred to Custom Organ Test Department, 1300 N. East 25th Ave., Hillsboro, OR 97223, tel. 503-648-4181.

Rotel of America, Inc.

Stereo receivers, amplifiers, tuners and tape decks are made by Rotel. RFI problems should be referred to Michael Gregory, National Service Manager, 13528 S. Normandie Ave., Gardenia, CA 90249. RFI problems will be handled according to the terms of our limited warranty.

Sansui Electronics Corporation

RFI problems should be directed to Mr. Frank Barth, Vice President Frank Barth, Inc., 500 5th Ave., New York, NY 10110, tel. 212-398-0820. Frank Barth, Inc. is the advertising and public relations agency representing Sansui. Mr. Barth will direct the customer to an appropriate Sansui Service Center. A Sansui representative has previously stated that all Sansui products are carefully checked prior to final engineering commitments for susceptibility to RFI. Units are often taken to high-rf-level areas such as New York City to determine any design flaws.

Sanyo Electric, Inc.

In the event an RFI problem should occur, the customer is requested to take the set to the nearest Sanyo authorized repair station. Transportation to and from the shop is the responsibility of the customer. Should the shop not alleviate the problem, either the customer or the shop should contact Mr. Brad Coulter, Consumer Relations Manager, Sanyo Electric, Inc., Electronics Division, 1200 W. Artesia Blvd., Compton, CA 90220, tel. 213-537-5830.

Scientific Audio Electronics, Inc.

Refer RFI inquiries to Mr. Michael L. Joseph, National Marketing Manager, or contact Mr. Robert Hunt, National Service Manager, 701 E. Macy St., Los Angeles, CA 90012, tel. 213-489-7600.

H. H. Scott, Inc.

This manufacturer offers a simple instruction sheet to aid customers in resolving problems involving rf pickup. The information includes suggestions about suitable equipment grounding, power-line bypassing and hints and suggestions on how to determine where rf is entering the equipment. Customers should refer any RFI problems to Mr. D. F. Merryman, Engineering Dept., 20 Commerce Way, Woburn, MA 01801, tel. 617-933-8800.

Sears, Roebuck and Company

Sears asks that customers with an RFI problem involving a Sears product contact the nearest Sears service department for assistance. Inquiries may be directed to Mr. R. C. Good, Manager Marketing Communications, Home Appliances, Dept. 703, Sears Tower, Chicago, IL 60684, tel. 312-875-8366.

Sharp Electronics Corporation

Sharp Electronics will, with proof of purchase, supply costumers with a Drake TV-300 high-pass filter at no cost. Audio rectification problems are handled on an individual basis by the Service Department. Refer RFI problems to Service Manager, 2 Keystone Pl., Paramus, NJ 07652, tel. 201-262-9000.

Sherwood, Division of Inkel Corporation

Customers with interference problems should contact Mr. David Daniels, Vice President Marketing, 17107 Kingsview Ave., Carson, CA 90746, tel. 213-515-6866.

Shure Brothers, Inc.

The manufacturer recommends the use of balanced-line, low-impedance microphones and cables. If an RFI problem persists after the above measures have been taken, the customer should contact Shure Brothers, Inc. with specifics so that they may be able to help solve the problem. Refer RFI problems to Customer Services Dept., 222 Hartrey Ave., Evanston, IL 60204, tel. 312-866-2553.

Sony Corporation of America

Primary products of Sony are color television, black-and-white television, video tape recorders, stereo equipment, audio components and word-processing equipment. RFI assistance is provided through regional service managers of Sony Factory Service Centers through the Customer Care Dept. An RFI booklet is available from the company on request. Sony Corp., 47-47 Van Dam St., Long Island City, NY 11101, tel. 212-361-8600.

Sound Concepts

All RFI complaints are handled at the main laboratories at 27 Newell Rd., Brookline, MA 02146, tel. 617-566-0110. The offending unit should be accompanied by a description of the nature of the RFI; there is no charge for this service.

Soundesign Corporation

Soundesign Corp./ Acoustic Dynamics requests that all service problems relating to nonstereo merchandise be referred to Mr. Thomas R. Greene, Administrative Vice President, 34 Exchange Pl., Jersey City, NJ 07302, tel. 201-434-1050. All service problems on stereo merchandise are to be referred to our authorized service centers. The nearest one can be found by calling toll free in the continental U.S., 800-631-3092.

Superscope/Marantz Corporation

Superscope/Marantz manufactures a-m/fm receivers, tuners, amplifiers, tape recorders, record players and audio systems. In the event of special RFI cases resulting from extremely high fields, contact the Technical Services Dept. at Superscope corporate offices. Modifications necessary to resolve such RFI problems are provided to customers on an individual basis. Superscope/Marantz Corp., 20525 Nordhoff St., Chatsworth, CA 91311, tel. 213-998-9333. For Service Dept., call toll free, 800-423-5224, Attention: Mr. Albert Almeida, Technical Service Manager.

Sylvania/Philco, Division of North American Phillips Corporation

Sylvania policy is as follows: Factory field service and field engineering personnel work together to solve many of the TVI and audio rectification problems. If the consumer has an interference condition, he should contact his local dealer. He is in touch with the manufacturer's services that will help resolve it. Consumers should contact the dealer and work through his services first. RFI problems are handled on an individual basis. Sylvania has available for their technicians an excellent pictorial TVI training manual titled, *Diagnosis, Identification and Elimination of TVI.* Sylvania/Philco, Mr. Jack Berquest, Manager Service Training, Consumer Electronics Division, 700 Ellicott St., Batavia, NY 14020, tel. 716-344-5000.

Tandberg of America, Inc.

When RFI occurs in Tandberg products, the manufacturer suggests that the unit be returned to them. Tandberg will do any modification possible to eliminate the RFI. Authorization should be obtained from Mr. Tor Sivertsen prior to return of the unit. Mr. Tor Sivertsen, Technical Vice President, Labriola Ct., Armonk, NY 10504, tel. 914-273-9150.

Thomas International Electronic Organs, Division of Whirlpool Corporation

RFI is usually resolved at the dealer level. If the manufacturer's field service is made aware of a consumer complaint regarding RFI, they contact the seller and advise him on how to eliminate the problem. Thomas has six field service engineers. In the event of a call for assistance, an engineer personally contacts the consumer by telephone and makes an appointment to visit the home of the consumer to correct the RFI condition, with or without the dealer's technician. The consumer is not charged for this service. Refer RFI complaints to the dealer. Inquiries may be directed to Mr. Daniel E. Hofer, Manager Field Service, 7300 Lehigh Ave., Chicago, IL 60648, tel. 312-647-8700 or 800-323-4301.

Toshiba America, Inc.

Customers should contact the nearest regional office, an updated listing of which appears below, for obtaining assistance in solving RFI problems involving Toshiba televisions, radios, tape products, amplifiers, tuners and receivers. Mr. Stanley Friedman, National Service Manager, 82 Totowa Rd., Wayne, NJ 07470, tel. 201-628-8000. Mr. Sy Rosenthal, *Eastern Regional* Service Manager, 82 Totowa Rd., Wayne, NJ 07470, tel. 201-628-8000. Mr. Ray Holich, *Mid-West Regional* Service Manager, 2900 MacArthur Blvd., Northbrook, IL 60062, tel. 312-564-5110. Mr. C. B. Monroe, *Southwest Regional* Service Manager, 3300 Royalty Row, Irving, TX 75062, tel. 214-438-5814. Mr. S. Ito, *Western Regional* Service Manager, 19515 S. Vermont Ave., Torrance, CA 90502, tel. 213-538-9960.

U.S. JVC Corporation

Inquiries related to RFI involving JVC products may be referred to Mr. T. Sadato, Chief Engineer, 41 Slater Dr., Elmwood, NJ 07407, tel. 800-526-5308.

U.S. Pioneer Electronics Corporation

Contact Mr. Andrew Adler, *Eastern Region,* 75 Oxford Dr., Moonachie, NJ 07074; Mr. John Noa, *Southern Region,* 1875 Walnut Hill Ln., Irving, TX 75062; Mr. Clarence Skroch, *Western Region,* 4880 W. Rosecrans Ave., Hawthorne, CA 90250; Mr. Daniel Brostoff, *Mid-West Region,* 737 Fargo Ave., Elk Grove Village, IL 60007.

Wells-Gardner Electronics Corporation

Wells-Gardner is a private-label manufacturer of consumer products. Inquiries related to RFI should be referred to the private-label customer whose address appears on the model-number label attached to the product. Special problems which may be encountered by private-label customers are usually referred to Wells-Gardner, Mr. Harry McComb, Service Manager, 2701 N. Kildare Ave., Chicago, IL 60639, tel. 312-252-8220.

Wurlitzer Company

The Wurlitzer Company makes available a toll-free telephone line, 800-435-2930, to assist any technician or customer in any and all needs pertaining to the Wurlitzer product. The Wurlitzer company maintains a staff of field service managers who can assist should an RFI problem arise. Wurlitzer Co., 403 E. Gurler Rd., DeKalb, IL 60015.

Yamaha International Corporation

The Yamaha organization attempts to cure each RFI problem on an individual basis. Yamaha supplies all necessary technical information at no charge. If interference is caused by design error, Yamaha takes steps at its own expense to remedy the problem. Refer RFI problems to the local dealer. The dealers are kept well informed and current on RFI countermeasures. Inquiries may be directed to Mr. William Perkins, Electronic Service Manager, Electronic Service Dept., P.O. Box 6600, Buena Park, CA 90622, tel. 714-522-9351.

Zenith Radio Corporation

Zenith gives consideration to handling and providing relief for RFI problems on a case-by-case basis. RFI problems should be referred to Service Division, 11000 W. Seymour Ave., Franklin Park, IL 60131, tel. 312-671-7550. RFI referrals should include model and serial numbers of the affected unit. Customers with a unique, difficult problem may direct a letter to Mr. Richard Wilson, National Service Manager, at the same address.

Other Manufacturers

Ms. Sally Browne, Director of Consumer Affairs, Consumer Electronics Group, Electronic Industries Association 2001 Eye St., N.W., Washington, DC 20006, tel. 202-457-4900, may be contacted for assistance or recommendations in the handling of RFI problems involving manufacturers not listed here, or for assistance when the product is no longer manufactured.

Bibliography of Published Material on RFI

Further information and individual's experience can be found in the following sources.

Automotive

Hall, M. E., "When RF Upsets Electronic Ignition," Hints and Kinks, December 1980 *QST*, p. 52.

Richards, B., "RFI to Automobile Cruise Control, Part 2," Technical Correspondence, August 1981 *QST*, p. 43.

Bonding, Shielding, and Lead Decoupling

DeMaw, D., "Kenwood TS-520S Transceiver," Product Review, May 1978 *QST*, p. 32.

Hartz, P. and Hartz B., "W1FB Advice Solves TVI Problem," Hints and Kinks, July 1979 *QST*, p. 50.

Howey, T. W., "RFI and the Urban Amateur," Technical Correspondence, April 1977 *QST*, p. 52.

Matisoff, B., "Good Shielding Techniques Control EMI and RFI," February 1981 *EDN*, p. 123.

Wiley, G., "Attenuation of Ferrite Beads,"

Technical Correspondence, March 1979 *QST*, p. 38.

Computers and Digital

Ciarcia, S., "Electromagnetic Interference," January 1981 *Byte*, p. 48.
Cooper, P. E., "Microcomputers and Radio Interference," March 1980 *QST*, p. 17.
Cooper, P. E., "Microcomputer RFI Addendum," Technical Correspondence, May 1980 *QST*, p. 35.
Cowen, J. H., "Trash All Your Worries," August 1980 *73*, p. 70.

Filters and Transmatches

Copeland, J. L., "A Simple TVI Filter for 50 Mc.," August 1966 *QST*, p. 34.
DeMaw, D., "Ultimate Transmatch Improved," Technical Correspondence, July 1980 *QST*, p. 39.
Emerson, P., "TVI Filter Resonance," Hints and Kinks, October 1979 *QST*, p. 51.
Imamura, K. B., "A Simple TVI Filter," Hints and Kinks, January 1979 *QST*, p. 50.
Maxwell, W., "The Ultimate Vs. the SPC Transmatch," Technical Correspondence, August 1981 *QST*, p. 42.
Randall, B., "Improving High-Pass Filter Connection on TV Set," Hints and Kinks, October 1981 *QST*, p. 45.
Wetherhold, E. E., "A Ten-Meter Harmonic TVI Filter," September 1967 *QST*, p. 37.
Wetherhold, E. E., "Elliptic Lowpass Filters For Transistor Amplifiers," January 1981 *Ham Radio*, p. 20.
Wetherhold, E. E., "Low-Pass Filters for Amateur Radio Transmitters," December 1979 *QST*, p. 44.

General

Bercovi, H., "How to Handle Telephone Interference," May 1972 *QST*, p. 46.
Frank, J. W., "RFI Cures: Avoiding Side Effects," September 1981 *Ham Radio*, p. 52.
Leeming, H., "Hi-Fi Interference — Causes and Cures," June 1975 *Ham Radio*, p. 26.
McCoy, L., "RFI," Beginner and Novice, July 1972 *QST*, p. 42.

Power-Line Interference

Holloway, R. G., "Power-Line Interference," July 1970 *QST*, p. 22.
Ingram, D., "Power-Line Noise — the Cause and Cure," February 1979 *Ham Radio*, p. 60.
Nelson, W. R., "Electrical Interference, Parts I and II," April (p. 11) and May (p. 39) 1966 *QST*.
Wallace, V., "Success Story — Riddance of Power-Line Noise," Technical Correspondence, May 1971 *QST*, p. 47.

Public Relations

Carlson, J. and Pardue, H. W., "How to Handle TVI Complaints," August 1979 *Ham Radio Horizons*, p. 28.
Richman, H. R., "The Amateur and Public Relations," May 1959 *QST*, p. 82.
Rowe, F. D. and Lake, R. E., "Diplomatics," June 1954 *QST*, p. 30.

Smoke Detectors

Cwalina, A. and Norman, D., 'Smoke Detector Interference — Part 2," Technical Correspondence, February 1981 *QST*, p. 45.
O'Dell, P., "SDI — Dangerous Crippler of Radio Amateurs," November 1980 *QST*, p. 34.
Zimmerman, C. E., "Smoke Detector Sensitivity," Technical Correspondence, July 1981 *QST*, p. 46.

Television Interference

Bachland, G. E., "Battery-Charger TVI," Technical Correspondence, August 1981 *QST*, p. 43.
Cohen, T. F., "Television Interference and the Citizens Band Radio Service," February 1978 *CQ*, p. 27.
Contini, D. A., "Pong Game Causes TVI," Hints and Kinks, June 1978 *QST*, p. 44.
Eichenauer, C., "Color TVI — A Solution," March 1981 *QST*, p. 22.
Harrington, E., "TVI Sleuths at Work," February 1977 *QST*, p. 11.
Slater, A., "How to TVI-Proof Your Greenhouse," Technical Correspondence, June 1978 *QST*, p. 41.
Tobias, J., "TVI From SWR Indicators and Power Meters," Technical Correspondence, April 1981 *QST*, p. 52.
Zander, P., "More on Color TVI," Technical Correspondence, April 1979 *QST*, p. 37.

Test Equipment and Usage

Dieringer, J. P., "Hunting Noise — With a Grid Dipper," July 1977 *73*, p. 58.
Peck, S., "Curing High-Power TVI," Hints and Kinks, January 1980 *QST*, p. 53.
Pitts, J. E., "TVI Locator," August 1978 *Ham Radio*, p. 24.
Shriner, B., and DeMaw, D., "A Simple RF Sniffer," Basic Amateur Radio, October 1979 *QST*, p. 15. Also see Feedback, November 1979 *QST*, p. 17.

Books and Booklets

Consumer Electronics Service Technician Interference Handbook — Audio Rectification (Washington, D.C.: CES, n.d.).*
Consumer Electronics Service Technician Interference Handbook — Television Interference (Washington, D.C.: CES, n.d.)*
Ficchi, R. F., *Electrical Interference* (New York, NY: Hayden Book Co., 1964).
Giving Two-Way Radio Its Voice (Toledo, OH: Champion Spark Plug Company, 1978).
IEEE Tutorial Course — The Location, Correction and Prevention of RI and TVI Sources from Overhead Power Line (New York: The Institute of Electrical and Electronic Engineers).
Nelson, W. R., *Interference Handbook* (Wilton, CT: Radio Publications, 1981).
Woodward, G. H. and Collins, G. J., *The Radio Amateurs Handbook*, 59th ed. (Newington, CT: ARRL, 1981).

*Single copies of the interference handbooks for audio rectification and television interference may be obtained by writing to: Director of Consumer Affairs, Consumer Electronics Group, Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006.

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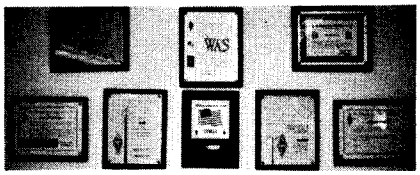

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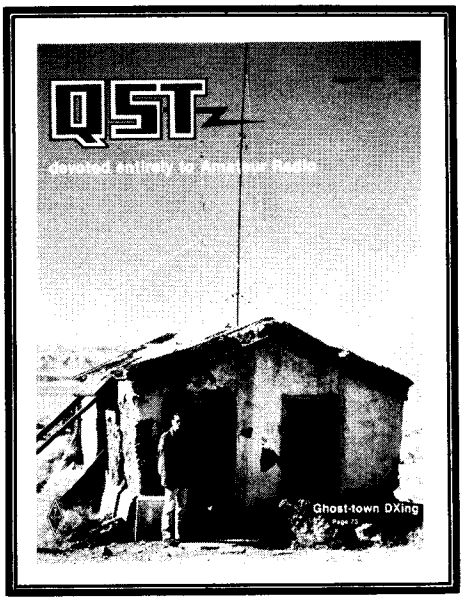

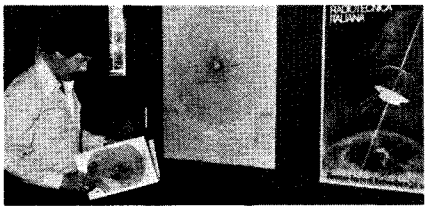

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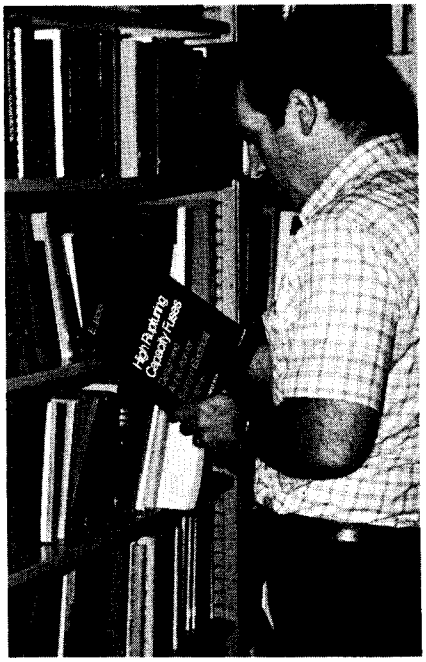

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RFI

This book covers what you need to know to combat RFI — radio frequency interference. If you are an Amateur Radio operator, you'll learn the causes of RFI and your legal responsibilities under FCC regulations. CBers will profit by knowing prevention techniques. The electronics technician will find that RFI can often be cured with simple modifications to the appliance or home-entertainment device. You'll find the cure to most RFI problems covered here.