Entertainment and Interference: The Two Faces of CATV

Heard any good TV on 2 meters lately? Are the neighbors watching your transmissions? Here are the ins and outs of cable television.

By Robert V. C. Dickinson,* W2CCE

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 12-channel capacity of the standard vhf television receiver. 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, 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.

Typical CATV System

A typical cable television network is illustrated in Fig. 1. This simplified drawing 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 alphanumerics, 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 subscriber TV set capacity. These converters are merely tuners that can select any channel in the system and convert it to a single TV channel. 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

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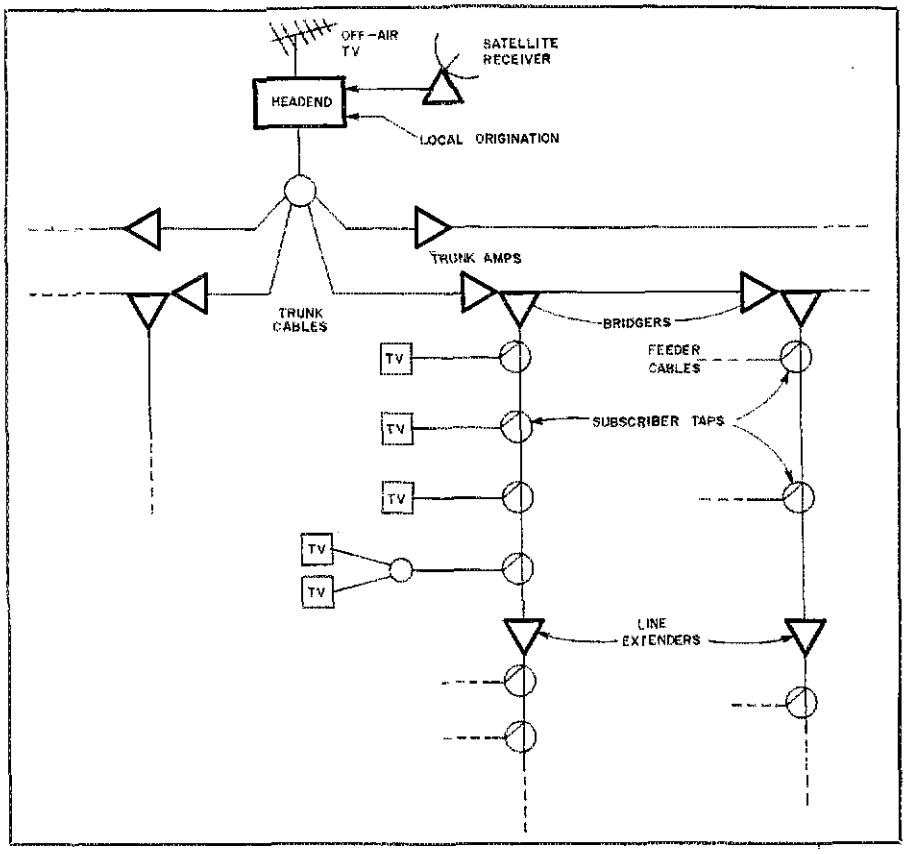

Fig. 1 — A typical CATV installation consists of the headend, trunk and distribution systems. Cable signals originate at the headend. The trunk system carries the signals to the various parts of the service area. Individual subscribers receive their signals from the distribution system.

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[1] to approximately 1 inch 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 that cause visible interference to the

[1] mm = in. × 25.4

Cable Television Regulations

Conducted By Richard K. Palm,* K1CE

The preceding article presents a tutorial on the technical and operating facets of cable television (CATV) as well as a discussion on systems' interference potential. This special edition of "Washington Mailbox" covers the matter of federal intervention in these areas.

As with the Amateur Radio Service, the Cable Television Service is regulated in this country by the Federal Communications Commission. The FCC is the government agency charged with the task of rulemaking in the CATV service and enforcement of the standards and regulations applicable to systems operation. As the familiar Part 97 affects amateurs, it is Part 76 of the Commission's rules that concerns cable system operators.

Q. How is cable TV defined by the Commission?

A. FCC defines a cable plant as follows:

> Cable Television System. A nonbroadcast facility consisting of a set of transmission paths and associated signal generation, reception and control equipment, under common ownership and control, that distributes or is designed to distribute to subscribers the signals of one or more television broadcast stations, but such term shall not include (1) any such facility that serves fewer than 50 subscribers, or (2) any such facility that serves or will serve only subscribers in one or more multiple unit dwellings under common ownership, control or management.

Key words include *nonbroadcast facility*; e.g., cable systems do not broadcast programming to subscribers. Programming is distributed by a closed system of cables and associated equipment — pathways which, by definition, do not utilize the airwaves.

The purpose of Part 76 is detailed in Section 76.1:

> The rules and regulations set forth in this part provide for the certification of cable television systems and for their operation in conformity with standards for carriage of television broadcast signals, program exclusivity, cablecasting, access channels and related matters.

Q. What is the substance of Part 76?

A. Subpart A provides the aforementioned purpose of the rules as well as a reference to applicable rules contained in other Parts. Definitions of key terms, information on special relief petitions and discussions of enforcement actions are also included in Subpart A.

Other subparts are concerned with registration and certification, federal-state/local regulatory relationships, carriage of TV broadcast signals in various market situations, nonduplication protection and syndicated exclusivity, cablecasting, diversification of control, forms and reports, technical standards and operation requirements. While discussion of most of these areas is beyond the scope of this treatise, subpart K, the technical standards portion, is of interest to amateurs in the matters of CATVI.

Q. What are the technical standards?

A. Just as amateurs are required to ensure that their operations meet certain technical standards, cable system operators must also comply with similar federally imposed standards.

The frequency boundaries for CATV channels are found in Section 76.605(a)(1) and generally conform to television (broadcast service) channel arrangements. However, other configurations may be approved by the Commission.

The limits for allowable radiation from a cable system are contained in Section 76.605(a)(12) of the rules:

Frequencies	*Radiation Limit (μv/m)*	*Distance*
Up to and including 54 MHz	15	100
Over 54 up to and including 216 MHz	20	10
Over 216 MHz	15	100

The rules also provide for the method of measurement of these parameters.

Section 76.609:

> (b) Measurements to determine the field strength of radio frequency energy radiated by cable television systems shall be made in accordance with standard engineering procedures. Measurements made on frequencies above 25 MHz shall include the following:
>
> (1) A field strength meter of adequate accuracy using a horizontal dipole antenna shall be employed.
>
> (2) Field strength shall be expressed in terms of the rms value of synchronizing peak for each cable television channel for which radiation can be measured.
>
> (3) The dipole antenna shall be placed 10 feet above the ground and positioned directly below the system components. Where such placement results in a separation of less than 10 feet between the center of the dipole antenna and the system components, the dipole shall be repositioned to provide a separation of 10 feet.
>
> (4) The horizontal dipole antenna shall be rotated about a vertical axis and the maximum meter reading shall be used.
>
> (5) Measurements shall be made where other conductors are 10 or more feet away from the measuring antenna.

Q. What are the rules pertaining to interference?

A. Section 76.613 regulates interference from cable television systems. Paragraph (a) defines harmful interference as "any emission, 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."

Of critical significance as far as amateurs experiencing CATVI are concerned is paragraph (b):

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

Paragraph (c) provides authority to an FCC engineer-in-charge (EIC) for the suspension of a cable system operation should harmful interference to radiocommunication involving the safety of life and protection of property not be promptly eliminated by the application of suitable techniques. Paragraph (d) states that "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 efficacy of the remedial measures."

Q. What should I do if I experience CATVI?

A. The first step is to determine the origin of the interfering signals: Where is the leak? Then, write a letter to the system operator outlining the problem and the steps you have taken thus far, and reminding him of his obligation under the rules to clean up the interference. Try to seek out someone within the company who has the technical background necessary to deal effectively with the problem. If possible, enlist the support of other amateurs who are experiencing similar interference. Should the cable company adopt an unresponsive or uncooperative attitude, write again, outlining the continuing problem, and send a copy to the local FCC district office and to the municipal government exercising local control over the company's operation. It is normally in the best interest of the company to be responsive to complaints, as it can face federally imposed fines and local enforcement action by towns' authority in franchise agreements.

The ARRL is becoming increasingly concerned with the escalating incidence of CATVI. On page 9, you will find an editorial treatment of the problem and a description of the measures taken and proposed by the League. Your input is invited in this matter; please direct any information or questions to K1CE, CATVI Desk, ARRL, 225 Main St., Newington, CT 06111.

*Assistant Manager, Membership Services, ARRL

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
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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

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 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. Other "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

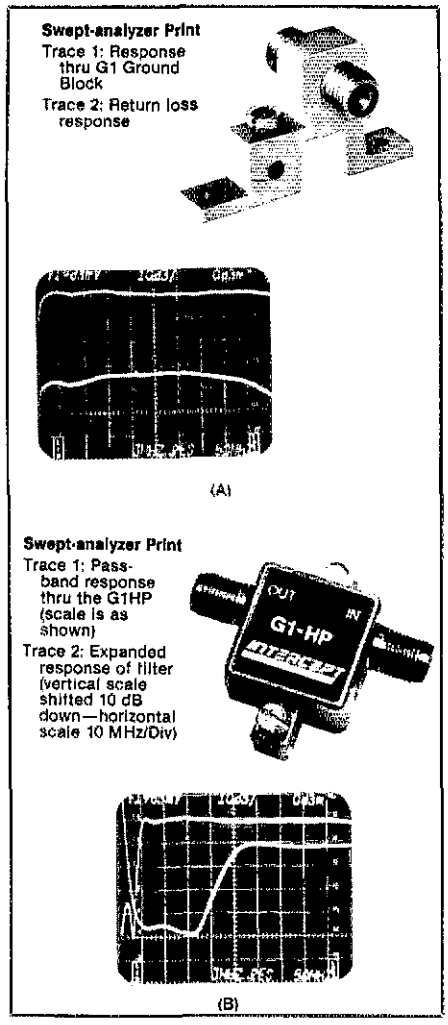

Fig. 2 — Grounding blocks are used at the subscriber drops. A typical unit is shown at A. The version at B contains a high-pass filter. *(photos courtesy of Intercept Corporation)*

radiation, it is possible that one or more of these taps is unused but not terminated. 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. QST