Apparently the British Post Office has charge of all kinds of communications in Great Britain.

He left there in 1947, and went with Rediffusion, of the British Broadcasting Agency, in London, and there he designed and installed the first cable system in England.

He grew up with the CATV industry in England, and in 1953, came across to Canada where he became the Chief Engineer for the first large CATV system in Canada, at Montreal.

Later, he joined Famous Players Canadian Corporation, in Toronto; and in 1963 became Vice President in charge of their CATV operations which serve and which involve systems serving 120,000 subscribers, which is approximately one-third of all the CATV subscribers in Canada.

He was active and he has been active in the Canadian Association.

It is my privilege and my pleasure to introduce for a discussion of SPACE DIVERSITY RECEPTION, Mr. Ken Easton. (Applause)

SPACE DIVERSITY RECEPTION FOR CATV

by

K. J. Easton

CATV has by its very nature always been at the frontiers of long-distance television reception. When the FCC in the United States first laid out its table of frequency allocations for television broadcasting it did so in the belief, uncontested by technical knowledge or experience at that time, that broadcast signals in the VHF band could only be received over line-of-sight paths and the coverage area of a station would therefore be limited literally to the horizon visible from the transmitting antenna.

It was soon found that this was very far from being the case, and that in fact stations could be received beyond the visible horizon. This threw the whole frequency allocation plan into the melting pot because the co-channel interference caused by propagation beyond the horizon proved to be much greater than anticipated, and in 1949 the FCC had to impose a freeze on the licensing of new television stations while the whole thing was sorted out. By the time the freeze was lifted some two years later a new frequency allocation plan had been prepared which allowed for this propagation beyond the horizon by imposing longer co-channel and adjacent channel spacings.

In the meantime it was this same freeze that gave birth to CATV, an industry that literally started by taking advantage of this same beyond the horizon feature of television propagation to bring television to people who otherwise could not enjoy this new entertainment medium. From that time up to the present therefore CATV has always been concerned with long-distance reception, and much knowledge and ingenuity has been used to constantly improve the quality and reliability of pictures brought in from beyond the TV horizon.

Just as the television channel allocations prior to 1949 were based on the concept that VHF signals were limited to a line-of-sight path, so far some years after this time during the early development of CATV it was thought that all beyond-the-horizon reception was due to a propagation condition known as smooth-earth diffraction. This is a condition arising from the electrical characteristics of the atmosphere which cause radio waves to bend in the direction of the earth and thus extend the radio horizon to a point approximately one third further than the visual horizon. Now it is a characteristic of a smooth-earth diffraction path that the path length can be extended, or alternatively the signal received at a given point can be increased by increasing the height of the receiving antenna above the ground--the well known height--gain phenomenon, so during this phase of CATV receiving antenna development it was usual to seek maximum height, either by locating the receiving station on high ground or by elevating the antennas well above ground level on high towers.

Since maximum antenna gain is also a prime requirement in order to extract the maximum signal from the field strength available at the location, multiple arrays became the order of the day for long distance reception. Unfortunately multiple arrays and high towers are incompatible for mechanical reasons, and this type of receiving equipment imposed a practical limitation on the strength of signal which could be received from a distant television station.

In the meantime during the early 1950's considerable scientific investigation was going on to learn more about long distance radio propagation in the frequency range from 40 to 10,000 MHZ, and in 1955 a number of papers were published under the sponsorship of the Institute of Radio Engineers describing a mode of long distance propagation which became known as "tropospheric forward scatter." It was found that communication was practicable at distances up to at least 300 miles under favorable conditions, and that diffraction theory could not account for the substantial field strengths that are produced at these ranges. A number of theories were put forward to account for this mechanism none of which were fully proved, but the most popular was that this long distance propagation resulted from atmospheric turbulence in the region between the stratosphere and the surface of the earth, known as the troposphere. This turbulence is thought to produce "blobs" of atmosphere whose refractive indices are sharply different from those of the surrounding atmosphere. When irradiated by a high frequency signal those blobs reradiate the signal scattering it in all directions. Some of this scattering is in the forward direction and it is this which produces the field at the receiving location.

These papers summarising this work led directly to an explosion of interest in this type of long distance radio communication, and in the succeeding 12 years since that date more than a hundred such communications systems have been built in many parts of the world for both military and commercial applications.

I should point out at this stage that all these systems were designed for point to point voice and data transmission, and there was no application for, and no attempt to adapt these techniques to long distance television transmission. Once again it was left to the CATV industry, whose specialty is long distance television reception, to pioneer the application of tropo-scatter in this field.

The first experiments were carried out in Canada and culminated in the first commercial use of tropo-scatter on a CATV system in North Bay, Ontario in 1963, providing reception of television programs from stations 240 miles from the community being served. Since then there has been a rapidly growing interest in this technique and a number of similar receiving systems have been installed both in Canada and in the United States. Experience with these systems has resulted in a growing knowledge and understanding of the techniques involved, resulting in steadily increasing improvement and sophistication.

Regardless of the true mechanical of tropo-scatter propagation much is now known about the characteristics of the radio frequency energy field propagated beyond the horizon. It has been learned through observation of a large mass of empirical data collected from operational tropo links.

First, it is known that the average amplitude of the field propagated beyond the horizon is greatly attenuated with respect to the transmitted field. For this reason it is necessary to use a receiving antenna with a very high gain. Conventional discrete-element antennas such as the Yagi are unsuitable for this purpose, and it is standard practice in tropo reception to use parabolic reflectors having a very large capture area and capable of concentrating the received signals onto a collector antenna located at the focal point of the paraboloid.

Second, the amount of attenuation can be calculated as a function of the angular distance between the transmitting and receiving sites. Angular distance is a parameter that takes into account the curvature of the earth, terrain configuration, and climatic conditions over the path, and is a measure of the intercept angle in the troposphere formed by the intersection of straight lines drawn from the transmitting and receiving sites to their respective horizons. For all but the most unusual circumstances angular distance is closely related to the linear distance between the two sites. Although site elevation is important in that it determines the distance to the horizon and therefore affects the angular distance, it is not nearly as significant as it is in the case of reception by diffraction, and the concept of height gain for the receiving antenna does not apply. For this reason, and because of the considerable mechanical difficulties in elevating a large parabolic antenna, it is usual to build these antennas virtually at ground level with an effective height of only 30 or 40 feet.

Third, the amplitude of the received field varies substantially with time over a given path. A mass of data on these variations has been gathered and analysed so that it is now possible to predict the amplitude-time distributions for most paths with a high degree of accuracy. For convenience these amplitude variations are separated into short-term and long-term distributions. Short-term aplitude-time distributions are those measured over periods shorter than a few minutes. The long-term distribution represents the variation of hourly median levels over a longer period of time-usually a month, a season, or a year.

Long-term variations of signal amplitude vary considerably with the season of the year and with geographical location, and when a system is being designed these factors must be taken into consideration. Determination of system parameters and design is usually based on the worst propagational month of the year--usually February or March in the Northern Hemisphere. Since long term variations on a given path are dependent on climatic conditions--temperature, humidity, etc. they affect both tropo-scatter and diffraction paths and must be taken into account in the design of any system.

Since tropo-scatter is apparently a mechanism associated with atmospheric turbulence, and since turbulence by its very nature is a state of constant change, short-term variations in signal amplitude are particularly apparent on tropo reception. Experience has shown that tropo-scatter reception of television signals using parabolic antennas is subject to fades which, although deep, are usually of quite short duration, generally less than a minute. Furthermore these fades do not occur simultaneously over a broad wave front, and if they are observed on two antennas located some distance apart they are completely uncorrelated, that is they occur at random and will not usually coincide at the two antennas. The application of this phenomenon to methods known as diversity techniques has been developed to counteract this fading and improve the propagational reliability.

Diversity can be defined as the utilization of more than one independent and uncorelated transmission path to provide greater reliability than that provided by a single transmitter and receiver at each end. There are two types of diversity used in point to point communications links--space diversity and frequency diversity. In space diversity two antennas are used separated in space by a minimum of 50 wavelengths and preferably 100 wavelengths or more. Signals separated in space by this distance show an almost complete absence of correlation. In frequency diversity two frequencies, separated by between one and ten per cent depending upon the frequency band in use, are transmitted over the path from the transmitting to the receiving station. Here again there is a minimum of correlation between the signals received on the two frequencies.

Although space and frequency diversity may be utilized independently in dual diversity, both may also be used simultaneously to afford quadruple diversity. For high reliability circuit requirements and in applications where the path length might otherwise produce a marginal circuit quadruple diversity is the preferred solution, and it is used in the vast majority of tropo-scatter communications links. Unfortunately in the application of tropo-scatter techniques to television reception the use of frequency diversity is out of the question since the transmitter already exists and only the receiving end of the system is under our control. Nevertheless considerable improvement in signal reliability can be obtained by application of dual space diversity, that is the reception of the same transmitted frequency on two separate antennas spaced a certain distance apart across the propagation path.

In planning a receiving system for signals being transmitted over a path on which substantial fading can be expected it is necessary first to determine what is the minimum signal to noise ratio that can be tolerated for an acceptable grade of service to the subscribers, and second, what the reliability of that grade of service will be, that is how constantly that grade of service will be available, or expressed another way, for what percentage of the time the grade of service will fall below the standard set.

In 1959 the Television Allocations Study Organization presented a lengthy and detailed report to the FCC which included the results of a measurement program to determine the subjective effects of various types of interference on television viewing both in black and white and in color. Based on the results from this report it has been determined that the minimum performance criteria are pictures rated passable or better by 50% of the viewers, and that so far as random noise is concerned this requires a signal to noise ratio at the antenna of not less than 29db.

Since the level of a tropo-scatter signal and, to a lesser extent, that of a diffraction signal, varies both within the hour and from hour to hour, some percentage of time must be affixed to this signal to noise ratio. It is usual on communications links to require the expected grade of service to be equalled or bettered at least 99.9% of the time, but in the case of television reception since it is an entertainment service and is not in use 24 hours a day it is possible to reduce this requirement.

Because signal conditions for tropo-scatter propagation are generally poorer in the afternoon, and since the prime viewing time is from 6 to 11 p.m. a recommended percentage of time for the value of acceptable signal to noise ratio to be equalled or exceeded is 99% of all hourly medians. This means that the hourly median value of signal to noise ratio may be below the recommended minimum value for approximately 90 hours each year or on an average about 15 minutes per day. Since prime television viewing time occupies only about 20% of the 24 hours this implies that on an average the grade of service will be below the recommended acceptable standard for about 3 minutes in prime time each day.

When planning a tropo-scatter receiving system we have to determine whether the required signal to noise ratio of 29 db available for at least 99% of the time can be achieved. This is done first by plotting the propagation path from transmitter to receiving site to determine the angular distance and hence the total path loss, and then equating this to the system parameters, including effective radiated power of the transmitter, receiving antenna gain, and receiving equipment noise figure.

Of these the parameter most readily under our control is antenna gain, and one of the reasons for using parabolic antennas for this type of reception is the availability of a relatively high gain, typically of the order of 28 db on the low band and 38 db on the high band for a reflector having an aperture of 13,500 square feet, that is 50 feet by 270 feet wide. Having determined the net loss over the path using an antenna of given gain it is then necessary to determine what signal to noise ratio can be expected for 99% of the time by the application of probability theory to measured data. If this value equals or exceeds 29db we can assume that the receiving system can be expected to provide the required grade of service from that television transmitter. If it is less than 29db then either we decide that the signal from that transmitter should not be used as part of the CATV service, or if we must use it we can expect that its reliability will be lower than might otherwise be considered desirable.

So far we have been discussing long-term fading, that is the fading represented by changes in hourly median signal levels. Even when these critera are met we may still be left with the short term fades, and from experience, with tropo-scatter reception using parabolic antennas it is a characteristic of the short term fades that they generally last for something less then a minute. The picture may be lost momentarily in a deep fade and then come back again within a very short space of time. Frequently these fades are of sufficiently short duration that they do not substantially affect program continuity, but even so they are annoying to the view, and it would be an improvement if their effects could be eliminated or at least reduced.

This is where the use of space diversity comes in. If two antennas are used, spaced at least 50 to 100 wavelengths apart, there will be very little correlation between the signals received from the two antennas, that is when the signal on one is fading out there is a high probability that the signal on the other is still at or above its median value. If therefore we can arrange to continuously measure the signal level on each antenna, and select the higher of the two for use on the system the probability is good that these short-term fades can be eliminated so far as their effect on the service given to the subscribers is concerned.

The question of cost of course immediately arises. A typical installed cost of a 270 foot parabolic antenna, exclusive of the head end equipment, is of the order of $17,000. If two of these are to be used for space diversity then the cost of the antennas alone would be $34,000. However a large proportion of the cost of a parabolic antenna is in the supporting towers and foundations, so that the cost is related closely to the number of towers used. A standard 270 foot antenna uses ten towers, and if this is split into two antennas using five towers each, the total cost of the two need not exceed about $18,000, the extra $1,000 being accounted for primarily by some additional end guying and the need for two focal point antennas instead of one. This arrangement results in the use of two 120 foot antennas instead of one 270 foot antenna, and the question then arises, since only one antenna is feeding the system at a time what effect will this smaller antenna have on the signal to noise ratio and will it still be within the acceptable limits?

A 120 foot antenna has an aperture of 6,000 square feet compared with 13,500 square feet for a 270 foot antenna, and since antenna gain is proportional to aperture, its gain will be 3.5db down compared with the larger antenna. However the use of diversity on signals derived from two similar antennas has the effect of improving the long-term hourly median by 2.5db, so that the net effect is a loss of gain from the antenna combination of only 1db, and certainly we would not be justified in spending an additional $16,000 just to pick up 1db of gain. It would in fact be possible to obtain the same net gain from two 150 foot antennas requiring a total of twelve towers instead of ten, for an additional cost of the order of $3,000, but whether this is justified is a question of how marginal the predicted results will be and how necessary it may be to squeeze every ounce of signal out of the system.

In tropo-scatter communications systems the carrier frequency used is usually in the band of 900 to 2,000 MHZ and the system band width is a very small percentage of the carrier frequency. Under these conditions it is practical to combine the signals from the two antennas, the resulting output signal being the sum of the two. However in television reception in the VHF band the channel bandwidth is a significant percentage of the carrier frequency and frequency selective fading can occur within the video band. If now the signals from the two antennas were combined it is probable that whilst certain sideband frequencies might be in phase other frequencies might be out of phase and this would give rise to serious distortion of the output signal. It is therefore necessary to arrange for continuous measurement of the signal levels from each antenna and switching of the system to the antenna producing the strongest signal.

The switching system consists essentially of two solid-state television receivers, one connected to each antenna. The demodulated output of each receiver is then connected to a D.C. comparator which compares the levels of the receiver outputs and produces a signal dependent upon which of the levels is higher and this operates a solid-state switch. The switch in turn is connected to the outputs of the antennas and determines which of the antennas is connected to the system. Synchronisation of the switching function to the vertical blanking interval is desirable in order to avoid loss of vertical synch and hence picture roll on subscriber's receivers when switching takes place. However solid-state switches are available with switching times of the order of 1 microsecond or better, and the use of these should make vertical blanking switching unnecessary. A delay of the order of one second is built into the switch and also a provision that switching will occur when there is a predetermined minimum difference between the two signal levels in order to prevent frequent switching taking place when the two levels are similar.

If more than one station is being received on the antenna system, which is generally the case, then it is necessary to switch the individual channels rather than the antennas themselves. It is not normal to receive adjacent channels on the same antenna system so that even on the high band there will be a difference between the channel frequencies of at least 3%, and this is sufficient to give rise to a substantial degree of frequency diversity, that is the signals from the two or more stations will not fade simultaneously. Separate diversity switches must therefore be used on each channel received.

To my knowledge the only CATV application of diversity so far in the United States has been on a system in Marlin, Texas, although I have no information on the design or performance of this system. Two dual space diversity television receiving systems for CATV in Canada have been built in the Ottawa area. The one with which I am associated uses four 120 foot parabolic antennas and two spaced Yagi arrays. Two of the parabolics are to be used for reception of channels 10 and 12 from Montreal. The axes of these antennas are spaced 400 feet apart giving a spacing of 79 wavelengths on channel 10 and 84 wavelengths on channel 12. The second pair of antennas will be used for reception of channel 7 from Watertown, N. Y. and channel 11 from Kingston. This layout becomes a little more complicated because there is a 38° difference between the paths from these two stations. One antenna is lined up on Kingston and the other on Watertown. The spacing between the antenna axes on Kingston is 400 feet which is 81.5 wavelengths on channel 11, but the spacing between the axes on Watertown will be only 213 feet due to the mutual slewing of the antennas and this is only 38.5 wavelengths on channel 7. It is probable this will be insufficient to obtain a good space diversity effect on this channel, but predictions indicate this may not be essential and it will give us a useful opportunity to determine by experience the minimum spacing required.

Another point arises from the use of the same antennas for reception of signals from stations which are 38° apart. The median level of the signal received from Kingston on the Watertown antenna 38° off the antenna axis is calculated to be 7db down on the median level of the same signal received on the axis of the Kingston antenna. With this difference in levels the 2.5 db effective diversity gain disappears so that the median signal level will in fact be 3.5 db down on the level which would be received using a 270 foot parabolic. However the improvement in reliability against short-term fading should still apply.

Two yagi arrays in space diversity are being used for reception of Plattsburg, N. Y. on channel 5. Yagis are being used instead of parabolics because predictions indicate that this is primarily a diffraction path and height gain becomes significant. However, depending on the results of tests being carried out we may apply space diversity also to this path. The spacing is 600 feet equivalent to 48 wavelengths on channel 5. This is close to the theoretical minimum spacing. However it will again give us an opportunity of checking the degree of correlation at this spacing, and if we find the spacing is inadequate we can readily increase it to 1200 feet or more to provide a spacing of the order of 100 wavelengths.

The construction of these antennas is now completed, but the diversity switching equipment is not yet ready for installation. In the meantime tests have been carried out to check the extent and effect of the diversity reception by monitoring color pictures and sound from each antenna of a pair and simultaneously measuring the picture carrier levels, and it is already clear from these tests that the use of diversity reception will result in a significant improvement in the reliability of the service given to subscribers. Even under conditions of heavy and frequent short-term fading it is estimated that at least 90% of the time when the picture from one antenna is lost due to a deep fade the other is still quite acceptable, and it is very apparent looking at the two pictures side by side that, when the better of the two can be selected for transmission to the system, the effect of these fades will be very greatly reduced with a corresponding improvement in service reliability.

Another interesting phenomenon that has been observed on these tests is the way in which a fade appears to sweep through the frequency band. Frequently there will be a rapid fade on sound followed a few seconds later by momentary loss of color and then later a deep fade on the picture carrier. Clearly the fading mechanism is very frequency selective and continuously changing, so that it would appear to sweep across the band of the channel concerned, first affecting the sound carrier, then sweeping through the adjacent color sub-carrier, and finally passing through the video carrier and its associated sidebands. It is possible that by demodulating the received signals and with some additional equipment complexity diversity switching could be applied independently to the sound carrier and the color subcarrier as well as to the picture itself, but experience will have to determine whether such added complexity would be justified.

It seems to me that the use of space diversity could be another major step forward in the improvement of the general standards of long distance television reception at no great increase in cost, and if the results bear out our expectations this technique could have a wide application in the CATV industry.

CHAIRMAN SCHATZEL: Thank you very much, Mr. Easton.

We are now going to leave the theoretical and more esoteric world for a few minutes and get down to something very practical.

I should apologize to Mr. Easton. I did not mean to imply that his antennas are not practical (laughter), because I am sure they are, but the subject we are going to talk about now is a more prosaic, humdrum one. It is, nonetheless, a very important one.

We have two gentlemen who are going to bring us up to date on the work that has been going on in connection with the National Electrical Code and the National Electrical Safety Code.

For the past couple of years there has been a considerable effort devoted to bringing CATV under the "umbrella" of these codes, and this has presented both problems and opportunities.

The gentleman who is going to tell us about CATV and the National Electrical Code is Mr. James Stilwell, who is Vice President of Engineering for TeleSystems Corporation.

Mr. Stilwell is a Mechanical Engineer who has picked up enough knowledge of electricity as he has gone along to give him a position of leadership in our industry.

So, without any further introduction, James Stilwell. (Applause)

MR. JAMES STILWELL (Vice President-Engineering, TeleSystems Corporation): Thank you, Mr. Chairman.

I think the inclusion of a talk on the National Electrical Code and the National Electrical Safety Code is pertinent to our group because for many years there was considerable confusion, in my own mind, as to which was what, and what applied to what we were doing.

I will attempt to describe what the National Electrical Code represents.

It is basically applicable to installations on private property, and if you think of its origin you had better understand what I mean. It was originated in 1897 by the united efforts of various groups of insurance companies; electrical manufacturers; architectural groups, and other allied associations, in an effort to standardize on installations so that the danger of fire hazard would be greatly lessened.

It continued in a somewhat disorganized manner until 1911, when the National Fire Protection Association took over complete sponsorship and continued to date.

As I mendioned, it is applicable to private property installation; yet, it is applicable to both inside building attachments as well as outside attachments, both on-pole or outside of buildings.

The limitation to private property I think is understandable if you consider that these are places where fire insurance claims might be made against a fire insurance carrier for specific property as opposed to an installation on a private utility pole which might fall on a public domain.

The Code itself is comprised of many different sections, each section trying to cover a certain, particular type of problem and application.

The Code is developed itself in accordance with a specific, definite procedure in preparation.

There are 18 so-called codemaking panels, all of which operations are coordinated by what is called a Correlating Committee. Serving on the panels and on the Committees are experienced men representing all of the various interests that might be involved.

The panels, the codemaking panels themselves, have specific calendar steps of time for the action which they are called upon to take.

The Code itself is issued on the basis of every three years with a major revision being undertaken to provide editions that are expected and hoped to carry on for a period of the following three years. It is possible for interchange to be approved and passed, but in general the editions that you would have to refer to would be effectively those that are in existence for a three-year period.

The present Code edition that we are operating under at the moment was published in 1965. Revisions at the present time, however, are under way for revisions to produce a new edition for 1968, and it is at this point where we become involved ourselves.

The Code panels themselves involved with the communications and telesystem specifications in the present Electrical Code realize the inappropriateness of the descriptions and the material that is presently embodied in the Code. They looked around and found that unfortunately our neighbors to the North were already a step ahead of us, and the Canadian Electrical Code had already been revised to incorporate a complete section relating to CATV, per se.

The Code panel committee then, the United States Code Panel Committee, began their study by taking the Canadian panel recommendations as they had adopted them, and used this as a guideline for their consideration.

We were fortunate, I think, in that about that time our CATV people became aware of the revisions that were under way, and were invited to meet with some of the Code panel chairmen to discuss what contributions we might make in their efforts to revise the Code.

We had a very interesting session. I had the pleasure of attending that initial talk. There was quite a bit of mutual discussion and quite a bit of exchange of information.

It was certainly obvious that these men had really insufficient insight into CATV to properly represent our interests in making up a code applicable to our business.

The matter was then taken to our NCTA Standards Committee, and it had a series of meetings, the result of which was to prepare a set of recommended rules for adoption as a special section in the 1968 Code, to be headed CATV SYSTEMS.

This special section is of interest, and I might call to your attention the fact that it is intended to pertain specifically to coaxial cable systems.

The Electrical Code as it exists today has two sections in it, one for communication, and one for antenna systems; and if you look at them carefully you will find that they refer to radio systems and mention specifically unshielded wire-type distribution systems.

The purpose, then, of collating all the CATV regulations into one section is obvious. When we have coaxial cable we do not have lightning section problems of the center conductor, so that one of the points in our discussions that we did cover was the fact that we are not going to be obligated to provide lightning protection in our systems once we get inside the shielding of a coaxial cable.

In our discussions several major points came up that affect all of us in our everyday way of doing business. It was of some surprise to ourselves because in our operations as a multiple-system operator, it has not been our practice to ground our house drops. In the discussions with the Code panel members they were just as shocked as I was, the opposite way, to find that we were not grounding our house drops.

We did get into a discussion, and it was the estimate that perhaps as high as 80 per cent of the CATV system subscribers were not presently grounded; and this was quite a shock to the Code panel members. They felt that the Code itself already contained references which should have called to our attention the desirability of such grounding.

This subject is now an important one to all of us in that it represents dollars out of our pockets through the expenditure for the devices and the labor necessary for making such grounding. It was the universal reaction of your Standards Committee that we had no defense to properly support our procedure of not grounding house drops. I say this because it was pointed out that although our system is totally grounded throughout the entire town, that the chance, remote as we might think it is, still exists in which a power line or other high-tension line might drop on our house drop cable, cause it to be severed, and that the severed portion on the house side could then carry the hazard voltage.

As a result, the NCTA's proposed specifications for consideration by the Code panel committee contains the following paragraph, and I am quoting now verbatim:

"Grounding of outer conductive shield of a coaxial cable. Where coaxial cables are exposed to lightning or to accidental contact with lightning or power conductors operating in a potential exceeding 300 volts, the outer conductive shield of the coaxial cable shall be grounded on the building premises as close to the port of entry as practicable."

The suggestions and specifications go on in detail as to what we recommend should be considered in terms of routing of the ground wire; making it as straight as possible; trying, if possible, to use a water pipe ground; also, attempting to use a common ground that the telephone and power units already may have in use. I will not go into the details of those.

Another point of major concern, however, to our group in discussing this with Code panel committees was our concern about the use of cable power equipment in a communications area. We covered this thoroughly, and I think we are reasonably satisfactorily covered in the statement, which reads as follows:

"The coaxial cable may be used to deliver low energy power to equipment directly associated with its radio frequency distribution system provided the voltage is limited to 60 volts and where the current supply is from a transformer or other device having energy-limiting characteristics."

I think that the opportunity which we have had of participating in the discussions leading to the preparation of this proposed revision for the 1968 Code has been a great step forward in our own recognition of the responsibilities that we do have from the safety angle, as well as the opportunity that we long since deserve in having a voice in the rules and regulations under which we must abide.

I thank you. (Applause)

CHAIRMAN SCHATZEL: Thank you, Mr. Stilwell.

The other portion of this presentation relating to the National Electrical Safety Code is going to be handled by another TeleSystems Vice President, Mr. William F. Karnes.

Mr. Karnes is the Vice President and General Manager of TeleSystems Services Corporation.

I am going to sum up his long record of experience by saying he has been in the CATV business for quite a while and knows a great deal about it. He is going to tell us about CATV and the National Electrical Safety Code.

Mr. Karnes. (Applause)

MR. WILLIAM KARNES (Vice President and General Manager, TeleSystems Services Corporation): That is the shortest, most complete, and most accurate introduction I have ever experienced.

The National Electrical Safety Code, as Mr. Stilwell pointed out, differs from the National Electrical Code in that it is primarily, concerned with the construction of electrical facilities on pole lines chiefly outside the property line of the private building, dwelling, or whatever service area is concerned.

The National Electrical Safety Code is sponsored by the National Bureau of Standards. It is written, amended, and controlled by what is called Sectional C-2 Committees of the National Bureau of Standards, headed by Mr. William J. Meese.

Without going into minute detail as to how the Code functions, I can tell you that about a year ago NCTA became concerned that here was a document under which nearly every one of us operate, because almost every pole attachment contract ever signed specifies the system will be built in accordance with this Code, and yet very few people are aware of the Code requirement, primarily because the Code is not easy to obtain in written form.

All of you I think are familiar with the basic 12 inches from Bell; 40 inches from power, et cetera, et cetera--the things we live with every day. Many of you may, or may not be aware of some of the other requirements--grounding; strength requirements; guy strength; structure conflict; conductor conflict;--things of this nature which are technical requirements that you are supposed to observe, but may or may not know about; and represent a matter of concern to each and every one of you.

Surprisingly enough a lot of telephone and power company engineers had never read the Code either; (perhaps it is not so surprising). (Laughter)

There are two points that I specifically would like to make with regard to the National Electrical Safety Code as it affects your daily operation, one of those being that CATV, as we all know, is a growing, dynamic industry, which is suddenly under the scrutiny of every public agency in the United States, including the utility commissions; the FCC; the railroad commissioners; you pick one and it is involved. Everybody is looking at CATV, and most of them want to control it in one way or another.

One of the areas in which I think we can be most vulnerable is that of proper construction. This Code spells out the rules. If they are ignored, and we have had a sample of that already, the telephone companies will say, "You see how those people build! We should do this construction" (and control the industry).

The TV industry will say, "You see how those people build. We'd better regulate them."

I would like to emphasize that the Code requirements are not unusually restrictive. I would, however, like to ask all of you as technicians and engineers to secure a copy of this Code and attempt to live by it. I do not say you should all go back and attempt to rebuild every system in the country; but in any area of new construction or system expansion; I would like to see all of these regulations observed so that we are not vulnerable to any criticism from that standpoint.

Some utility engineers, chiefly telephone company people, are attempting to establish a concept of communications and power space on a pole. I want to bring this up because it can result in dollar expense to you if you are not equipped to discuss, intelligently, with these people, their ideas. Many of them will cite the Code and say that the Code requirement establishes X inches of communication space, and this space varies around the country.

New York Telephone has one number; New Jersey has another; California has another, depending on their engineers. They will attempt to tell you that in order for you to attach to a pole you must preserve this X number of inches of space for them because the Code calls for it. I would like to emphasize the Code does not call for any communication space.

One of my favorite projects is to fight, wherever I can the concept of reserved space. I do not wish to see the belief grow any further that there is reserved space on any pole for anybody, "according to the Code." If the two utilities involved want to get together and decide this for themselves, that is their prerogative; but the Code does not call for it. I would not like to see any engineer be successful in using the National Electrical Safety Code to cost you money in that manner.

We had one instance in Michigan, incidentally, involving a telephone company engineer, where an attempt was made to force a very costly change on a cable operator, using the Code as the background, insisting that the cable operator had used a type of construction which was not permitted; in that he used the same thing most of us do, quarter-inch strand which has a breaking strength of 4,750 pounds. This engineer insisted that the Code called for 7,000-pound strand. Therefore, the cable operator was required to tear down all of his stand and replace it.

I hope nobody is ever again faced with that proposition. We were able to go back to the Code, however, and point out that the rules did not require this; and the engineer had to back down.

My point, however, is that had the CATV operator not been aware of the Code requirements and in a position to argue with the engineer, he could very well have spent a great deal of money without really having had to do so.

I said earlier that the Code is not too familiar to many people, because it is not easily available. The National Electrical Code has been reprinted and very widely distributed by the electrical suppliers, such people as Graybar, Westinghouse, and others. The National Electrical Safety Code is available, should any of you wish to order a copy of it, from the Superintendent of Documents, U.S. Government Printing Office, Washington. It is Handbook H-81, and it costs $1.75. It could very well be the cheapest investment you ever made; and I strongly urge that each of you secure a copy of it.

This concludes my remarks, Mr. Chairman. (Applause)

CHAIRMAN SCHATZEL: Thank you very much, Mr. Karnes; and again we say thank you, Mr. Stilwell.

I believe we all appreciate the work these two gentlemen have been doing to further the interests of the CATV industry in connection with these Codes.

Serving with Mr. Stilwell on this Committee is a gentleman who is in our audience, and I note that he wishes to make a comment.

MR. H. J. SCHLAFLY, JR.: Mr. Chairman, I did serve with Mr. Stilwell on this Committee, and I want to emphasize a point that he spoke of, and that is that the draft on the National Electrical Code has not been approved nor adopted by the NEC as yet.

I want to read a word of caution from our current print:

"The above draft has been proposed by the NCTA Standards Committee and delivered to the appropriate NEC panels for their consideration, but there has been no assurance nor indication that the draft will be adopted in this form for the 1968 publication as part of the Code."

So, if it comes out in the end with slightly different flavor than we have been able to report today, please do not be too greatly surprised; but your Standards Committee will endeavor to retain it in its present form if at all possible.

CHAIRMAN SCHATZEL: Before going to the next speaker I would like to present an announcement.

(Announcements)

We are going to change the agenda, moving past the panel which was scheduled to appear next, and going to the last of the morning items which is entitled, COMPARISON OF DEMODULATOR-MODULATOR VERSUS HETERODYNE SIGNAL PROCESSING FOR CATV HEAD ENDS.

The speaker who is going to discuss this subject, I heard a couple of years ago in Denver, when he discussed transmission distortion in CATV. At that time, as I recall it, he was discussing envelope delay distortion, and it was a most interesting paper. What he was talking about was a problem that was facing us in transmitting signals over CATV systems.

It is my hope this morning that perhaps he is going to give us some of the answers to that problem, among others.

Our speaker is Mr. Gaylord Rogeness, who holds Bachelor's and Master's Degrees in Electrical Engineering from the University of Illinois. After several years of experience with various companies in the electronics industry, he joined AMECO, where he is now the Director of Engineering, located in Phoenix.

At AMECO he developed the solid state heterodyne signal processor which AMECO has recently introduced. He has, also contributed to several other items developed by his company.

It is a privilege and a pleasure to introduce Gaylord Rogeness. (Applause)

COMPARISON OF DEMODULATOR-MODULATOR VERSUS HETERODYNE SIGNAL PROCESSING FOR CATV HEAD ENDS

by

Gaylord G. Rogeness

1. Introduction

Two techniques which have been used to receive and process television signals before they are applied to the cable system are the Demodulator-Modulator combination and the Heterodyne converter. The intent of this paper is to compare the two techniques.

With present day microwave relay equipment, at least one demodulatin-modulation is required before the television signal can be applied to the cable system. Hence it is imperative that the demodulator and modulator have characteristics which will minimize distortion of the television signal. However, when the choice between use of a heterodyne converter or a demodulator-modulator pair exists, the heterodyne converter is currently the best choice. Reasons for this choice will be given in the paper.

2. Heterodyne or Converter with IF Amplifier

The VHF converter with IF Amplifier, which will be referred to as heterodyne in the remainder of this paper, must convert any incoming VHF channel to any desired output VHF channel. The signal received from the antenna must not be degraded during the conversion process. Ideally, one requirement of the system is a flat passband from 750 khz below the picture carrier to 4.18 mhz above the picture carrier.

Figure 1 shows a block diagram of the heterodyne. The VHF signal input is amplified by an RF amplifier before it is converted to IF frequencies by the local oscillator in the input mixer. Adjacent channel trapping is accomplished in the IF amplifier. The IF sound carrier is normally separated from the