The next subject concerns critical characteristics of coaxial cable for community television applications, and on this we will hear from David Karrman, Staff Engineer, Times Wire and Cable Company.

MR. DAVID E. KARRMANN: Looking ahead in providing quality systems with long life and trying to meet new standards for the industry, I would like to discuss what we think to be a very critical characteristic of cable itself. This is the impedance uniformity. Impedance uniformity should be measured by a return loss method. Many people measure the impedance uniformity of their cable by sweeping it for attenuation uniformity. An attenuation uniformity sweep will give an output that will show a level suckout at a particular frequency where there is a mismatch within the cable. Now in general, in trying to measure attenuation you are limited to a few tenths of a db of accuracy. A few tenths of a db of accuracy in attenuation could be related to a VSWR of about 1.5 to 1. This type of VSWR would represent a rather poor return loss quality from the cable, actually about 14 db. We think the cable should have a much higher quality than this and we propose using return loss sweep as a quality measurement. We sweep the cable for return loss using a return loss bridge. These bridges can have a dynamic range of 50 to 55 db which enables us to read impedance uniformities in the vicinity of 1.01 to 1 or better.

Before proceeding I want to define return loss. The return loss of a cable is the db difference between a signal applied to a cable and the signal which reflects back out the same end of the cable. This measurement is made by connecting a terminated length of cable to be evaluated to an impedance bridge (such as the Jerrold KSB-75) and sweeping the cable from 50 to 220 mcs and observing the reflected signal on an oscilloscope. A marker generator and variable attenuator are used to measure the frequency and amplitude of any spike in the pattern of the returned signal. The effective VSWR at that frequency can be found from figure C.

A return loss spike represents a unique situation within the cable, in that there are many little structural discontinuities, each of which are reasonably small and are located a half wave length apart at the frequency of the spike.

The reflections from each of these discontinuities sum together to form the relatively large total reflection. At other frequencies the little reflections will add with a randum phase relationship, canceling each other, and therefore not being visible in the trace of reflected signal.

This measurement of return loss can be translated into a degree of picture degradation. Since return loss is a measurement of a reflected signal within a cable, and since a ghost is a reflection as viewed on a TV receiver, there is obviously a distinct relationship between these characteristics.

For the purpose of this work, we have taken the assumption that the reflection coefficients of all the discontinuities are equal, and therefore the reflections of all discontinuities are equal at the point of reflection. This is a justified assumption, in that they are generally introduced by a repetitive fault in the manufacturing process, the sharpness of the reflection spike is indicative of a cascaded fault, and even if the amplitudes of the individual discontinuities are not equal, the averaging effect of the summation makes this error negligible.

Obviously, the frequency of a return loss spike is a function of the spacing, and there are, therefore, a discrete number of discontinuities within a given length of line. The size of the cable and the frequency of the spike under study control the attenuation between the individual reflections and hence the reinforcement of the first reflection by subsequent reflections. These phenomena have been taken into consideration in calculating the set of curves shown in FIGURE 1.

This figure presents the magnitude of each individual discontinuity compared to the magnitude of the effective total as indicated by the return loss measurement for cellular polyethylene dielectric cables. The curves are presented as a function of attenuation at a given frequency rather than a particular physical size to increase the flexibility in extrapolation of data for all cellular cable constructions. For cables longer than those shown on figure 1, the lowest number indicated should be taken, as reflections from points beyond that length are individually so small compared to the total, and are attenuated so greatly, they do not further increase the total reflection. Figure B shows the relationship between two unequal signals when they are added.

We must now take into consideration the effect of delay time on the perceptibility of reflections as viewed on TV screen. Figure A shows the relationships between the reflection magnitude and its delay relative to the desired signal for a "just perceptible" or "just acceptable" ghost. The larger reflection which can be tolerated with short delays is due to the loss in picture resolution of two closely spaced signals.

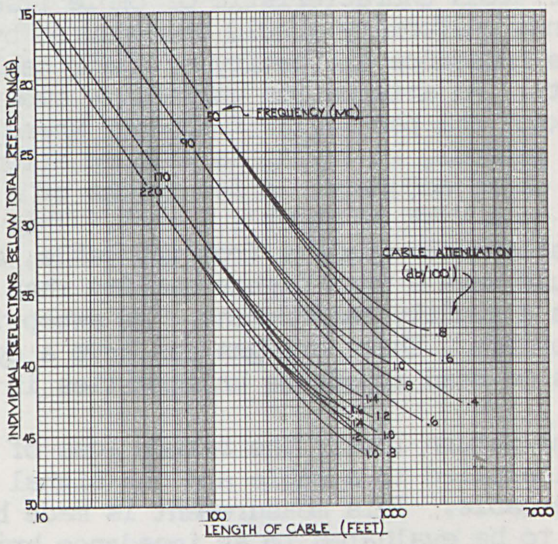


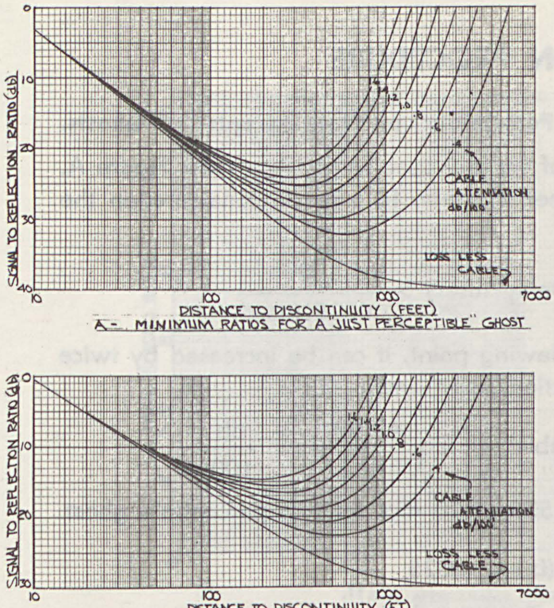
FIG.1 RELATIONSHIPS OF TOTAL REFLECTED SIGNALS TO INDIVIDUAL REFLECTIONS AT EACH DISCONTINUITY

In considering reflections coming from a cable, the attenuation of the reflections must be considered. A reflection coming from any point in the cable will be delayed and attenuated by twice the transit time to the point of reflection. Taking the attenaation of the reflection and the relationship of amplitude and delay in mind, the critical point in a cable was found. Figures 2A and 2B show the minimum signal to reflection ratios at the point of reflection ratios at the point of reflection for a "just perceptible" or "just acceptable" ghost. Again the curves are plotted as a function of attenuation for full flexibility in consideration of various cable sizes and constructions as well as operating frequency.

We can now convert our "return loss" measurement into picture degradation with the aid of the relationships established in figures 1 and 2. By summing the individual reflections over a 2 microsecond delay time centered at the critical point of the cable, the magniture of the resulting picture degradation can be calculated as a function of the signal to reflect in ratio as measured by a return loss sweep. This has been done and the results are shown in figure 3 as minimum return loss at any channel for several typical cable.

It must be kept in mind that this discussion includes only the effect of the discontinuities within the cable and that there will probably be other impedance mismatches in the system (taps, in and output matches to amplifiers, connectors, and splices) which will introduce additional ghost degradation. Therefore, a return loss specification of 26 db at Channel 2 with a weighting factor of 3 db per octave appears to be a minimum quality level for a system which is slightly better

Figure 2



A - MINIMUM RATIOS FOR A "JUST PERCEPTIBLE" GHOST

B - MINIMUM RATIOS FOR A "JUST ACCEPTABLE" GHOST

FIG.2 - SIGNAL TO REFLECTION RATIOS AS A FUNCTION OF CABLE ATTENUATION AND LOCATION OF REFLECTION POINT FOR CELLULAR POLYETHYLENE DIELECTRIC COAXIAL CABLES

than "just acceptable." A system designed for the highest picture quality should incorporate 30 db return loss cable.

Although the degradation introduced by devices inserted in the line often is considered more significant than the effect of the cable, the overall long term performance is certainly improved by atleast starting with good cable in the system, cable which will still provide top quality when the degradation introduced by other system components is reduced by advances in the state of the art.

Acknowledgements:
The author wishes to thank Mr. Ken Simons for the information used to set the signal to ghost ratio versus delay for a minimum acceptable standard.

Thank you. (Applause)

Figure 3

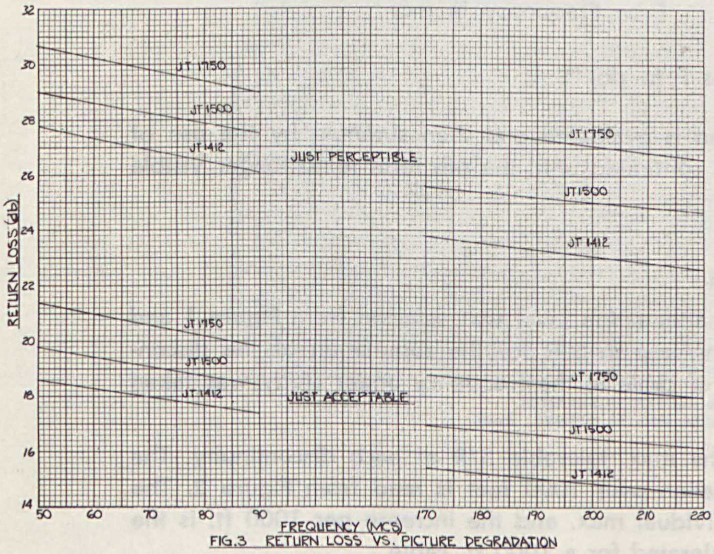


FIG.3 RETURN LOSS VS. PICTURE DEGRADATION

CALCULATION PROCEDURE

I. Critical S/R vs. Location for "Just Perceptible" or "Just Acceptable" Ghosts.

The tolerable S/R for time delays of up to 9 usec were taken from Figure A. These delays were converted to feet of cable, taking into consideration the two-way transmission time.

$$\text{Cable Length (ft.)} = \text{Delay (usec)} \times \frac{1 \text{ (ft.)}}{.0025 \text{ (usec)}}$$

Since this tolerable S/R is at the viewing point, it can be increased by twice the cable attenuation to the reflection point under study.

$$\text{S/R (min. at A)} = \text{S/R (tolerable)} + 2\left(\frac{\text{A (ft.)}}{100} \times \alpha \frac{\text{db}}{100 \text{ ft.}}\right)$$

Example: Min. S/R at 500′ of JT1500 at 90 mcs for just perceptible ghost.

$$\text{Delay} = \text{Cable Length (ft.)} \times .0025 \frac{\text{usec}}{\text{ft.}}$$

$$\text{Delay} = 1.25 \text{ usec}$$

$$\text{S/R (Min.)} = 36 \text{ db} + 2 (5 \times .8 \text{ db/100 ft.}) = 28 \text{ db}$$

II. Total S/R or Return Loss (RL) for the Sum of Many Small Reflections for L Feet of Cable at Frequency F.

$$\text{RL Total} = \underset{0\ \ L}{\overrightarrow{\Sigma}}\ rl_1 + (rl_2 + 2S\alpha) + \ldots + (rl_n + 2S(n-1)\alpha)$$

where rl_n = return loss of each discontinuity

S = separation between each discontinuity

$$S = \frac{984 \times .81}{2F} \qquad F = \text{Frequency in mcs}$$

α = attenuation at F in db/ft.

Each term in this expression is evaluated and then summed by the use of Figure 3. The summation is continued until the nth term is no longer visible in the total.

III. Return Loss vs. Ghost Effect.

The critical portion of each attenuation level was selected from Figure 1 and the S/R noted. The total increase in S/R for the summation of the discontinuities in 800 ft. (2 usec) of cable at the frequency under study was taken from Figure 2.

The sum of these equals the max. tolerable S/R of each discontinuity. The total increase in the summation over 1000 feet is read from Figure 2. The difference between the individual max. and the increase per 1000 ft. is the maximum RL that can be tolerated for a 1000 ft. cable.

Max. RL = (Critical S/R + Increase in S/R for 800 ft. summation) − Increase in S/R for summation of total cable.

Figure A

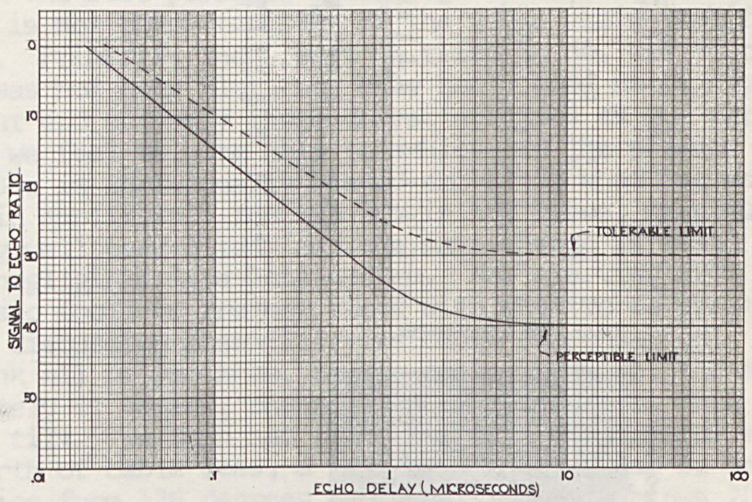


FIG. A. APPROXIMATE TOLERANCES OF ECHO AMPLITUDE AS A FUNCTION OF ECHO DELAY

Figure B

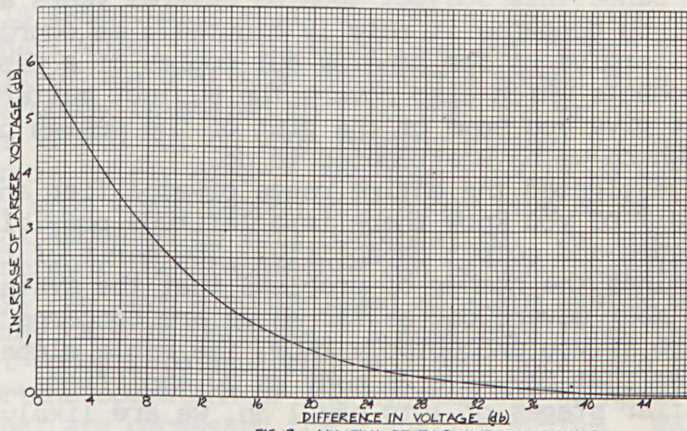


FIG. B ADDITION OF TWO UNEQUAL SIGNALS

Figure C and D

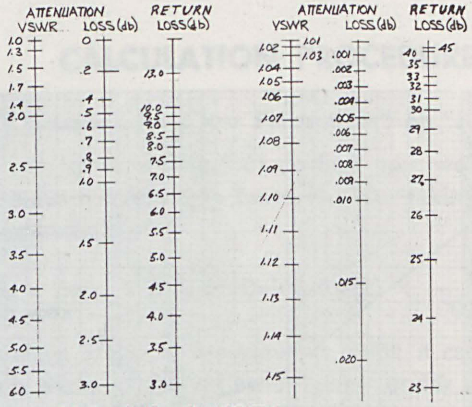


FIG.C- VSWR NOMAGRAPHS

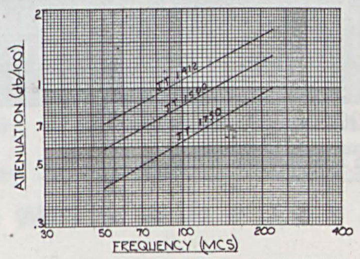


FIG.D. ATTENUATION CHARACTERISTICS OF ALUMINUM SHEATH COAXIAL CABLES

MR. W. K. HEADLEY: As we look ahead in our industry, one thing that is important to keep in mind is the standards for the distribution of TV by coaxial cable. On this subject we will hear from Mr. Isaac Blonder, better known to most of us as Ike Blonder, Chairman of the Board at Blonder-Tongue Laboratories.

MR. ISAAC BLONDER: Since this subject took us several years at our plant, and, one might ask, can you condense it into 10 minutes?; of course our answer is no. I hope you will forgive us for handing out copies of a paper commercially designed to sell our products which also covers the subject matter.

However, let me just give you some of the gist of the design philosophy behind the cable compensation which we have attempted to do.

First of all, we investigated the entire range of amplifier and amplifier capabilities. I think all of you know there is a latitude possible in system design between noise figure and output capability. The merit of the system or its dynamic range determines the number of problems that the system can encounter and still survive. The most severe one as far as we are concerned, really resides in the cable, where as you undoubtedly know, the cable slope changes with temperature. In a system that may have as many as 20 amplifiers, if there is a variation between amplifier stages of lets say 1 db, we are likely to wind up with a 20 db variation between one end of the band and the other and since the dynamic range in most long systems is not as high as 12 db obviously you are going to run into either noise or cross-mod.

The first problem that we ran into of course is the amplifier, and there we simulated virtually everything that has been built or that we could think of building, keeping in mind the db per dollar problem, the installation problem and the reliability problem. Since transistors have not yet achieved the output capabilities that we would desire, we had to regretfully delay their usage until