turn to new techniques so well adapted to his operations and that the G-Line should become for long distance what coaxial cable is for short distance wiring: a permanent instrument in CATV installations? This tool, in spite of its unorthodox suspension methods, is much closer to the wiring techniques of CATV than microwave towers.

The new technique could give Community and Pay Television relative independence not only from the FCC, but also from the old communication carriers in possession of established rights.

It has become a transmission medium in its own right, usually superior and frequently irreplaceable. It has also become more sophisticated.

The development of the G-Line parallels the development of modern solid-state technique. This also started around 1950 with the introduction of germanium diodes used at the outset only as detectors, but gradually penetrating the entire amplifier technique in the form of multi-electrode transistors.

What was once a single wire G-Line has now become a multi-conductor cable, adding to the surface wave, the conduction of high tension currents, the grounding for safety, and the capability of coupling in transit.

It can combine the functions of several components into a single unit having all these functions.

This is progress.

MR. TAYLOR: Thank you very much, Dr. Hafner, for a very interesting talk on a very interesting subject, which I have had some opportunity to fool with myself, as you said. I think that we had best move along. We started a half hour late because of the very remarkable performance we had at noontime and we have two very interesting and important papers to hear this afternoon.

Mr. Rudy Riley, President of Systems Engineering, Inc. is sponsored in this paper by Phelps-Dodge Electronics Products Company and he is speaking on "Just Twelve Inches Away". Mr. Riley.

MR. RUDY RILEY (President, Systems Engineering Inc.): A casual glance at a well-constructed CATV plant reveals the striking similarity to its neighbor, just 12 inches away. Since the beginning of our industry, telephone research, techniques and equipment have contributed immeasurably to the success of CATV.

Historically, the basic problems experienced by the telephone companies have proved to be common to all cabled communication networks.

This paper will discuss the two factors that effect the economics of a cable system most: Cable and its maintainence.

Cable

The advent of color television and all band transmission has created a demand for CATV cable with minimum frequency and delay distortion.* An air-insulated rigid coaxial cable meets these requirements. In this cable the center conductor is supported with a minimum number of carefully spaced, low-loss insulators. However, this type of construction is not practical for use in strand supported CATV systems.

Therefore, a semi-rigid cable using polyethylene, to uniformly support the center conductor, is generally used.

[* Subcommittee on Wire Communication of American Standards Association Sectional Committee on Electrical Definitions.
Frequency Distortion - Frequency distortion is that form of distortion in which the change is in the relative magnitudes of the different frequency components of a wave, provided that the change is not caused by non-linear distortion.
Delay Distortion - Delay distortion is that form of distortion which occurs when the phase angle of the transfer impedance with respect to two chosed pairs of terminals is not linear with frequency within a desired range, thus making the time of transmission or delay vary with frequency in that range.]

In order to reduce RF losses, the dielectric constant of the line is reduced by foaming the polyethylene or using a spiral ribbon of the material to support the center conductor. To satisfy the above mentioned criteria, extremely close manufacturing tolerances must be observed. Any anomalies in the supporting dielectric or the concentric cross section will cause wave reflections. These reflections give rise to delay distortion in the form of echoes, and, therefore, cause picture degradation.

Recent state-of-the-art breakthroughs in cable design promise to reduce the wave distortion products to an acceptable level.

One of these cables uses a thin helical membrane as the center support. Tests on several 1000 foot sections, using time domain reflectometry techniques, reveals that the departure from the normal characteristic impedance within the section does not exceed 1%. The attenuation is 6.6 dbmv per thousand feet at 216 megacycles and 70 degrees F.

By using the above described techniques, it is possible to determine the effect of bending radius and splices. Evaluation of these tests establishes the fact that the radius should be not less than 15 times the cable diameter and that splice VSWR should not exceed 1.04.

Future development of high quality cables will undoubtedly follow this trend toward the air dielectric configuration. Therefore, the thin supporting membranes will require new techniques for preventing excursions, with temperature, of the center conductor at cable junctions.

A new splice has been developed that requires no restrictive bends in the cable and exhibits a VSWR of 1.02. This splice is so designed that it might also serve as a bulkhead fitting for a hermetically sealed tap device.

In light of these recent developments, it is highly probable that future CATV systems will be pressurized.

Pressurization of Cable

Many of the older CATV systems used pressurized cable. This cable exhibited excellent electrical characteristics. However, its use was gradually discontinued because of several factors. The major factor was development of foam dielectric, aluminum sheathed, 75 ohm cable at a lower price. Other factors were:

A. Standard configuration had characteristic impedance of 70 ohms.

B. No satisfactory connectors were available.

C. Improper installation and maintenance.

D. An almost total misconception on the part of the installer and user concerning proper pressurization procedure.

E. Lack of industry standards.

As stated earlier in this paper, the need for cable with a return loss in excess of 36 db will probably dictate the return to this or a similar type. In addition, there are several compelling reasons why existing cables should be pressurized.

Why Pressurize Cable

Any pinhole or hairline crack that occurs in the sheath of a cable, regardless of its construction, becomes a potential source of trouble. The sheath openings may be categorized as follows:

Manufacturing Faults - These faults, while comparatively rare, do exist.

External - Caused by workmen, machines, ice, fire, rodents, etc.

Electrical - Due to lightning, corrosion, electrolysis, contact with wires, etc.

Moisture Entry

Moisture entering the cable by any means, either in the form of water or water vapor, will have a deleterious effect on system performance.

Water in cables can cause serious trouble. If water remains in the cable for long periods, electrolytic action or chemical corrosion may set in and eventually eat away the outer shield or affect the return loss of the cable. Water accumulating in the cable can freeze; as it turns into ice and expands, it can puncture the shield.

Moisture vapor can enter the cable by "cable breathing"; this is caused by temperature changes in non-pressurized cables. Air within such cables expands with rising temperatures, therefore building up a pressure. In the presence of any sheath opening, this pressure forces air out. Conversely, with falling temperatures, air in the cable contracts and draws additional air into the cable. Once inside the cable, the vapor tends to migrate freely and will travel considerable distances. This vapor will frequently precipitate out as free water under conditions of temperature change. Connectors are particularly susceptible to this water because there is usually some air space within the device.

Poly-sheathed, corrugated copper cable is susceptible to moisture entry because of its "tender" sheath and its low pneumatic resistance.

Positive Pressure

By maintaining a positive pressure within the cable, it is possible to prevent the entry of moisture. The cable will remain dry if the internal pressure exceeds the outside pressure; or in the case of buried cable, if the cable pressure exceeds the hydrostatic head of water exerted externally on the cable sheath.

Standard telephone procedure is to supply air to cable networks at pressures ranging from 5 to 10 psi. The usual practice is to feed dry air at a pressure of 10 psi into underground and buried cables and maintain them at 5 to 7 psi minimum pressures. These minimum figures are required to provide such cables with protection against the possible presence of hydrostatic heads of water in manholes, etc. Water exerts slightly less than 1/2 psi pressure for each foot of depth. A manhole 8 feet deep filled with water would develop 4 psi pressure on cables located near the bottom. Therefore, a minimum cable pressure of 4 psi would protect against moisture entry through a sheath break, but increasing the minimum pressure to 5/7 psi increases the interval after occurence of a leak before the pressure in the cable falls to a dangerously low level.

The normal procedure on aerial cables is to pressurize them at 7 psi unless they are very old and the sheath too weak to withstand this pressure. As noted previously, such cable is subject to rapid temperature changes, sometimes 50 to 60 degrees. Such variations can produce pressures within the cables varying from 1.5 to 2 psi from atmospheric due to cable breathing. Experience has shown that a minimum end point pressure of 2 psi will supply the required protection for the entire network and prevent cable breathing of aerial cables.

Pressurizing Techniques and Maintenance

Telephone cable is pressurized by admitting dry air from an air-drying machine into the cable at the central office. Contactors are installed at strategic points along the cable to provide alarm points for detecting leaks in the cable by the drop in the pressure which causes operation of the particular contactor in the vicinity of a leak.

The contactor operates to connect a resistor across a working cable pair. This resistor has no effect on dialing and transmission and the customer can use the circuit through the pair. The cable pairs associated with the connectors at different locations are periodically tested by the testboard personnel to detect operated connectors. An operated connector is indicated by a high resistance reading on the testboard meter.

It is possible to provide this alarm feature on CATV systems by diplexing a tone interrogator into coaxial cable. Operated contactors would be indicated by reed-type transponders. These transponders may also indicate amplifier levels. This method of detection is being used in a CATV system presently being constructed for Georgia TV Cable Co. in Athens, Georgia. There are several commercially available devices that can perform this operation. It is also possible to lash cable pairs with the coaxial system. Telephone companies will provide a similar service for approximately $3.00 per loop per month.

Alarm devices are supplemented by metering panels that measure air flow rates, delivered air humidity and pressure. The combination of these detection methods insures the continuity of plant operation.

When a leak is indicated, repairmen are dispatched to the approximate location. The actual break is located by a device which sprays a soap solution onto the cable. As the spray passes over the hole, the escaping air causes a foaming action that is visible from the ground.

Another type of leak detector that was recently developed makes use of an ultrasonic translator which picks up the sound of the air escaping from the holes in the sheath. These sounds are very high in frequency, in the 35,000 to 45,000 cycle range which are converted into audible sounds by the translator and heard in a headset receiver. A barium-titanate detector probe is used on a carriage arrangement to pick up the ultrasonic frequencies.

Removing Water from the Cable

When water has gained access through a sheath opening and causes trouble, there is no alternative but to remove it.

To remove water by evaporation merely by pumping dry nitrogen or dry air through the cable is impracticable because the cable section may contain a large quantity of water plus the fact that a large (224 cubic foot) cylinder of nitrogen or equivalent volume of dry air will only evaporate four or five tablespoons of water at 60 degrees F.

A method for removing water from cable has been developed utilizing acetone, a liquid which mixes completely with water in any proportion. A cable section containing water is flushed with acetone until the discharge liquid indicates a low water content. Then as much of the acetone as possible is forced out in liquid form and the remaining acetone is evaporated with nitrogen. Acetone has a low boiling point of 133 degrees F and, therefore, evaporates much more readily than water.

There are certain precautions, however, associated with the use of acetone. Since it is a volatile and combustible liquid comparable to gasoline, flames or sparks must be avoided. Prior to injecting acetone into the cable, nitrogen should be pumped into the section to purge the cable of oxygen, thereby minimizing the possibility of creating a combustible mixture of air and acetone.

Moreover, since acetone is a mild cracking agent to polyethylene, and since it will attack polyvinyl chloride, it is imperative that all acetone be removed from the cable section after the water is flushed out.

MR. TAYLOR: Thank you very much, Rudy. Our next speaker is talking on a very important problem. Mr. E. Mark Wolf, Assistant to the Vice-President of Engineering with the Rome Cable Division of ALCOA. Mr. Wolf.

MR. E. MARK WOLF (Assistant to the Vice-President of Engineering, Rome Calbe Division of ALCOA): Well, I think someone, and probably our good friend Mr. Taylor, deserves a high compliment for the efficiency of this setup. I have talked to a lot of people about underground cable, but this is the first time I've gone underground to do it. (Laughter) Maybe it's a good idea. But I guess we're here because we all have in