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 common an interest in the problems of going underground with CATV; I think any list of problems probably has somewhere near the top the cost of such an installation and its reliability. These are both problems and important problems, but they should not be approached with fear and with worry, because we believe that underground CATV systems can be both reliable and economical.

We'll have a look here, a very short look, at some of the very extensive experience that exists, the background of engineering experience that exists, the background of engineering knowledge that goes with it in the manufacture and the use of underground power cable and underground telephone cable. And, I think we will see that much of this knowledge and experience is directly applicable to our problems in CATV.

In the CATV system construction field there are few subject which generate so much real concern as that of underground cable installation. Most of this concern centers around two areas; either fear that an underground system will prove unreliable and costly to maintain, or a conviction that initial cost will be unreasonably high. We do not believe that either of these worries is justified, and hope that by explaining to you our reasons we can help you to sleep a little better the next time the subject of going underground confronts you.

First of all, underground cable installation is not new. Power companies and telephone companies have been installing cable underground for many years. Thirty or forty years ago these installations were very costly, and some of them gave trouble. But in the past decade there have been remarkable changes in both cable design and installation techniques. Today, both cable cost and installation cost are drastically lower, and underground installations are giving very reliable and trouble-free service experience. Utilities are able and willing to cope with, and in some areas even to promote, complete underground systems.

It is worth examining the accumulated engineering knowledge and experience in putting power and telephone cables underground, since much of this knowledge and experience is directly applicable to CATV cables.

In St. Louis, Missouri, in April 1964, the Institute of Electrical and Electronics Engineers (IEEE) sponsored a three-day technical conference on Underground Residential Distribution. Over 30 technical papers were presented and discussed at this meeting, by engineers from power companies, telephone companies, cable manufacturers, transformer and accessory manufacturers. IEEE have bound these papers into a volume which can be purchased. This compilation records in detail the practices and experiences of the nation's leading utilities and manufacturers in providing underground power and communication services to residential neighborhoods. It is recommended to you as a reference book for underground techniques.

In applying this knowledge and experience to our own problems in putting CATV services underground, we should first examine the CATV cable itself to be certain that the construction used is adequate for the underground environment. We are talking about the modern low loss coaxial cable, with an inner copper conductor, foamed polyethylene dielectric, and an outer aluminum conductor (sheath).

Foamed polyethylene must not be exposed to the wet underground environment. This is true whether the cable is to be directly buried, or enclosed in conduit or duct. In this respect, foamed polyethylene is similar to the paper insulation long used in both telephone cables and power cables. These insulations must operate in a dry, stable environment, unaffected by external conditions other than temperature. This requirement is nicely met by enclosing the dielectric in a completely impervious seamless aluminum sheath. Aluminum has the necessary electrical and mechanical characteristics, and is more economical than other metals which might be chosen.

The remaining problem is a physical or chemical one, rather than electrical. We have the insulated inner conductor enclosed in a seamless metallic sheath, and thus isolated completely and permanently from external environmental affects, and have only the problem of protecting this sheath from unfriendly environments which might cause damaging corrosion. Practical and economical solutions to this problem exist and have been widely and successfully employed by others.

The protective covering over the aluminum sheath must perform several functions:

1. It must provide an impervious barrier between the sheath and the underground environment.
2. It must be heavy enough and tough enough to withstand handling incident to installation.
3. It must withstand widely varying soil conditions without deterioration.
4. It must withstand exposure to atmospheric conditions, sunlight and weather without degradation.

We know of no material better suited to fulfill these needs than a member of the polyethylene family. Fortunately, the polyethylenes are also more economical for such application than any other materials which might be considered as candidates at present. This may change in the future, since we are always evaluating promising new materials.

Polyethylene can provide the impervious barrier needed. The only requirement, other than freedom from holes, is that it be in intimate contact with the aluminum sheath. The polyethylene jacket must fit tightly so that there are no air pockets or voids between it and the sheath. The presence of an air pocket, under certain conditions, can permit the jacket to act as an osmotic membrane and pass moisture vapor, even though the polyethylene itself will not absorb moisture. Application of a tight-fitting jacket over the aluminum sheath is easily within the capability of modern manufacturing techniques.

Polyethylene is tough enough to withstand a reasonable amount of abuse in handling during installation. It should be handled with care and respect, but certainly not with any "kid glove" techniques. The object is to get the cable in place without any deep scrapes, cuts, or gouges in the jacket.

The thickness of the polyethylene jacket is determined by two factors. One is the ability of modern plastic extrusion equipment to reliably apply a homogeneous, continuous jacket, free from holes or other discontinuities. The purpose of the dielectric, or "spark" test on the jacket is to assure its freedom from such imperfections. This test is usually accomplished in the extrusion line by running the jacketed cable (with sheath grounded) through a charged electrode several feet long. The voltage on the electrode is selected so that if the jacket has holes or thin spots, an arc, or voltage breakdown will occur, and an alarm will be set off.

Diameter Over Aluminum Sheath Inches	Average Jacket Thickness Inches
0 - 0.750	0.050
0.751 - 1.500	0.065
1.501 - 2.250	0.080

Figure 1

Average Thickness of Thermoplastic Jacket over Aluminum Sheathed Cable From IPCEA S-61-402

Fig. 1

The other factor determining jacket thickness is the need to withstand "reasonable abuse" during installation and to withstand the moderate pressure or abrasion from ground movement during period of freezing and thawing, etc. Neither of these requirements is peculiar to CATV cable, and we can use the experience of power cable engineers in determining the proper and safe jacket thicknesses to be used. The Insulated Power Cable Engineers Association publish the most comprehensive wire and cable specifications which we have in this industry. They are highly regarded and widely used by public utilities; They reflect quite accurately the needs of cable users as well as the capabilities of cable producers. These standards specify the wall thicknesses to be used when a thermoplastic jacket is required over an aluminum sheath. The adequacy of these thicknesses is supported by extensive experience with heavy power cables, and we would be foolish not to profit by it.

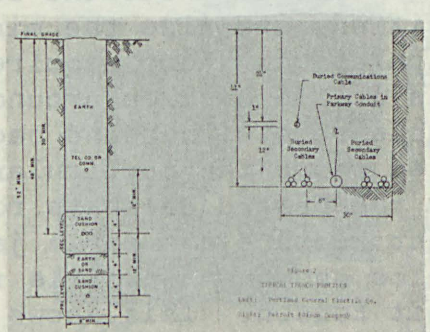

Fig. 2

IPCEA standards specify that thermoplastic jackets over aluminum sheathed cable shall have an average thickness not less than than shown in Figure 1.

The type of polyethylene used for this jacket is also important. Polyethylene is a family of materials. Members of the family are all identical chemically, but differ in molecular structure. In the early days of polyethylene the importance of these differences was not completely understood, and there were many cases of underground cable failure. Today the mechanism of these failures is well understood. We now have standard industry tests for environmental adequacy, and it is well known that what we call High Molecular Weight polyethylenes are completely reliable underground. It is interesting to note that this is the type polyethylene used on modern transoceanic telephone cables.

Polyethylene jackets should also contain proper black

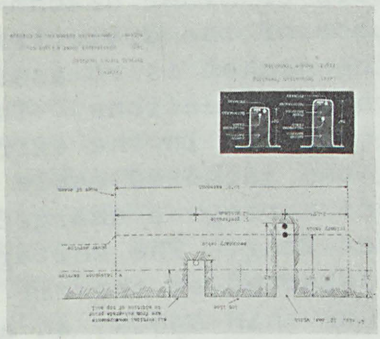

Fig. 3

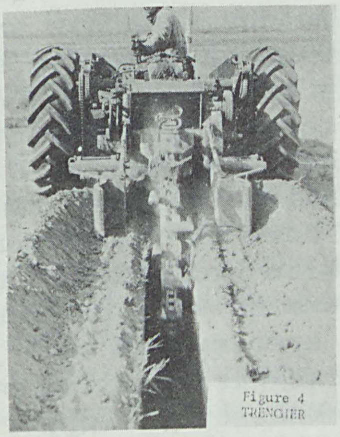

Figure 4
TRENCHER

Fig. 4

Figure 5
TRENCHER

Fig. 5

pigmentation to protect them from deterioration where exposed to sunlight. Such a cable, properly installed, will give many years of reliable and trouble-free underground service.

Now let's examine the meaning of "properly installed".

Here is where things can get a bit confused, because the term has several definitions, depending upon who is making the rules, and what part of the country we are talking about. We will discuss some of the practices in use by various utilities, and the reasons for them. If you become involved in, or are considering underground CATV system installation, you should first find out what the local rules and practices are. The local power company underground engineer is one good place to get this information. You are a customer of his, and he should have an interest in helping you. His background and experience is valuable, and for the most part, directly applicable to your problems.

Let's look first at the trenching practices in use by several typical utilities.

Figure 2 shows the trench profile specified by Portland General Electric Co. (Oregon). It shows the use of a single trench for primary power, secondary power, and telephone cables, with each class of service at its own level. Note the 12" separation specified, and also the minimum below-grade stipulation. Also required in this instance is a sand cushion around each of the power cable runs. The sand backfill is specified where the particular terrain introduces the hazard of sharp rocks, etc., which might rupture the cable jacket.

Figure 2 also shows one profile required by Detroit Edison. This shows primary and secondary power all at the same level below grade, and again the 12" separation between power and telephone.

Figure 3 is the profile used by Mississippi Power & Light Co. It shows separate trenches for power and telephone cables.

And finally, Figure 3 also shows two profiles used by Commonwealth Edison Co. of Chicago. One shows the 12" separation between power and telephone cable, and the other shows the practice of random lay. In this case, all cables are placed in the trench in a random manner, with no separation between. This provides a substantial saving, since it permits backfilling in a single operation. Which of these practices, or variations of them, may be used will depend on what is permitted by local approving agencies. Random lay is rapidly gaining wide acceptance due to its obvious economy.

Figure 6 TRENCHER

Fig. 6

Where the shared trench idea is not feasible, the practices are simpler. Preferably the cable should always be at least 24" below grade. 36" is even better. This largely avoids trouble from accidental dig-ins, from soil bacteria, and from frost heaving. The sand cushion is not necessary unless the terrain has sharp rocks. Trenching equipment comes in many sizes and shapes, as shown in Figures 4 - 7. Some of these are particularly interesting where installation must be made under established lawns or grades. Trenchers are available which open a slit less than 1" wide. Backfill is often not necessary, and the scar disappears in a short time. Also, the trench can follow an irregular path to avoid shrubbery or other obstructions. Depending on the locality, you may find trenching equipment is available locally, on a contract or rental basis. Your local power company is a good place to go for advice on this matter.

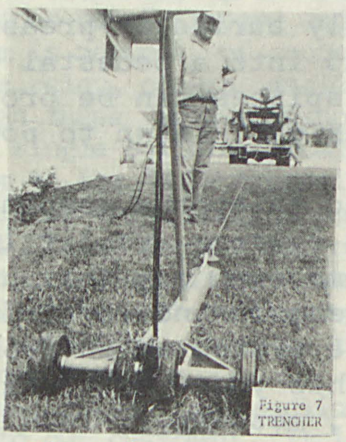
Figure 7 TRENCHER

Fig. 7

Obviously, trenching costs will vary widely, depending upon a number of things. Many power companies figure that under "normal" conditions they can trench and backfill for 30-35 cents per foot. This can run as low as 10 cents, but could also run higher under adverse conditions. The economic advantage of joint trench use is obvious.

In recent years there has been intense and increasing interest, for URD systems, in a preassembled cable in coilable plastic pipe. In this construction, the cable, installed in plastic pipe is delivered to the job-site in long lengths on reels, ready for installation. The pipe is made from another member of the polyethylene family, black high-density polyethylene. This material is tough, strong, abrasion resistant, and very economical compared to metallic pipe, or duct of other materials. Use of this system accomplishes several things:

1. It provides a hole in the ground for cable replacement, if ever needed.
2. It protects the cable from damage during installation.
3. It reduces the need for sand cushion in rocky terrain, or for protective planking under roadways.

4. It can provide for possible future expansion.

At present there are no industry standards for preassembled cable in pipe, but work on such specifications is under way in an industry committee. In the meantime, individual manufacturers, working with power company engineers, have developed workable standards of their own. These standards define the properties and dimensions of the various sizes of pipe, the percent fill to be used in determining the proper pipe size, as well as the various cable constructions to be furnished. Figure 8 shows Rome Cable's publication describing this product and its use for power cable. Experience has provided simple rules for determining proper pipe size to be used with various cable sizes. A number of other manufacturers have similar publications describing their product. This construction should be equally attractive for CATV systems. The added protection given to the cable during installation is a distinct advantage, and in many cases makes installation easier and faster. The built-in hole in the ground can be extremely valuable, particularly where system expansion or cable replacement would otherwise dig up established lawns or rear lot line shrubbery plantings. The added cost for one cable preassembled in pipe would probably be about 8-12 cents per foot. If you choose to buy the pipe and pull it in yourself, you can save about 5 cents of this. One very important principle to remember is that the cable used, whether directly buried or preassembled in pipe, should be suitable for exposure to the underground environment. Whether directly buried or preassembled in pipe, cable terminations should be stubbed up into a pedestal which can be sealed from moisture. Straight-through splices can be protected for direct burial using materials and procedures well known to power and telephone cable manufacturers and users.

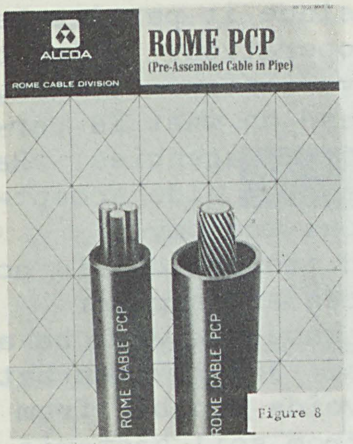

Fig. 8

An increasing number of power companies and telephone companies are coming to the conclusion that underground cable systems are little, if any more costly, than aerial installations. Some even say that underground is cheaper. They are finding that maintenance and servicing costs are significantly less because the cable is in a protected environment, unaffected by storms, accidents, etc. Add to this your additional savings from elimination of pole rentals, pole hardware, messenger, lashing wire, etc., the economics of underground CATV would not appear to be discouraging. In fact, it may well be almost a stand-off with overhead, without even considering the reduced maintenance and servicing costs. [Applause.]

MR. TAYLOR: Thank you very much, Mark Wolf, for a very interesting talk. This concludes the formal presentations. Thank you very much for coming.