United States Patent

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Continuation of application Ser. No. 599,599, Dec. 6, 1966.

[54] **ELECTRICAL CABLES**
2 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **174/22,** 174/102, 174/105, 174/110
[51] **Int. Cl.** **H01b 7/18,** H02g 15/24
[50] **Field of Search** 174/102, 102.3, 102.6, 105, 105.2, 106, 106.6, 107, 36, 110.44, 20, 22, 23, 76, 75.2, 88.2, 89

[56] **References Cited**

UNITED STATES PATENTS

3,339,007	8/1967	Blodgett	174/25
3,206,541	9/1965	Jachimowicz	174/105
3,379,821	4/1968	Garner	174/36
3,315,025	4/1967	Tomlinson	174/107
3,272,911	9/1966	Rollins et al.	174/106
3,340,112	9/1967	Davis et al.	174/23X
3,215,761	11/1965	Gelpey	174/76X
3,321,572	5/1967	Garner	174/105
2,216,435	10/1940	Eckel	174/102
3,340,353	10/1967	Mildner	174/106
2,589,700	3/1952	Johnstone	174/106

FOREIGN PATENTS

1,419,843	10/1964	France	174/107

OTHER REFERENCES

Kearney Airseal, Elec World Dec. 4, 1950

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ABSTRACT: Entry of water and water vapor into the core and splice case of a cable is avoided, despite the puncturing effect of lightning, by surrounding the core with an overlapped-seam plastic-coated aluminum vapor barrier which is bonded to a surrounding polyethylene tube thick enough to withstand the inner radial force of a sealing gland in a splice case without distorting and leaking. Surrounding this tube and vapor barrier, to protect them from the effects of lightning, is a lightning-absorbing aluminum shield and an outer polyethylene jacket.

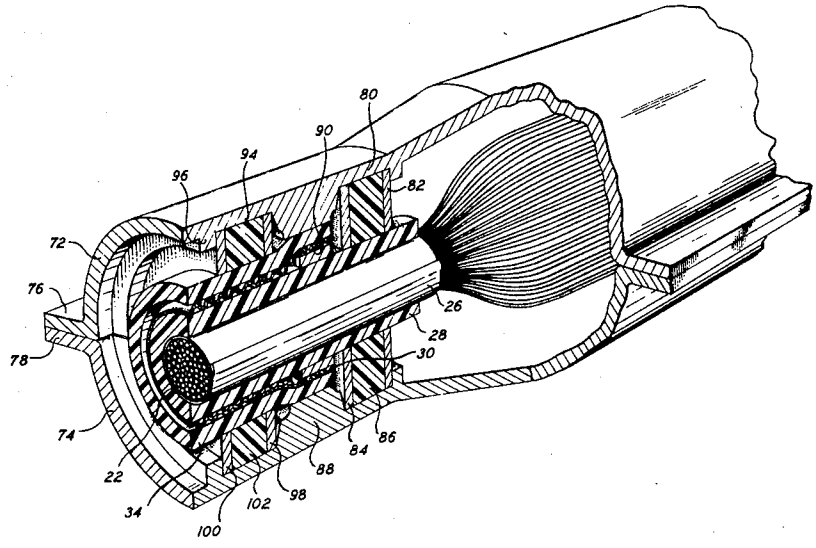


FIG. 1

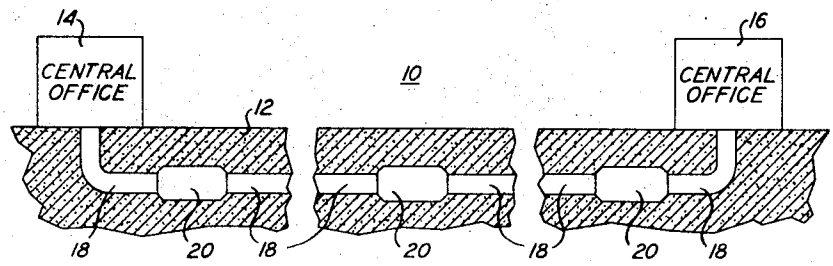
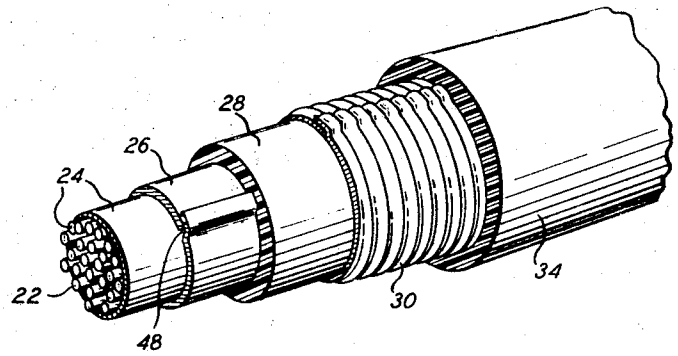


FIG. 2



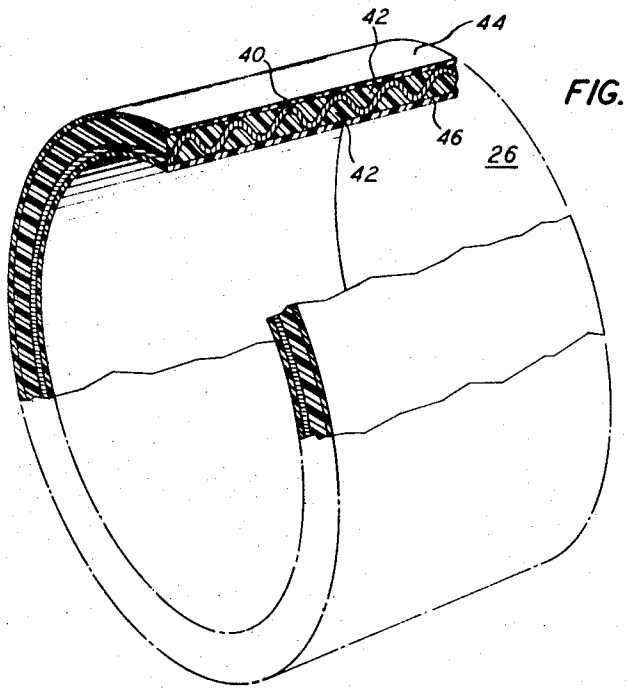


FIG. 3

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FIG. 4

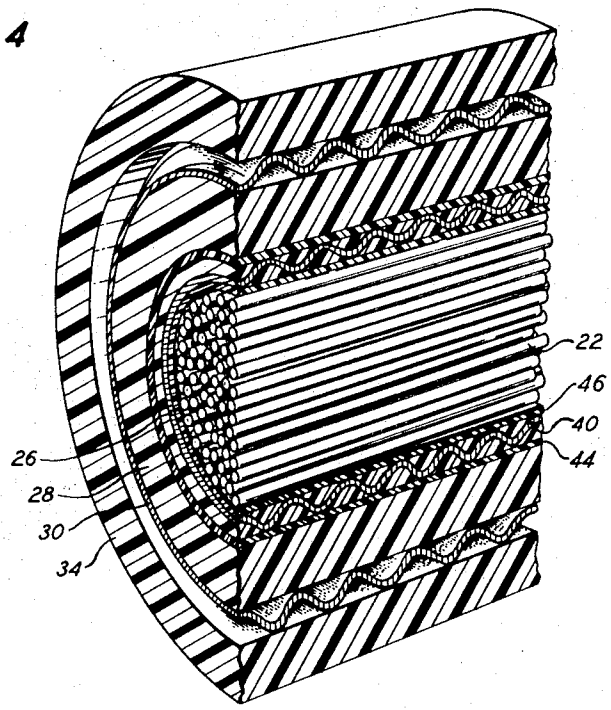


FIG. 5

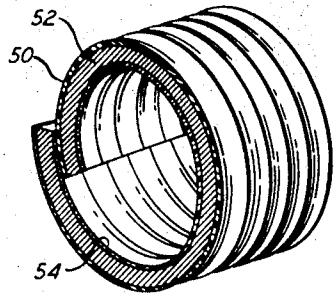


FIG. 6

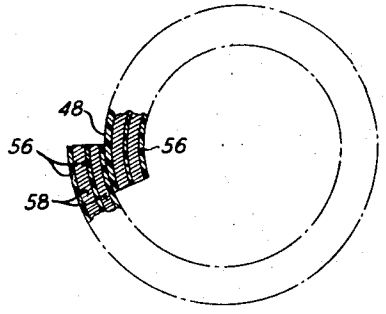
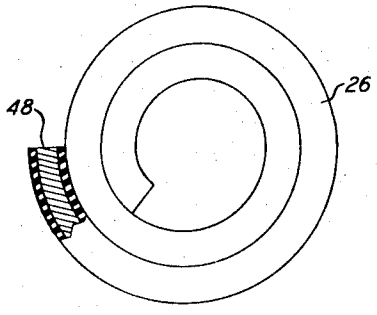


FIG. 7



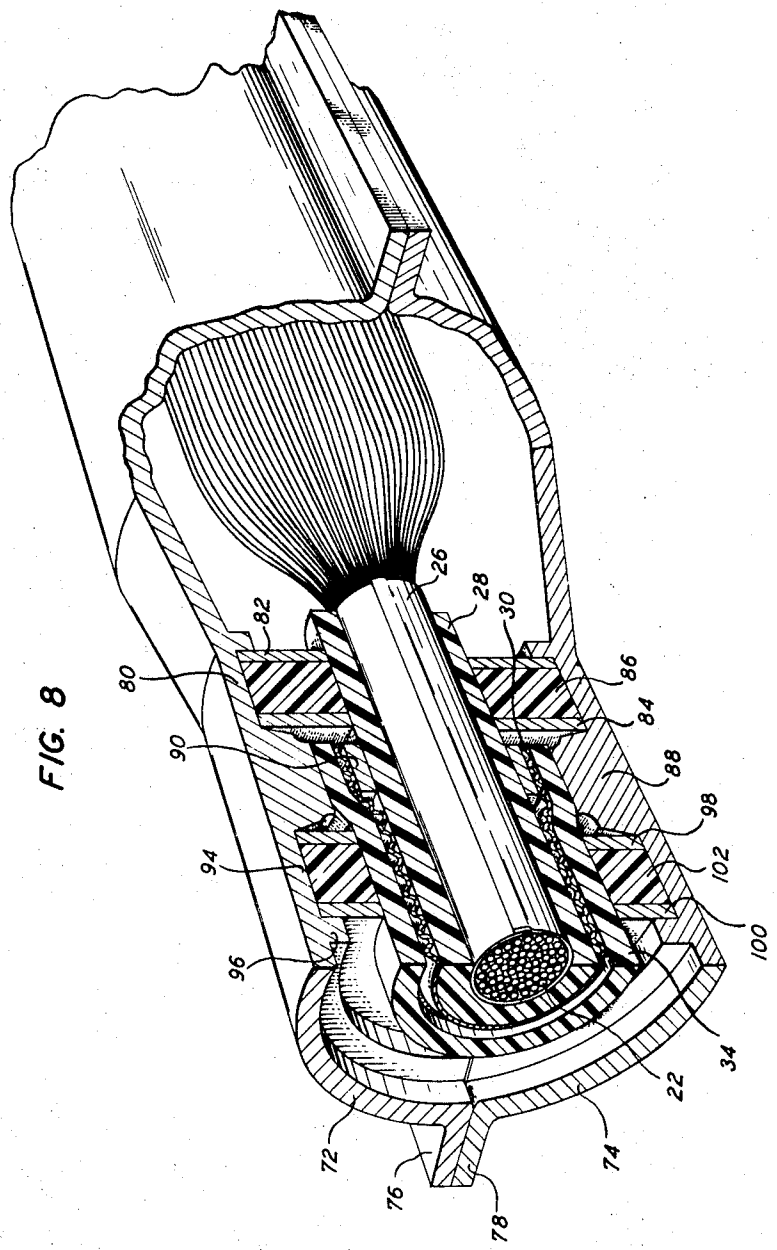


FIG. 8

ELECTRICAL CABLES

This is a continuation of the copending application of M. C. Biskeborn, Ser. No. 599,599 filed Dec. 6, 1966 for Electrical Cables.

This invention relates to electrical cables, and particularly, although not exclusively, to underground communications cables systems for carrying telephone messages.

Buried communication cables are ordinarily sheathed in one or more protective plastic jackets to prevent ambient ground water from entering the cable core and either shorting the cables' message-carrying conductors or, by virtue of the electrical potentials on the conductors, causing electrolytic deterioration of the metals. The plastic jacket, together with insulation surrounding the conductors affords buried cable some short term immunity from water. However, lightning striking the cable during its 30- to 50-year life expectancy, punctures the plastic. Water then rapidly enters the cable core and contacts the conductors to cause considerable damage and interruption of communication. This problem is especially critical when the conductors are made of aluminum.

Even without lightning punctures water eventually enters the cable core. This occurs by the process of "pumping." That is, while liquid water cannot pass through the plastic jacket, even jackets made of the least permeable plastic material available transmit water vapor into voids in the core in response to a "positive vapor differential," that is, a higher relative humidity, or vapor partial pressure, outside the cable than inside the core. The vapor itself does no significant harm. However, vapor condensing when the temperature drops flows into the core interstices. Then, in response to temperature cycles the relative humidity in large voids lags significantly behind the changes in ambient relative humidity. A rise in temperature then draws more vapor into the core. A drop in temperature condenses the vapor. As long as the void remains comparatively large, pumping continues to fill the voids with water.

In some cables, attempts are made to protect an inner jacket from lightning strokes surrounding the jacket with a metal shield and an outer jacket. In other cables attempts are made to prevent pumping by incorporating a vapor-impervious metal barrier in the cable. However, even these expedients fail to eliminate entry of water into the core. The shields are either not made watertight, or if they are, lightning ultimately punctures such shields. Water then entering the cable through lightning punctures travels axially outside the inner jacket until pumping occurs throughout the cable. On the other hand, vapor barriers are also punctured by lightning, and in any case, do not from watertight seals with the cable splices joining adjacent cable lengths. Thus axially flowing water ultimately spills into the cable splices where it flows back to the core and through the cores of adjacent lengths of cable.

An object of this invention is to improve cables, particularly communications cables for underground use.

More generally, an object of this invention is to improve cable systems which involve splices at periodic locations.

Still another object of the invention is to reduce the effect of vapor pumping that leads water into a cable core while nevertheless eliminating the effects of lightning upon the cable.

Yet another object of the invention is to minimize axial flow of water both within the cable and between the cable and the cable splices.

According to the invention, these ends are achieved in whole or in part by bonding the outer surfaces of a plastic-coated aluminum vapor barrier that surrounds the core to a water-resisting structurally-supporting plastic jacket substantially thicker than the barrier so as the render possible a watertight seal at a cable splice, and by protecting this inner component from the effects of lightning with an aluminum or other metal shield and an outer polyethylene jacket.

According to another feature of the invention the axial flow of water between the cable and the splice case is minimized by grasping both the inner and outer jacket with separate sealing glands whose thickness is sufficient relative to the area to prevent the effect of vapor migration.

These and other features of the invention are pointed out in the claims. Other objects and advantages will become obvious from the following detailed description when read in light of the accompanying drawings wherein:

FIG. 1 is a schematic diagram of a cable system embodying features of the invention;

FIG. 2 is a partly sectional perspective view of a cable shown in FIG. 1 and embodying features of the invention;

FIG. 3 is a partly sectional perspective view of an embodiment of the vapor barrier used in the cable of FIG. 2 and embodying features of the invention;

FIG. 4 is a detailed sectional perspective view of the cable in FIG. 2 utilizing the vapor barrier of FIG. 3;

FIGS. 5, 6, and 7 are sectional showings of vapor barriers suitable for use in the cable of FIG. 2 and embodying features of the invention; and

FIG. 8 is a sectional view of a splice case in FIG. 1 showing its connection to the cable of FIG. 1 according to a feature of the invention.

FIG. 1, a communications cable line **10** embodying features of the invention is buried in the ground **12** for transmitting messages between central offices **14** and **16** in different cities. These central offices in turn receive and send messages to local subscribers on local distribution cables, not shown. The cable line **10** is formed of sections of underground cable also embodying features of the invention which are joined to each other by splices **20**.

Details of the cable **18** appear in FIG. 2. Here, a number of s separately insulated conductors **22** are wound with tape to form a cable core **24**. The conductors **22** carry messages between the central offices **14** and **16** where they connect to carrier frequency terminals or to conventional switching networks that join them to local subscriber distribution cables. Wire connectors such as shown in the U.S. Pat. No. 3,064,072 join the individual conductors **22** of successive sections of cable **18** in the splices **20**.

Protecting the conductors **22** in the core **24** from the entrance of liquid water or water vapor is a vapor barrier **26** composed of a metal layer bonded on each side to a plastic layer that is heat-sealable to other plastic materials. The vapor barrier **26** surrounds the core. It is heat-sealed by means of its plastic layers along an overlapping longitudinal seam that extends throughout the length of the cable **18**. The thickness of the vapor barrier here is somewhat exaggerated for clarity.

To give the vapor barrier structural strength, a low-density or a high-density polyethylene jacket **28**, substantially thicker than the vapor barrier is extruded about the vapor barrier so that its interior surface conforms closely to the barrier's exterior surface and is bonded thereto substantially throughout its circumference. A transversely corrugated conductive lightning shield **30** which is longitudinally overlapped surrounds the structural jacket **28**. The shield **30** preferably is composed of aluminum. However, the shield may also be composed of combinations of aluminum and steel either bonded or unbonded to each other. If the shield is ordinary aluminum, it is made about 8 mils thick so as to withstand flexure of the cable during handling, but not be heavy enough to make the cable stiff. Where used the steel layer or tape affords the aluminum additional strength and protection against rodent attack. The entire structure is encased in an extruded outer plastic jacket **34** preferably made of polyethylene.

According to an embodiment of the invention, the vapor barrier is constructed as shown in FIG. 3. Here, a strip of aluminum foil **40** is corrugated by embossing it transverse to its longitudinal direction. Its undulations are filled under heat with a graft copolymer of polyethylene and monomers with respective carboxyl groups such as acrylic acid or acrylic acid esters. These are described in U.S. Pat. No. 2,987,501 and 3,027,346. They are available from the Dow Chemical Company of Midland, Michigan under the designation Copolymer Resin QX 3623, QX 4262.6 and the trademark Zetabond. They form both a mechanical and a chemical bond with the aluminum. To strengthen this flimsy assembly, laminating films **44** and **46** made of the same graft copolymer or

polyethylene are applied to the outside surfaces. The thus-formed vapor barrier is rolled transverse to its embossed corrugations and overlapped as shown in FIG. 2. The plastic films or lamina 44 and 46 are bonded to each other at the overlap 48. The barrier's entire exterior surface is heat-sealed to the jacket 28. In FIG. 3, the thickness of the vapor barrier and especially the magnitude of the undulations are also exaggerated.

FIG. 4 illustrates in more detail the appearance of the cable 18 utilizing the vapor barrier illustrated in FIG. 3. Here the thickness of the vapor barrier is again exaggerated. This vapor barrier has the advantage of using only very thin aluminum and thus reducing expenditure of this metal. For example, it is contemplated that the aluminum be as thin as .25 mils. The total vapor barrier may be as thin as ten mils. The corrugations of the aluminum permit the cable to flex without breaking the aluminum foil while the plastic material 42 filling the undulations and the layers 44 and 46 afford additional strength. The aluminum layer and the whole vapor barrier may of course be thicker.

The vapor barrier of FIG. 3 is eminently suitable for use in most environments. However, often during manufacture, it is desirable to limit the types of material handled within the plant. It is possible, therefore, to apply the principles of the invention for the vapor barrier by utilizing the comparatively heavy 8 -mil thick aluminum of the shield 30. This involves laminating the 8-mil aluminum thickness between 1 or 2-mil thick layers of the beforementioned graft copolymer before corrugating it transversely so that when formed the vapor barrier will have the appearance shown in FIG. 5. Here, the vapor barrier possesses an outer plastic layer 50, an intermediate aluminum layer 52 and another outside layer 54 made of plastic. These three layers may, for example, have thicknesses of 2, 8 and 2 mils. The plastic layers 50 and 54 are bonded chemically and mechanically to the aluminum layer. The outer layer 50 forming the barrier's outside surface is heat-sealed to the jacket 28. A convenient thickness for the jacket 28 is .057 inches. The outer jacket may, for example, be .067 inches. The core may, for example, be composed of 50 pairs of 17-guage plastic covered aluminum wire.

The vapor barrier according to the invention may also be made with two or more aluminum layers bonded between alternate plastic layers with plastic layers outside and inside as shown in FIG. 6. This affords the barrier redundant vapor-excluding properties. Again, the plastic layers 56 at the ends are bonded to each other to form the seam 48 while also bonded to the intermediate aluminum layers 58. Preferably, these multi-aluminum-layered barriers are corrugated transverse to their longitudinal direction. The seam 48 is sealed for at least the thickness of the jacket 28 and preferably three-eighths to one-half inch in the peripheral direction throughout the length of each cable 18. The redundant vapor-excluding properties available from the barrier in FIG. 6 may also be obtained for the barriers 26 of FIGS. 3 and 4 by wrapping them twice about the core and heat-sealing the outerfaces. This forms a helical seam 48 as shown in FIG. 7. In all cases, the vapor barriers's outside surface is heat-sealed to the jacket 28.

The cable is manufactured according to the invention by first forming the core from the individual conductors 22 in the conventional cable manufacturing manner. The vapor barrier 26 which must be preformed is then wrapped about the core and overlapped along the seam 48. The manufacturing process continues by extruding the polyethylene jacket about the vapor barrier with sufficient heat and pressure so that the jacket 28 fills any open interstices in the exterior surface of the vapor barrier and bonds itself throughout the entire surface of the vapor barrier while additionally furnishing enough heat to heat-seal the seam 48. This heat bonding preferably occurs over the entire barrier surface. An exemplary heat range for this is 350° to 450° F.

To insure such complete bonding each vapor barrier 26 of FIGS. 3, 5 6 or 7 should have its plastic layers extend beyond the longitudinal edges of the aluminum so that the edges are completely coated with plastic bonding material. This requires preforming each vapor barrier separately form predetermined widths of vapor barrier material. It is much simpler to preform each vapor barrier by cutting a length from a large laminated sheet. However, such a length has no edge coverings. Wrapped about a core and covered with the jacket 28, it leaves an unbonded section at one edge where the jacket abuts against the aluminum. Nevertheless, since the thickness of the aluminum is slight, and since the jacket 28 fits snugly against the aluminum edges, such lack of bonding is acceptable in practice. Thus, either method of preforming may be used.

The cable manufacture continues by wrapping the shield 30 about the polyethylene jacket and extruding the outer jacket 34 about the shield.

The invention contemplates coating the shield with the plastic bonding material so that the outer jacket 34 when extruded over the shield 30 closes the seam at the shield and adheres to it. However, this alternative is usable only where comparatively stiff cable is acceptable.

The cable is used by burying it in the ground and connecting the conductors 22 to suitable connectors at each central office. In the splices 20 the wires 22 are joined by wire connectors as disclosed in U.S. Pat. No. 3,064,072. These connection are protected in the splices as shown in FIG. 8. Here, two splice case sections 72 and 74 are bolted together at flanges 76 and 78. They form a pressure fit about the jackets 28 and 34 in the cable 18. These jackets as well as the vapor barrier 26 and the shield 30 are stripped back from the end of the cable as shown in FIG. 8. A gland 80 formed by the end of the sections 72 and 74 embraces two discs 82 and 84 which carry between them a so-called "B sealing compound" 86 composed of a putty-like substance that, under pressure forms an airtight joint about the jacket 28. The compound 86 is composed of a mixture of rubber, butyls, and other materials which prevent it from hardening or shrinking with age while maintaining its mechanical pressure against the jacket surface.

The jackets 28 and 34 hold the cable in position within the splice case being squeezed, with pressure from the flanges 76 and 78, between an annular protrusion 88 that presses the jacket 34, whose end is flared by longitudinal cuts, and a similarly flared shield 30 against a ring 90 that rests on the jacket 28. The ring 90 possesses ends that project through the cuts in the shield 30 and the jacket 34 to make electrical contact with the protrusion 88 of the section 72. A second gland 94 for producing watertight contact between the splice case and the outer jacket 34 is formed suitable annular protrusions 96 that hold lead discs 98 and 100 so that radial pressure from the flanges 76 and 78 will press more sealing compound 102 between the sections 72, 74 and the jacket 34.

In use, the cable's outer jacket 36 generally is susceptible to penetration by ground water that collects about the polyethylene jacket, due both to so-called "pumping" from temperature variations and lightning-made holes. Water thus inevitably reaches the surface of the shield 30. There the water seeps through its overlap. While the shield 30 may be made watertight, it ultimately corrodes or lightning inevitably burns holes that allow further passage of water. This water flows both circumferentially and axially through the cable. Water vapor then migrates through, or permeates, the polyethylene jacket 28 at a comparatively slow rate. It continues such permeation until it reaches the aluminum layer in the vapor barrier. The latter is effective for excluding both water and water vapor from the core 24. At the seam 48 the plastic permits some migration. However, since the distance between the aluminum layers is small and the circumferential dimension of the seam large, the rate of vapor flow is too slow to respond significantly to cyclical temperature-engendered vapor differentials. Thus, the barrier represented by the plastic in the seam is adequate for keeping the core substantially dry over the cable's 30-to- 50-year life expectancy.

At the cable splice 20, water traveling axially under the jacket 34 and shield 30 can enter the portion between the glands 94 and 80. However, here no free axial path is available

and the pumping rate is limited by the lead discs **84** and **82** as well as the width of the compound **86** and the comparatively long distance of the jacket **28** one too slow to be significantly affected by temperature cycles.

While conceivably, the lack of a bond at the seam **48** between the aluminum layer and the jacket **28** might provide an axial flow path for water, this path is substantially insignificant. The pumping action, by virtue of which water migrates through the polyethylene, requires a void in which vapor can collect and condense. By hugging the aluminum edge fast, such pumping is substantially avoided and axial water flow therein minimized.

While embodiments of the invention have been described in detail, it will be obvious to one skilled in the art that the invention may be practiced otherwise without departing from its spirit and scope.

I claim:

1. A cable system comprising a plurality of cable lengths, splice means connecting said cable lengths; each of said cable lengths including a core of communications-carrying conductor means for transmitting messages electrically, longitudinally seamed vapor barrier means surrounding said core and having a metal layer, fluid-obstructing structural support means bonded to substantially the entire outer surface of said vapor barrier means and conforming to the shape of the outer surface of said vapor barrier means, said structural means including a plastic sheath, bonded on the inside to the vapor barrier means and having a smooth substantially unbroken and round outer periphery, said structural means being substantially thicker than said vapor barrier means and having a substantially greater resistance to radial distortion than said vapor barrier means, electroconductive means surrounding said structural means, and a plastic jacket surrounding said electroconductive means; said splice means including a substantially rigid splice case for forming a pressure sheath about said cable lengths, said case having first and second glands containing a puttylike sealing means for holding said cable lengths in position within said splice case, whereby a barrier against the axial flow of water is formed.

2. A system as in claim **1** wherein said vapor barrier means comprise, in addition to said metal layer, two plastic outer layers adhering to opposite sides of said metal layer and forming an adhesive for bonding said vapor barrier means to said structural means.