June 24, 1969 R. A. KEMPF 3,452,320

COAXIAL CABLES

Original Filed June 25, 1965 Sheet 1 of 3

FIG. 1

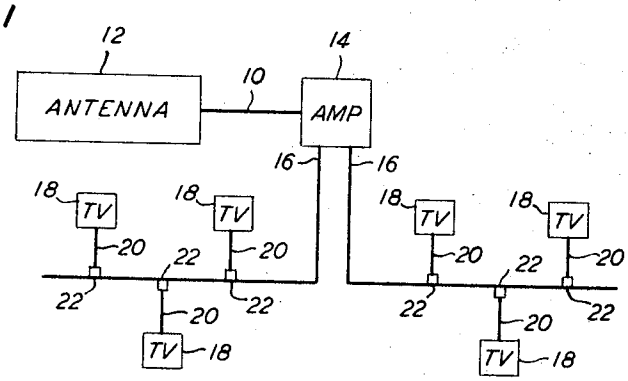


FIG. 2

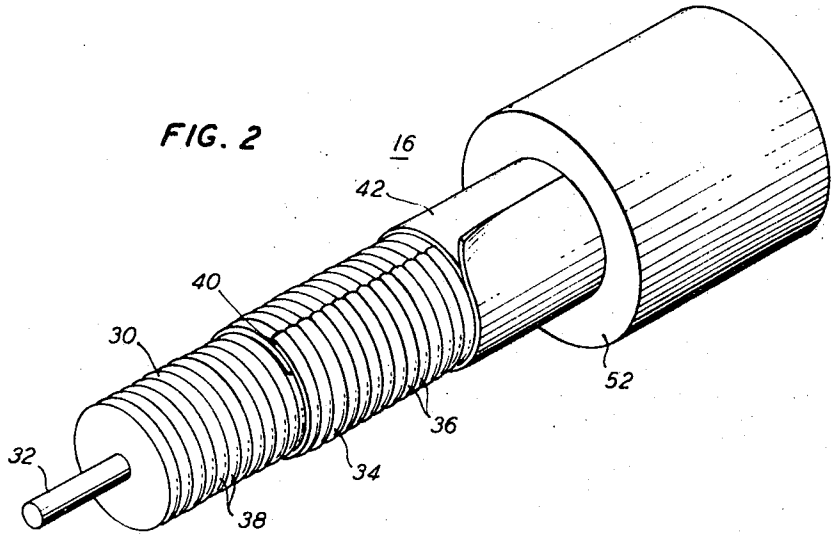
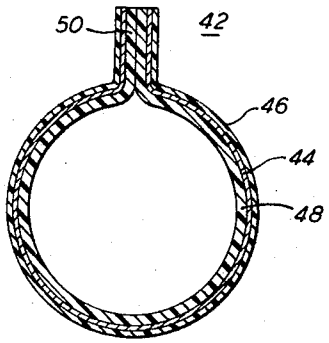


FIG. 3



INVENTOR
R. A. KEMPF
BY Leo Stanger
ATTORNEY

FIG. 4

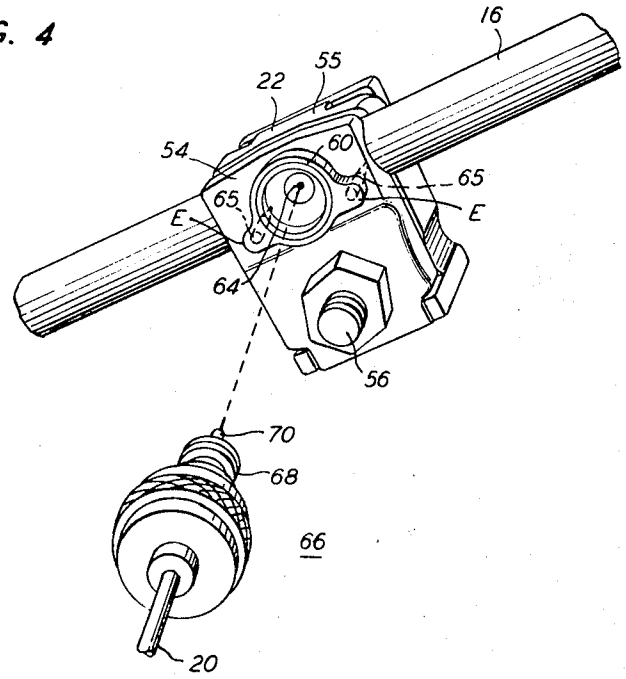

16
55
22
54
60
65
65
E
E
64
56
70
68
66
20

FIG. 5

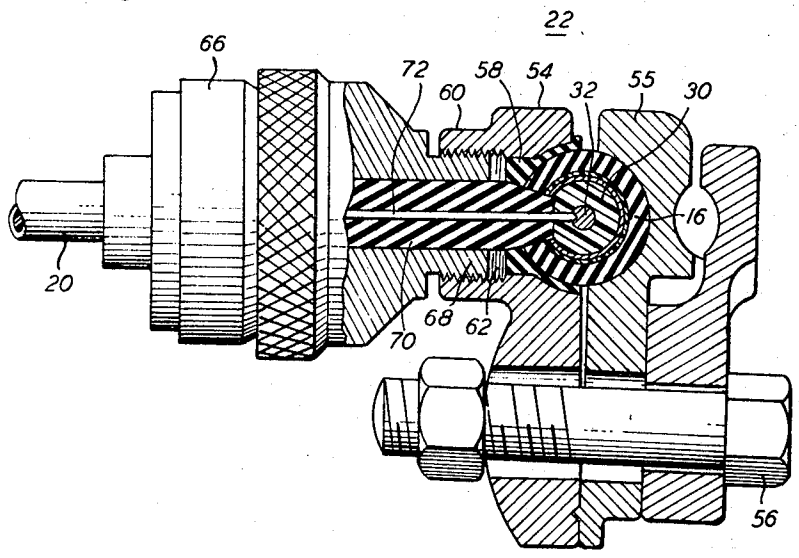

22
66
72
58
54
60
32
55
30
16
20
68
62
70
56

FIG. 6

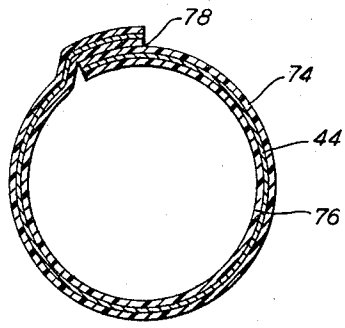


FIG. 7

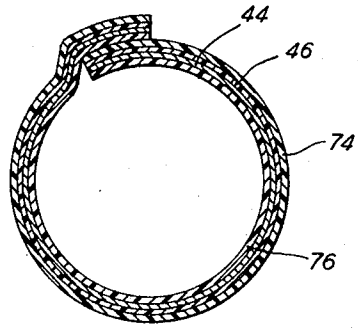
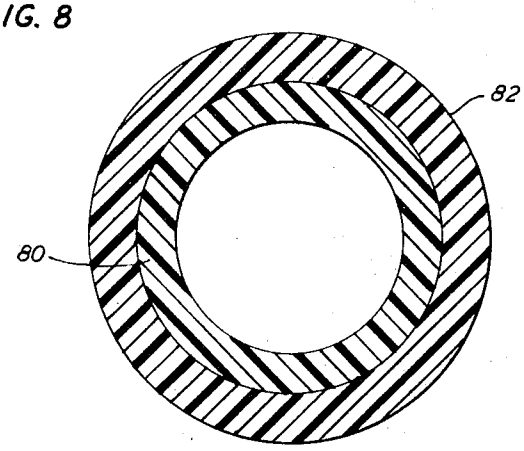


FIG. 8



United States Patent Office 3,452,320 Patented June 24, 1969

3,452,320

COAXIAL CABLES

Raymond A. Kempf, Baltimore, Md., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Original application June 25, 1965, Ser. No. 466,999, now Patent No. 3,379,824. Divided and this application Nov. 29, 1967, Ser. No. 705,581

Int. Cl. H01r 11/20, 17/18

U.S. Cl. 339—97 2 Claims

ABSTRACT OF THE DISCLOSURE

High frequency energy is distributed from a high frequency voltage source to respective electrical loads by means of distribution cable having inner and outer coaxial conductors spaced from each other by an expanded plastic insulator, and by means of tap-offs whose prongs contact the conductors. Drop-off cable means connect the tap-offs to the loads. The cable's outer conductor has a bare metal-to-metal seam so as to avoid having solder or welding fluxes from being absorbed by the expanded plastic insulator. A laminated plastic-metal-plastic vapor barrier protects the insulator from moisture and the expanded plastic insulator continuously holds the conductors in position against the radial force of the prongs in the tap-offs.

This is a division of parent application Serial No. 466,999, filed June 25, 1965, now Patent No. 3,379,824.

This invention relates to high-frequency signal distribution systems, and particularly to coaxial cables for distributing high-frequency signals from a source such as a community television antenna to a number of receivers such as television receivers in subscribing homes.

A convenient and inexpensive system for distributing signals from a community antenna includes an amplifier that passes the signals from a feeder cable to a number of distribution cables. So-called "tap-off" couplings along the distribution cables pass signal energy through respective drop-off cables to local subscribers. A tap-off coupling, or tap-off, is an attenuating coupling that embraces a distribution line with a clamp that has prongs penetrating the cable outer conductor. A threaded opening in the clamp exposes a hole bored through the outer jacket and outer conductor. A signal-attenuating connector screwed into the opening of the tap-off coupling connects to a drop-off cable, and with a stud projects through the insulation spacing the outer conductor from the inner conductor and pierces the inner or central conductor. With such a tap-off coupling, drop-off cables can be easily applied and removed. The attenuation in the tap-off coupling maintains the impedance of the distribution cable and prevents excessive energy from feeding through any one drop-off cable.

Such tap-off couplings operate especially well with distribution cables having solid insulation separating the inner from the outer conductor. Unfortunately, they fail with disk-spaced cables. There, because between the spacers the central conductor is substanially unsupported, the projecting prong will tend to displace the central conductor without proper penetration and contact. However, cables with solid insulators do not have the signal propagating properties available in disk-spaced cables, where the air provides a desirable low dielectric constant.

An object of this invention is to improve the propagating characteristics of cables susceptible to connection with tap-off couplings.

Another object of the invention is to accomplish this without subjecting the cable to other degrading effects.

According to a feature of this invention these objects

are obtained by surrounding the inner conductor with so-called expanded polyethylene or other expanded plastic, then applying a coaxial outer conductor having a bare overlapped seam, and embracing the outer conductor with a high-frequency shield that comprises a layer of aluminum laminated between two plastic layers which are heat sealed along a seam offset from the seam of the outer conductor. Another feature of the invention involves making the width of the heat seal transverse to the cable axis long compared to the thickness of the plastic separating the aluminum surfaces at the seal.

The expanded plastic is formed by fusing grains of plastic, in the presence of a gas-releasing agent that operates like the leavening in baking of bread. Such insulation constitutes a combination of plastic and air, exhibiting a dielectric constant lower than that of solid plastic and therefore improving the signal propagating properties of the cable which uses it.

By virtue of the invention the inner conductor is not only held securely for tap-off stud penetration by a high performance expanded plastic, but the high performance is maintained becauses the porous plastic is at once freed from the performance-degrading effects of flux seeping therein from the solder joint which might be used to close the seam of the outer conductor, and yet is protected from entry of performance-degrading ambient water vapor by the triple laminate electric shield. All this is accomplished without a solder joint which would stiffen the cable and interfere with bending during installation.

These and other features of the invention are pointed out more particularly in the claims. Other objects and advantages of the invention 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 system embodying features of the invention;

FIG. 2 is a perspective view of a cut-away portion of a distribution cable forming part of FIG. 1 and embodying features of the invention;

FIG. 3 is a cross section of a portion of the cable in FIG. 1;

FIG. 4 is a detailed and exploded perspective of the distribution cable and tap-off in FIG. 1;

FIG. 5 is a section transverse to the cable of FIG. 4;

FIGS. 6 and 7 are sections of other embodiments of the cable sheath in FIG. 2; and

FIG. 8 is a section of another embodiment of the cable jacket of FIG. 2.

In FIG. 1 a feeder cable **10** passes signals from a community antenna **12**, which may be located on a mountain top, to a central amplifier **14**. Two distribution cables **16** each carry the amplified television signals into the various streets of neighborhood subscribers. The television receivers **18** of local subscribers in the vicinity of the distribution cables **16** hook into the distribution cables through drop-off cables **20** by means of respective tap-off couplings **22**. The distribution cables are preferably aerially suspended, but underground cables are not excluded.

FIG. 2 illustrates a cut-away portion of a distribution cable **16** in detail. Here an expanded-polyethylene insulator **30** coaxially surrounds a copper central or inner conductor **32** and spaces the latter from a corrugated coaxial outer conductor **34**. The outer conductor **34** has corrugations **36** transverse to the longitudinal axis of the central conductor **32**. It is formed from an elongated corrugated ribbon that is folded to tightly embrace the insulator **30**, thereby forming some corrugations **38** in the insulation. The conductor **34** closes in a longitudinal overlapping seam **40**. The seam **40** comprises the bare overlapped edges of the outer conductor **34** contacting each other.

Surrounding the corrugated unsealed outer conductor **34** is a laminated sheath **42** illustrated in more detail in FIG. 3. Here the thicknesses of the layers are somewhat exaggerated for purposes of illustration. The sheath **42** comprises a one-mil-thick aluminum layer **44** bonded between a one-half-mil-thick layer **46** of polyethylene terephthalate, available commercially as "Mylar" and a five-mil-thick polypropylene layer **48**. The sleeve is formed by first producing the three-layer laminate in the shape of a long ribbon and rolling it around the copper outer conductor **34** with the polypropylene layer **48** on the inside, and bending the longitudinal edges of the ribbon upwardly to form a fin **50** about one-quarter-inch wide. The sheath is completed by heat sealing the polypropylene faces in the fin **50** to each other, and the fin **50** is bent over. The sheath **42** mechanically closes the seam on the outer conductor **34**. A polyethylene or polyvinyl chloride jacket **52** is extruded about the sheath to form the completed cable **16**. According to one manufacturing method the heat of the jacket **52** being extruded onto the sheath **42** seals the polypropylene faces in the fin to each other.

The laminate sheath **42** serves as a moisture barrier to prevent entrance of water vapors into the expanded polyethylene insulation. Such water vapor would eventually degrade the propagation characteristics of the cable.

FIGS. 4 and 5 are details of the distribution cable **16** where it meets one of the tap-off couplings **22**. In the coupling **22** two conductive metal clamp members **54** and **55**, whose interior surfaces are recessed, are squeezed onto the cable **16** by a bolt **56**. An insulating gasket **58** on the clamp member **54** protects the cable **16** from deformation. A boss **60** peripherally surrounding a threaded opening **62** exposes a hole **64** bored transverse to the axis of cable **16** and through the gasket **58**, the jacket **52**, the sheath **42**, and the outer conductor **34**. Conductive prongs **65** project inwardly from the clamp member **54** from a location behind the ears E of the boss **60**. They project through the gasket **58**, the jacket **52**, and the sheath **42** until they pierce and conductively connect to the outer conductor **34**.

The tap-off coupling **22** also includes a connector **66** whose threaded protrusion **68** conductively engages the outer conductor on the drop-off cable **20** and screws into the threads in the opening **62**. Insulation **70** centrally mounts a stud **72** within the protrusion **68**, The stud **72** is conductively connected with the inner conductor on the cable **20**. When the connector **66** is tightly screwed into the opening **62** in clamp member **54**, the stud passes through the insulation **30** in the line **16** until it pierces the inner or central conductor **32**. The bulk of the expanded plastic insulator **30** holds the central conductor **32** in the path of the advancing and piercing stud. This assures proper penetration and connection of the stud **72** with central conductor **32**. An attenuator (not shown) in the connector **66** reduces the energy passing from the cable **16** to cable **20** and thus maintains the impedance of cable **16**.

The attenuator network in the tap-off coupling **22** bridges the distribution cable **16** without excessively disturbing its impedance and also limits radiation of the local oscillator of the television receiver **18** back into the distribution network. The attenuation is selected to provide an appropriate signal level at the television receiver related to the position of the drop along the distribution cable **16** measured from the nearest amplifier **14**.

In operation the antenna **12** feeds signals from television transmitters, over a range of frequencies of 54 megacycles to 216 megacycles, through the feeder cable **10** to the amplifier **14**. The amplifier **14** is a wide-band amplifier suitable for operating over this broad range of frequencies. It passes the amplified signals through the lines **16** to the tap-off couplings **22**. Here connection is made between the outer conductors of cable **16** and cable **20** through the prongs **65** and the protrusion **68**. Connection is made between the inner conductors through the stud **72**. The drop-off cables **20** carry the broad-band signals to individual television receivers **18**.

Connecting a cable **20** from television receiver **18** to the signal-carrying distribution cable **16** is readily accomplished. It involves first securing the two clamp members **54** of the tap-off coupling **22** to the line **16**, and, with a threaded corer (not shown) rotated in the threads of the boss **60**, boring a hole in the jacket **52**, the sheath **42**, and the outer conductor **34**. The connection is completed by mounting the connector portion **66** onto the cable **20**, and then screwing the connector onto the clamp members **54** until the stud **72** pierces the inner conductor **32**.

Assuring accurate interconductor spacing and excellent propagation characteristics, and assuring adequate support of the inner conductor during the penetrating process of the stud **72**, while nevertheless preventing degradation of the dielectric constant, are the expanded plastic insulator **30**, the seam **40** on the outer conductor **34**, and the sheath **42**. The expanded plastic of insulator **30** provides the body for centering and supporting the inner conductor **32**. Its high air content is responsible for a low dielectric constant that improves the propagation characteristics of the cable. The outer conductor **34** and the sheath **42** together maintain the low dielectric constant of the insulator **30** and maximize its effect. They do this by leaving the edges of seam **40** bare and thus avoid the use of solder to close the seam **40**; such a solder joint requires a flux which otherwise seeps into the expanded polyethylene and destroys its desirable characteristics. They complete the partial electrical shielding of energy in the cable with the aluminum layer **44** of the laminate sheath **42**. They prevent ingress of vapor to the porous insulation **30**, unprotected by a solder seam on the outer conductor **34**. The sheath **42** is virtually vapor impenetrable at the aluminum layer **44**. The fin **50** presents such vapor with a comparatively long ingress path along the heat seal, which ingress path is also extremely narrow due to the small spacing between the edges of the aluminum layer **44**. By folding the fin **50** over along a line offset from the outer edge of seam **40** the sheath **42** forms a shield that helps the outer conductor prevent loss of electrical energy through the seam **40**. On the other hand, high-intensity interference in the vicinity of the cable is effectively prevented from entering the cable.

According to another embodiment of the invention the heat seal of the sheath **42** in FIG. 2 is formed by overlapping the sheath edges rather than by folding the fin **50**. Such a sheath, suitable to replace the sheath **42** in FIG. 2, is illustrated in FIG. 6. Here again the thicknesses of the layers shown are exaggerated for clarity. The aluminum layer **44** of sheath **42** is sandwiched between two 5-mil-thick polypropylene layers **74** and **76**. After the sheath is folded tightly about the outer conductor **34**, the longitudinal edges of the sheath are overlapped and the outer sheath **74** welded to the inner sheath **76** to form a heat seal **78**. This heat sealing operation can be performed with a special heating source. On the other hand, the heat energy for the heat seal **78** may be obtained from the heat emitted when the jacket **52** is extruded about the sheath **42**.

FIG. 7 illustrates another embodiment of the sheath **42** with exaggerated layer thicknesses. Here again the overlapping sheath edges form the heat seal **78** as illustrated in FIG. 6. However, here it is the aluminum layer **44** as well as the Mylar layer **46** that is sandwiched between the two 5-mil-thick polypropylene layers **74** and **76**. The Mylar layer is approximately one-half-mil thick. However, it imparts considerable strength to the entire sheath. Mylar has far greater torsional, tear, and tensile strength as compared to polypropylene or similar thicknesses of aluminum. Moreover, the Mylar layer is quite flexible. Here again, the heat seal **78** is formed either by a separate step or as part of the jacket extruding process. In both FIGS. 6 and 7 the heat seal along the overlap extends one-quarter inch in the peripheral direction.

According to the invention the jacket **52** may be either polyethylene or polyvinyl chloride. It may also be composed of two thick layers, that is, an interior layer of polyethylene and an exterior layer of polyvinyl chloride. The polyvinyl chloride imparts heat resistance and fire protection properties to the cable. Structures using polyvinyl chloride cable are suitable in locations where they are subject to high temperatures or fires. FIG. 8 illustrates a compound jacket **52** of polyethylene **80** and polyvinyl chloride **82**.

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

What is claimed is:

1. A high-frequency distribution system comprising a high-frequency voltage source, a distribution cable having inner and outer coaxial conductors spaced from each other by an expanded plastic insulator, said outer conductor being corrugated, said outer conductor having portions forming a seam and being surrounded by laminated shielding means, said portions being bare and directly contactable, said shielding means having a metal layer sandwiched between respective plastic layers and having edges forming a seal, said layers having edge sections, said seal having two of said edge sections welded together, an outer protective jacket surrounding said shielding means, a plurality of tap-off means having prongs contacting said conductors, and drop-off cable means connecting said tap-off means to respective electrical loads.

2. A high-frequency distribution system comprising a high-frequency voltage source, a distribution cable having

inner and outer coaxial conductors spaced from each other by an expanded plastic insulator, said outer conductor being corrugated, said outer conductor having portions forming a seam and being surrounded by laminated plastic-metal-plastic shielding means, said portions being bare and directly contactable, said shielding means having a metal layer sandwiched between respective plastic layers and having edges forming a seal, said layers having edge sections, said seal having two of said edge sections welded together, an outer protective jacket surrounding said shielding means, a plurality of tap-off means having prongs penetrating said conductors, said prong penetrating said outer conductor also penetrating said shielding means and thereby connecting said shielding means to said outer conductor, and drop-off cable means connecting said tap-off means to respective electrical loads.

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MARVIN A. CHAMPION, *Primary Examiner.*

JOSEPH H. McGLYNN, *Assistant Examiner.*

U.S. Cl. X.R.

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