

Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an electrical cable for a transmission line in either round or flat form and, in particular, to an electrical cable having a plurality of conductors therein wherein each conductor or set of conductors is physically separated and electromagnetically isolated along their entire axial length by a corrugated septum.

Description of the Prior Art

Round cables are presently used for relatively high speed data transmission between various system components in data processing networks. Such cables utilize twisted pairs of conductors to achieve the necessary electrical characteristics, particularly characteristic impedance and cross-talk control.

One such cable arrangement is that sold by Hewlett-Packard as the HPIB cable. This cable includes concentrically spaced inner and outer conducting members disposed about a central, axially extending core. The inner member is typically a metallized film sheath while the outer member is a metallized film sheath surrounded by a metallic braid. A first layer of twisted pairs of conductors is disposed in the annular space defined between the core and the inner surface of the inner conducting member while a second layer of twisted pairs of conductors is disposed in the annular space between the outer surface of the inner member and the inner surface of the outer conducting member. The conductors in the inner layer are used as data transmission lines while the conductors in the outer layer serve as control lines. One conductor in each twisted pair carries the appropriate data or control signal while the other of the conductors in that pair serves as the signal return for that signal. In typical usage the inner conducting member is electrically grounded and acts to isolate the data pairs from the control pairs.

A round cable assembly as described above is bulky and generally expensive to manufacture due to its complexity. Twisted conductor pairs result in an overall diameter of the twisted pair cable that is significantly larger than that of standard cables. Such a twisted pair cable can range from twenty to fifty percent larger than a standard cable depending upon conductor size and the number of conductors. These factors also result in a relatively stiffer cable construction which must be carefully fabricated in order to prevent failure due to cable flexing. Twisted pair cables often do not exhibit a

uniform cross-section and can thus present problems when using automatic stripping apparatus. Furthermore, providing the appropriate terminations at each end of each cable is a relatively labor intensive endeavor since before the ends of the conductors can be terminated in a suitable connector the conductors comprising each twisted pair must be untwisted.

Despite their problems twisted pair cables are utilised because they provide electrical characteristics that are closely comparable to the electrical characteristics of coaxial cable. Of course, the cost of coaxial cable prevents its widespread use in the environment here discussed.

In view of the foregoing it is believed advantageous to provide a cable structure that utilizes ordinary insulated jacketed conductors, makes maximum use of such conductors for signal carrying purposes, and yet electromagnetically isolates each signal carrying conductor along its entire axial length. In addition, it is believed advantageous to use ordinary jacketed conductors in both round and flat cable forms which maintains total electromagnetic isolation of the conductors along their entire axial length, thus approximating closely the electrical performance of a coaxial cable.

EP-A-0073622 describes a flat cable assembly composed of individually shielded coaxial cables placed side-by-side and in which a conductive screen or web extends intermittently between adjacent cables and is bonded in with a corrugated jacket to form clusters of individually shielded cables.

DE-C-624008 describes a round cable assembly with an array of conductors disposed in the grooves of a corrugated screen to lie on a common radial spacing.

US-A-4551576 describes a flat cable which has a serpentine conductive shield passing in a step-like manner above and below groups of signal conductors. In making this cable the shield is sandwiched between insulating layers of preformed cable layers.

In accordance with the invention there is provided a cable comprising:

an outer insulated jacket;

a corrugated member within the jacket the corrugated member having opposed surfaces each with spaced open grooves therein and at least conductive layers in the grooves which are in electrical contact with one another;

first and second conductive members within the jacket disposed adjacent the conductive layers of the corrugated member and in electrical contact therewith, the conductive members co-operating with the associated conductive layers to close the grooves and define a plurality of enclosed tubular envelopes; and

at least one electrical conductor or group of electrical conductors disposed in each of the envelopes and insulated from the conductive layers and the conductive members, the conductive layers and the conductive members being, in use, maintained at a predetermined electrical potential to ensure each of the conductors or groups of conductor is substantially totally electromagnetically isolated along its axial length from the remaining conductors or groups of conductors.

The cable may be flat or round. To fabricate a round cable the invention provides, in another aspect, a method of forming a cable comprising the steps of:

providing an inner metallic sheath;

spirally wrapping a first, inner array of conductors about the inner sheath such that a predetermined circumferential spacing is defined between adjacent ones of the conductors of the inner array;

loosely spirally wrapping a flexible compressible member having metallic conductive inner and outer surfaces about the inner array of conductors with the spiral wraps of the flexible member edgewise overlapping so that the inner and outer surfaces thereof are in contact;

spirally wrapping a second, outer array of conductors about the flexible member such that the conductors of the outer array register with the spaces between adjacent conductors of the inner array;

radially compressing the structure defined by the preceding steps to cause the axes of the conductors in the inner and outer arrays to lie on substantially the same radial distance from the axis of the cable and to impart a corrugated shape to the flexible member; and

providing an outer metallic sheath and an insulated jacket about the outer array of conductors to produce a structure wherein the inner sheath, the outer sheath and the inner and outer surfaces of the flexible member are in electrical contact with each other for maintaining at a predetermined electrical potential and each of the conductors is insulated from the sheaths and lies enclosed in a substantially tubular envelope for substantially total electromagnetic isolation throughout its entire axial length.

To fabricate a flat cable two alternative methods can be adopted. Thus, in another aspect, the invention provides a method of forming a cable comprising the initial steps of: laying an array of conductors on one side of a flexible compressible member having metallic conductive surface layers with a predetermined lateral spacing being defined between the conductors in the array, relatively compressing the conductors in the array toward the member to impart to the member a corrugated shape with a plurality of grooves on both sides and

then laying another array of conductors in the grooves in the other side of the member. Alternatively, these preliminary steps may involve placing two arrays of conductors one on each side of the member and compressing each array to produce the corrugated shape. The structure then produced by either of these treatments has first and second arrays of conductors in the grooves in both sides of the member with the arrays on a substantially linear locus. Thereafter the method comprises folding the member along a first fold line substantially parallel to the axes of the conductors to overlay the corrugated region of the member over the first array of conductors; folding the member along a second, spaced, fold line substantially parallel to the axes of the conductors to overlay the corrugated region of the member over the second array of conductors and providing an insulated jacket to the structure with the surface layers of the member in electrical contact for maintaining at a predetermined electrical potential so that each of the conductors is insulated from the surface layers of the member and lies enclosed in a substantially tubular envelope for substantially total electromagnetic isolation throughout its entire length.

The corrugated member can be a metallic foil with the conductive layers integral with the rest of the member or made of a plastics material provided with coatings or layers providing the conductive layers. The conductive layers can be continuous or non-continuous.

In a round cable configuration, the conductive members are in the form of an inner and an outer sheath, concentrically arranged to define an annular axially extending volume on the interior of the cable. The corrugated member or septum has a plurality of alternating ridges and grooves and is disposed in the annular volume, with each of the ridges contacting against the surface of the sheath to which it is radially proximal. As a result the plurality of axially extending substantially tubular envelopes are defined. The conductors are in the envelopes having their axes lying on a circular locus. Such a cable structure utilizes each of the conductors as a signal carrying conductor, while at the same time provides electrical characteristics that closely approximate the characteristics of coaxial cable.

In some of the embodiments of the invention the corrugated member is defined by the flexible tape that is caused to sinuously surround the conductors in inner and outer arrays. Overlapping the edges of the flexible tape and the subsequent compressing of the assembled structure insures the electrical interconnection of the septum and the inner and outer sheaths.

In the flat cable configuration the corrugated member is substantially planar with the axes of the

conductors lying on a linear locus. In one embodiment the corrugated member or septum has a single flap integrally formed along one edge thereof. Both conductive members are disposed on this flap. When the flap is folded along a first and a second fold line each conductive member is placed into contact with the conductive layers on one surface of the septum. In an alternate embodiment the septum has a pair of flaps, one of which is integrally formed along each longitudinal edge of the septum. A conductive member is disposed on each flap. When folded along a fold line each flap overlies a surface of the septum so that the conductive member on that flap is placed into contact with the conductive layers on that surface of the septum which it overlies.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more clearly understood from the following detailed description thereof, taken in connection with the accompanying drawings which form a part of this application and in which:

Figure 1 is a side elevational view of a round cable in accordance with the present invention with the various elements of the cable being axially stepwise spaced for illustrative purposes; Figure 2 is a sectional view taken along section line 2-2 of Figure 1 illustrating a cable arrangement having a single insulated jacketed conductor in each electromagnetically isolated envelope;

Figure 3 is a sectional view similar to Figure 2 illustrating a cable arrangement having a plurality of insulated jacket conductors in each electromagnetically isolated envelope;

Figures 4 and 5 are sectional views similar to Figures 2 and 3, respectively, illustrating alternate embodiments of the present invention; Figures 6A through 6F diagrammatically illustrate the method steps involved in manufacture of a cable in accordance with the present invention:

Figure 7 is a perspective view of a flat cable in accordance with the present invention with various elements of the cable being axially stepwise spaced for illustrative purposes;

Figures 8 and 9 are sectional views taken along view lines 8,9-8,9 in Figure 7 illustrating alternate embodiments of the flat cable of Figure 7; and

Figures 10A through 10E are diagrammatic illustrations of a method for manufacturing a flat cable in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Throughout the following detailed description similar reference characters refer to similar elements in all Figures of the drawings.

Referring to Figures 1 and 2 respectively shown in side elevation and in section is a round cable generally indicated by reference character 10 in accordance with the present invention. The cable 10 includes a central axially extending elastomeric filler, or core, 12 (Figure 1) having a central axis 14 of the cable extending therethrough. The core 12 may be omitted, if desired. It should be noted that in Figures 2 through 5 the core 12 is omitted from the drawings for clarity of illustration.

An inner conducting member, or sheath, 22 surrounds the core 12. Spaced a predetermined radial distance outward from the inner sheath 22 is a second, radially outer, conducting member, or sheath, 24. The inner and outer sheaths 22 and 24 cooperate to define an axially extending annular volume 26 (Figure 2) on the interior of the cable. Each sheath 22, 24 may be provided in any suitable form, such as a spiral winding of a metal foil, a metallized plastic film, a metallic braid or a metallic served shield.

Disposed in the volume 26 defined between the inner and outer sheaths 22, 24 is a corrugated septum 30 having an array of corresponding ridges 32 and grooves 34 formed therein. The septum 30 is positioned in the volume 26 such that the peaks of the ridges 32 on the inner surface 30I of the septum 30 contact against the inner sheath 22, as indicated at contact points 36. The contact points 36 between the sheath 22 and the septum 30 extend throughout the axial length of the cable 10. Similarly, the peaks of the ridges 32 on the outer surface 30E of the septum 30 contact against the inner surface of the outer sheath 24 throughout the axial length of the cable 10, as indicated by the contact points 38. The septum 30 may be formed from a suitable plastic material so long as at least the inner surface 30I and the outer surface 30E of the septum 30 are provided with a coating or layer of a conducting material. Alternately, the septum 30 may be formed entirely from a conducting material, such as a metallic foil.

The cooperative interaction of the corrugated septum 30 and the inner and outer sheaths 22, 24, respectively, defines a plurality of enclosed, substantially tubular regions, or envelopes, 44A through 44L extending axially along the interior of the cable. A conductor 48A through 48L is disposed respectively in each of the tubular envelopes 44A through 44L. Each conductor 48A through 48L includes a central current carrying wire 50 surrounded by an insulating jacket 52 as illustrated in connection with the conductor 48K. Preferably the

wires 50 for the individual conductors 48 are each 30 AWG annealed tinned copper. Polyolefin or fluorocarbon material may be used as the insulating jacket 52 for the individual conductors. It should, however, be understood that any suitable conductors may be used in the cable of the present invention including bare wire conductors, assuming proper precautions are taken to insure that the individual conductors do not contact the septum 30 or the sheath 22, 24, as the case may be, forming the envelopes 44 in which the conductor is disposed.

The conductors 48 are arranged in the envelopes 44 such that the axis of each of the conductors 48 lies on a substantially circular locus with each conductor axis being a predetermined distance 56 from the axis 14 of the cable 10. It should be understood, however, that such an arrangement is not necessarily required.

As may be seen from Figure 2, the conductors 48A through 48F are received in the envelopes 44A through 44F that are defined by the radially outer surface 30E of the septum 30 and the outer sheath 24. These conductors may be construed to comprise one conductor array. Similarly, a second conductor array is comprised of the conductors 48G through 48L. These conductors are received in the corresponding envelopes 44G through 44L defined by the radially inner surface 30I of the septum 30 and the inner sheath 22. The number of conductors in each of the conductor arrays is equal.

Surrounding the exterior of the outer sheath 24 is an insulated jacket 58 preferably formed of thirty-five mil PVC per UL 2464.

As shown in the alternate embodiment of the cable 10 shown in Figure 3, more than one conductor 48 may be disposed in each of the envelopes 44. Thus, for example, the envelope 44A contains the conductors 48A, 48B. In such an arrangement a balanced pair of conductors may be defined within each of the envelopes, with one of the conductors serving as a signal carrying conductor while the second of the conductors serves as the signal return.

It should also be understood that different envelopes may contain differing numbers of conductors and remain within the contemplation of this invention. For example, alternate envelopes may contain two conductors while the intermediate envelopes may carry only a single conductor. It is also possible in a cable having more than one conductor in a given envelope to stack the conductors radially with respect to the axis of the cable. In such an instance, of course, the axis of all the conductors would not lie the same predetermined radial distance from the axis of the cable.

In accordance with the present invention the inner sheath 22, the outer sheath 24, the inner

surface 30I and the outer surface 30E of the septum 30 are electrically interconnected. Any suitable arrangement to effect this interconnection may be used and lie within the contemplation of the present invention.

In addition, as seen from Figures 4 and 5, an additional annular volume 66 may be defined by the provision of an additional sheath 68 disposed radially outwardly of the sheath 24, thus placing that sheath 24 intermediate or medially between the outermost sheath 68 and the innermost sheath 22. Into the annular volume 66 so defined an additional septum 30' is positioned so as to define another array of tubular envelopes 44'. Additional arrays of individual conductors 48' are arranged in the envelopes 44'. These additional conductors 48' may be identical to or different from the conductors 48. In the Figures 4 and 5, the conductors 48 and 48' shown as slightly different in size to illustrate the possibility that a difference in conductors lies within the contemplation of this invention. Such arrangements are shown in Figures 4 and 5, which are, respectively, similar to the arrangement of conductors in each envelope as described in Figures 2 and 3. It should also be appreciated that the conductors in the inner array may be arranged in their respective envelopes in a manner that differs from the arrangement in the outer envelopes. The extension to more than two annular volumes should be readily apparent to those skilled in the art. Similarly, the interconnection of the sheaths and corrugated septum in each volume is also an extension of the teachings above presented.

Referring to Figures 6A through 6G shown in schematic diagram form are the steps useful to form the round cable 10 in accordance with the present invention. The steps may be manually effected, or an automated apparatus, such as a planetary cable winder, may be used.

As seen in Figure 6A, as a first step the inner metallic sheath 22 is provided over the core 12. This is effected, for example, by spirally wrapping a metallized foil about the core 12. The inner array of conductors 48G through 48L is next laid onto the central portion defined by the core 12 and the inner sheath 22. The conductors are spirally wrapped about the inner sheath 22 such that a predetermined circumferential spacing 72 is defined between adjacent ones of the conductors 48G through 48L of the inner conductor array.

The septum 30 is then loosely spirally wrapped (Figure 6B) about the inner array of conductors. In the preferred case the septum 30 is provided using a flexible metallized foil or tape having metallic inner and outer surfaces. The requisite contact between the inner surface 30I and outer surface 30E of the septum 30 is insured by having each succeeding spiral wrapping of the flexible metal-

lized tape edgewise overlap the previously laid wraps.

The second, outer, array of conductors 48A through 48F is next laid (Figure 6C) about the assembly such that the conductors of the outer array register with the spaces 72 between the circumferentially adjacent adjacent conductors of the inner array.

A radially inwardly compressive force is then applied to the structure of Figure 6C to deform the outer array of conductors 48A through 48F as well as the flexible septum 30 into the structure shown in Figure 6D. As a result, the axes of each of the conductors 48A through 48F in the outer array and the conductors 48F through 48L in the inner array lie on substantially the same radial distance from the axis of the cable. The compression imparts the corrugated shape to the septum 30. In addition, compressing the outer array of conductors brings the peaks of the ridges on the inner surface 30I of the septum 30 into contact with the inner sheath 22, as indicated by the contact points 36.

As seen from Figure 6E, the outer metallic sheath 24 is provided about the outer array of conductors. This causes the peaks of the ridges on the outer surface 30E of the septum to contact against the outer sheath 24 at the contact points 38 and thus produces a structure wherein the inner sheath 22, the outer sheath 24 and the inner and outer surfaces 30I and 30E, respectively, of the flexible septum 30 into electrical contact with each other. Thus, each of the conductors 48A through 48L lies enclosed in a substantially tubular envelope throughout its entire axial length.

At any appropriate step the medium whereby the sheaths 22, 24 and the septum 30 are interconnected is introduced into the cable. For example, in Figure 6E, the spiral drain wire 59 may be provided on the outer sheath 24 so as to lie within one of the envelopes. If the sheath 24 is realized by a metallic foil (without an intermediate insulating layer) then the drain wire 59 may be wrapped about the exterior of the sheath 24. For example, a bare drain wire 59 may be disposed within a selected envelope to effect the desired electrical interconnection. Other exemplary expedients whereby the sheaths and the septum may be interconnected include a contact foil, a braid, a spiral drain wire or a served shield. Thereafter, as shown in Figure 6F, the insulated jacket 58 is provided over the cable assembly. If a cable as shown in Figures 4 and 5 is to be fabricated, the steps shown in Figures 6A through 6F repeated, using a structure shown in Figure 6E (with the sheath 24 as the outside layer) as the central portion about which additional conductors are placed.

In operation, a predetermined electrical potential, typically ground potential, is applied to the

interconnected sheaths 22, 24 and the surface of the septum 30 (and to the sheath 68 and septum 30', if provided, Figures 4 and 5). By applying the potential to these conducting members each of the conductors 48 enclosed within the individual envelopes is electromagnetically isolated and shielded. If a balanced pair of conductors are disposed in each of the envelopes (as, for example, in Figures 4 and 5), even higher levels of performance may be achieved.

It has been found that the structure of the cable 10 in accordance with the present invention provides electrical characteristics comparable to those produced by a coaxial cable.

Figure 7 illustrates a perspective view of a flat cable 10' also in accordance with the present invention. The cable 10' includes a corrugated septum 30' formed into a generally planar configuration. The septum 30' has extending ridges 32' and grooves 34' provided on opposed surface 30'I and 30'E thereof. The septum 30' may be formed from a suitable plastic material so long as conductive layers 78 are provided in each of the grooves 34' provided on the opposed surfaces 30'E and 30'I of the septum 30'. The conductive layers 78 may be arranged in the form of separated stripes on each surface, or the layers 78 may be continuous over each surface. Alternately the septum 30' may be formed entirely from a metallized plastic film or from a conductive material, such as a metallic foil. In the Figures 7 through 10 the conductive layers 78 are shown as being continuous over the surface of the septum 30'. In whatever manner provided, the conductive layers 78 lying in the grooves 34' on each surface of the septum 30' are in electrical contact with each other so as to be connectible to a common potential. The electrical interconnection between the layers 78 may be effected in any convenient fashion. For example, the layers 78 from opposed surfaces of the septum 30' may be contacted with each other, as by folding, at the axial ends or lateral edges of the cable. Alternatively bare drain wires (e.g., the wires 59' in Figures 8 and 9) could be provided, with each drain wire being connected to a layer 78 by mechanical contact. The drains themselves are interconnected or connected to a common potential.

Disposed in each of the grooves 78 is an insulated jacketed conductor 48. The conductors 48 disposed in the grooves 34' formed in one side 30'E of the septum 30' define a first array of conductors, while the conductors 48 disposed in the opposed surface 30'I of the septum 30' define a second conductor array. In any event, the axes of the conductors 48 in both arrays thereof lie on a common locus that takes a linear form.

In such a flat cable arrangement 10' as heretofore described, with the conducting layers 78

connected to a common (typically ground) potential, the individual conductors 48 are afforded some degree of electromagnetic isolation one from the other when the layers 78 are connected to the common potential. If desired sheath members formed of a nonconducting material, similar in form to the sheaths 22', 24' to be discussed, may be laid over septum 30' to cover the grooves and the conductors 48 received therein. As will be developed, to provide structural integrity to the flat cable an adhesive layer is provided between these nonconducting sheath members and the septum 30'. Such nonconducting sheaths may also be used in place of the sheaths 22', 24' shown in the round cable of Figures 1 to 6.

However, in accordance with the more preferred embodiment of the invention a first and a second conductive member or sheath 22', 24' is respectively disposed adjacent one of the surfaces 30'E, 30'I of the septum 30'. The sheaths 22', 24' are shown in the drawing as formed of a metallized plastic film material, although it should be understood that a metal foil may also be used. The conductive sheaths 22', 24' are arranged to contact the ridges 34' on the respective surface of the septum 30' to which the sheath is adjacent to define the axially extending envelopes 44'. The sheaths 22', 24' are electrically interconnected to the layers 78 by mechanical contact therebetween. Any convenient alternate expedient may be used to connect the sheaths to the layers 78. For example, suitable single or multi-strand bare drain wires 59' (not shown in Figure 7 but seen in Figures 8 and 9) may be provided into an envelope on one side or on each side of the septum. The drains 59' may be inserted into any one of the grooves. The drain wires 59' are thus interconnected with the sheaths 22', 24' and the layers 78. The sheaths 22', 24' may, in such an arrangement, be themselves interconnected by connecting the drains together or to a common potential. Conductors 48, whether used with the round cable or with the flat cable, may be single or multi-strands of wire and may be jacketed with a foamed polyolefin or fluorocarbon material.

To provide structural integrity to the cable 10' shown in Figure 7 in order to hold the same together a layer of adhesive 79 is disposed on the inner surfaces 22'I and 24'I of the sheaths 22' and 24', respectively. Any pressure sensitive adhesive, such as the acrylic adhesive transfer tape sold by 3M Corporation, Minneapolis, Minnesota as tape No. 924 may be used. Alternatively any elastomeric, silicone, rubber, or plastic adhesive may be used. The adhesive 79 is disposed, as a minimum, along the ridges 32' on each side of the septum 30' at the points of mechanical contact between the sheaths 22', 24' and the septum 30'. In practice the adhesive 79 is disposed as a con-

tinuous layer on the inner surfaces of the sheaths 22', 24'. The pressure of the adhesive layer does not significantly impair the requisite electrical contact between the sheaths 22', 24' and the septum 30'. Moreover, if the conductors 48 are jacketed with a polyolefin or fluorocarbon material, these jackets would not readily bond to the adhesive. Thus such jacketed conductors may move relatively to the septum and to the sheaths during bending, resulting in greater cable flexibility. The adhesive 79 causes the sheaths 22', 24' to adhere to the septum 30' and thereby imparts an integrity to the structure of the cable 10' so produced.

In cables where foamed insulating jackets are used for the conductors, the forms can be readily damaged, both during the manufacturing process, and during subsequent use since the foams are relatively fragile. Adhesively bonding the corrugated septum to the outer sheaths provides a semi-rigid structure which protects the fragile jackets of the conductors from stresses which are both compressive and tensile in mode. If the adhesive were not present, the tensile stresses would tend to pull the cable apart, the conductors would become disarrayed, and the electrical characteristics of the cable would be significantly changed.

If the adhesive were not used and compressive stresses were imparted to the cable, the corrugated septum could easily slide relative to the sheath and the conductors would be easily damaged. The adhesive bond prevents the septum from sliding relative to the sheath, and consequently the structure resists compression, thus protecting the relatively fragile conductors.

Figures 8 and 9 illustrate alternate embodiments of a flat cable 10' in accordance with the present invention. In the embodiment of Figure 8 the septum 30' has a single flap 82 integrally formed therewith and extending along one longitudinal edge of the septum 30'. The conducting sheaths 22', 24' are defined as separate layers of conductive material on the surface of the flap 82. The flap 82, when folded along fold lines 84A and 84B, causes the conductive sheaths 22', 24' to overlie a respective surface of the septum 30' and contact the ridges thereon to define the envelopes 44'.

In the alternate arrangement shown in Figure 9 the septum 30' is provided with a pair of flaps 86, 88 integrally formed along the opposed longitudinal edges of the septum 30'. The conductive sheaths 22', 24' are provided on a respective one of the flaps 86, 88. In this instance when each of the flaps 86, 88 is folded along an appropriate fold line 90, 92, respectively, the conductor sheaths 22', 24' are brought into overlying position with respect to a surface of the septum 30' thereby to contact the ridges 34' thereof to define the axially extending

tubular envelopes 44'.

As is the case in the embodiment of the invention shown in Figure 7 the layers of adhesive 79 are disposed on the inner surface of the single flap 82 (Figure 8) and on the inner surfaces of the flaps 86, 88 (Figure 9).

Large drain wires 59' are disposed in the grooves at at each lateral edge of the septum so as to lie at each lateral end of the linear array of conductors 48 provided in the cable 10'. The drains 59' should have outer diameter dimension of the same as those of the conductors 48. The drains 59' are provided primarily to terminate the sheaths. Secondly, when the foamed conductors are used as the conductors 48, the drains 59' at each lateral end of the linear array provide protection for the fragile foamed conductors. It should also be appreciated that the drains or other protective wires (whether or not interconnected in an electrical circuit) can be interspersed along the width of the linear array of conductors in order to provide mechanical protection for foamed conductors, if they be used in the cable. Thirdly, the drains 59' serve as strain relief for the cable 10' when a connector is added.

A suitable insulating jacket 58' is formed over the septum 30', whether or not the septum 30' is overlaid with the conductive sheaths 22', 24'.

As is the case in the circular cable discussed in conjunction with Figures 1 through 6, each tubular envelopes 44' in the flat cable 10' may contain multiple conductors, or alternate ones of the envelopes may contain single conductors 48 while the other of the envelope contain multiple conductors 48.

A flat cable 10' in accordance with the present invention may be fabricated using the steps shown in Figures 10A through 10E.

As shown in Figure 10A an array of conductors is laid against on surface 30'1 of the septum 30'. The septum is compressed against the array of conductors, thus imparting the corrugated shape thereto. A second array of conductors 48 may then be laid into the grooves 34' formed in the septum 30'. Alternately, as shown in Figure 10B an array of conductors 48 is laid simultaneously against each surface of a resilient material used to form the septum 30'. The conductors 48 are laid with a gap defined therebetween such that when the conductors 48 and the septum 30' are exposed to a compressive force the corrugated shaped is imparted to the septum 30'. In each instance the compressive force must be applied either from the center of the septum 30' outwardly or from one side toward the other. By whatever alternative used, the structure shown in Figure 10C is produced.

The further steps of the manufacturing process are dependent upon the form which the sheaths 22', 24' take. If each edge of the septum 30' is provided with a flap 86, 88, respectively (as illustrated in Figure 10C), the flaps 86, 88 are provided with the adhesive layer 79 and folded, as shown in Figure 10D; along their appropriate fold lines 90, 92, respectively to dispose the sheaths 22', 24' in their overlapping relationship to the septum 30'. If the single flap 82 is used, as shown in Figure 10E, the single flap 82 provided with the adhesive 79 on those portions of the inner surface of the flap 82 and the flap 82 is folded along the fold lines 84A, 84B as shown in Figure 10E to dispose the sheaths 22', 24' carried on the flap 82 in their overlapping relationship with respect to each surface of the septum. The resultant structure is then covered with the insulating jacket 58'. The drain wires 59', if used, are provided on the flap (or flaps) so as to appropriately locate the drain.

As an alternate mode of manufacture a metalized plastic foil used to form the septum may be unwound from a supply reel and corrugated using a corrugator having a series of contoured rollers therein. The septum is corrugated first in the central region thereof, with the corrugations being formed progressively toward the lateral edges of the septum as the septum moves through the corrugator. Conductors and drains, as appropriate, are laid into selected grooves on each surface of the septum. The adhesive layer is then applied to the exposed portions of each surface of the septum and the conductors and drains. The backing of the transfer tape (identified earlier) is stripped therefrom as the tape is drawn from a supply roll and pressed onto the septum, conductors and drains as the assembly passes through a pair of nip rolls. Outer sheaths (whether of conducting or nonconducting material) are laid onto both surfaces of the septum. The lateral edges of the assembly so produced are trimmed to an appropriate width. The cable assembly may then be jacketed with a suitable insulating jacket 58', preferably formed of polyvinylchloride (PVC).

In view of the foregoing, those skilled in the art may readily appreciate that a cable, in round or flat form, in accordance with the present invention provides electrical performance substantially equal to that produced by a corresponding coaxial cable. However, since ordinary shielded cable has been used to form the cable 10, such performances has been achieved at a fraction of the cost. Those skilled in the art, having benefit of the teachings of the present invention as hereinabove set forth may effect numerous modifications thereto. However, such modifications are to be construed as lying within the scope of the present invention, as defined by the appended claims.



Claims

1. A cable (10,10') comprising:
an outer insulated jacket (58,58');
a corrugated member (30,30') within the jacket (58,58'), the corrugated member having opposed surfaces (30I,30E) each with spaced open grooves (34,34') therein and at least conductive layers (78) in the grooves which are in electrical contact with one another;
first and second conductive members (22,24,22',24') within the jacket (58,58') disposed adjacent the conductive layers (78) of the corrugated member (30,30') and in electrical contact therewith, the conductive members (22,24,22',24') co-operating with the associated conductive layers (78) to close the grooves (34,34') and define a plurality of enclosed tubular envelopes (44,44',44A-44L); and
at least one electrical conductor or a group of electrical conductors (48,48',48A-48L) disposed in each of the envelopes (44,44',44A-44L) and insulated from the conductive layers (78) and the conductive members (22,24,22',24'), the conductive layers (78) and the conductive members (22,24,22',24') being in use, maintained at a predetermined electrical potential to ensure that each of the conductors or groups of conductors (48,48',48A-48L) is substantially totally electromagnetically isolated along its axial length from the remaining conductors or groups of conductors.
2. A cable according to claim 1, wherein each conductive member (22,24) is a spiral winding of a metal foil, a metallized plastics film, a metallic braid or a metallic served shield.
3. A cable according to claim 1, or 2, wherein the corrugated member (30,30') is formed from a metallic foil and the conductive layers (78), are integral with the rest of the corrugated member (30,30').
4. A cable according to claim 1,2, or 3, wherein the corrugated member (30,30') is a plastics material provided with coatings or layers of a conductive material providing the conductive layers (78).
5. A cable according to any one of claims 1 to 4, wherein the conductive layers (78) are continuous.
6. A cable according to any one of the preceding claims, wherein there is a second electrical conductor (48,48',48A-48L) in each of the envelopes (44A-4L) and all the conductors (48,48',48A-48L) are electromagnetically isolated during use.
7. A cable according to any one of the preceding claims, wherein the predetermined electrical potential is ground potential.
8. A cable according to any one of the preceding claims, wherein each of the conductors (48,48',48A-48L) comprise single or multi-stranded wire (50) surrounded by an insulated jacket (52), such as a foamed plastic.
9. A cable according to any one of the preceding claims, wherein the corrugated member (30') is substantially planar in configuration and the axes of the conductors (48) lie on a common, substantially linear locus.
10. A cable according to claim 9, wherein the corrugated member (30') has a first and a second flap (86,88) integrally formed along longitudinal edges thereof with the conductive members (22',24') disposed on the flaps (86,88), the flaps (86,88) being foldable to overlie a respective surface (30'I,30'E) of the corrugated member (30') thereby to dispose each conductive member (22',24') into contact with its respective conductive layer (78) to define the tubular envelopes (44').
11. A cable according to claim 9, wherein the corrugated member (30') has a flap (82) integrally formed along one longitudinal edge thereof with the conductive members (22',24') disposed on the flap (82), the flap (82) being foldable along two fold lines (84A,84B) such that a portion of the flap overlies each surface (30'E,30'I) of the corrugated member (30') thereby to dispose each conductive member (22',24') into contact with its respective conductive layer (78) to define the tubular envelopes (44').
12. A cable according to claim 10 or 11, wherein the conductive members (22',24') are defined as metal layers on the surface of the or each flap (82,86,88).
13. A cable according to any one of claims 9 to 12 and further comprising an adhesive layer (79) disposed between each conductive member (22',24') and the corrugated member (30').
14. A cable according to any one of claims 9 to 13, wherein the corrugated member (30') has a groove adjacent each lateral edge thereof and a drain wire (59') is disposed in each such



groove to provide the predetermined potential.

15. A cable according to any one of claims 1 to 8, wherein the corrugated member (30,) is a flexible tape helically wrapped along an axis of the cable such that the inner surface of the tape contacts and edgewise overlaps the outer surface of the tape at least one point.

16. A cable according to any one of claims 1 to 8, or claim 15, wherein the corrugated member (30), is substantially circular in configuration and the axes of the conductors (48,48A-48L) lie on a common, substantially circular locus.

17. A cable according to any one of claim 1 to 8, or claim 15, wherein the corrugated member (30) and the conductive members (22,24) are substantially circular and concentric.

18. A cable according to claim 16 or 17, and further comprising an additional conductive member (68) concentrically disposed with respect to the other conductive members (22,24) to define an inner and an outer annular volume (26,66) therebetween with the corrugated member (30) in one volume; a further corrugated member (30') disposed in the other annular volume, the further corrugated member (30') having opposed surfaces each with spaced open grooves (34) therein and conductive layers (78) in the grooves (34) and in electrical contact with one another, the additional conductive member (68) and the second conductive member (24) being disposed adjacent the conductive layers (78) of the further corrugated member (30) and in electrical contact therewith, the additional and second conductive members (68,24) co-operating with the associated conductive layers (78) of the further corrugated member (30') to close the grooves (34) of the further corrugated member (30') and define a further plurality of enclosed tubular envelopes (44') extending axially along the cable; at least one further electrical conductor (48') disposed in each of the further tubular envelopes (44') with the additional and the second conductive members (68,24) and the further corrugated member (30') being, in use, at the predetermined electrical potential such that each of the further conductors (48') is electromagnetically isolated along its axial length.

19. A cable according to any one of claims 1 to 8, 15,16,17 or 18, wherein a contact foil, a braid, a spiral drain wire or a served shield serves to interconnect the conductive members (22,24)

and the corrugated member (30,30').

20. A method of forming a circular cable comprising the steps of:

- a) providing an inner metallic sheath (22);
- b) spirally wrapping a first, inner array of conductors (48G-48L) about the inner sheath (22) such that a predetermined circumferential spacing (72) is defined between adjacent ones of the conductors (48G-48L) of the inner array;
- c) loosely spirally wrapping a flexible compressible member (30) having metallic conductive inner and outer surfaces about the inner array of conductors (48G-48L) with the spiral wraps of the flexible member (30) edgewise overlapping so that the inner and outer surfaces thereof are in contact;
- d) spirally wrapping a second, outer array of conductors (48A-48F) about the flexible member (30) such that the conductors (48A-48F) of the outer array register with the spaces between adjacent conductors (48G-48L) of the inner array;
- e) radially compressing the structure defined by the preceding steps to cause the axes of the conductors (48A-48L) in the inner and outer arrays to lie on substantially the same radial distance from the axis of the cable and to impart a corrugated shape to the flexible member (30); and
- f) providing an outer metallic sheath (24) and an insulated jacket (58) about the outer array of conductors (48A-48F) to produce a structure wherein the inner sheath (22) the outer sheath (24) and the inner and outer surfaces of the flexible member (30) are in electrical contact with each other for maintaining at a predetermined electrical potential and each of the conductors (48a-48L) is insulated from the sheaths (22,24) and lies enclosed in a substantially tubular envelope (44) for substantially total electromagnetic isolation throughout its entire axial length.

21. A method of forming a flat cable comprising the steps of

- a) laying an array of conductors (48) on one or both sides (30'E,30'I) of a flexible compressible member (30') having metallic conductive surface layers with a predetermined lateral spacing being defined between the conductors (46) in the array;
- b) in the case where the array is on one side of the member (30') relatively compressing the conductors (48) in the array towards the member (30') to impart to the member (30') a corrugated shape with a



plurality of grooves (34) defined on both side surfaces of the member and laying another array of conductors in the grooves on the side opposite to said one side formed by the compression of the conductors in the array on said one side or in the case where there are arrays of conductors (48) on both sides of the member (30') relatively compressing the conductors (48) in both arrays towards the member (30') to impart to the member (30') a corrugated shape (34) with a plurality of grooves defined on both side surfaces of the member so that in both cases first and second arrays of conductors (48) are disposed in the grooves (34) in both sides of the member (30') with the arrays on a substantially linear locus;

c) folding the member (30') along a first fold line substantially parallel to the axes of the conductors (48) to overlay the corrugated region of the member (30') over the first array of conductors (48);

d) folding the member (30') along a second, spaced, fold line substantially parallel to the axes of the conductors to overlay the corrugated region of the member (30') the second array of conductors (48); and

e) providing an insulated jacket (58') to the structure with the surface layers of the member (30') in electrical contact for maintaining at a predetermined electrical potential so that each of the conductors (48), which is insulated from the surface layers of the member (30'), lies enclosed in a substantially tubular envelope (44') for substantially total electromagnetic isolation throughout its entire length.

22. A method according to claim 21 and further comprising providing adhesive layers (79) on the folded parts (82,86,88) of the member (30') prior to folding to impart structural integrity to the cable.

Patentansprüche

1. Kabel (10, 10'), welches folgendes aufweist:
einen äußeren Isoliermantel (58, 58');
ein gewelltes Teil (30, 30') in dem Mantel (58, 58'), wobei das gewellte Teil gegenüberliegende Flächen (30I, 30E) mit jeweils darin befindlichen und im Abstand angeordneten, offenen Ausnehmungen (34, 34') sowie wenigstens leitende Schichten (78) in den Ausnehmungen hat, welche in elektrischem Kontakt miteinander sind;
erste und zweite leitende Teile (22, 24,

22', 24') in den Mänteln (58, 58'), welche den leitenden Schichten (78) des gewellten Teils (30, 30') benachbart angeordnet und in elektrischem Kontakt hiermit sind, wobei die leitenden Teile (22, 24, 22', 24') mit den zugeordneten leitenden Schichten (78) zusammenarbeiten, um die Ausnehmungen (34, 34') zu schließen und eine Mehrzahl von eingeschlossenen, rohrförmigen Umhüllungen (44, 44', 44A-44L) zu bilden; und

wenigstens einen elektrischen Leiter oder eine Gruppe von elektrischen Leitern (48, 48', 48A-48L), welche jeweils in den Umhüllungen (44, 44', 44A-44L) angeordnet und von den leitenden Schichten (78) isoliert sind, und die leitenden Teile (22, 24, 22', 24'), die leitenden Schichten (78) und die leitenden Teile (22, 24, 22', 24') im Gebrauchszustand auf einem vorbestimmten elektrischen Potential derart gehalten sind, daß jeder der Leiter oder jede Gruppe von Leitern (48, 48', 48A-48L) im wesentlichen vollständig entlang der axialen Längserstreckung von den verbleibenden Leitern oder Gruppen von Leitern isoliert ist.

2. Kabel nach Anspruch 1, bei dem jedes leitende Teil (22, 24) eine spiralförmige Wicklung aus einer Metallfolie, einer metallisierten Kunststoffolie, eines Metallgeflechts oder einer metallarmierten Abschirmung ist.
3. Kabel nach Anspruch 1 oder 2, bei dem das gewellte Teil (30, 30') aus einer Metallfolie ausgebildet ist, und die leitenden Schichten (78) mit dem verbleibenden gewellten Teil (30, 30') einteilig sind.
4. Kabel nach Anspruch 1, 2 oder 3, bei dem das gewellte Teil (30, 30') ein Kunststoffmaterial ist, welches mit Überzügen oder Schichten aus einem leitenden Material versehen ist, welche die leitenden Schichten (78) bilden.
5. Kabel nach einem der Ansprüche 1 bis 4, bei dem die leitenden Schichten (78) durchgehend sind.
6. Kabel nach einem der vorangehenden Ansprüche, bei dem ein zweiter elektrischer Leiter (48, 48', 48A-48L) in jeder Umhüllung (44A-44L) vorgesehen ist und alle Leiter (48, 48', 48A-48L) im Gebrauchszustand elektromagnetisch isoliert sind.
7. Kabel nach einem der vorangehenden Ansprüche, bei dem das vorbestimmte elektrische Potential Massepotential ist.



8. Kabel nach einem der vorangehenden Ansprüche, bei dem jeder Leiter (48, 48', 48A-48L) eine einzige oder eine mehradrige Leitung (50) aufweist, welche von einem Isoliermantel (52), wie einem Schaumkunststoff, umgeben ist. 5
9. Kabel nach einem der vorangehenden Ansprüche, bei dem das gewellte Teil (30') im wesentlichen planar ausgebildet ist und die Achsen der Leiter (48) auf einer gemeinsamen, im wesentlichen linearen Stelle liegen. 10
10. Kabel nach Anspruch 9, bei dem das gewellte Teil (30') eine erste und eine zweite Umschlagklappe (86, 88) hat, an deren Längsränder einteilig die leitenden Teile (22', 24') an den Umschlagklappen (86, 88) vorgesehen sind, und bei der die Umschlagklappen (86, 88) derart faltbar sind, daß sie auf einer zugeordneten Fläche (30'I, 30'E) des gewellten Teils (30') zu liegen kommen, wodurch jedes leitende Teil (22', 24') in Kontakt mit der zugeordneten leitenden Schicht (78) angeordnet wird, um die rohrförmigen Umhüllungen (44') zu bilden. 15
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11. Kabel nach Anspruch 9, bei dem das gewellte Teil (30') eine Umschlagklappe (82) hat, an deren Längsrand einteilig die leitenden Teile (22', 24') ausgebildet sind, die an der Umschlagklappe (82) angebracht sind, und bei dem die Klappe (82) entlang zwei Faltlinien (84A, 84B) derart gefaltet werden kann, daß ein Teil der Umschlagklappe über der jeweiligen Fläche (30'E, 30'I) des gewellten Teils (30') zu liegen kommt wodurch jedes leitende Teil (22', 24') in Kontakt mit der zugeordneten leitenden Schicht (78) angeordnet wird, um die rohrförmigen Umhüllungen (44') zu bilden. 25
30
35
12. Kabel nach Anspruch 10 oder 11, bei dem die leitenden Teile (22', 24') als Metallschichten auf der Oberfläche der oder jeder Umschlagklappe (82, 86, 88) ausgebildet sind. 40
13. Kabel nach einem der Ansprüche 9 bis 12, welches ferner eine Haftschrift bzw. Klebstoffschicht (29) aufweist, welche zwischen jedem leitenden Teil (22', 24') und dem gewellten Teil (30') angeordnet ist. 45
50
14. Kabel nach einem der Ansprüche 9 bis 13, bei dem das gewellte Teil (30') eine Ausnehmung angrenzend an den jeweiligen Querrand hiervon hat, und eine Ableitung (59') in jeder derartigen Ausnehmung angeordnet ist, um das vorbestimmte Potential bereitzustellen. 55
15. Kabel nach einem der Ansprüche 1 bis 8, bei dem das gewellte Teil (30) ein flexibles Band ist, welches spiralförmig entlang einer Achse des Kabels derart gewickelt ist, daß die innere Fläche des Bandes die äußere Fläche des Bandes wenigstens an einer Stelle berührt und an den Rändern eine Überlappung vorhanden ist.
16. Kabel nach einem der Ansprüche 1 bis 8 oder Anspruch 15, bei dem das gewellte Teil (30) im wesentlichen kreisförmig ausgebildet ist und die Achsen der Leiter (48, 48A-48L) an einem gemeinsamen, im wesentlichen kreisförmigen Ort liegen.
17. Kabel nach einem der Ansprüche 1 bis 8 oder Anspruch 15, bei dem das gewellte Teil (30) und die leitenden Teile (22, 24) im wesentlichen kreisförmig und konzentrisch sind.
18. Kabel nach Anspruch 16 und 17, welches ferner ein zusätzliches, leitendes Teil (68) aufweist, das konzentrisch bezüglich der anderen leitenden Teile (22, 24) angeordnet ist, um dazwischen einen inneren und einen äußeren, ringförmigen Raum (26, 66) zu bilden, wobei das gewellte Teil (30) in einem Raum sich befindet; ein weiteres gewelltes Teil (30') in dem anderen ringförmigen Raum angeordnet ist, das weitere gewellte Teil (30') gegenüberliegende Flächen hat, die jeweils im Abstand angeordnete, offene Ausnehmungen (34) darin haben und leitende Schichten (78) in den Ausnehmungen (34) und in elektrischem Kontakt miteinander vorgesehen sind, das zusätzliche leitende Teil (68) und das zweite leitende Teil (24) angrenzend an die leitenden Schichten (78) des weiteren gewellten Teils (30) und in elektrischem Kontakt hiermit vorgesehen sind, das zusätzliche und das zweite leitende Teil (68, 24) mit den zugeordneten, leitenden Schichten (78) des weiteren gewellten Teils (30) zusammenarbeiten, um die Ausnehmungen (34) des weiteren, gewellten Teils (30) zu schließen und eine weitere Mehrzahl von eingeschlossenen, rohrförmigen Umhüllungen (44') zu bilden, welche in axialer Richtung entlang des Kabels verlaufen; wenigstens ein weiterer elektrischer Leiter (48') in der jeweiligen weiteren rohrförmigen Umhüllung (44') zusammen mit dem zusätzlichen und dem zweiten leitenden Teil (68, 24) angeordnet ist, und das weitere, gewellte Teil (30') im Gebrauchszustand sich auf einem vorbestimmten elektrischen Potential derart befindet, daß jeder der weiteren Leiter (48') entlang der axialen Längserstreckung elektromagnetisch isoliert ist.



19. Kabel nach einem der Ansprüche 1 bis 8, 15, 16, 17 oder 18, bei dem eine Kontaktfolie, ein Geflecht, eine spiralförmige Ableitung oder eine armierte Abschirmung dazu dient, daß die leitenden Teile (22, 24) und das gewellte Teil (30, 30') verbunden werden.

20. Verfahren zum Herstellen eines kreisförmigen Kabels, welches die folgenden Schritte aufweist:

a) Bereitstellen einer inneren, metallischen Hülle (22);

b) spiralförmiges Wickeln einer ersten, inneren Gruppe von Leitern (48G-48L) um die innere Hülle (22) derart, daß ein vorbestimmter Umfangszwischenraum (72) zwischen benachbarten Leitern (48G-48L) der inneren Reihe gebildet wird;

c) loses spiralförmiges Wickeln eines flexiblen, komprimierbaren Teils (30), welches metallische, leitende, innere und äußere Flächen hat, um die innere Reihe von Leitern (48G-48L), wobei die spiralförmigen Wicklungen des flexiblen Teils (30) an den Rändern derart überlappen, daß die inneren und äußeren Flächen hiervon in Kontakt sind;

d) spiralförmiges Wickeln einer zweiten, äußeren Reihe von Leitern (48A-48F) um das flexible Teil (30) derart, daß die Leiter (48A-48F) der äußeren Reihe zu den Zwischenräumen zwischen benachbarten Leitern (48G-48L) der inneren Reihe ausgerichtet sind;

e) radiales Komprimieren der nach den voranstehenden Schritten gebildeten Anordnung, um zu bewirken, daß die Achsen der Leiter (48A-48L) in den inneren und äußeren Reihen in einem im wesentlichen gleichen Radialabstand von der Achse des Kabels liegen und dem flexiblen Teil (30) eine gewellte Gestalt verleihen; und

f) Vorsehen einer äußeren metallischen Hülle (24) und eines Isoliermantels (28) um die äußere Reihe von Leitern (48A-48F), um eine Anordnung zu bilden, bei der die innere Hülle (22), die äußere Hülle (24) und die inneren und äußeren Flächen des flexiblen Teils (30) in elektrischem Kontakt miteinander sind, um ein vorbestimmtes elektrisches Potential aufrechtzuerhalten, und wobei jeder Leiter (48A-48L) von den Hüllen (22, 24) isoliert ist und in einer im wesentlichen rohrförmigen Umhüllung (44) eingeschlossen angeordnet ist, um eine im wesentlichen vollständige elektromagnetische Isolierung über die gesamte axiale Längserstreckung hinweg zu haben.

21. Verfahren zum Herstellen eines Flachkabels, welches die folgenden Schritte aufweist:

a) Legen einer Reihe von Leitern (48) auf die eine oder beide Seiten (30'E, 30'I) eines flexiblen, komprimierbaren Teils (30'), welches metallische, leitende Oberflächenschichten hat, wobei ein vorbestimmter Querabstand zwischen den Leitern (46) in der Reihe vorhanden ist;

b) wenn die Reihe auf einer Seite des Teils (30') angeordnet ist, die Leiter (48) in der Reihe in Richtung auf das Teil (30') relativ zusammengedrückt werden, um dem Teil (30') eine wellige Gestalt mit einer Mehrzahl von Ausnehmungen (34) zu verleihen, welche auf beiden Seitenflächen des Teils ausgebildet sind und Einlegen einer weiteren Reihe von Leitern in die Ausnehmungen auf der Seite, die jener Seite gegenüberliegt, die durch das Zusammendrücken der Leiter in der Reihe auf einer Seite ausgebildet ist, oder wenn die Reihen von Leitern (48) auf beiden Seiten des Teils (30') vorgesehen sind, die Leiter (48) in beiden Reihen in Richtung auf das Teil (30') zusammengedrückt werden, um dem Teil (30') eine gewellte Gestalt (34) in einer Mehrzahl von Ausnehmungen zu verleihen, die auf beiden Seitenflächen des Teils derart ausgebildet sind, daß in beiden Fällen erste und zweite Reihen von Leitern (48) in den Ausnehmungen (34) auf beiden Seiten des Teils (30') angeordnet sind, wobei die Reihen eine im wesentlichen lineare Ortslage einnehmen;

c) Falten des Teils (30') entlang einer ersten Faltlinie, welche im wesentlichen parallel zu den Achsen der Leiter (48) ist, um den gewellten Bereich des Teils (30') über der ersten Reihe von Leitern (48') übereinanderliegender Anordnungen vorzusehen;

d) Falten des Teils (30') entlang einer zweiten, im Abstand angeordneten Faltlinie, welche im wesentlichen parallel zu den Achsen der Leiter ist, um den gewellten Bereich des Teils (30') auf der zweiten Reihe von Leitern (48') anzuordnen; und

e) Vorsehen eines Isoliermantels (58') an der Anordnung, wobei die Oberflächenschichten des Teils (30') in elektrischem Kontakt sind, um ein vorbestimmtes elektrisches Potential derart aufrechtzuhalten, daß jeder Leiter (48), welcher von den Oberflächenschichten des Teils (30') isoliert ist, in einer im wesentlichen rohrförmigen Umhüllung (44') eingeschlossen liegt, um eine im wesentlichen vollständige elektromagnetische Isolierung über die gesamte Länge hinweg zu haben.



22. Verfahren nach Anspruch 21, bei dem ferner Klebstoffschichten (79) auf den gefalteten Teilen (82, 86, 88) des Teils (30') vor dem Falten vorgesehen werden, um dem Kabel ein konstruktiv zusammenhängendes Gebilde zu verleihen.

Revendications

1. Un câble (10, 10') comprenant:

- une gaine isolée extérieure (58, 58');
- un organe ondulé (30, 30') situé à l'intérieur de la gaine (58, 58'), l'organe ondulé présentant des surfaces opposées (30I, 30E), chacune d'entre elles comportant des gorges ouvertes (34, 34') espacées en son sein et au moins des couches conductrices (78) dans les gorges, qui se situent en contact électrique entre elles;
- des premier et second organes conducteurs (22, 24, 22', 24') situés dans la gaine (58, 58'), disposés de façon adjacente aux couches conductrices (78) de l'organe ondulé (30, 30') et en contact électrique avec ce dernier, les organes conducteurs (22, 24, 22', 24') coopérant avec les couches conductrices (78) associées pour fermer les gorges (34, 34') et définir une pluralité d'enveloppes tubulaires enfermées (44, 44', 44A à 44L); et
- au moins un conducteur électrique ou un groupe de conducteurs électriques (48, 48', 48A à 48L) disposés dans chacune des enveloppes (44, 44', 44A à 44L) et isolés des couches conductrices (78) et des organes conducteurs (22, 24, 22', 24'), les couches conductrices (78) et les organes conducteurs (22, 24, 22', 24') étant maintenus, en utilisation, à un potentiel électrique prédéterminé pour assurer le fait que chacun des conducteurs ou des groupes de conducteurs (48, 48', 48A à 48L) soit sensiblement totalement isolé de façon électromagnétique, sur sa longueur axiale, des conducteurs ou groupes de conducteurs restants.

2. Un câble selon la revendication 1, dans lequel chaque organe conducteur (22, 24) est un enroulement hélicoïdal d'une feuille métallique, d'un film en matériau synthétique métallisé, d'une tresse métallique ou d'un écran à revêtement métallique.

3. Un câble selon la revendication 1 ou 2, dans lequel l'organe ondulé (30, 30') est constitué d'une feuille métallique et les couches conduc-

trices (78) sont réalisées d'un seul tenant avec le restant de l'organe ondulé (30, 30').

4. Un câble selon la revendication 1, 2 ou 3, dans lequel l'organe ondulé (30, 30') est constitué d'un matériau plastique pourvu de revêtements ou de couches de matériau conducteur constituant les couches conductrices (78).

5. Un câble selon l'une quelconque des revendications 1 à 4, dans lequel les couches conductrices (78) sont continues.

6. Un câble selon l'une quelconque des revendications précédentes, dans lequel il existe un second conducteur électrique (48, 48', 48A à 48L) dans chacune des enveloppes (44A à 44L) et tous les conducteurs (48, 48', 48A à 48L) sont isolés de façon électromagnétique durant l'utilisation.

7. Un câble selon l'une quelconque des revendications précédentes, dans lequel le potentiel électrique prédéterminé est le potentiel de la masse.

8. Un câble selon l'une quelconque des revendications précédentes, dans lequel chacun des conducteurs (48, 48', 48A à 48L) comprend un fil à toron unique ou multiple (50), entouré par une gaine isolée (52), tel qu'un matériau plastique alvéolaire.

9. Un câble selon l'une quelconque des revendications précédentes, dans lequel l'organe ondulé (30') présente une configuration sensiblement plane et les axes des conducteurs (48) se situent sur un emplacement commun, sensiblement linéaire.

10. Un câble selon la revendication 9, dans lequel l'organe ondulé (30') présente un premier et un second volets (86, 88) réalisés d'un seul tenant, le long de ses bords longitudinaux, avec les organes conducteurs (22', 24') disposés sur les volets (86, 88), les volets (86, 88) étant pliables pour recouvrir une surface (30'I, 30'E) respective de l'organe ondulé (30'), de manière à disposer chaque organe conducteur (22', 24') en contact avec sa couche conductrice (78) respective pour définir les enveloppes tubulaires (44').

11. Un câble selon la revendication 9, dans lequel l'organe ondulé (30') présente un volet (82) réalisé d'un seul tenant, le long de l'un de ses bords longitudinaux, avec les organes conducteurs (22', 24') disposés sur le volet (82), le



- volet (82) étant pliable le long de deux lignes de pliage (84A, 84B), de manière qu'une partie du volet recouvre chaque surface (30'E, 30'I) de l'organe ondulé (30'), en vue de disposer chaque organe conducteur (22', 24') en contact avec sa couche conductrice (78) respective pour définir les enveloppes tubulaires (44').
- 5
12. Câble selon la revendication 10 ou 11, dans lequel les organes conducteurs (22', 24') sont définis comme des couches métalliques sur la surface du ou de chaque volet (82, 86, 88).
- 10
13. Un câble selon l'une quelconque des revendications 9 à 12, comprenant en outre une couche adhésive (79) disposée entre chaque organe conducteur (22', 24') et l'organe ondulé (30').
- 15
14. Un câble selon l'une quelconque des revendications 9 à 13, dans lequel l'organe ondulé (30') présente une gorge adjacente à chacun de ses bords latéraux et un fil de drain (59') est disposés dans chacune de ces gorges, pour fournir le potentiel prédéterminé.
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- 25
15. Un câble selon l'une quelconque des revendications 1 à 8, dans lequel l'organe ondulé (30) est une bande flexible enroulée hélicoïdalement le long d'un axe du câble, de manière que la surface intérieure de la bande entre en contact avec et recouvre latéralement la surface extérieure de la bande, en au moins un point.
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16. Un câble selon l'une quelconque des revendications 1 à 8, dans lequel l'organe ondulé (30) présente une configuration sensiblement circulaire et les axes des conducteurs (48, 48A à 48L) se situent sur un emplacement commun, sensiblement circulaire.
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17. Un câble selon l'une quelconque des revendications 1 à 8 ou la revendication 15, dans lequel l'organe ondulé (30) et les organes conducteurs (22, 24) sont sensiblement circulaire et concentriques.
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18. Un câble selon la revendication 16 ou 17, comprenant en outre un organe conducteur (68) supplémentaire, disposé de manière concentrique par rapport aux organes conducteurs (22, 24), pour définir un volume annulaire intérieur et extérieur (26, 66) entre eux, l'organe ondulé (30) étant situé dans un volume; un organe ondulé (30') supplémentaire disposés dans l'autre volume annulaire, l'organe ondulé (30') supplémentaire présentant des surfaces opposées, chacune d'entre elles comportant des gorges ouvertes (34) espacées en son sein et des couches conductrices (78) dans les gorges (34), qui se situent en contact électrique entre elles, l'organe conducteur (68) supplémentaire et le second organe conducteur (24) étant disposés de façon adjacente aux couches conductrice (78) de l'organe ondulé (30) supplémentaire et en contact électrique avec ce dernier, l'organe conducteur supplémentaire et le second organe conducteur (68, 24) coopérant avec les couches conductrices (78) associées de l'organe ondulé (30') supplémentaire pour fermer les gorges (34) et définir une pluralité supplémentaire d'enveloppes tubulaires enfermées (44'), s'étendant axialement le long du câble; au moins un conducteur électrique (48') supplémentaire disposé dans chacune des enveloppes tubulaires (44') supplémentaires, l'organe conducteur supplémentaire et le second organe conducteur (68, 24) et l'organe ondulé (30') supplémentaire étant maintenus, en utilisation, au potentiel électrique prédéterminé, de manière que chacun des conducteurs supplémentaires (48') soit isolé de façon électromagnétique sur sa longueur axiale.
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19. Un câble selon l'une quelconque des revendications 1 à 8, 15, 16, 17 ou 18, dans lequel une feuille, une tresse, un fil de drain hélicoïdal ou un écran à revêtement de contact, sert à relier les organes conducteurs (22, 24) et l'organe ondulé (30, 30') entre eux.
20. Un procédé de formation d'un câble circulaire comprenant les étapes de:
- a) agencement d'une gaine métallique intérieure (22);
- b) enroulement hélicoïdal d'une première matrice intérieure de conducteurs (48G à 48L) autour de la gaine intérieure (22), de manière qu'un espacement circonférentiel (72) prédéterminé soit défini entre des conducteurs adjacents parmi les conducteurs (48G à 48L) de la matrice intérieure;
- c) enroulement hélicoïdal lâche d'un organe compressible flexible (30) présentant des surfaces intérieure et extérieure conductrices métalliques autour de la première matrice de conducteurs (48G à 48L), les enroulements hélicoïdaux de l'organe flexible (30) se superposant latéralement, de manière que ses surfaces intérieure et extérieure soient en contact;
- d) enroulement hélicoïdal d'une deuxième matrice extérieure de conducteurs (48A à 48F) autour de l'organe flexible (30), de



manière que les conducteurs (48A à 48F) de la matrice extérieure coïncide avec les espaces présents entre des conducteurs (48G à 48L) adjacents de la matrice intérieure;

e) compression radiale de la structure définie par les étapes précédentes, pour provoquer la disposition des axes des conducteurs (48A à 48L) contenus dans les matrices intérieure et extérieure sur sensiblement la même distance radiale par rapport à l'axe du câble et conférer une forme ondulée à l'organe flexible (30); et

f) agencement d'une gaine métallique extérieure (24) et d'une gaine isolée (58) autour de la matrice extérieure des conducteurs (48A à 48F), pour produire une structure dans laquelle la gaine intérieure (22) et la gaine extérieure (24) et les surfaces intérieure et extérieure de l'organe flexible (30) sont en contact électrique entre elles, pour maintenir un potentiel électrique prédéterminé et chacun des conducteurs (48A à 48L) est isolé des gaines (22, 24) et se trouve enfermé dans une enveloppe (44) sensiblement tubulaire, pour réaliser une isolation électromagnétique sensiblement totale sur toute la longueur axiale.

21. Un procédé de formation d'un câble plat, comprenant les étapes de:

a) disposition d'une matrice de conducteurs (48) sur un ou deux côtés (30'E, 30'I) d'un organe compressible flexible (30') présentant des couches de surface conductrices métalliques, un espacement latéral prédéterminé étant défini entre les conducteurs (48) situés dans la matrice;

b) dans le cas où la matrice se situe sur un côté de l'organe (30'), compression relative des conducteurs (48) contenus dans la matrice vers l'organe (30'), pour conférer une forme ondulée à l'organe (30'), une pluralité de gorges (34) étant définie sur les deux surfaces latérales de l'organe et disposition d'une autre matrice de conducteurs dans les gorges, sur le côté opposé audit côté formé par la compression des conducteurs contenus dans la matrice, sur ledit côté ou dans le cas où il existe des matrices de conducteurs (48) sur les deux côtés de l'organe (30'), compression relative des conducteurs (48) contenus dans les deux matrices vers l'organe (30'), pour conférer une forme ondulée à l'organe (30'), une pluralité de gorges étant définie sur les deux surfaces latérales de l'organe, de manière que dans les deux cas, les première

et second matrices de conducteurs (48) soient disposées dans les gorges (34) ménagées dans les deux côtés de l'organe (30'), les matrices se situant sur un emplacement sensiblement linéaire;

c) pliage de l'organe (30') suivant une première ligne de pliage sensiblement parallèle aux axes des conducteurs (48), pour recouvrir la zone ondulée de l'organe (30') sur la première matrice de conducteurs (48);

d) pliage de l'organe (30') suivant une deuxième ligne de pliage espacée, sensiblement parallèle aux axes des conducteurs, pour recouvrir la zone ondulée de l'organe (30') sur la deuxième matrice de conducteurs (48); et

e) agencement d'une gaine isolée (58') sur la structure, les couches de surface de l'organe (30') étant en contact électrique pour maintenir un potentiel électrique prédéterminé, de manière que chacun des conducteurs (48), qui est isolé des couches de surface de l'organe (30'), se trouve enfermé dans une enveloppe sensiblement tubulaire (44'), pour produire une isolation électromagnétique sensiblement totale sur toute sa longueur.

22. Un procédé selon la revendication 21, comprenant en outre l'agencement de couches adhésives (79) sur les parties pliées (82, 86, 88) de l'organe (30') avant le pliage, pour conférer une intégrité structurelle au câble.