(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 182 435**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **85201861.3**

(22) Date of filing: **12.11.85**

(51) Int. Cl.⁴: **H 01 B 11/00**

(30) Priority: **13.11.84 US 670948**
27.08.85 US 769725

(43) Date of publication of application: **28.05.86**
Bulletin 86/22

(84) Designated Contracting States: **AT BE CH DE FR GB IT LI LU NL SE**

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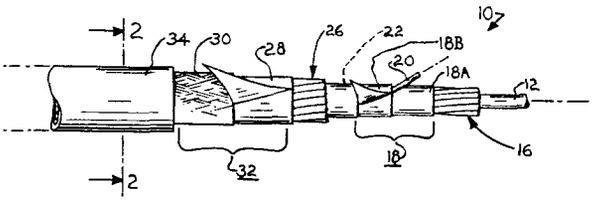
(54) Transmission cable having concentric layers of conductors.

(57) A transmission cable is formed of one or more concentric layers (16, 26) of individual conductors. Each layer is surrounded by an electrically conducting member (18, 28). Alternate conductors in each layer are signal carrying conductors (5) while the other conductors (X) in a layer are either all ground, signal return or signal conductors. The conducting members (18, 28) are electrically connectable to a ground potential to form a grounded structure in which each signal carrying conductor is at least partially electrically shielded along its entire axial length.



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TITLE

TRANSMISSION CABLE HAVING CONCENTRIC LAYERS OF CONDUCTORS

BACKGROUND OF THE INVENTION

This invention relates to transmission cables which have a generally circular cross-section and, in particular, to a transmission line having a generally circular cross-section which utilizes one or more layers of parallel conductors.

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 manufactured and sold by Hewlett-Packard and sold 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 interposed 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 ground for that signal. In typical usage the inner conducting member is electrically grounded and acts to isolate the data from the control pairs.

A round cable assembly as described above is bulky and generally expensive to manufacture due to its complexity. 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 each twisted pair must be untwisted so that the axis of each conductor is coplanar with the axis of each adjacent conductor.

The increase in the expense and the bulk of such cable can also be attributed to the use of twisted conductor pairs. The twisted conductor pairs result in an overall diameter of the twisted cable that is significantly larger than 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. Moreover, twisted pair cables often do not exhibit a uniform cross-section and can thus present problems when using automatic stripping apparatus.

Accordingly, in view of the foregoing, it is believed desirable to provide a cable assembly of such a construction that is less expensive to manufacture, less bulky and more flexible when manufactured and yet provides substantially equivalent or better electrical characteristics as are available in a cable using twisted pairs of signal and ground conductors. Moreover, the relatively less expensive material cost associated with an individual jacketed conductor as compared to twisted pairs militates forming a cable from such conductors.

SUMMARY OF THE INVENTION

A cable in accordance with the present invention comprises an inner and an outer concentric layer of individual electrical conductors. The present invention is applicable to single layer cable also. The axis of each of the conductors in each layer lies in a generally parallel spiraling configuration along the length of the cable. The cable may be constructed in three different ways. In a first embodiment of the invention, alternate conductors in each layer are connectable as signal carrying conductors while the others in the layer are grounded conductors. In a second embodiment, useful in a balanced system, alternate conductors in each layer are connectable as signal carrying conductors while the others in the layer are signal return conductors. In a third embodiment, all conductors in each layer are signal carrying conductors. Where there are two or more layers, each layer may have its conductors connected differently, in accordance with any one of the above-described embodiments. The first inner layer may, for example, consist of all signal carrying conductors while the second layer may

have alternating signal and ground conductors or alternating signal and signal return conductors.

Disposed radially outwardly of each of the inner and outer conductor layers is an annular conducting member. Each conducting member is connectable to a ground potential. In the first embodiment of alternating signal and ground conductors, this will define a grounded structure in which each signal carrying conductor is electrically shielded along its entire length. In the second and third embodiments, partial shielding is accomplished along the entire length of each signal carrying conductor. The conducting members act both as a shield and in a manner analogous to a ground plane surface in planar cables thereby to impart to a cable formed of layers of individual conductors electrical characteristics (e.g., characteristic impedance and low cross-talk interference) which closely approximate the corresponding characteristics of a cable formed of layers of twisted pairs. The particular electrical characteristics are dependent upon the particular connection effected between the conducting members, the conductors and the ground potential.

The cable structure above defined may include three or more layers of conductors with an annular conducting member disposed radially outwardly of each conductor layer. Also, as noted above, the cable structure may consist of only a single layer of conductors with one annular conducting member disposed radially inward and another annular conducting member disposed radially outward of the single layer of conductors. Each conducting member in the single and multiple layer cable structure is connectable to a ground potential.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully 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 lines 2-2 of Figure 1; and,

Figure 3 is a more stylized sectional view generally similar to Figure 2 showing the arrangement of a cable having three layered arrays of conductors in accordance with the present invention.

Figure 4 is also a stylized sectional view showing the arrangement of a cable having a single layer of conductors in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

About the following detailed description similar reference numerals refer to similar elements in Figures 1-3 of the drawings.

With reference 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 is formed of an integer number M (where M is one or more) concentric layers of individual conductors and is useful, for example, for high-speed signal transmission between constituent system components of a data processing system. In the examples of Figures 1 and 2, two concentric layers of conductors are shown. Figure 3 shows a three conductor layer arrangement while

Figure 4 illustrates a single conductor layer construction. The cable 10 fabricated in accordance with the present invention eliminates the use of twisted pairs of conductors yet provides substantially equivalent electrical characteristics. Moreover, the cable 10 in accordance with the invention will, as will be developed herein, simplify cable construction and assembly techniques. The cable 10 may be terminated at each end with a suitable connector (not shown). Each connector is receivable in a header whereby the cable may be electrically connected to predetermined signal lines, signal return lines (when used) and other various grounding potentials such as logic and chassis ground.

The cable 10 includes an optional inner filler or core 12 fabricated of an elastomer disposed centrally and axially of the cable. Surrounding the core 12 is a first, inner layer 16 of individual electrical conductors. Although in the Figure 2 six individual conductors are used in the inner layer 16, it should be understood that any convenient number of individual conductors may be used to define the inner layer 16 of conductors. The individual conductors in the layer 16 are preferably formed using 26 AWG 7/34 annealed tinned copper 1012 semi-rigid PVC UL1061/CSA SR. Polypropylene or polyethylene are useful as an acceptable jacket for the individual conductors for improving cable capacitance. Due to their connection to the circuitry on the boards to which the cable is connected via the connector/header, alternate conductors in layers 16, indicated by the indicia "S", are all signal carrying conductors. The other conductors in layer 16, indicated by the indicia "X", are in the first embodiment of the invention all

connected as ground conductors. In the second embodiment, conductors "X" are all connected as signal return conductors. In the third embodiment, conductors "X" are all connected as signal carrying conductors so that all conductors in the layer are then signal carrying conductors.

Spaced radially outwardly of the inner layer 16 is a first annular conducting member 18 in the form of a metallized polyester film shield. The shield is preferably fabricated of an inner aluminized film wrap 18A and an outer aluminized film wrap 18B. Each wrap is shown as comprising an aluminum layer 18A' and 18B' and an insulating film layer, 18A'' and 18B'', with aluminum layers being in facing contact with each other. Of course, the first conducting member 18 may be implemented using any other suitable metallized polyester film wrap, metallized wrap or braid. Intermediate of each of the wraps 18A and 18B and in contact with the aluminum layers of each is a generally spirally wound drain wire 20. Optionally (as shown only in Figure 1) wrap 22 of a polyester film may be provided about the conducting member 18.

A second, outer, layer 26 of individual conductors is disposed in substantially concentric arrangement about the inner layer 16. Each of the individual conductors in the outer layer 26 spirals along the length of the cable and is fabricated of a similar material as the conductors in the inner layer 16. Like the inner layer, the axis of each of the individual conductors in the layer 26 is substantially parallel along the axial length of the cable 10. Any convenient number of conductors may be used in the layer 26. Again, due to their connection via the connector/header, alternate conductors in layer 26,

indicated by the indicia "S", are all signal carrying conductors. The other conductors in layer 26, indicated by the indicia "X", are in the first embodiment of the invention, all connected as ground conductors. In the alternative second and third embodiments, conductors "X" are all connected as either signal return conductors or all signal carrying conductors, respectively. It should be understood that the conductors in one layer need not be connected in the same manner as conductors in the other layer(s). For example, the conductors in layer 16 may be connected as alternating signal and ground conductors while the conductors in layer 26 may be connected as all signal conductors or as alternating signal and signal return conductors.

Surrounding the outer layer 26 of conductors is a second annular conducting member 32. Preferably the member 32 takes the form of a shield 28 fabricated of metallized film comprising a metal layer 28A and an insulating layer 28B, similar to the wraps 18A, 18B. Shield 28 is surrounded by a metallic braid 30. The braid 30 and the shield 28 together define the electrical conducting member 32 disposed about the radially outer surface of the outer layer 26 of individual conductors. Surrounding the entire structure as above described is a jacket 34 preferably of thirty-five mil PVC per UL2464 at 80°C, 300 volts.

As seen in Fig. 3, a cable 10' constructed as described above may be expanded to three (or more) layers of individual conductors. However many layered arrays of conductors are disposed within the cable, an electrical conducting member is disposed about the radially outer surface of each layer of conductors in the array. To expand the cable 10' an

additional electrically conducting member 38 similar to conducting member 18 is provided about the layer 26. Radially outwardly therefrom an additional layer 40 of individual conductors is provided. Additional layers are similarly provided using an added conducting member and a conductor layer. Radially outwardly of the outermost layer of conductors is the conducting member 30.

As noted, the individual conductors in each conductor layer 16, 26 (and in Figure 3 40) are arranged circumferentially, alternating signal carrying conductors indicated by the indicia "S" and other conductors indicated by the indicia "X". As explained earlier, in a first embodiment of the invention, conductors "S" and "X" are alternating signal carrying conductors and grounded conductors, respectively according to their connection with the appropriate signal and ground lines of the circuitry via the connector/header. Also, as noted before, all conductors designated "X" in a given layer may alternatively all be connected as either all signal return conductors or all signal carrying conductors.

Each of the electrically conducting members 18, 32 (and for Figure 3 38) are connected to a suitable ground, again via the connector/header. In one common pattern the inner conducting members 18 (and 38) are connected to the signal return conductors (i.e., logic ground potential) while the outer conducting member 32 is connected to chassis ground potential. In the first embodiment of the present invention, the conducting members and the ground conductors together define a grounded structure that provides electrical shielding for each signal carrying conductor in each layer throughout

its entire axial length. In the alternative embodiments when conductors "X" are either all signal return or signal carrying conductors, the conducting members define a grounded structure that provides partial electrical shielding for each signal carrying conductor in each layer along its entire axial length.

The cable 10 as above described in which the members 18 and 32 are respectively connected to logic and chassis ground has been demonstrated to provide electrical characteristics (specifically characteristic impedance and cross-talk interference) substantially equivalent to or better than a cable formed with a plurality of twisted wire pairs such as used in the above-described commercially available cable. Moreover, the cable in accordance with the present invention is less expensive and easier to fabricate and, due to the concentric lay of the layers, more flexible than the described commercially available.

The electrical characteristics of the cable 10 (or 10") may vary dependent upon the particular interconnection effected between the conducting members 18, 32 (and 38), the conductors and ground potentials. However, it is the use of the conducting members in the dual capacity as both a shield and as a ground surface that permits a cable 10 or 10' fabricated of individual conductors to exhibit electrical characteristics comparable or superior to those exhibited by a cable fabricated of twisted conductor pairs. The conducting members define ground potential surfaces which behave analogously to the ground plane potential surfaces in ribbon cables to impart the particular electrical characteristics to the cable 10 (or 10').

Figure 4 illustrates the present invention for a cable 40 having only a single layer 42 of alternating conductors indicated by the indicia "S" and "X". As before the conductors designated "S" are connected as signal carrying conductors. Also, as explained before, the conductors designated "X" are connected either as all grounded conductors, as all signal return conductor or as all signal carrying conductors, depending upon which of the three embodiments of the invention is utilized.

In the single layer cable, an inner conducting member 44 surrounds an inner filler or core 46. An outer conducting member 48 surrounds the conductor layer 42 so that the conducting layer 42 is located in the annular space between the outer surface of the inner conducting member 44 and the inner surface of the outer conducting member 48. Conducting member 44 may be similar to conducting member 18 and 38 in Figures 1-3 while conducting member 48 may be similar to outer conducting member 32. Surrounding the entire structure is a jacket 50 similar to jacket 34 of Figures 1 and 2. A suitable drain wire 52 is provided within the inner conducting member 44 similar to drain wire 20 described earlier.

As in the multilayer construction, the conducting members are each connected to a suitable ground via the connector/header to define a grounded structure with a grounded plane so as to electrically shield the signal carrying conductors of the layer along its length, and thereby reduce cross-talk between the signal conductors.

Those skilled in the art having the benefits of the present invention as set forth herein may effect modifications thereto. These modifications are to be construed as lying within the scope of the present invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. An electrical cable adapted to receive a connector at each end thereof for interconnection of the cable with predetermined signal lines and predetermined ground potentials comprising:

a first and a second layer of individual electrical conductors, said layers being concentric, the axis of each conductor in each layer being substantially parallel to the axis of each of the other conductors in that layer along the length of the cable, alternate conductors in each layer being insulated and connectable as signal carrying conductors with the other conductors in at least one of the layers being connectable as grounded conductors; and,

a first and a second annular conducting member respectively disposed radially outwardly of the first and second conductor layers,

the conducting members each being electrically connectable to a ground potential to impart predetermined electrical characteristics to the cable dependent upon the connection effected between the conducting members, the conductors and the ground potential,

the conducting members and the grounded conductors together defining a grounded structure in which each signal carrying conductor in each layer is, in operation, electrically shielded entirely along its axial length.

2. An electrical cable adapted to receive a connector at each end thereof for interconnection of the cable with predetermined signal lines, signal return lines and predetermined ground potentials comprising:

a first and a second layer of individual electrical conductors, said layers being concentric, the axis of each conductor in each layer being substantially parallel to the axis of each of the other conductors in that layer along the length of the cable, alternate conductors in each layer being insulated and connectable as signal carrying conductors with the other conductors in at least one of the layers being connectable as signal return conductors; and,

a first and a second annular conducting member respectively disposed radially outwardly of the first and second conductor layers,

the conducting members each being electrically connectable to a ground potential to impart predetermined electrical characteristics to the cable dependent upon the connection effected between the conducting members, the conductors and the ground potential,

the conducting members defining a grounded structure in which each signal carrying conductor in each layer is, in operation, partially electrically shielded along its entire axial length.

3. An electrical cable adapted to receive a connector at each end thereof for interconnection of

the cable with predetermined signal lines and predetermined ground potentials comprising:

a first and a second layer of individual electrical conductors, said layers being concentric, the axis of each conductor in each layer being substantially parallel to the axis of each of the other conductors in that layer along the length of the cable, alternate conductors in each layer being insulated and connectable as signal carrying conductors with the other conductors in at least one of the layers also being connectable as signal carrying conductors; and,

a first and a second annular conducting member respectively disposed radially outwardly of the first and second conductor layers,

the conducting members each being electrically connectable to a ground potential to impart predetermined electrical characteristics to the cable dependent upon the connection effected between the conducting members, the conductors and the ground potential,

the conducting members defining a grounded structure in which each signal carrying conductor in each layer is, in operation, partially electrically shielded along its entire axial length.

4. The cable of claim 1 wherein the other conductors of each layer are connectable as grounded conductors.

5. The cable of claim 1 wherein the other conductors of the other layer are all connectable

either as signal return conductors or as signal carrying conductors.

6. The cable of claim 2 wherein the other conductors of each layer are connectable as signal return conductors.

7. The cable of claim 2 wherein the other conductors of the other layer are all connectable either as grounded conductors or as signal carrying conductors.

8. The cable of claim 3 wherein all conductors of each layer are connectable as signal carrying conductors.

9. The cable of claim 3 wherein the other conductors of the other layer are all connectable either as grounded conductors or as signal return conductors.

10. A cable according to any one of claims 1, 2 or 3, further comprising at least one additional concentric layer of individual conductors disposed radially outward of said second conducting member, and at least one additional conducting member disposed radially outwardly of said additional layer of conductors.

11. A round electrical cable comprising:

at least one layer of individual electrical conductors disposed around the axis of the cable, the axis of each conductor in said layer being substantially parallel to the axis of each of the other conductors in the layer along the length of the cable;

a first annular conducting member disposed radially inwardly of said one layer,

a second annular conducting member disposed radially outwardly of said one layer,

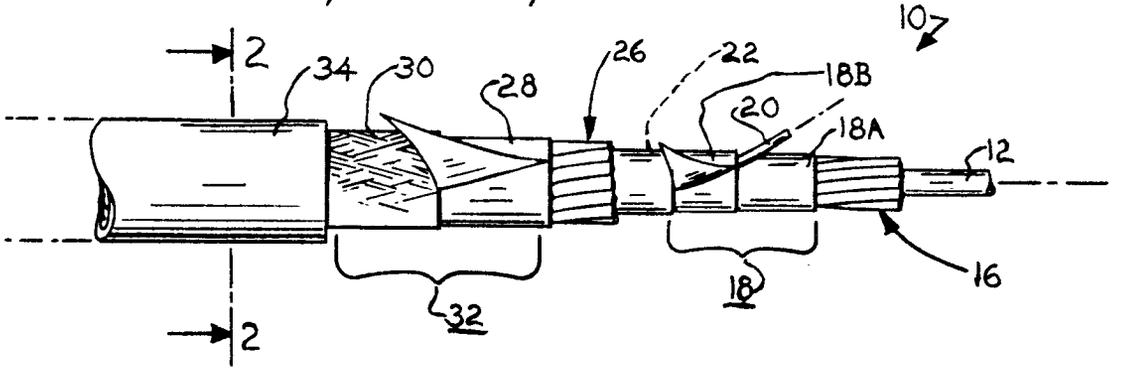
alternate conductors in said layer being insulated and connectable as signal carrying conductors while the other conductors in said layer being connectable either as all grounded conductors or as all signal return conductors or as all signal carrying conductors,

the conducting members each being electrically connectable to a ground potential to impart predetermined electrical characteristics to the cable dependent upon the connection effected between the conducting members, the conductors and the ground potential,

the conducting members defining a grounded structure in which each signal carrying conductor is, in operation, at least partially electrically shielded along its entire axial length.

12. The cable of claim 11 further comprising at least one additional concentric layer of conductors disposed radially outward of the second annular conducting member, and at least one additional annular conducting members disposed radially outward of said additional layer.

Fig. 1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2
34
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28
26
22
18B
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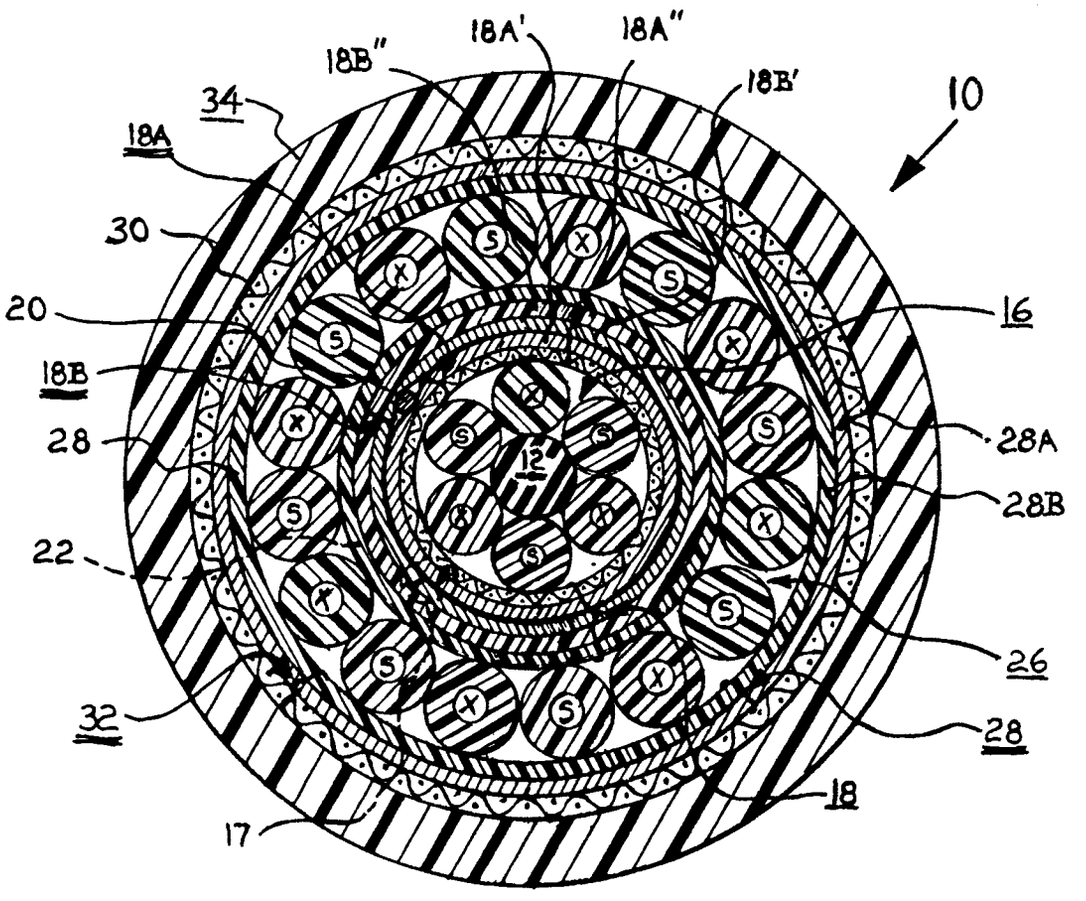
18A
12
16
18
32
2

Fig. 2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18A"
18B'
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17

Fig. 3

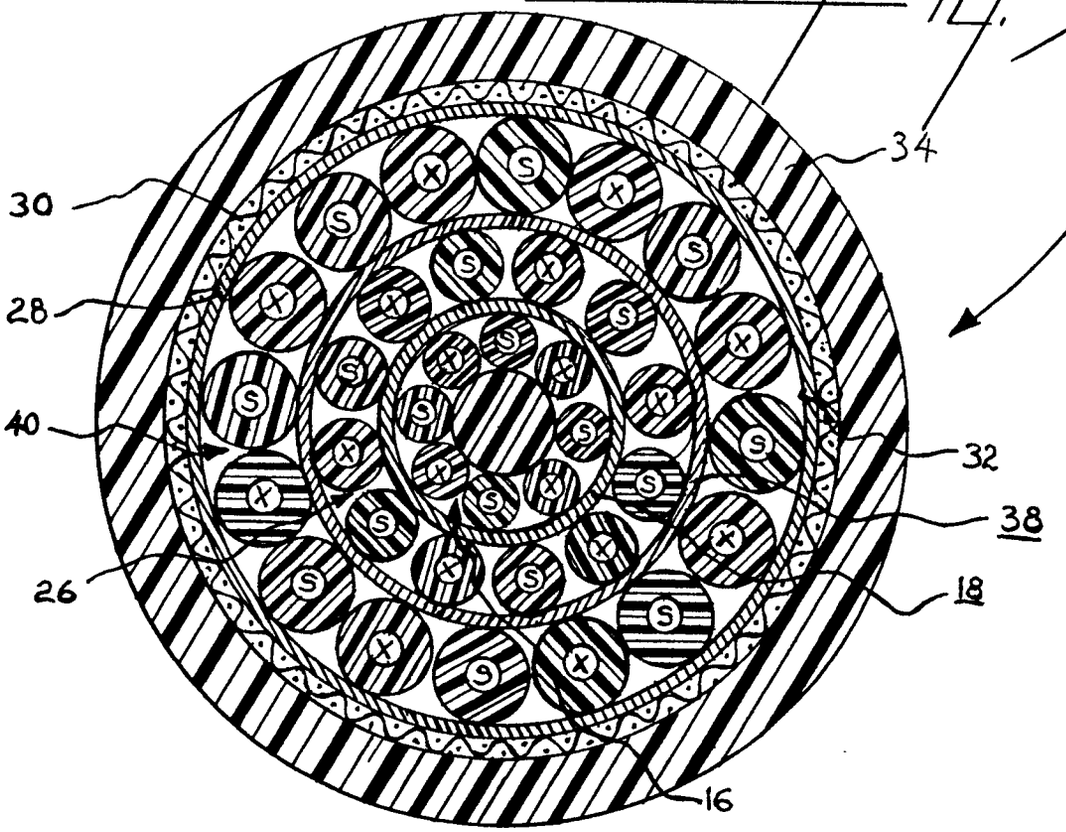

Fig. 4