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(71) Applicant:
W.L. GORE & ASSOCIATES GmbH
85640 Putzbrunn (DE)

(72) Inventor: **Seigerschmidt, Helmut**
91798 Fiegenstall-Höttingen (DE)
(74) Representative:
Harrison, Robert John
W.L. Gore & Associates GmbH,
Hermann-Oberth-Strasse 22
85640 Putzbrunn (DE)

(54) **Electrical signal line cable assembly**

(57) The invention discloses an electrical signal cable assembly (10, 110, 210, 710) with a plurality of subcable assemblies (20, 120, 220, 320, 620, 720) stacked on each other. Each subcable assembly (20, 120, 220, 320, 620, 720) includes a plurality of coplanar electrical signal conductors (30, 130, 230, 330, 730) encased within an insulator (40a, 40b) and which are separated from each other by a first pitch distance (a), whereby the first pitch distance (a) is between 0,1 mm and 10 mm. The characteristic impedance of the electrical

signal cable assembly (10, 110, 210, 710) is in the range of 50 Ω to 200 Ω . In the preferred embodiment of the electrical signal cable assembly (10, 110, 210, 710) the insulator (40a, 340a, 640a, 740a, 40b, 340b, 640b, 740b) comprises an upper insulator (40a, 340a, 640a, 740a) laminated to a lower insulator (40b, 340b, 640b, 740b) and is made from expanded polytetrafluorethylene.

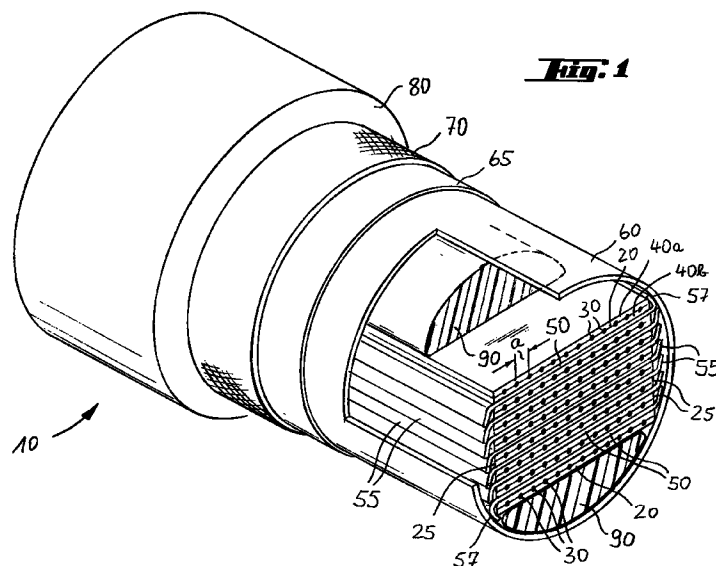


Fig. 1

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Description

Field of the Invention

5 [0001] The invention relates to an electrical signal line cable assembly.

Prior Art

10 [0002] Electrical signal lines are known, for example, from European Patent Application EP-A-0 735 544 (Cartier et al.) assigned to Hewlett-Packard Company. This patent application describes an ultrasound system with a transducer cable for providing an electrical connection between a transducer and a display processor. The third embodiment of the transducer cable in this application uses three layers of extruded ribbon assemblies separated from each other by shield conductors comprising thin-strips of bare copper. The stack of ribbon assemblies and shield conductors are extruded with a ribbon jacket to form a desired length of the transducer cable.

15 [0003] US-A-4 847 443 (Basconi) assigned to the Amphenol Corporation teaches another example of an electrical signal line cable formed from a plurality of generally flat electrical signal line segments stacked together in an interlocking relationship. Each electrical signal line segment of this prior art cable contains at least one signal conductor surrounded on either side by ground conductors. The plurality of ground conductors effectively form a ground plane which inhibit the cross-talk between the adjacent signal conductors. The insulating materials in which the conductors are disposed is extruded over the individual signal conductors.

20 [0004] European Patent EP-B-0 605 600 (Springer et al.) assigned to the Minnesota Mining and Manufacturing Company teaches a ribbon cable and a lamination method for manufacturing the same. The ribbon cable manufactured comprises a plurality of evenly spaced flexible conductors surrounded by an insulator which is a microporous polypropylene.

25 [0005] US Patent US-A-4 847 443 (Crawley et al.) assigned to W.L.Gore & Associates teaches a multi-conductor flat ribbon cable having a plurality of electrical conductors disposed within an insulator consisting of expanded polytetrafluoroethylene (ePTFE).

30 [0006] PCT patent application WO-A-91/09406 (Ritchie et al) teaches an electrical wiring composed of elongated electrically conductive metal foil strips laminated between opposing layers of insulating films by means of adhesive securing the foil strips between the laminating films.

[0007] German patent application DE-A-24 24 442 assigned to Siemens teaches a cable assembly which comprises a plurality of flat cables laminated between insulating films.

35 [0008] PCT patent application WO-A-80/00369 (Clarke) assigned to Square D company of Palatine, Illinois, teaches an input/output data cable for use with programmable controllers. The cable has a ground conductor, a logic level voltage conductor and a number of signal tracks. The conductors are disposed on two or three layers of flexible plastics material in specified ways to give high immunity to interference and low inductive losses. The layers are glued together to form a laminate structure.

[0009] W.L.Gore & Associates, Inc., in Phoenix, Arizona, sell a round cable under the part number 02-07605 which comprises 132 miniature co-axial cables enclosed within a braided shield of tin-plated copper and a jacket tube of PVC.

40 [0010] There remains a need in the art to develop an electrical signal cable assembly having a plurality of ribbon cables which is light in weight and offers coaxial performance characteristics.

Summary of the Invention

45 [0011] It is therefore an object of this invention to develop an improved signal cable assembly.

[0012] It is furthermore an object of the invention to develop a signal cable assembly having a plurality of ribbon cables which has a characteristic impedance similar to that of coaxial cables.

[0013] It is furthermore an object of this invention to develop a signal cable assembly having a plurality of ribbon cables which has a capacitance per unit length substantially better than that offered by prior art ribbon cables.

50 [0014] It is furthermore an object of this invention to develop a signal cable assembly having a plurality of ribbon cables in which the cross talk between the individual signal conductors is minimised.

[0015] It is furthermore an object of this invention to develop a signal cable assembly having a plurality of ribbon cables which is light in weight compared to a comparable assembly of miniature coaxial cables.

55 [0016] These and other objects of the invention are achieved by providing an electrical signal cable assembly with a plurality of subcable assemblies stacked on each other, each subcable assembly including a plurality of coplanar electrical signal conductors encased within an insulator and being separated from each other by a first pitch distance, whereby the first pitch distance is between 0,1 mm and 10 mm and the characteristic impedance of the electrical signal line is in the range of 50 Ω to 200 Ω . Constructing the electrical signal cable assembly in accordance with these features

will provide a lightweight cable assembly offering coaxial performance.

[0017] In one embodiment of the invention, the electrical signal cable assembly is constructed with the insulator comprising an upper insulator attached to a lower insulator by means of a lamination bonding. This method of manufacture is comparatively simple and allows the manufacture of a long lengths of cable assembly in a comparatively short period of time.

[0018] Preferably the upper insulator and the lower insulator are formed from the group of insulating materials consisting of polyethylene, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene and more preferably they are formed from expanded polytetrafluoroethylene (ePTFE). Expanded PTFE has a very low dielectric constant and dissipation and accordingly provides electrical signal cables with very good electrical performance.

[0019] In one embodiment of the invention, a shielding strip is situated between at least two of said subcable assemblies to electromagnetically shield the signal conductors in one subcable assembly from the signals being carried on the signal conductors in another one of the subcable assemblies. Using the shielding strip, the cross-talk between the signal conductors in two adjacent subcable assemblies is reduced to more than acceptable levels. The shielding strip can be attached to the insulators by lamination bonding.

[0020] In a further embodiment of the invention, first shielding means surrounding said subcable assemblies are provided in electrical contact with at least one end of the said shielding strips. The ends of the shielding strips are thus mechanically protected from damage and can also not act as antennas. Furthermore, an insulating layer can be provided which surrounds said first shielding means and then second shielding means are provided surrounding said insulating layer. The second shielding means shield the signal conductors within the subcable assemblies from stray electromagnetic fields outside the electrical signal cable assembly. A cable jacket is then placed over the second shielding means surrounding said subcable assemblies to protect the complete signal cable assembly from mechanical damage.

[0021] In one embodiment of the invention, at least one spacer is disposed within the cable jacket for shaping the electrical signal line, i.e. for holding the subcable assemblies in place within the cable jacket. The subcable assemblies can be arranged substantially in parallel planes to each other in which case two crescent-shaped spacers are provided. The subcable assemblies can also be arranged helically around the spacer in which case the spacer is cylindrical in shape.

Description of the Drawings

[0022]

Fig. 1 shows the electrical signal line cable assembly according to a first embodiment of the invention.

Fig. 2 shows a method for the manufacture of an electrical signal line cable assembly of the invention.

Fig. 3 shows the electrical signal line cable according to a second embodiment of the invention.

Fig. 4 shows the electrical signal line cable according to a third embodiment of the invention.

Fig. 5 shows a device for the manufacture of the subcable assemblies in the electrical signal line cable.

Fig. 6 shows a sintering device used in the manufacture of the subcable assemblies.

Fig. 7 shows a further example of a subcable assembly suitable for use in the invention.

Fig. 8 shows a fourth embodiment of the invention.

Detailed Description of the Invention

[0023] Fig. 1 shows a first embodiment of the invention. It shows an electrical signal line 10 comprising a plurality of subcable assemblies 20. In Fig. 1 eight sub cable assemblies 20 are shown. However, this is merely illustrative of the invention and not intended to be limiting.

[0024] Each subcable assembly 20 comprises a plurality of individual signal conductors 30 arranged in a parallel plane and surrounded by an upper insulating layer 40a and a lower insulating layer 40b. The upper insulating layer 40a and the lower insulating layer 40b are laminated together as will be explained later. The individual signal conductors 30 can be made from any conducting material such as copper, nickel-plated copper, tin-plated copper, silver-plated copper, tin-plated alloys, silver-plated alloys or copper alloys. Preferably the individual signal conductors are made of round copper wire. It would also be possible to use flat conductors.

[0025] The number of individual signal conductors 30 depicted in Fig. 1 is not intended to limiting of the invention. The axes of the individual signal conductors 30 are separated by a first pitch distance a which is in the range of 0,1 to 1 mm. The upper insulating layer 40a and the lower insulating layer 40b can be made of any insulating dielectric material such as polyethylene, polyester, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene. Preferably expanded polytetrafluoroethylene such as that described in US-A-3 953 556, US-A-4 187 390 or US-A-4 443 657 is used.

[0026] The subcable assemblies 20 are separated from each other by a shielding strip 50. The shielding strip 50 is made for example from a metal foil, metal braid, conductive tape or a metallised textile. The following metals can be used: copper, tin, silver, aluminium or alloys thereof. In one embodiment of the invention the shielding strip 50 was made from copper-coated polyamide fabric of the Kassel type supplied by the Statex company in Hamburg, Germany, and had a thickness of approximately 0,1 mm and a width of around 9 mm.

[0027] The subcable assemblies 20 were arranged in a planar manner, one above another, to form a bundle of subcable assemblies 20 using the apparatus 100 shown diagrammatically in Fig. 2.

[0028] Fig. 2 shows a plurality of first spools 102 onto which is rolled a first strip 103 forming the subcable assembly 20 and a plurality of second spools 104 onto which is rolled a second strip 105 forming the shielding strip 50. A plurality of first (subcable assembly) strips 103, separated from each other by a second (shielding) strip 105 is rolled respectively off the plurality of first spools 102 and the plurality of second spools 104 and joined together at position 106 to form a bundle 107.

[0029] The thus created bundle 107 of subcable assemblies 20 was slid into a tube which forms a first shielding means 60. The first shielding means 60 may be made of a metal foil, such as a foil made from copper, aluminium or silver, or from metallised textile. In one embodiment of the invention the first shielding means was made from Kassel copper-coated polyamide fabric supplied by the Statex company in Hamburg, Germany, and had a thickness of approximately 0,1 mm and a width of around 9 mm. Crescent-shaped Spacers 90 were positioned between the plurality of subcable assemblies 20 and the first shielding means 60 in order to maintain a substantially tubular shape. The spacers 90 are made from permeable ePTFE, PTFE, polyamide, perslon or any other dielectric material.

[0030] Shielding strip ends 55 project beyond an edge 25 of the subcable assemblies 20 and are bent downwardly or upwardly such that each shielding strip end 55 touches another one of the shielding strip ends 55. At least one of the shielding strip ends 55 is in electrical contact with the first shielding means 60. In Fig. 1, the shielding strip ends 55 of the outermost ones of the plurality of subcable assemblies 20 and the subcable assemblies 20 immediately adjacent to the outermost ones of the subcable assemblies 20 is shown as being in electrical contact with the first shielding means 60. Each of the shielding strips 50 and the first shielding means 60 are therefore held at the same potential. It would, of course, be possible to hold the shielding strips 50 and the first shielding means 60 at a different potential. In this latter case the shielding strip ends 55 would not electrically contact with the shielding means 60.

[0031] An insulating layer 65 was then wrapped around the first shielding means 60 using known wire wrapping techniques. The insulating layer 65 may be made, for example, from PTFE, FEP, ePTFE or polyester. Preferably the insulating layer 65 is made from sintered GORE-TEX[®] tape which is obtainable from W.L.Gore & Associates.

[0032] A second shielding means 70 surrounds the first shielding means 60. The second shielded means 70 is a braid, foil or wire shield made from a metal or a metallised polymer, such as copper, aluminum, tin-plated copper, silver-plated copper, nickel-plated copper or aluminised polyester. In one embodiment of the invention the second shielding means 70 is made from a copper braid with a braiding angle of about 35°.

[0033] A jacket 80 is placed over the second shielding means 70. The jacket 80 is made from silicone or polyolefins such as polyethylene, polypropylene or polyethylpentene; fluorinated polymers such as fluorinated ethylene/propylene (FEP); fluorinated alkoxypolymer such as perfluoro(alkoxy)alkylanes, eg. a co-polymer of TFE and perfluoropropylvinyl ether (PFA); polyurethane, polyvinylchloride (PVC) or polytetrafluoromethylene (PTFE) or expanded PTFE. In one embodiment of the invention the jacket 80 was made from PVC.

[0034] A second embodiment of the invention is shown in Fig. 3. In this figure, the same reference numerals are used to denote components of the electrical signal line 110 having the same function as the components of the electrical signal line 10 of Fig. 1 except that the numerals are increased by 100. In this embodiment of the invention a tubular spacer 190 is used in the core of the electrical signal line 110 and the subcable assemblies 120 are wrapped in a helical manner with an axis through the core 200 of the electrical signal line 110. The materials used for the construction of this embodiment of the electrical signal line 110 are the same as those used above.

[0035] The second embodiment of the electrical signal line 110 has the advantage that it is substantially more flexible than the first embodiment.

[0036] A third embodiment of the electrical signal line is shown in Fig. 4. Again the same reference numerals are used to denote components of the electrical signal line 210 having the same function as the components of the electrical signal line 10 of Fig. 1 or the electrical signal line 110 of Fig. 2 except that the numerals are increased by a further 100. In this embodiment of the electrical signal line, the plurality of subcable assemblies 220 are twisted before being placed within the first shielding means 270 thus obtaining a substantially more flexible electrical signal line 210. Again the same materials are used for the construction of this electrical signal line 210 as are described in the first embodiment of the invention.

[0037] Manufacture of the subcable assemblies 20, 120 and 220 is illustrated in Fig. 5 for the embodiment in which the upper insulating layer 40a and the lower insulating layer 40b are made from expanded PTFE. This method is essentially the same as that taught in US-A-3082292 (Gore). The same reference numerals are used to denote the components of the subcable assembly 20, 120 and 220 as those used for the components of the subcable assembly 20 in the

first embodiment of the invention (Fig. 1) except that they are increased by 300. A plurality of individual signal conductors 330, an upper insulator 340a located above the plurality of individual signal conductors 330, and a lower insulator 340b located below the plurality of individual signal conductors 340b were communally passed between two contra-rotating pressure rollers 400a and 400b at a lamination temperature sufficient to achieve bonding between the lower insulator 340b and the upper insulator 340a, e.g. between 327°C and 410 °C. A subcable assembly 320 was thereby formed. For this purpose, the upper pressure rollers 400a is provided with a number of upper peripheral grooves 410a each separated by an upper peripheral rib 420a which are lined up at a distance from one another along the circumference of the pressure rollers 400a. Similarly, the lower pressure rollers 400b is provided with a number of lower peripheral grooves 410b each separated by a lower peripheral rib 420a which are lined up at a distance from one another along the circumference of the pressure roller 400b. Each upper peripheral groove 410a of the upper pressure roller 400a together with the adjacent upper peripheral ribs 420a lines up with one of the lower peripheral grooves 410b with the adjacent lower peripheral ribs 420b of the lower pressure roller 400b to form a passageway channel for one of the individual signal conductors 330. The distance between the two pressure rollers 400a, 400b and the peripheral grooves 410a, 410b are designed in terms of their dimensions in such a way that a single conductor 330 and the upper insulator 340a and the lower insulator 340b pass continuously between a pair consisting of one of the upper peripheral grooves 420a and one of the lower peripheral grooves 420b. The upper peripheral ribs 420a and the lower peripheral ribs 420b have such a small separation from one other that the upper insulator 340a and the lower insulator 340b are firmly pressed together at these positions to form an intermediate zone 440 in the subcable assembly 320.

[0038] In order to improve their adhesion of the upper insulator 340a to the lower insulator 340b to the individual signal conductors 330 and with each other within the subcable assembly 320, the subcable assembly was led through a sintering device in which the subcable assembly 320 is heated such that one achieves intimate joining in the intermediate zones 440 of the subcable assembly 320. If using an upper insulator 340a and a lower insulator 340b made of PTFE, use is made of a sintering temperature in the range from 327° to 410°C.

[0039] An example of an embodiment of a sintering device in the form of a sintering oven 450 comprising a salt bath is illustrated in a schematic and simplified form in Figure 6. In this example, the subcable assembly 320 is continually passed through the sintering oven 450.

[0040] Fig. 7 shows a further example of a subcable assembly 620 which comprises a plurality of individual signal electrical signal conductors 630 arranged in a parallel plane and surrounded by an upper insulating layer 640a and a lower insulating layer 640b. The subcable assembly 620 further included an upper shielding means 650a and a lower shielding means 650b attached to the outer surfaces of the upper insulating layer 640a and the lower insulating layer 640b respectively. The upper shielding means 650a and the lower shielding means 650b can be made, for example, from copper or aluminium foil, perforated copper foil or metallised polyamide. In the preferred embodiment they are made from copper foil. The upper shielding means 650a and the lower shielding means 650b are joined to each other at ends 660a and 660b as shown in Fig. 7. A jacket 680 made from ePTFE was attached to the upper shielding means 650a and the lower shielding means 650b. The jacket 680 could also be made from PFA, FEP or PTFE.

[0041] Manufacture of the embodiment of the subcable assembly 620 depicted in Fig. 7 is carried out in a similar manner as the subcable assembly 320 described above and depicted in Fig. 5. In addition to the upper insulator 340a and the lower insulator 340b being passed through the contra-rotating pressure rollers 400a and 400b at a lamination temperature, the material to form the upper shielding means 650a, the lower shielding means 650b and the jacket 680 are additionally passed through contra-rotating pressure rollers at a temperature sufficient to ensure that the upper shielding means 650a and the lower shielding means 650b are laminated to the upper insulating 640a and the lower insulator 640b and to each other at the ends 660a, 660b.

[0042] Use of the laminated upper shielding means 650a and the lower shielding means 650b allows the construction of an electrical signal line 10 with a plurality of subcable assemblies 620 without a shielding strip 50 placed between the subcable assemblies 620.

Examples

Example A

[0043] The construction of this example is depicted in Fig. 8 in which the same reference numerals are used to denote the same feature as those in Fig. 1 except that the numerals are increased by 700. The individual signal conductors 730 were made from AWG 4001 copper wire and embedded within an upper insulating layer 740a and a lower insulating layer 740b of GORE-TEX® tapes made in the Pleinfeld, Germany, plant of W.L.Gore & Associates. Each subcable assembly 720 contained sixteen of the individual signal conductors 730. The pitch distance $\underline{a}$ between the individual signal conductors was 0.35 mm. Four subcable assemblies 720 were bundled together on top of each other with no shielding strip 750 between them to form a subcable assembly bundle 725. A pair of subcable assembly bundles 725 were then placed together with a shielding strip 750 made of Kassel copper-coated polyamide fabric supplied

by the Statex company. The pair of subcable assemblies bundles 725 were slipped inside a tube forming the first shielding means 760 and made of Kassel copper-coated polyamide fabric. One of a shielding strip end 755 was placed in electrical contact with the first shielding means 765. An insulating layer 765 of GORE-TEX® insulating tape was subsequently wrapped around the first shielding means 760. The second shielding means 770 was made of tin-coated copper braid and a jacket 780 made from polyvinyl chloride was then slipped over the insulating layer 765. An electrical signal line cable assembly 710 containing eight subcable assemblies 720 and 128 individual signal conductors 730 was thus obtained.

Example B

[0044] This example was constructed according to the first embodiment of the invention and is depicted in Fig. 1. The individual signal conductors 30 were made from AWG 4001 tin-plated copper wire and embedded within an upper insulating layer 40a and a lower insulating layer 40b of GORE-TEX® tapes made in the Pleinfeld, Germany, plant of W.L.Gore & Associates. Each subcable assembly 20 contained sixteen of the individual signal conductors 30. The pitch distance a between the individual signal conductors was 0.35 mm. Eight subcable assemblies 20 were bundled together on top of each other with a shielding strip 50 strip made of Kassel copper-coated polyamide fabric supplied by the Statex company between each of the subcable assemblies 20. The shielding strip ends 55 were placed in electrical contact with the first shielding means 65. The eight subcable assemblies 20 were slipped inside a tube made of Kassel copper-coated polyamide fabric forming the first shielding means 60 and an insulating layer 65 of GORE-TEX® insulating tape was wrapped around the Kassel fabric. The second shielding means 70 was made of tin-plated copper braid and a jacket 80 made from polyvinyl chloride was then slipped over the insulating layer. An electrical signal line cable assembly 10 containing 8 layers and 128 individual signal conductors was thus obtained.

Example C

[0045] This was manufactured in the same manner and using the same materials as example B except that AWG 4207 copper wire was used.

Comparative Example

[0046] As a comparison a conventional flat cable comprising a bundle of 132 miniature co-axial cables was used. The conductors were made of AWG 4207 silver-plated alloy wire, the insulator of ePTFE and the outer conductor of silver-plated copper. A jacket of a fluoropolymer was extruded over the outer conductor. A braided shield of tin-plated copper was then slid over the bundle of 132 miniature co-axial cables and a jacket tube of PVC was slid over the braided shield. This electrical signal line assembly is commercially available from W.L.Gore & Associates under the part number 02-07605

Table 1 shows a comparison of the electrical and mechanical properties of the electrical signal line manufactured according to this invention in comparison to the cables of the comparative example, an electrical signal line available from W.L.Gore & Associates.

Electrical Properties					Comparative Example (02-07605)
Impedance	Example A	Example B	Example C		78 Ω
Capacitance	~ 100 Ω	~ 75 Ω	~ 100 Ω		52 pF
Attenuation @ 5 MHz	~ 48 pF/m	~ 57 pF/m	~ 48 pF/m		1,09 dB/Assy.
Attenuation @ 10 MHz	1,20 dB/Assy.	0,73 dB/Assy.	0,7 dB/Assy.		1,17 dB/Assy.
Velocity of Signal Propagation compared to velocity of light.	1,67 dB/Assy.	0,89 dB/Assy.			76,6 %
X-talk: Signal/Signal	81,1 %	81,0 %	81,0 %		36 dB
Subcable1/subcable2	17,4 dB	20,3 dB			-----
Subcable1/subcable3	30,1 dB	35,4 dB	36 dB		-----
Subcable1/subcable4	39,4 dB	42,3 dB			-----
Bundle/Bundle (SC4/SC5)	47,6 dB	44,4 dB			-----
	50,5 dB	-----	-----		-----
Mechanical Properties					
Weight	225 g	237 g			ca. 300 g
Length	2,5 m	2,5 m			2,5 m

[0047] For Examples A and B five values are given for the cross-talk. The signal/signal value is the cross-talk between any two adjacent electrical signal conductors 30 in the same subcable assembly 20. For example A, the value for subcable1/subcable2 is the cross talk between two corresponding electrical signal conductors 730 in two adjacent sub-

cable assemblies 720 in the same subcable assembly bundle 725, i.e. with no shielding strip 750 between the two adjacent subcable assemblies 720. The value for subcable1/subcable3 is the cross talk between two corresponding electrical signal conductors 730 in two subcable assemblies 720 separated by one subcable assembly 730 in the same subcable assembly bundle 725. Similarly, the value for subcable1/subcable4 is the cross talk between two corresponding electrical signal conductors 730 in two subcable assemblies 720 separated by two subcable assemblies 720 in the same subcable assembly bundle 725, i.e. the first and last subcable assemblies 720 in one of the subcable assembly bundles 725. The value for the bundle/bundle crosstalk of example A is obtained by measuring the cross talk between two corresponding electrical signal conductors 730 in the subcable assemblies 720 immediately adjacent to the shielding strip 750, i.e. the first subcable assembly 720 in one of the subcable assembly bundles 725 and the last subcable assembly 720 in the other of the subcable assembly bundles 725.

[0048] The cross talk values for examples B and C are measured in the same manner except, of course, that there is always at least one shielding strip 50 between the two electrical signal conductors 30 in the different subcable assemblies 20. There is no value given for the bundle/bundle cross talk since the subcable assemblies 20 of examples B and C are not bundled.

[0049] The value for the cross talk given for the comparative example is the value measured between any two adjacent electrical signal conductors.

[0050] It can be seen from this table that the electrical signal lines manufactured according to this invention have a much better velocity of signal propagation compared to the comparative example. By suitable choice of electrical signal conductors the cross-talk can be reduced to a value which is at least comparable to that in the comparative example. Indeed in practice it is known that any value greater than 20 dB is acceptable. For the same length of line, the inventive electrical signal lines are substantially lighter, i.e. for 132 lines a weight saving of up to 25% is achievable.

Examples D-M

[0051] Table 2 shows the results of further examples of the invention which are constructed according to the embodiment depicted in Fig. 1.

Table 2

Example	D	E	F	G	H	I	J	K	L	M
Signal Conductor (AWG)	4607	4607	3807	3807	2807	2807	2807	2807	2807	2807
Dielectric	ePTFE	ePTFE	ePTFE	ePTFE	ePTFE	ePTFE	ePTFE	FEP	FEP	FEP
Characteristic Impedance (Ω)	50	80	50	80	50	80	200	50	80	200
Dist. between conductors (mm)	0.09	0.18	0.21	0.44	0.77	2.24	15.85	1.04	3.85	44.7
Capacitance (pF/m)	76	47	76	47	76	38	19	96	48	24

[0052] As signal conductors, copper wire is used. AWG 4607 copper wire has an outer diameter of 0.048 mm. AWG 3807 has an outer diameter of 0.12 mm. AWG 2807 has an outer diameter of 0.381 mm. ePTFE dielectric has a dielectric constant of 1.3 and FEP has a dielectric constant of 2.1.

[0053] It will be seen from table 2, that by a suitable choice of dielectric, distance between conductors and signal conductor, it is possible to construct electrical signal cable assemblies with characteristic impedances between 50 Ω and 200 Ω .

Examples N-P

[0054] Table 3 shows further examples constructed according to the embodiment shown in Fig. 1 but using different dielectric materials.

Table 3

Example	N	O	P
Signal Conductor (AWG)	4007	4007	4007
Dielectric	PFA	PE	PES
Characteristic Impedance (Ω)	50	50	50
Dist. between conductors (mm)	0.22	0.24	0.32
Capacitance (pF/m)	96	101	120

[0055] In examples N-P AWG 4007 copper wire is used with an outer diameter of 0.09 mm. The dielectric material PFA has a dielectric constant of 2.1, polyethylene (PE) has a dielectric constant of 2.3 and polyester (PES) has a dielectric constant of 3.3.

[0056] Although a few exemplary embodiments of the present invention have been described in detail above, those skilled in the art readily appreciate that many modifications are possible without materially departing from the novel teachings and advantages which are described herein.

[0057] Accordingly, all such modifications are intended to be included within the scope of the present invention, as defined by the following claims.

Claims**1.** Electrical signal cable assembly (10, 110, 210, 710) with

a plurality of subcable assemblies (20, 120, 220, 320, 620, 720) stacked on each other, each subcable assembly (20, 120, 220, 320, 620, 720) including a plurality of coplanar electrical signal conductors (30, 130, 230, 330, 730) encased within an insulator (40a, 40b) and being separated from each other by a first pitch distance (a), whereby the first pitch distance (a) is between 0,1 mm and 10 mm and the characteristic impedance of the electrical signal cable assembly (10, 110, 210, 710) is in the range of 50 Ω to 200 Ω

2. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein the insulator (40a, 340a, 640a, 740a, 40b, 340b, 640b, 740b) comprises an upper insulator (40a, 340a, 640a, 740a) attached to a lower insulator (40b, 340b, 640b, 740b).

3. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein said upper insulator (40a, 340a, 640a, 740a) is laminated to said lower insulator (40b, 340b, 640b, 740b).

4. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein

said upper insulator (40a, 340a, 640a, 740a) and said lower insulator (40b, 340b, 640b, 740b) are formed from the group of insulating materials consisting of polyethylene, perfluoroalkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene

5. Electrical signal cable assembly (10, 110, 210, 710) according to claim 4, wherein

said upper insulator (40a, 340a, 640a, 740a) and said lower insulator (40b, 340b, 640b, 740b) are formed from expanded polytetrafluoroethylene.

6. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein

a shielding strip (50, 150, 250, 650, 750) is situated between at least two of said subcable assemblies (20, 120, 220, 320, 720).

7. Electrical signal cable assembly (10, 110, 210, 710) according to claim 6, wherein

said shielding strip (50, 150, 250, 650, 750) is attached to said insulator (40a, 340a, 640a, 740a, 40b, 340b, 640b, 740b).

8. Electrical signal cable assembly (10, 110, 210, 710) according to claim 7, wherein

said shielding strip (50, 150, 250, 650, 750) is laminated to said insulator (40a, 340a, 640a, 740a, 40b, 340b, 640b, 740b)

9. Electrical signal cable assembly (10, 110, 210, 710) according to claim 6 further including

first shielding means (60, 260, 760) in electrical contact with at least one end (55) of the said shielding strips (50, 150, 250, 650, 750).

10. Electrical signal cable assembly (10, 110, 210, 710) according to claim 9 wherein

the first shielding means (60, 260, 760) surrounds said subcable assemblies (20, 120, 220, 320, 720).

11. Electrical signal cable assembly (10, 110, 210, 710) according to claim 10 wherein

an insulating layer (65) surrounds said first shielding means (60, 260, 760).

12. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein

second shielding means (70, 170, 270, 770) surrounding said subcable assemblies (20, 120, 220, 320, 720).

13. Electrical signal cable assembly (10, 110, 210, 710) according to claim 12, wherein

the insulating layer (65, 165, 265, 765) is disposed between the first shielding means (60, 260, 760) and the second shielding means (70, 170, 270, 770).

14. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1 further including

a cable jacket (80, 180, 280, 780) surrounding said subcable assemblies (20, 120, 220, 320, 720).

15. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1 further including

at least one spacer (90, 190, 290, 790) disposed within the cable jacket (80, 180, 280, 780) for shaping the electrical signal cable assembly (10, 110, 210, 710).

16. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein

said subcable assemblies (20, 320, 720) are arranged substantially in parallel planes to each other and have a top side and a bottom side.

17. Electrical signal cable assembly (10, 110, 210, 710) according to claim 16, the electrical signal cable assembly (10, 110, 210, 710) including a cable jacket (80, 280, 780) surrounding said subcable assemblies (20, 320, 720), wherein said at least one spacer (90, 290, 790) comprise

a first crescent-shaped spacer (90, 290, 790) disposed between the top side of said subcable assemblies (20, 320, 720) arranged substantially in parallel planes to each other and the cable jacket (80, 280, 780), and
a second crescent-shaped spacer (90, 290, 790) disposed between the bottom side of said subcable assem-

blies (20, 320, 720) arranged substantially in parallel planes to each other and the cable jacket (80, 280, 780),

18. Electrical signal cable assembly (10, 110, 210, 710) according to claim 154, wherein

5 said subcable assemblies (120) are arranged helically around the spacer (190).

19. Electrical signal cable assembly (10, 110, 210, 710) according to claim 18, wherein

10 the electrical signal cable assembly (10, 110, 210, 710) is cylindrical in shape and has an axis and
 said spacer (190) is cylindrical in shape and has an axis, the axis of said spacer (190) being concentric with
 the axis of the electrical signal cable assembly (10, 110, 210, 710).

20. Electrical signal cable assembly (10, 110, 210, 710) according to claim 1, wherein

15 said electrical signal cable assembly (220) is twisted about its own axis.

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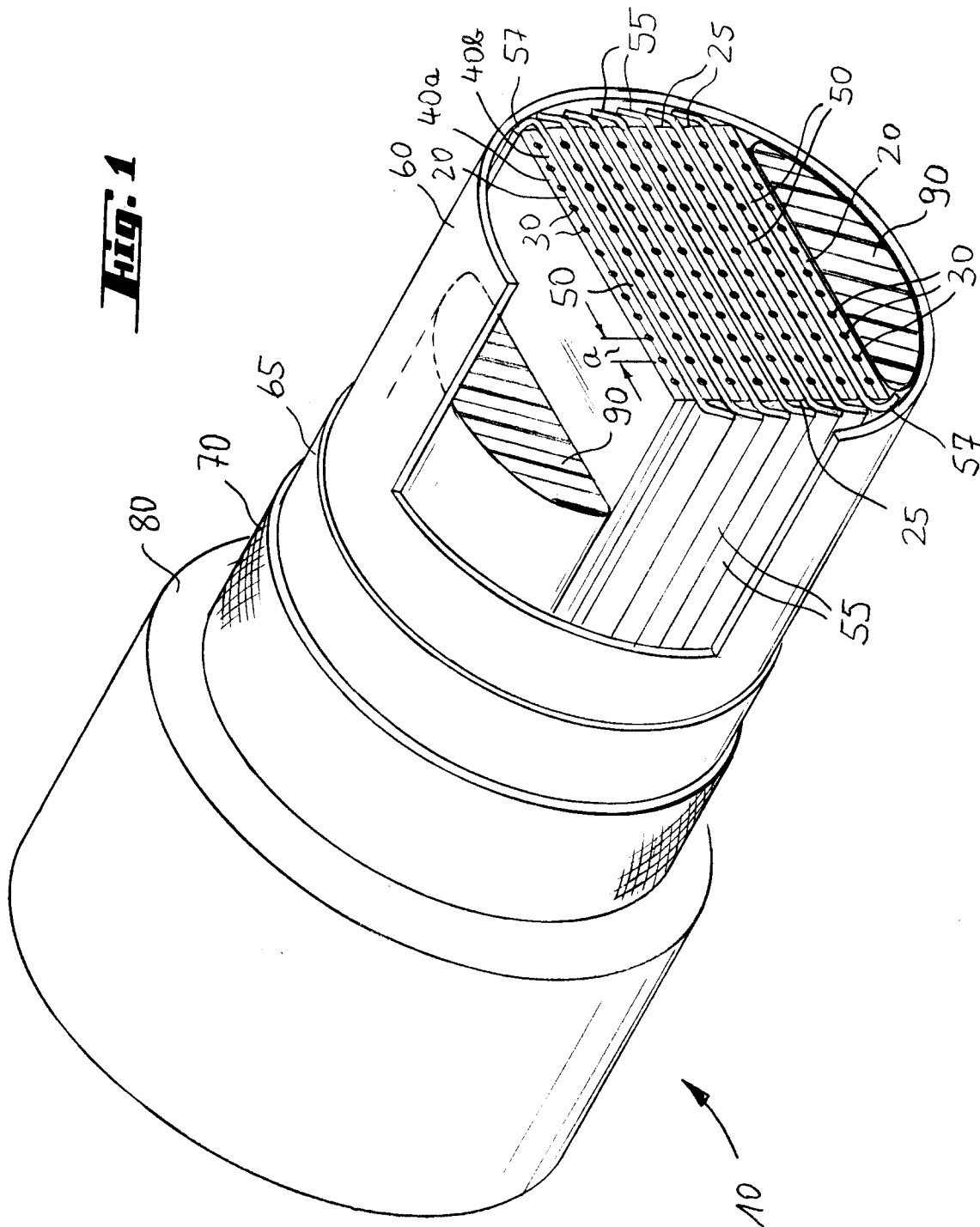
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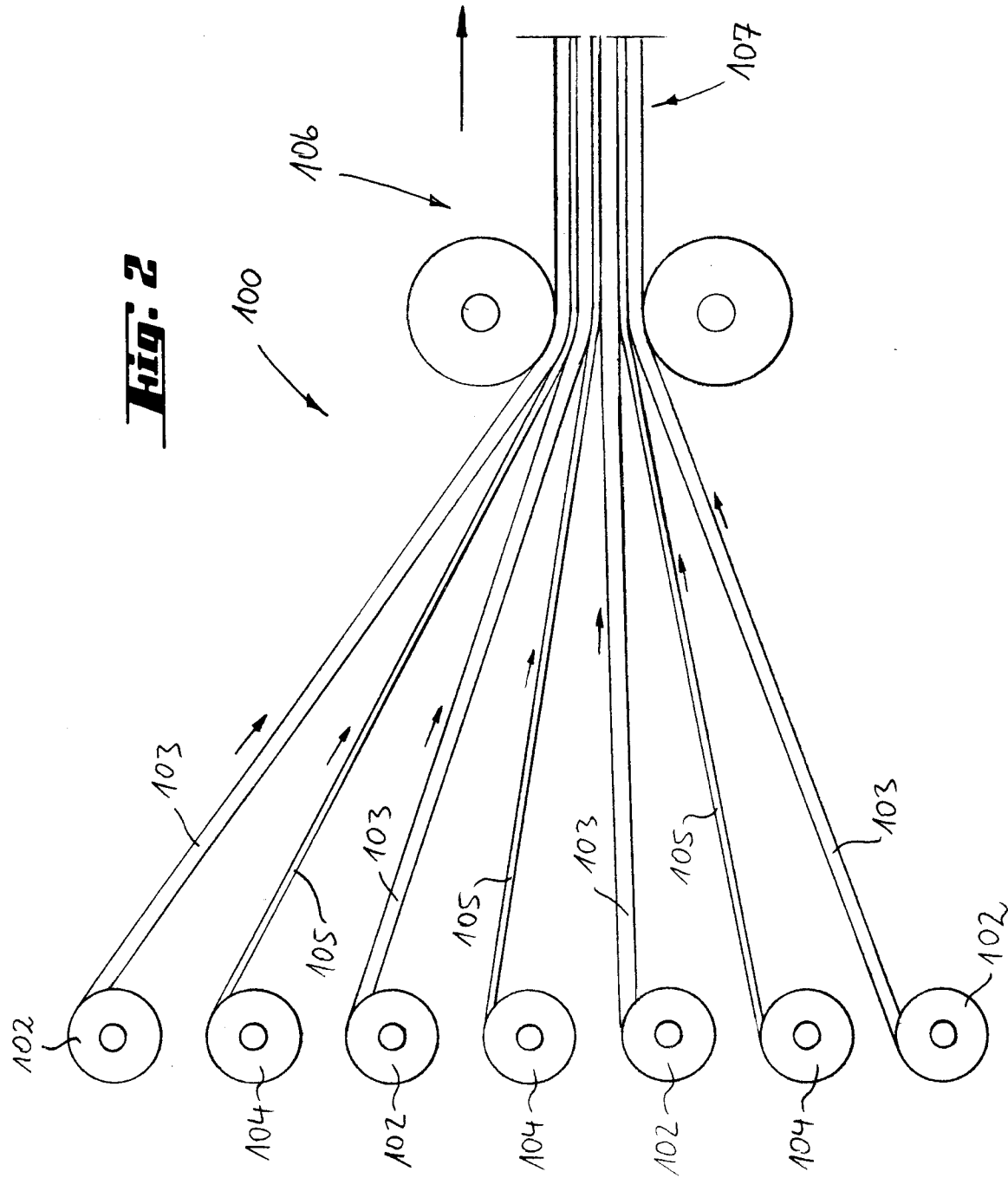
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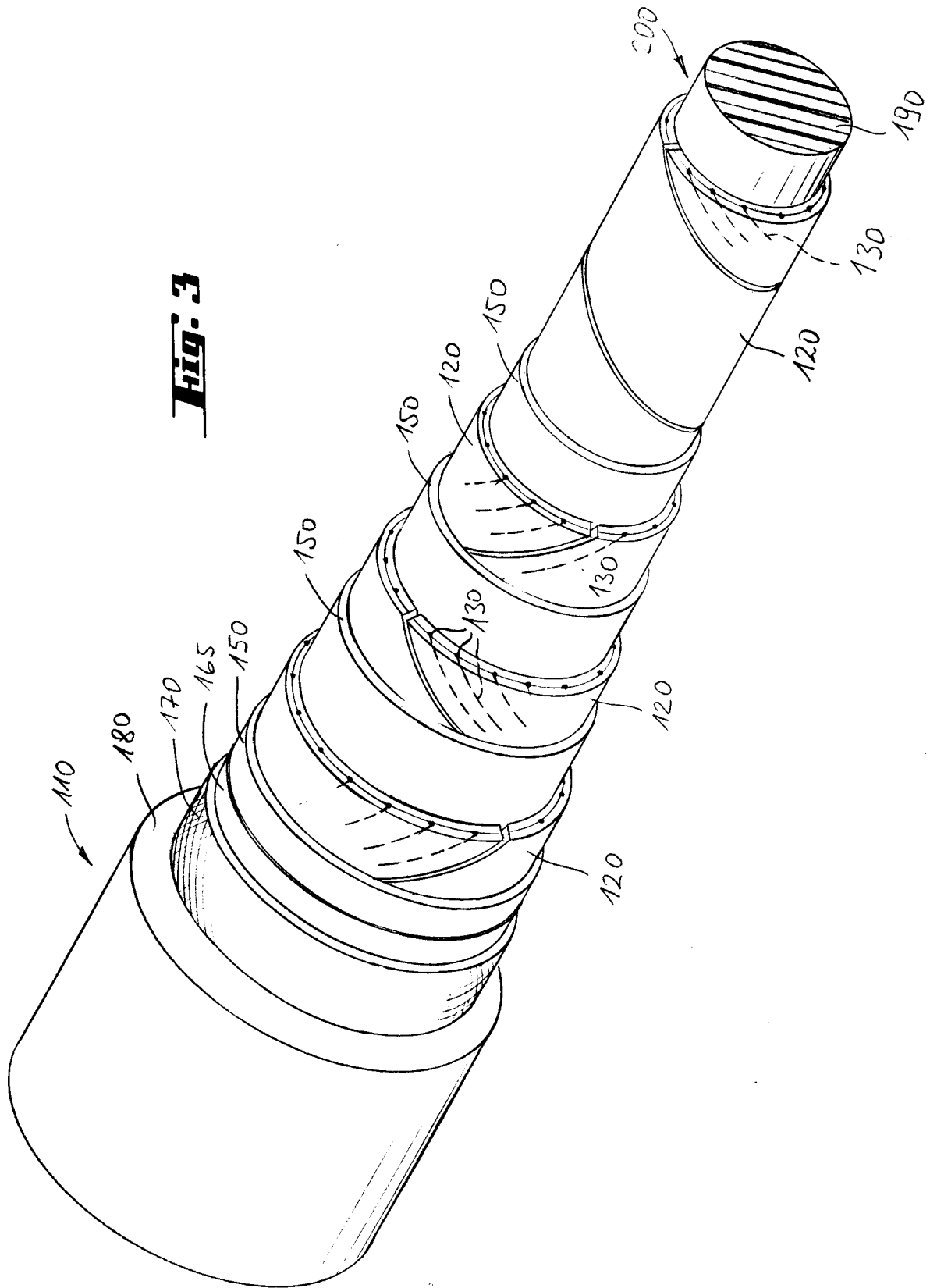
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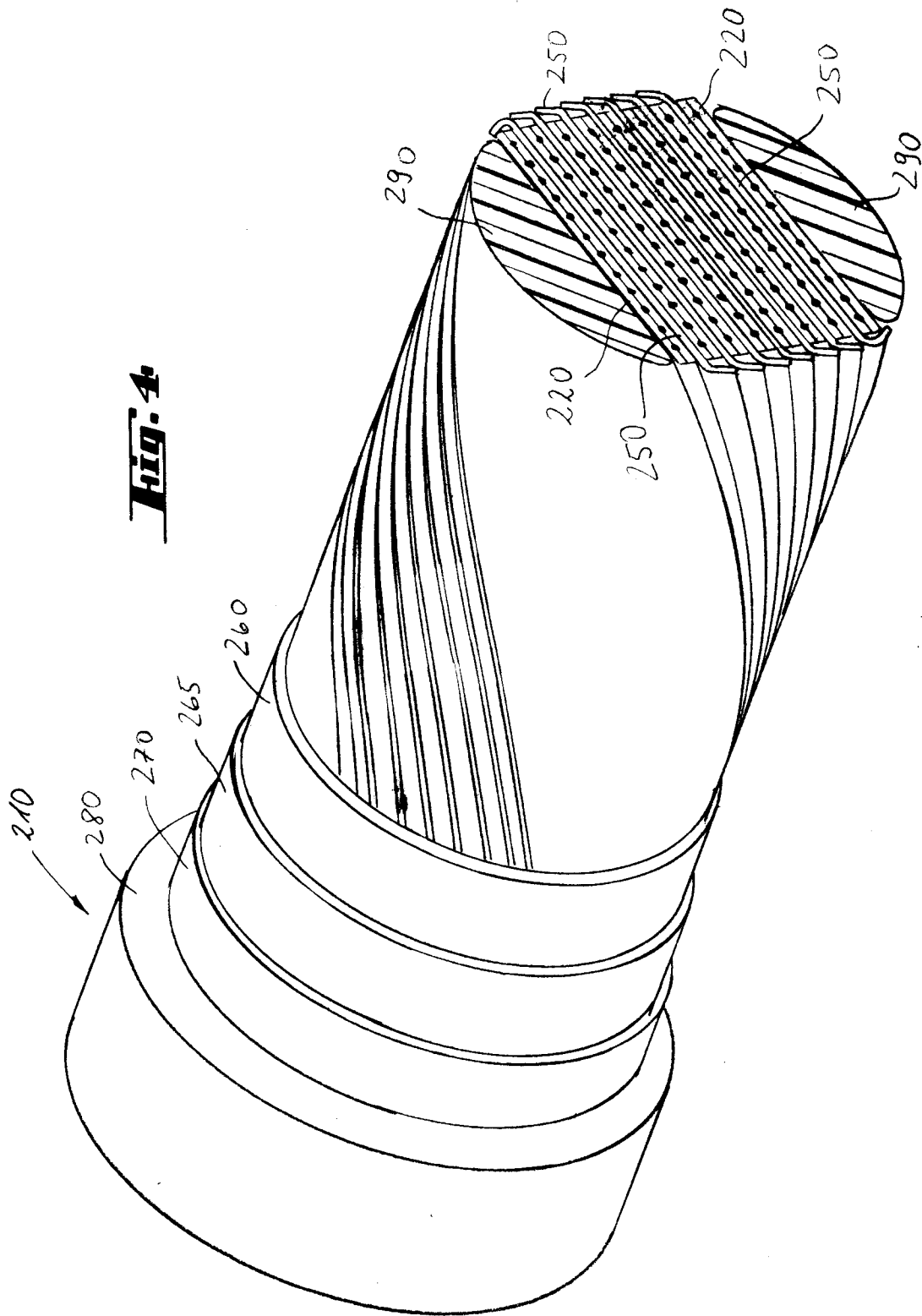
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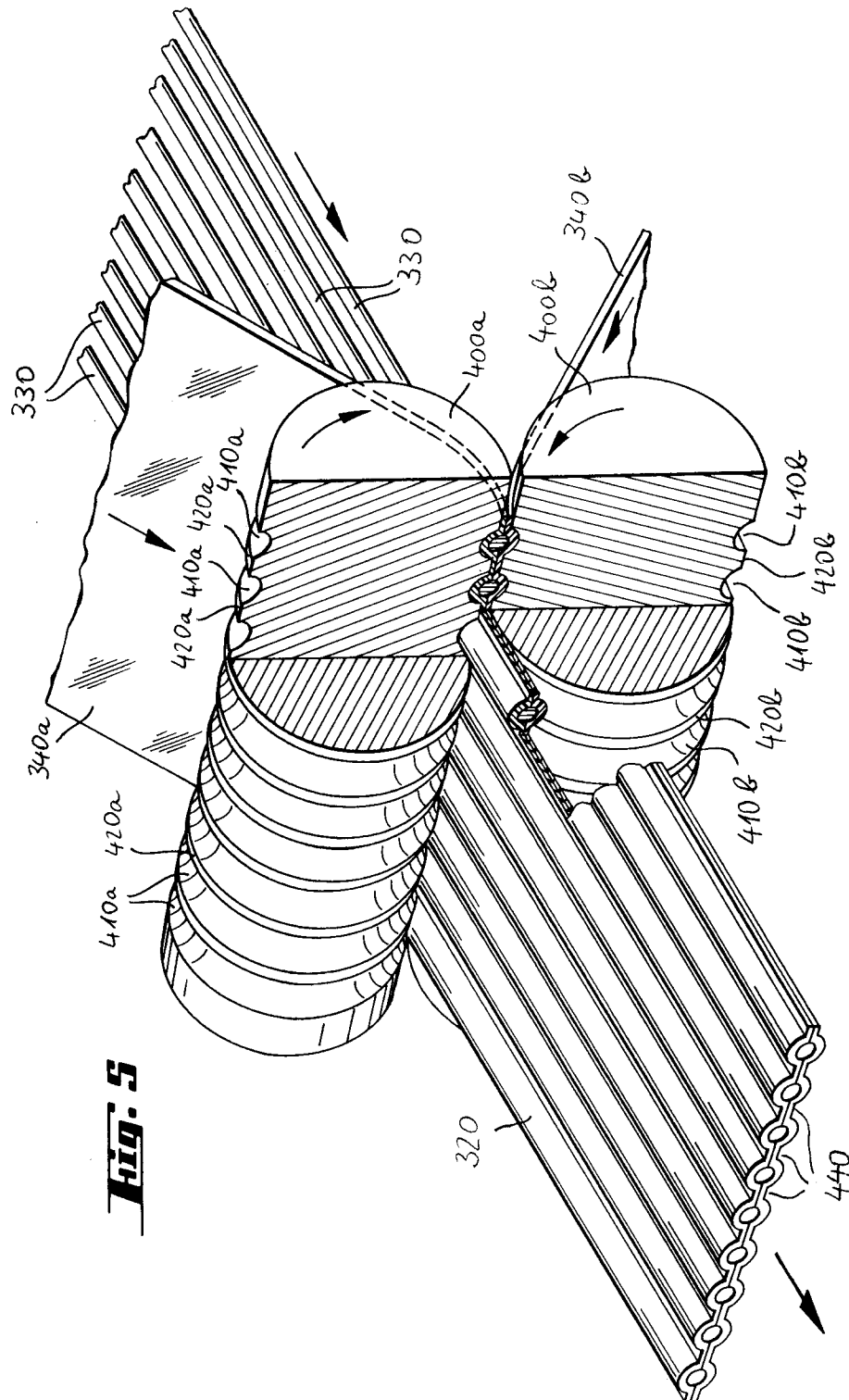
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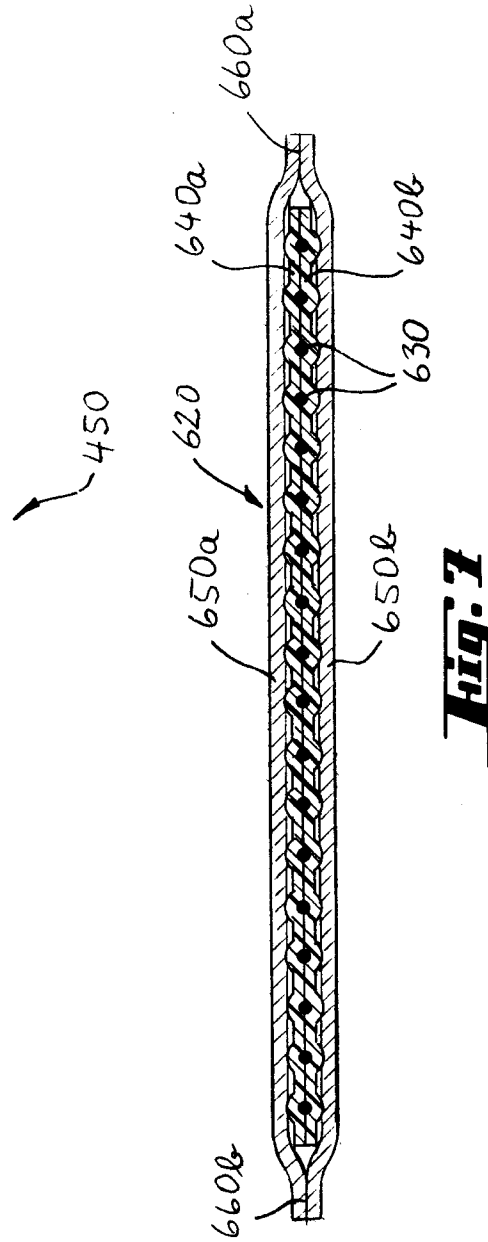
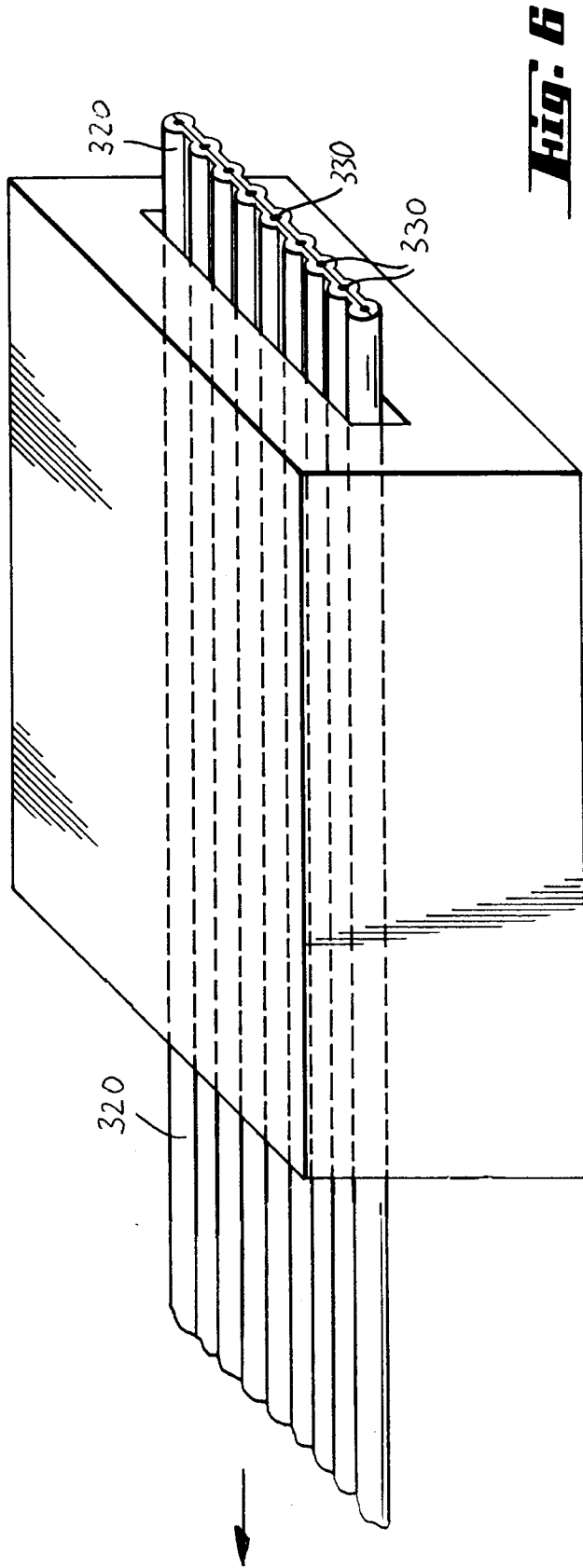


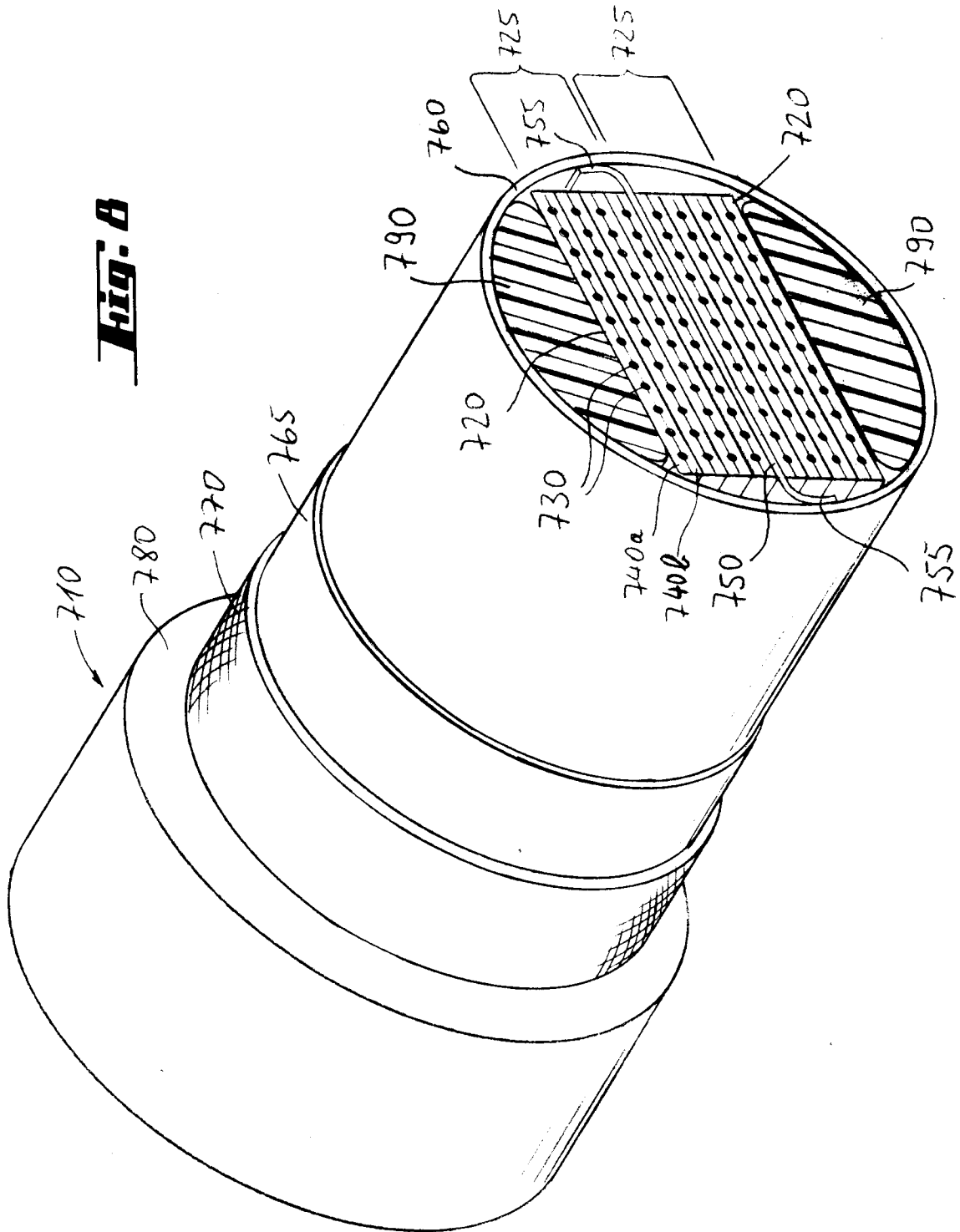














European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 97 11 6396

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	US 4 847 443 A (BASCONI) * column 2, line 36 - column 4, line 66; figures 1-6 *	1	H01B7/08
A,D	US 5 552 565 A (CARTIER ET AL.) * column 2, line 29 - column 6, line 9; figures 4,5 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		12 February 1998	Demolder, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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