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(11)

EP 1 103 987 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

30.05.2001 Bulletin 2001/22

(51) Int Cl.7: **H01B 11/20, H01B 7/06**

(21) Application number: **99114959.2**

(22) Date of filing: **06.08.1999**

(84) Designated Contracting States:

**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**

Designated Extension States:

AL LT LV MK RO SI

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(54) **Set coil**

(57) A cable (100) for use in a telecommunications equipment such as a mobile telephone to connect an antenna to a telecommunications circuit is described. The cable (100) comprises a plurality of coaxial cables (110) embedded within a jacket (160). The coaxial ca-

bles (110) each have an inner conductor (120), a dielectric insulator (130) surrounding the inner conductor (120), and a shield (140) surrounding the dielectric insulator (130). The cable (100) of the design has sufficient resilience to allow it to return to its original position without degrading its electrical properties.

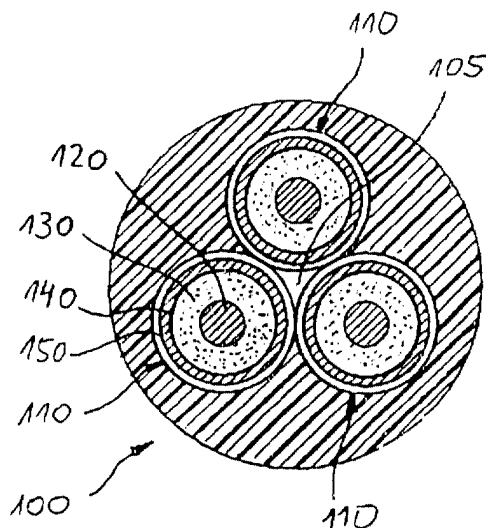


Fig. 3

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Description

Field of the Invention

[0001] The invention relates to an electrical cable having a plurality of coaxial cables embedded within a jacket. The invention furthermore relates to a telecommunications apparatus having an extendable antenna which is connected to a telecommunications electronics circuit in the telecommunications apparatus by means of the cable.

Prior Art

[0002] Mobile telecommunications equipment such as cell phones, walky-talkies or radios all possess an aerial or antenna to transmit and receive signals. Depending on the size of the equipment and the frequency of the signals, these antennas may be extendible outside of the casing of the telecommunications equipment to allow the user to pull the antenna out of the casing and thus obtain better reception or transmission. After use, the user pushes the antenna back into the casing to ensure that it is not damaged.

[0003] The antenna is connected to the electronic telecommunications signal processing circuits within the equipment by means of a cable which must be capable of extension and retraction within the casing of the mobile telecommunications equipment. The frequent extension and retraction of the antenna over time affects both the mechanical and electrical performance of the cable. It is found, for example, that the electrical attenuation of the cable increases whilst the memory effect of the cable, i.e. its ability to return to its original position after retraction into the casing decreases.

[0004] The increasing trend towards miniaturisation of telecommunications equipment means that the space within the casing of the equipment able to incorporate the cable diminishes. Thus conventional solutions for improving the attenuation of the cable by providing thicker central conductors in a coaxial cable are not possible. Similarly the space is not available to provide sturdier jackets or thicker dielectric materials to improve the mechanical stability of the cable.

Summary of the Invention

[0005] It is therefore an object of the invention to provide an improved extendable cable for use in a telecommunications apparatus.

[0006] It is furthermore an object of the invention to provide a cable which after multiple extension still maintains a memory effect.

[0007] It is furthermore an object of the invention to provide a cable in which electrical attenuation is substantially undiminished after multiple extension.

[0008] These and other objects of the invention are solved by providing a cable with a plurality of coaxial

cables embedded within a jacket. Each of the coaxial cables comprises an inner conductor, a dielectric insulator surrounding the inner conductor and a shield surrounding the dielectric insulator. It has been found that a construction of this design allows the use of coaxial cables with adequate electrical properties for the application whilst the jacket ensures that the cable has sufficient mechanical stability to withstand multiple extensions and also to have sufficient resilience to provide a sufficient memory effect, i.e. returns to its original (unextended) position. The jacket can be made from a variety of materials such as material selected from the group of polymers comprising polyester, polyurethane, polyethylene and polyvinylchloride. Tests have shown that the best material for ensuring sufficient resilience has a Shore hardness of 36D. In one preferred embodiment of the invention this is achieved by using a polyurethane for the jacket.

[0009] In a preferred embodiment of the invention, the coaxial cable is provided with a protective layer about the shield to which the jacket is attached. This protective layer serves to provide sufficient mechanical stability and resiliency. In a preferred embodiment of the invention, the protective layer is made from polyimide.

[0010] The dielectric insulator is made from a material selected from the group of dielectric materials comprising polyethylene, polyester, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene PTFE and most preferably from expanded PTFE which offers excellent electrical performance in small dimensions.

[0011] In a preferred embodiment of the invention, the coaxial cable is provided with a protective layer about the shield to which the jacket is attached. This protective layer serves to provide sufficient mechanical stability and also to increase the resiliency. In one embodiment of the invention, the protective layer is made from a material selected from the group of polymers comprising polyester, polyimide, polyetheretherketone or polycarbonate. In the most preferred embodiment of the invention polyester is used which is found to provide sufficient resilience to the cable.

[0012] The cable preferably incorporates three coaxial cables which is found to be ideal for applications such as a mobile telephones.

[0013] In a telecommunications application the cable is connected to an extendable antenna and is spirally wound within the casing of the application. The cable has in an unextended position a certain predefined unextended length. After extension of the antenna outside of the casing, the cable has a specified extended length. The ratio of the extended length to the unextended length is found to be greater than 1:7 which is found to offer the best compromise between the space required to store the cable within the casing in an unextended position and the length required to allow sufficient extension of the antenna outside of the casing.

Description of the Drawings

[0014]

- Fig. 1 shows a mobile telephone in accordance with the invention
- Fig. 2 shows the cable used to connect the antenna electronic circuit of the invention to the telecommunications electronic circuit in the mobile telephone.
- Fig. 3 shows a cross section of the cable of Fig. 2.

Detailed Description of the Invention

[0015] Fig. 1 shows a mobile telephone 10 in accordance with the invention. The mobile telephone 10 has a casing 15 and an antenna 20 which has both an extended position A outside of the casing 15 shown as a dotted line in the Figure and an unextended position B. In the latter position B the antenna 20 is substantially or completely positioned within the casing 15 of the mobile telephone 10. Attached to the antenna 20 is an antenna electronic circuit 30 which is connected by means of a cable 100 to a telecommunications electronic circuit 40 also within the casing 15 of the mobile telephone 10. In the unextended position B of the antenna 20, the cable 100 is substantially spirally wound as is shown in the Figure. In this position B the cable 100 has a length C and a spiral diameter D and is enclosed within a cable storage department 50 within the casing 15. In the extended position A of the antenna 20 the cable 100 is substantially straight and has a length E as shown in the Figure. At intermediate positions the cable is spirally wound and has a spiral diameter less than that of D and a length between the lengths C and E. In use the antenna 20 will be pulled out of the casing 15 by the user of the mobile telephone 10 when the mobile telephone 10 is being used and then pushed into the casing 15 when the mobile telephone 10 is no longer being used.

[0016] In one example of a mobile telephone 10, the antenna 20 can be extended by 100 mm. The dimensions of the cable storage department 50 are approx. 14 mm x 14 mm. However, these dimensions are not limiting of the invention. Although this invention is described with respect to a mobile telephone 10, it should be noted that it can also be used in any apparatus in which an extendible cable is required. Examples of such apparatus include radios and walky-talkies.

[0017] The construction of the cable 100 used in the mobile telephone 10 is shown in Figs. 2 and 3. In the preferred embodiment, the cable 100 has three coaxial cables 110 arranged equidistant about a centre 105 of the cable 100. Each of the three coaxial cables 110 has an inner conductor 120 made from a metal conductor such as copper, tin plated copper or silver plated copper. The inner conductor 120 is surrounded by a dielectric insulator 130 made from a material selected from the group of dielectric materials comprising polyethylene,

polyester, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene (PTFE). Preferably a fluoropolymer such as expanded PTFE is used.

[0018] The dielectric insulator 130 is surrounded by a shield 140 which may be braided or surfed from metal wire or may be made from a metallised fabric, such as metallised polyester fabric. Finally a protective layer 150 is placed about the shield 140. The protective layer 150 is made from a material selected from the group of polymers comprising polyester, polyimide, polyetheretherketone or polycarbonate. Preferably polyimide is used as the protective layer 150.

[0019] The three coaxial cables 110 are then extruded within a jacket 160 made of a material selected from the group of polymers comprising polyester, polyurethane, polyethylene and polyvinylchloride. Preferably polyurethane is used. The jacket 160 has a Shore hardness of 36D since this is found to provide the cable 100 with sufficient resilience that it returns to its original position after extension.

[0020] The cable 100 is formed into a spiral coil by wrapping it about a cylindrical former with an appropriate diameter. Depending on the material from which the protective layer 150 and the jacket 160 are made, the cable 100 is heated at a temperature between 100°C and 150°C for between 30 minutes and 2 hours after which time the cable 100 has assumed a spiral form.

[0021] The invention may also find application other areas such as mini-robots or sensors such as position sensors, temperature sensors or marking sensors.

Example I

[0022] A cable 100 is made in accordance with the design shown in Figs. 2 and 3. The inner conductors 120 are made of silver plated copper and have a diameter of AWG 30 (0.3mm). The dielectric insulator 130 is made of ePTFE tapes which are wrapped about the inner conductors 120 to form a layer of 0.2 mm thickness and the shield 140 is made of silver plated copper wire of AWG 44 (0.05 mm) wrapped about the dielectric insulator 130. The protective layer 150 of thickness 0.04 mm is made from polyester which is extruded about the shield 140. The three coaxial cables 110 are then passed through an extruder to form the polyurethane jacket 160. The cable 100 has a diameter of 2.4 mm and is cut into lengths of 200 to 250 mm.

[0023] The cut lengths are then spirally wound by winding the cable 100 around a cylindrical former and heated to between 120°C and 130°C for between 70 and 120 minutes. The cable 100 assumes a spiral form and is then ready for placing into the casing 15 of the mobile telephone 10. The spirally wound cable 199 has an unextended length of 14 mm and a diameter of 13.8 mm. It can be extended by 100 mm.

[0024] Tests carried out on the cable 100 show that at

2.2 GHz it has an attenuation of 2.36 dB/m after manufacture.

Example 2

[0025] A cable 100 was made using the same method as described in Example 1 except that the spirally wound cable had a length of 45 mm and an spiral outside diameter of 13,8 mm in the unextended position. In the extended position the cable 100 had a length of 300 mm. The cable 100 of this example is also for use in a mobile telephone 10.

Claims

1. Cable (100) with

a plurality of coaxial cables (110) embedded within a jacket (160),
wherein at least one of the plurality of coaxial cables (110) comprises:

- an inner conductor (120),
- a dielectric insulator (130) surrounding the inner conductor (120), and
- a shield (140) surrounding the dielectric insulator (130).

2. Cable (100) according to claim 1, wherein the at least one of the plurality of coaxial cables (110) further comprises a protective layer (150) surrounding the shield (140).

3. Cable (100) according to claim 1, wherein three coaxial cables (100) are embedded within the jacket (120).

4. Cable (100) according to claim 1 wherein the jacket (160) is made from a material having a Shore hardness of 36D.

5. Cable (100) according to claim 1 wherein the jacket (160) is made from a material selected from the group of polymers comprising polyester, polyurethane, polyethylene and polyvinylchloride.

6. Cable (100) according to claim 5 wherein the jacket (160) is made from polyurethane.

7. Cable (100) according to claim 1 wherein the dielectric insulator (130) is made from a material selected from the group of dielectric materials comprising polyethylene, polyester, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene (PTFE).

8. Cable (100) according to claim 7 wherein the dielectric insulator (140) is made from expanded PTFE.

9. Cable (100) according to claim 1 wherein the protective layer (150) is made from a material selected from the group of polymers comprising polyester, polyimide, polyetheretherketone or polycarbonate.

10. Cable (100) according to claim 9 wherein the protective layer (150) is made from polyimide.

11. Telecommunications apparatus (10) comprising:

- an extendible antenna (20) with an antenna electronic circuit (30) and having an extended position (A) and an unextended position (B);
- a telecommunications electronic circuit (40), connected to the antenna electronic circuit (30) by means of a cable (100); and
- a cable storage compartment (50) in which the cable (100) is substantially positioned when the extendible antenna (20) is in an unextended position (B);

wherein said cable (100) is substantially spirally wound and has an unextended length when the extendible antenna (20) is in an unextended position (B) and has an extended length when the extendible antenna (20) is in an extended position and the ratio of the unextended length to the extended length is greater than 1:7.

12. Telecommunications apparatus (10) according to claim 11 wherein said cable (100) contains at least one coaxial cable (110).

13. Telecommunications apparatus (10) according to claim 12 wherein said cable (100) contains three coaxial cables (110).

14. Telecommunications apparatus (10) according to claim 11 wherein the at least one coaxial cable (110) comprises:

- an inner conductor (120),
- a dielectric insulator (130) surrounding the inner conductor (120), and
- a shield (140) surrounding the dielectric insulator.

15. Telecommunications apparatus (10) according to claim 11 wherein the at least one coaxial cable (110) further comprises a protective layer (150) surrounding the shield (140).

16. Telecommunications apparatus (10) according to claim 11 wherein the at least one coaxial cable (100)

is embedded within a jacket (120).

17. Telecommunications apparatus (10) according to claim 16 wherein the jacket (120) is made from a material having a Shore hardness of 36D. 5
18. Telecommunications apparatus (10) according to claim 16 wherein the jacket (160) is made from a material selected from the group of polymers comprising polyester, polyurethane, polyethylene and polyvinylchloride. 10
19. Telecommunications apparatus (10) according to claim 16 wherein the jacket (160) is made from polyurethane. 15
20. Telecommunications apparatus (10) according to claim 16 wherein the dielectric insulator (130) is made from a material selected from the group of dielectric materials comprising polyethylene, polyester, perfluoralkoxy, fluoroethylene-propylene, polypropylene, polymethylpentene, polytetrafluoroethylene or expanded polytetrafluoroethylene (PTFE). 20
21. Telecommunications apparatus (10) according to claim 14 wherein the dielectric insulator (140) is made from expanded PTFE. 25
22. Telecommunications apparatus (10) according to claim 15 wherein the protective layer (150) is made from a material selected from the group of polymers comprising polyester, polyimide, polyetheretherketone or polycarbonate. 30
23. Telecommunications apparatus (10) according to claim 22 wherein the protective layer (150) is made from polyimide. 35

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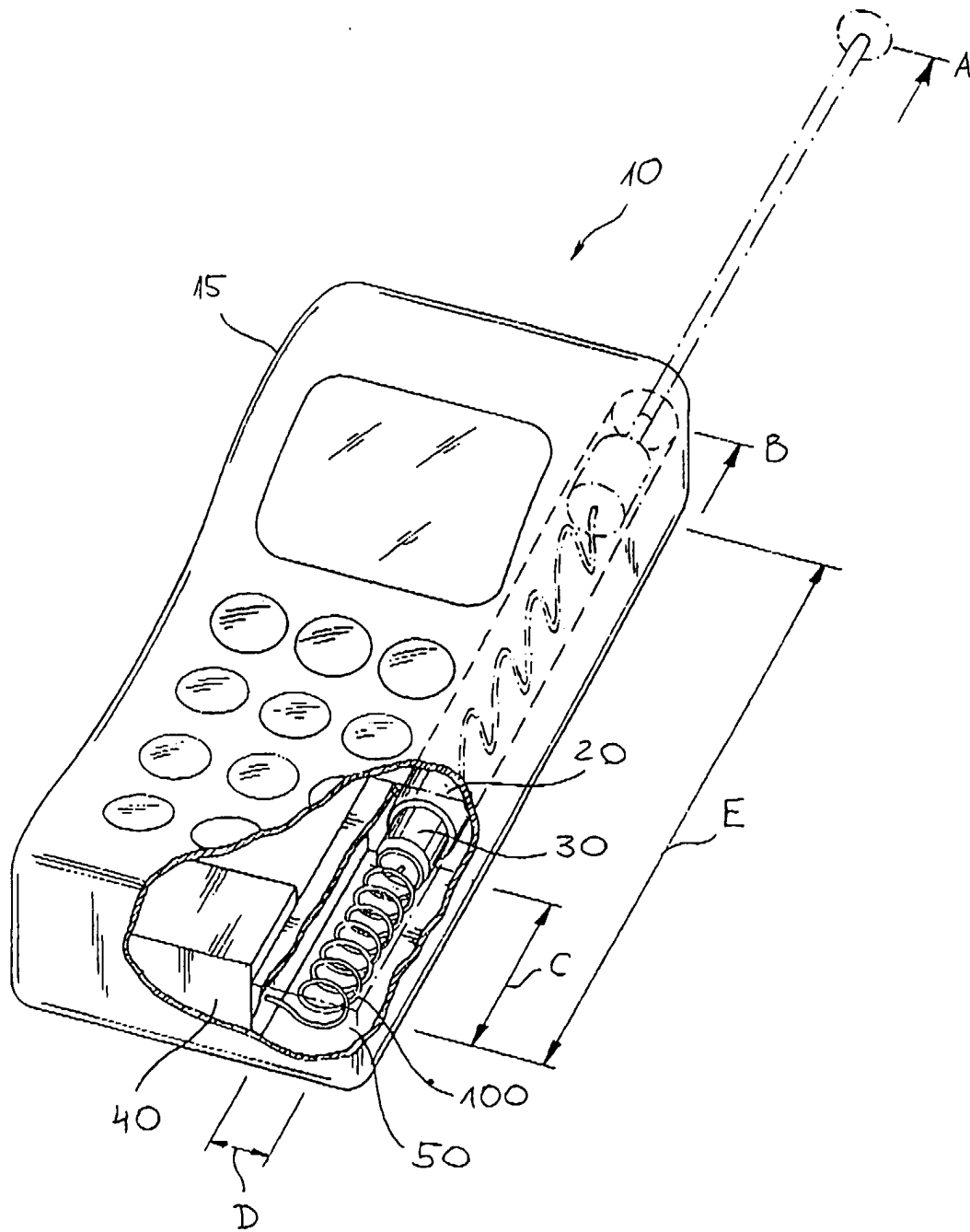


Fig. 1

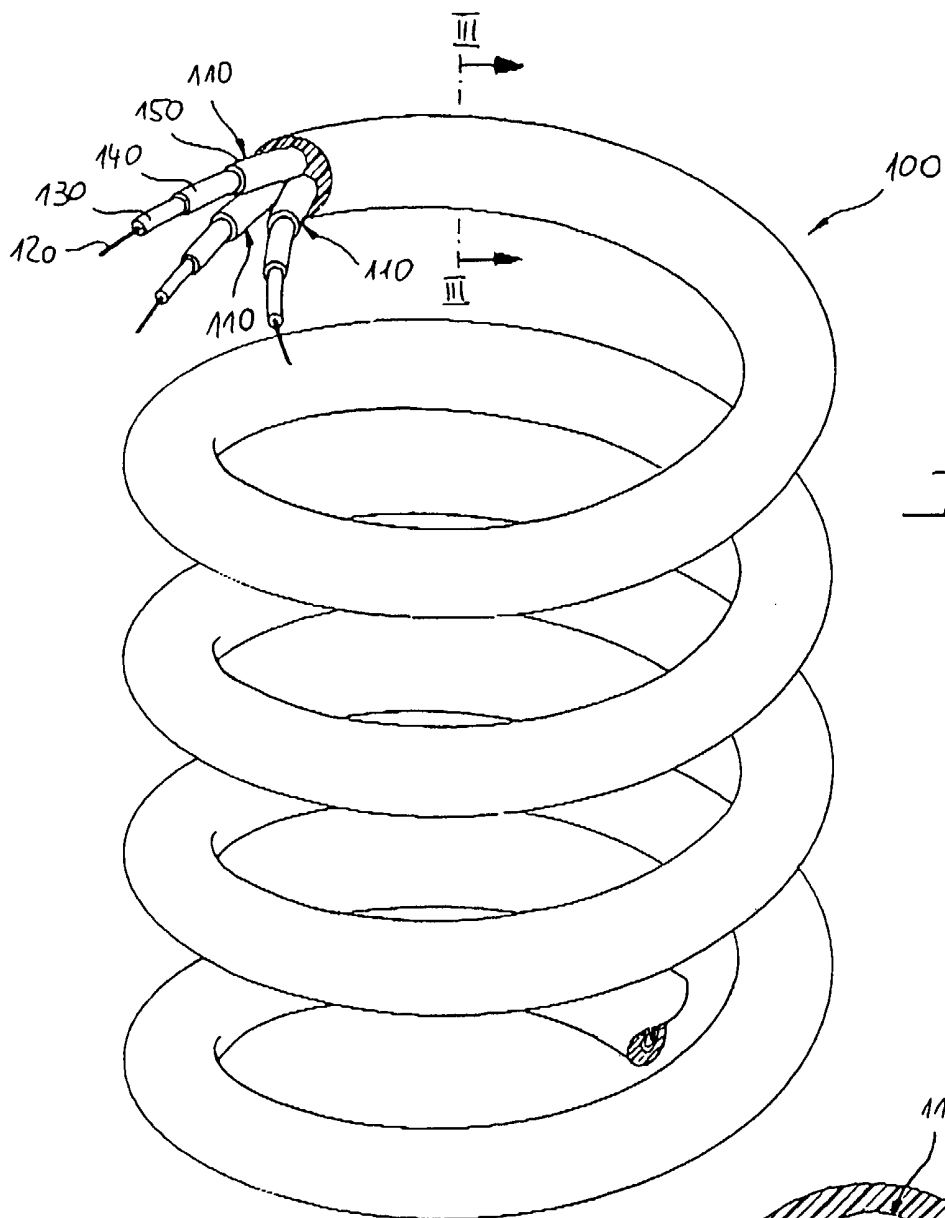


Fig. 2

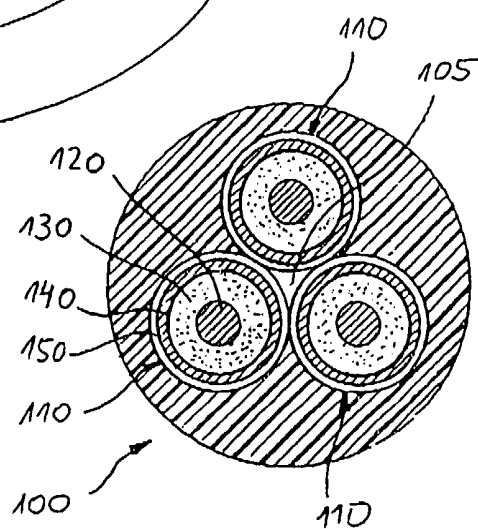


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 99 11 4959

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.7)
X	WO 94 16451 A (GORE & ASS) 21 July 1994 (1994-07-21) * page 3, line 16 - page 6, line 29; figures 2,3 *	1-3,5-9	H01B11/20 H01B7/06
X	US 4 552 989 A (SASS RICHARD G) 12 November 1985 (1985-11-12) * column 2, line 16 - column 5, line 59; figures 1-5 *	1-3,5,7,9	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H01B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28 December 1999	Examiner Demolder, J
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 11 4959

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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28-12-1999

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9416451	A	21-07-1994	NONE	
US 4552989	A	12-11-1985	NONE	