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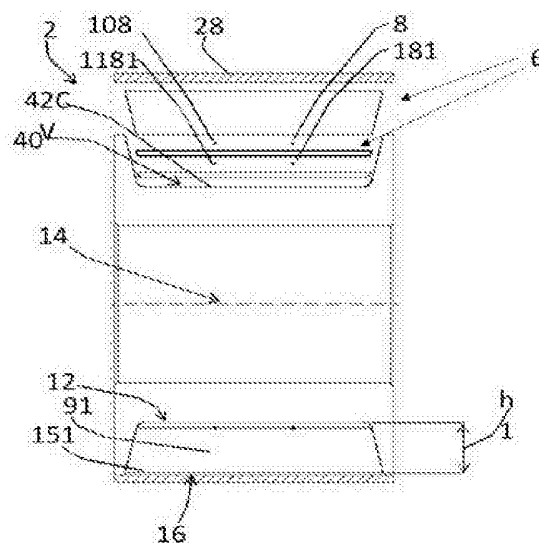
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Cable with a first and a second thimble and at least one yarn, and method for producing an endless winding cable.

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A cable comprises a first and a second thimble (2, 4), and at least one main yarn (6) and an auxiliary yarn (7). The first and the second thimble are provided at opposite ends of the cable. The at least one main yarn (6) and the auxiliary yarn (7) each forms turns around the first and second thimble (2, 4). Each thimble (2, 4) comprises a bearing surface (40), and holds a stack (19) of layers (10) of turns of the main yarn (6). A stack (119) of turns of the auxiliary yarn (7) comprising at least a first layer (13) of turns of the auxiliary yarn (7) lies on the bearing surface (40) of the respective thimble (2, 4).



Title: Cable with a first and a second thimble and at least one yarn, and method for producing an endless winding cable

The invention relates to a cable according to the preamble of claim 1.

5 A cable of this type can be used in different types of industry, including but not limited to offshore, mining and heavy lifting and construction. In offshore, a cable of this type can be used as a mooring line for a floating oil exploration or production facility, or for a floating wind turbine. In mining and heavy lifting such a cable may be used as a pendant for a crane. In construction such a cable may be used as a tension member in a bridge or suspension cable of a roof.

10 A cable of this type is known from WO-A1-2005/075286, which discloses a cable which is used as a stay for sailing vessels. The stay comprises plastic load bearing fibres which extend between a first and a second thimble and turn around these thimbles forming a stack of fibres.

A disadvantage of the known cable is that it wears more quickly than one would predict based on the properties of the fibres and the load on the cable.

15 The invention aims to solve this problem, or at least to provide an alternative. In particular, the invention aims to provide a cable with a longer life span.

This aim is achieved by a cable according to claim 1.

A cable comprises a first thimble and a second thimble, and at least one main yarn. The main yarn comprises fibres of a first type. The first thimble and the second thimble are provided at
20 opposite ends of the cable. The main yarn extends from the first thimble to the second thimble, turns around the second thimble, extends from the second thimble to the first thimble, and turns around the first thimble, such that the main yarn forms turns around the first and second thimbles. Each thimble comprises a bearing surface, and holds a stack of layers of turns of the main yarn. The cable comprises fibres of a second type, wherein the second type is different from the first type. A
25 stack comprising at least a first layer of the fibres of the second type lies on the bearing surface of at least one of the first and second thimbles. The stack of layers of turns of the main yarn is located on top of the stack of the fibres of the second type.

Within the context of this document, a turn of a yarn may be either a semi-continuous loop, or a continuous loop. The term semi-continuous loop refers to the fact that the yarn has a finite
30 length with distinct ends, while in a continuous loop a yarn has no ends. So in a semi-continuous loop, the at least one yarn is wound around the first and second thimble a plurality of times, forming a plurality of loops around these thimbles, which is not completely continuous as the ends of the yarn are not connected to each other. Within the context of this document, a thimble is defined as a ring of any shape and made of any material around which the at least one yarn is
35 turned.

The invention is based on the insight that cables of this type that are subject to a large number of load cycles fail after a prolonged period, because the varying cyclic loads result in a small movement of the first layer of yarn turns along the bearing surface of the thimble. Repetition of this movement a large number of times results in wearing and breaking of the yarns of this lower layer.

5 After they have broken, the next layer of yarns starts wearing, until so many layers have worn that the remaining layers can no longer take the full load applied on the cable, and the cable fails completely. The stack of the fibres of the second type avoids direct contact between the main yarn and the bearing surface. As a result, the main yarn does not wear due to movements of the main yarn relative to the bearing surface. The properties of the fibres of the second type are chosen such
10 that their wear is less than that of the main yarn.

In an embodiment, the fibres of the second type have a friction coefficient relative to the material of the bearing surface, for example stainless steel, which is lower than a friction coefficient relative to the material of the bearing surface of the fibres of the first type. Thanks to the lower friction coefficient, any movement between the auxiliary yarn and the bearing surface results in less
15 warmth being generated and hence in less wear.

In an embodiment, the fibres of the second type have a modulus of elasticity which is higher than the modulus of elasticity of the fibres of the first type. This results in less elongation of the auxiliary yarn when the cable is subject to a load, and thus in less movement between the auxiliary yarn and the bearing surface when the cable is subjected to load cycles.

20 In an embodiment, the cable comprises at least one auxiliary yarn, which comprises the fibres of the second type. The auxiliary yarn extends from the first thimble to the second thimble, turns around the second thimble, extends from the second thimble to the first thimble, and turns around the first thimble, such that the auxiliary yarn forms turns around the first and second thimbles, and the first layer of the fibres of the second type is a first layer of turns of the auxiliary
25 yarn. By having the fibres of the second type in the form of an auxiliary yarn and winding this around the thimbles too, the fibres of the second type will elongate together with the main yarns under load. This reduces the movement between the fibres of the second type and the main yarns, resulting in even less wear.

In an alternative embodiment, the cable comprises a sheet made of the fibres of the second
30 type. The sheet comprises at least the first layer of the fibres of the second type, and is positioned on the bearing surface of at least one of the first and second thimbles. Such a sheet is easily and quickly positioned on the bearing surface of the thimble, after which the winding of the main yarn may start directly.

In particular, the sheet made of the fibres of the second type is a non-woven sheet, a woven sheet, a braided sheet, or a knitted sheet.

In an embodiment, the stack of the fibres of the second type comprises a plurality of layers, in particular at least five layers, more in particular at least ten layers, more in particular at least
 5 twenty layers. Because there is more than one layer of the fibres of the second type, one or more of these layers may wear before direct contact between the main yarn and the bearing surface arises. This increases the life span of the cable even further.

In an embodiment, an overall stack height is defined as the distance from the first layer of the fibres of the second type to a last layer of turns of the main yarn, and a stack height of the fibres
 10 of the second type is at least 1%, in particular at least 2%, more in particular at least 5%, of the overall stack height. This increases the life span of the cable, because the stack of the fibres of the second type wears before direct contact between the main yarn and the bearing surface arises.

In an embodiment, an overall stack height is defined as the distance from the first layer of the fibres of the second type to a last layer of turns of the main yarn, and a stack height of the layers
 15 the fibres of the second type is less than 25%, in particular less than 15%, more in particular less than 10% of the overall stack height. A maximum height of stack of the fibres of the second type provides a balance between the extended life span, and the extra cost and cable thickness due to these layers.

The invention further relates to a cable comprising a first thimble and a second thimble, and
 20 at least one yarn. The first thimble and the second thimble are provided at opposite ends of the cable. The at least one yarn extends from the first thimble to the second thimble, turns around the second thimble, extends from the second thimble to the first thimble, and turns around the first thimble, such that the at least one yarn forms turns around the first and second thimbles. Each thimble comprises a bearing surface, and holds a stack of layers of turns of the at least one yarn. A
 25 first layer of turns of the at least one yarn lies on the bearing surface of the respective thimble. The bearing surface of at least one of the thimbles is provided with a friction reducing coating.

Within the context of this document, a friction reducing coating is a coating that provides the bearing surface with a friction coefficient between the bearing surface and the yarns that is lower than the friction coefficient between a bearing surface of manually polished stainless steel
 30 with a surface roughness of R_A of $0.3\text{ }\mu\text{m}$ and the same yarns.

By applying a friction reducing coating on the bearing surface of the thimble, the wear due to repetitive movement between the yarns and the bearing surface is reduced, so that it takes longer before the yarns start breaking. A friction reducing coating is advantageous in combination with the fibres of the second type of the present invention, i.e. the fibres that lie on the bearing

surface are the the fibres of the second type. However, a friction reducing coating is advantageous without fibres of the second type too, i.e. in an embodiment wherein the main yarns lie on the bearing surface.

5 In an embodiment, the friction reducing coating comprises a fluoropolymer. Such a friction reducing coating has a low friction coefficient.

In particular, the friction reducing coating comprises polytetrafluoroethylene. This material, as well as some related friction reducing materials, are sold under the DuPont owned trade mark Teflon®.

10 In an embodiment, the bearing surfaces of both thimbles are provided with the friction reducing coating.

In an embodiment, the thimble is a metal thimble, in particular a steel thimble. A metal thimble has good mechanical properties.

In particular, the bearing surface is pre-treated by abrasive blasting before applying the coating. This results in a better adhesion of the coating to the thimble.

15 In particular, the bearing surface is pre-treated by polishing before applying the coating. More in particular, the bearing surface is manually polished. Such a polished surface further decreases the wear of the yarns.

In an embodiment, the bearing surface without the coating has a surface roughness R_A in the range of $0.1 - 3.0 \mu\text{m}$. A surface roughness in this range provides both lower wear of the yarns, and/or an improved adhesion of the coating to the thimble.

In particular, the bearing surface has a surface roughness R_A in the range of $0.24 - 0.36 \mu\text{m}$, more in particular $0.27 - 0.33 \mu\text{m}$. A surface roughness in this range results in a lower wear of the yarns.

25 In a variant, the bearing surface has a surface roughness R_A in the range of $1.6 - 2.4 \mu\text{m}$, in particular $1.8 - 2.2 \mu\text{m}$. A surface roughness in this range provides an improved adhesion of the coating to the thimble.

The invention further relates to a cable comprising a first thimble and a second thimble, at least one yarn, and at least a first conductive fibre for monitoring the cable. The first and the second thimble are provided at opposite ends of the cable. The at least one yarn extends from the first thimble to the second thimble, turns around the second thimble, extends from the second thimble to the first thimble, and turns around the first thimble, such that the at least one yarn forms turns around the first and second thimbles. Each thimble holds a stack of layers of turns of the at least one yarn. An inside of the stack is defined as a side of a first layer of turns of the at least one yarn being closest to a centre of the respective thimble. An outside of the stack is defined as a side of a

last layer of turns of the at least one yarn being farthest away of the centre of the respective thimble. A stack height is defined as a distance from the inside of the stack to the outside of the stack. The first conductive fibre is designed to signal the wear of the yarn turns by breaking when a predetermined portion of turns of the at least one yarn breaks. The first conductive fibre is
 5 positioned at the first thimble between the turns of the at least one yarn at a first predetermined height of the stack measured from the inside of the stack, and the first predetermined height is less than 50% of the stack height.

This aspect of the invention is based on the above described insight in the wear mechanism of cables of this type. Once the yarn turns close to the conductive fibre wear and break, the
 10 conductive fibre itself will break too. By locating the conductive fibre at a predetermined height in the stack, and by measuring whether the conductive fibre is still conductive over its full length, a user can derive that a certain part of the yarns have broken. If the relevant material properties, such as the resistance against wear, of the yarns and the conductive fibre are the same, they will break approximately at the same time. Accordingly, the conductive fibre breaks when
 15 approximately all layers of yarns below the conductive fibre have broken. If the relevant material properties differ, i.e. either the yarns of the conductive fibre wears quicker than the other one, the breaking will not be at the same time, but it will be possible to determine what portion of the yarn turns have broken when the conductive fibre breaks, based on the known difference between the relevant material properties, and/or based on wear tests. The exact predetermined height of the
 20 conductive fibre will be determined on the basis of these differences and of the desired safety margin of the cable, i.e. the difference between the advertised break load and the actual break load of a new cable. When the conductive fibre breaks, and as a result is not conductive anymore, the user knows that a certain amount of the load of the cable is gone and that the actual break load of the cable is close to the advertised break load and that the cable should be replaced immediately,
 25 or within a known period of time. By positioning the conductive fibre at a predetermined height which is less than 50% of the stack height, the conductive fibre is within the lower half of the yarns, and at least 50% of the yarns is still intact when the conductive fibre breaks. As a result, a cable according to the invention provides a much more reliable indication of the residual strength, and thus the wear, than a cable of the prior art of which just the elongation could be measured.

30 A conductive fibre is advantageous in combination with the fibres of the second type of the present invention. In particular, a conductive fibre is positioned at the first thimble between the stack of layers of turns of the main yarn and the stack of the fibres of the second type. This enables signalling that substantially all fibres of the second type have worn, and that the cable needs to be replaced within a specified period of time, e.g. immediately, as the turns of the main yarn start to

wear. However, a conductive fibre is advantageous in a cable without auxiliary yarns too, i.e. in an embodiment wherein the main yarns lie on the bearing surface.

In particular, the predetermined height is less than 40%, more in particular less than 30%, even more in particular less than 20% of the stack height. A lower predetermined height results in a cable which requires less yarn turns for the same design load, as the conductive fibre will enable an earlier warning that a corresponding portion of the yarns have broken.

In an embodiment, the cable comprises a plurality of conductive fibres. The plurality of conductive fibres includes the first conductive fibre. By using a plurality of conductive fibres, a more detailed and/or reliable insight in the residual strength and life expectancy of the cable is obtainable.

An embodiment comprises a plurality of conductive fibres, wherein at least two of the plurality of conductive fibres are positioned at the first thimble at the same layer of turns of the main or auxiliary yarn, spaced apart from each other in a width direction of the first thimble. This enables a more reliable monitoring of the cable in cases of unequal loads on one of the thimbles which may result in a quicker wear at one side, in width direction, of the respective thimble than at the other side.

In particular, a part of the plurality of conductive fibres is positioned at the first thimble between the turns of the at least one yarn at one or more further predetermined heights of the stack, wherein the further predetermined heights of the stack are different from the first predetermined height of the stack. Positioning conductive fibres at different heights enables obtaining a more detailed insight in the residual strength and life expectancy of the cable, as breaking of each of the conductive fibres corresponds to a certain amount of wear of the yarn turns.

More in particular, the cable comprises a second conductive fibre provided at the first thimble between the turns of the at least one yarn at a second predetermined height of the stack, and the second predetermined height of the stack is less than the first predetermined height of the stack. The second conductive fibre at a lower predetermined height enables a pre-warning of the wear of the cable. While the wear is not so much, that the cable needs to be replaced, the second conductive fibre will break when the cable is used and wears, which enables the user to observe that wear to a predetermined level has occurred and that actions, such as ordering a new cable, could or should be performed.

In an embodiment, the first conductive fibre extends at least from the first thimble to the second thimble, and is positioned at the second thimble between the turns of the at least one yarn at approximately the same first predetermined height of the stack measured from the inside of the

stack as at the first thimble. This embodiment provides a simple solution for measuring the wear at both thimbles with just one conductive fibre. The wear at one thimble might be greater than that at the other thimble. The conductive fibre will break at the thimble where the wear is greatest, enabling a warning signal to the user. For the user it is not important to know where the wear occurs, but much more important to know that there is wear at one or more of the critical points at one of the thimbles.

In an embodiment, the cable comprises a cable cover which extends around the cable from the first thimble to the second thimble, and bundles all main yarns and fibres of the second type extending between the first and the second thimble in one compact bundle in a middle section of the cable. This results in a compact cable.

In an embodiment, the fibres of the first type shows less creep than the fibres of the second type. In particular, the fibres of the first type are carbon fibres, basalt fibres, or plastic fibres, in particular polyamide fibres, polyester fibres, polypropylene fibres, polyethylene fibres, aramid fibres, LCAP fibres, or PBO fibres. Each of these types of fibres has its own properties, which makes it suitable for specific purposes. An advantage of aramid yarns is that they show very low creep.

In an embodiment, the fibres of the second type are HMPE fibres. This type of fibres has a relative high modulus of elasticity, and a low friction coefficient.

Preferred embodiments are defined in the dependent claims.

The invention further relates to a method for producing an endless winding cable, as defined in claims 17, and 18.

The invention, its effects, and advantages will be explained in more detail on the basis of the schematic drawing, in which:

Fig. 1 shows an end of a cable according to the invention;

Fig. 2 shows a cross section through a thimble of the cable of fig. 1;

Fig. 3 shows detail III from fig. 2;

Fig. 4 shows detail IV from fig. 2;

fig. 5. shows detail V from fig. 2;

Fig. 6 shows a top view of the cable of fig. 1;

Fig. 7 shows a plan view of the cable of fig. 1;

Fig. 8 shows section VIII-VIII from fig. 6;

Fig. 9 shows section IV-IV from fig. 6, and

Fig. 10 shows a cross section through a thimble of a second embodiment of a cable according to the invention..

The figures 1-9 show a cable according to a first embodiment of the invention, which is denoted in its entirety by reference number 1. The cable 1 has a first thimble 2 and a second thimble 4, a plurality of main yarns 6, a plurality of auxiliary yarns 7, and a plurality of conductive fibres, in this embodiment four optical fibres 8, 18, 108, 118 for signalling wear of the cable 1. The first 2 and the second 4 thimble are made of stainless steel, and are provided at opposite ends of the cable 1. The plurality of main yarns 6 are in this embodiment ten main yarns 6 which all extend from the first to the second thimble, turn around the second thimble 4, extend from the second thimble 4 to the first thimble 2, and turn around the first thimble 2. In this manner each of the plurality of main yarns 6 forms a semi-continuous loop around the first and second thimbles. This loop is repeated a plurality of times, in this embodiment 950 times. So each of the main yarns 6 makes 950 turns, resulting in a total of 9500 turns of main yarns 6. The main yarns 6 consist of fibres, in this embodiment aramid fibres of 3220 dTex. These main yarns are sold under the name Twaron® 2200 by Teijin Aramid. The plurality of auxiliary yarns 7 are in this embodiment ten auxiliary yarns 7 which all extend from the first to the second thimble, turn around the second thimble 4, extend from the second thimble 4 to the first thimble 2, and turn around the first thimble 2. In this manner each of the plurality of auxiliary yarns 7 forms a semi-continuous loop around the first and second thimbles. This loop is repeated a plurality of times, in this embodiment 50 times. So each of the auxiliary yarns 7 makes 50 turns, resulting in a total of 500 turns of auxiliary yarns 7. The auxiliary yarns 7 consist of fibres, in this embodiment HMPE (high-modulus polyethylene) fibres, which are sold under the name Dyneema® by DSM Dyneema B.V. This type of fibres has a higher modulus of elasticity, and a lower friction coefficient, than the aramid fibres of the main yarns 6.

Figure 2 shows that the thimble 2 holds a main stack 9 which comprises a stack 19 with a plurality of layers 10 of turns of the main yarns 6, and a stack 119 with a plurality of layers 110 of turns of the auxiliary yarns 7. The stack 119 with the plurality of layers 110 of turns of the auxiliary yarns 7 is provided on a bearing surface 40 of the first thimble 2. The stack 19 of layers 10 of turns of the main yarns 6 is provided on the stack 119 of turns of the auxiliary yarns 7. This is shown in more detail in figures 3 and 4. The second thimble 4 holds layers of the same turns of the main yarns 6 and of the auxiliary yarns 7 in the same manner and is thus not shown in detail. The properties of the auxiliary yarns 7, in this embodiment both a higher modulus of elasticity, and a lower friction coefficient, than the fibres of the main yarns 6, result in a lower wear of the auxiliary yarns 7, than the wear of the main yarns 6 if these were in direct contact with bearing surface 40. At the same time, the fibres of the main yarns 6 show less creep than the auxiliary yarns 7, resulting in a dimensionally more stable cable 1 than a cable made just of the auxiliary yarns 7.

An inside of the stack 12 is defined as a side of a first layer 13 of turns of the auxiliary yarns 7 being closest to a centre 14 of the thimble 2. An outside of the stack 16 is defined as a side of a last layer 15 of turns of the main yarns 6 being farthest away from the centre 14 of the thimble 2. A stack height h is defined as the distance from the inside of the stack 12 to the outside of the stack 16.

The first, second, third and fourth optical fibres 8, 18, 108, 118 are designed to signal the wear of the turns of the auxiliary yarns 7 by breaking when a predetermined portion of the turns of the auxiliary yarns 7 break. Fig. 2 and 5 show that the first and third optical fibre 8, 108 are positioned at the first thimble 2 between the main yarns 6 and the auxiliary yarns 7 at a first predetermined height h_1 of the main stack 9 measured from the inside of the stack 12, spaced apart in the width direction of the first thimble 2. The first predetermined height h_1 is in this embodiment 5% of the stack height h . The first and third optical fibres 8, 108 perform the same function in this embodiment, in that they both signal when substantially all turns of the auxiliary yarns 7 have broken, and the cable 1 should be replaced. Due to unequal loading, it could be that the turns of the auxiliary yarns 7 at one side of the thimble 2 wear more quickly than at the other side. Accordingly it is advantageous to have two optical fibres 8, 108 at the same height h_1 , but at opposite sides of the thimble 2. If the turns of the auxiliary yarns 7 at one side break earlier than at the other side, this will result in breaking of the first or third optical fibre 8, 108 which is at the side where more turns of the auxiliary yarns 7 have broken.

The cable 1 has a second and fourth optical fibre 18, 118, which are provided at the first thimble 2 between the turns of the auxiliary yarns 7 at a second predetermined height h_2 of the main stack 9. The second predetermined height h_2 of the main stack 9 is less than the first predetermined height h_1 of the main stack 9, in this case 3% of the stack height h . The second and fourth optical fibre 18, 118 perform the same function, in that they both provide an early warning about the wear of the turns of the auxiliary yarns 7. There are two optical fibres 18, 118 in this embodiment at the second predetermined height h_2 of the main stack 9, spaced apart in the width direction of the first thimble 2, in case there is an unequal load and resulting unequal wear of the turns of the auxiliary yarns 7.

Figures 6 and 7 show that in this embodiment, the first optical fibre 8 extends from the first thimble 2 to the second thimble 4, and is positioned at the second thimble 4 between the main 6 and the auxiliary yarns 7 at the same first predetermined height h_1 of the main stack 9 measured from the inside of the stack as at the first thimble 2.

Figures 1, 7, and 8 show a casing 20. Both ends 22, 24 of the first optical fibre 8 are located in the casing 20.

In this embodiment, the above description relating to the presence of the first optical fibre 8 at the second thimble 4, and the position of the ends in the casing 20 applies to the second, third, and fourth optical fibres 18, 108, 118 too, and is not shown in figures 6, 7 and 8 for the sake of clarity.

5 A light source, in this embodiment a laser light 26, is provided in the casing 20 and is operatively connected to the first end 22 of the first optical fibre 8. Further laser lights 26 are connected to the first ends of the second, third, and fourth optical fibre (not shown in figure 8).

10 A cable cover 28 extends around the cable 1 from the first thimble 2 to the second thimble 4, and bundles all turns of the main yarns 6 and the auxiliary yarns 7 extending between the first and the second thimble 2, 4 in one compact bundle 30 in a middle section 32 of the cable 1. In this embodiment, the cable cover 28 also covers the turns of the main yarns 6 and the auxiliary yarns 7 at the thimbles 2, 4. In this embodiment, the casing 20 is located between the middle section 32 of the cable 1 and thimble 2.

15 Referring to fig. 2, the first thimble 2 has a bearing surface 40. In this embodiment, the bearing surface 40 is a cylindrical shaped surface, wherein the centre of the cylindrical shaped surface coincides with the centre 14 of the thimble 2. The first layer of turns of the auxiliary yarns 7 lies on the bearing surface 40 of the thimble 2. The bearing surface 40 of the thimble 2 has been pre-treated by manually polishing the surface to a surface roughness RA of approximately 0.3 μm . The bearing surface 40 is provided with a friction reducing coating 42, in this embodiment a coating 20 that polytetrafluoroethylene (PTFE, sold under the trade mark Teflon®). In this embodiment, the PTFE coating comprises a resin that ensures adhesion of the coating to the bearing surface, which coating system is sold under the name Cruson 166 by Cruson Coatings B.V. The layer thickness of the coating is 20 – 30 μm . In this embodiment, the second thimble 4 has a bearing surface with the same shape as bearing surface 40, and is also provided with a coating of PTFE. Applying such 25 coatings 42 on a manually polished bearing surface 40 results in an increase of the life span.

30 The cable 1 is used in the following manner in an embodiment of the invention, to monitor the cable and determine the residual strength. A user measures whether the second and fourth optical fibres 18, 118 are still conductive to light. To this purpose, the second and fourth optical fibres are permanently connected to the laser lights 26, which in turn are operatively connected to a battery (not shown). It is also possible to provide a switch between the battery and the laser lights 26, or to connect a battery to the laser lights each time the measurement is performed. If the second and fourth optical fibres 18, 118 are conductive to light, then light will emit from the respective ends 24 in the casing 30, which will be observed by the user. If both ends 24 emit light, then it is known that the cable 1 has at least a certain residual strength.

The measurement will be repeated after a predetermined amount of time. The length of the predetermined amount of time depends on the design and use of the cable, and may be displayed as a graph or table in a service manual. If, for instance, the design life span is three years, then the predetermined amount of time may be one or more months, but less than a year. If the design life span is for instance ten years, or more, then the predetermined amount of time may be one or several years.

If it turns out at the measurement that one of, or both, the second and fourth optical fibre 18, 118 is not conductive anymore, then the user knows that turns of the auxiliary yarns 7 that correspond to the height h_2 of the second and fourth optical fibre have worn, and that he has to prepare to replace the cable 1 in the near future. Such preparations will typically include ordering a replacement cable.

According to this embodiment of the invention, the user repeatedly monitors whether the first and in this case third optical fibres 8, 108 are still conductive to light in the same manner as described in relation to the second and fourth optical fibres 18, 118. As long as both the first optical fibre 8 and the third optical fibre 108 still emit light at their second ends 24, the cable 1 is still safe to use and the measurement should be repeated after a predetermined amount of time. This predetermined amount of time may be specified in the service manual, and may be the same as, or different from, in particular shorter than, the predetermined amount of time for measuring if the second and fourth optical fibres 18, 118 are still conductive to light. If either the first optical fibre 8 the third optical fibre 108, or both, is no longer conductive to light, the user should stop using the cable within a replacement period. In this embodiment, the replacement period is zero days. In other words, the user should immediately stop using the cable 1 and replace it with a new one. Thanks to the low friction and high modulus of elasticity of the first layer of HMPE fibres, the cable of this embodiment of the invention can take up to 40 million load cycles, which is very favourable compared to the approximately 70.000 load cycles of a comparable steel cable.

Figure 10 shows a cable 201 according to a second embodiment of the invention. Elements of the cable 201 that are similar to that of the first embodiment are denoted with the same reference numbers and will not be described in detail. While figure 10 shows a cross section through a first thimble 2 of the cable 201, it is understood that there is a second thimble as well, and the side and top views of cable 201 are similar to those of the first embodiment, as described above.

The cable 201 comprises a plurality of main yarns 6, and a plurality of conductive fibres, in this embodiment two optical fibres 8, 108, for signalling wear of the cable 201. The first 2 and the second thimble are made of stainless steel, and are provided at opposite ends of the cable 201. The

plurality of main yarns 6 are in this embodiment ten main yarns 6 which all form turns over the first and the second thimble. The main yarns 6 consist of fibres, in this embodiment aramid fibres of 3220 dTex. The cable further comprises a sheet 219, woven of auxiliary yarns 207. The auxiliary yarns 207 consist of fibres, in this embodiment HMPE fibres.

5 Figure 10 shows that the thimble 2 holds a main stack 9 which comprises a stack 19 with a plurality of layers 10 of turns of the main yarns 6, and the sheet 219 made of the auxiliary yarns 207. The sheet 219 made of the auxiliary yarns 207 is provided on a bearing surface 40 of the first thimble 2. It lies on that part of the bearing surface 40 that actually holds main yarns 6 and extends a couple of centimetres beyond the bearing surface 40, substantially in the same direction as the
10 main yarns 6.

 The stack 19 of layers 10 of turns of the main yarns 6 is provided on the sheet 219 of the auxiliary yarns 207. The second thimble holds layers of the same turns of the main yarns 6 and a second sheet woven of the auxiliary yarns 207 in the same manner, and is not shown in detail. The properties of the auxiliary yarns 207, in this embodiment both a higher modulus of elasticity, and a
15 lower friction coefficient, than the fibres of the main yarns 6, result in a lower wear of the auxiliary yarns 207, than the wear of the main yarns 6 if these were in direct contact with bearing surface 40.

 The first, and second optical fibres 8, 108 are designed to signal the wear of the turns of the auxiliary yarns 207 by breaking when a predetermined portion of the turns of the auxiliary yarns 207 break, as has been described in more detail relating to the first embodiment. In this
20 embodiment the first and second optical fibre 8, 108 are positioned at the first thimble 2 between the main yarns 6 and the auxiliary yarns 207 at a first predetermined height of the main stack 9, spaced apart in the width direction of the first thimble 2. The first predetermined height is in this embodiment 2% of the stack height h and equals the thickness of the sheet 218. The first and second optical fibres 8, 108 perform the same function in this embodiment, in that they both signal
25 when substantially all the auxiliary yarns 207 of the sheet 218 have broken, and the cable 201 should be replaced. Due to unequal loading, it could be that the auxiliary yarns 207 at one side of the thimble 2 wear more quickly than at the other side. Accordingly it is advantageous to have two optical fibres 8, 108 at the same height, but at opposite sides of the thimble 2, as described above.

 A cable cover 28 extends around the cable 201 from the first thimble 2 to the second
30 thimble, and bundles all turns of the main yarns 6 extending between the first and the second thimble 2 in one compact bundle in a middle section of the cable 201. Moreover, the cable cover 28 covers both the main yarns 6 and the sheet 218 of the auxiliary yarns 207 at the thimbles.

 The first thimble 2 has a bearing surface 40. In this embodiment, the bearing surface 40 is a cylindrical shaped surface, wherein the centre of the cylindrical shaped surface coincides with the

centre 14 of the thimble 2. The sheet 218 of the auxiliary yarns 7 lies on the bearing surface 40 of the thimble 2. The bearing surface 40 of the thimble 2 has been pre-treated by manually polishing the surface to a surface roughness RA of approximately 0.3 μm . The bearing surface 40 of this embodiment is not provided with a friction reducing coating. The second thimble has a bearing surface with the same shape as bearing surface 40.

Several variants are possible within the scope of the attached claims. The features of the above described preferred embodiments may be replaced by any other feature within the scope of the attached claims, such as the features described in relation to the other preferred embodiment, and in the following paragraphs.

Different types of main yarns may be used, such as aramid yarns with a weight of 1610 dTex, 6440 dTex, or 4830 dTex, with or without a coating. Instead of using aramid fibres, one could use other types of plastic fibres, such as polyamide fibres, polyester fibres, polypropylene fibres, polyethylene fibres, HMPE fibres, LCAP fibres, or PBO fibres. The cable could even comprise other types of main yarns, e.g. yarns made of carbon fibres, a metal, or a natural fibre, such as fibres made of basalt. Yarns of fibres may consist for 100% of the relevant fibre type, but could also comprise a small portion of an auxiliary material, e.g. a coating on the fibres to protect the fibres against wear and/or environmental influences. As such auxiliary material is only a small portion in weight, and does not contribute to the strength of the cable, the phrase 'yarn consisting of fibres' is considered to include embodiments with such auxiliary materials within the context of this document.

Alternative fibre types for the auxiliary yarns or sheet are fibres with a higher modulus of elasticity, and/or a lower friction coefficient relative to stainless steel, than the fibres of the main yarn of the relevant cable.

A cable according to the invention may be made of more or less than ten main yarns, such as one main yarn, two main yarns, or at least five main yarns. The number of main yarn turns depends on the required strength of the cable, and the strength of one individual main yarn, as well as the required safety margin. The number of main yarn layers depends on the required number of main yarn turns, and the available width in the thimble resulting in a maximum number of main yarn turns in the width direction.

A cable according to the invention may be made of more or fewer than ten auxiliary yarns, such as one auxiliary yarn, two auxiliary yarns, or at least five auxiliary yarns. The number of auxiliary yarn layers in the stack of layers is at least one, but is usually a plurality of layers. The number of layers depends on the required life time of the cable; the more layers, the longer it takes before the auxiliary yarns are worn, resulting in a direct contact between the main yarns and the

bearing surface of the thimble. Instead of a two distinct layers of auxiliary and main fibres, other embodiments are possible. An embodiment has at least one stack with both auxiliary yarns and main yarns, in particular a first stack with auxiliary yarns, and a second stack with both auxiliary and main yarns. A further embodiment comprises a third stack with only main yarns. Another
 5 embodiment has more than two types of yarn, preferably arranged in separate stacks, and/or in one or more stacks, each stack comprising one or more types of yarn.

The sheet with fibres of the second type may be a woven sheet, a non-woven sheet, a braided sheet, or a knitted sheet. The sheet with fibres of the second type is positioned on the bearing surface of the respective thimble before the main yarns are wound around the thimbles.
 10 The sheet with fibres of the second type of the shown embodiment is draped over the bearing surface and its loose ends extend beyond the bearing surface. In an alternative embodiment, the sheet with fibres of the second type is wound around the respective thimble one or a plurality of times before the main yarns are wound around the thimbles.

Although it is preferred to provide a casing and a permanent laser light, one could also have
 15 the ends installed in a casing without permanent laser light or the loose ends of the conductive fibre exiting the cable and connect a measuring device, in case of an optical fibre a laser light, to one end of the conductive fibre each time the cable is tested.

The conductive fibre can be any fibre capable of carrying a signal. Instead of an optical fibre, another type of conductivity is possible within the scope of the invention, such as an electric
 20 conductive fibre, for example a carbon fibre or an electrical conductive metal fibre.

The most important location to monitor the wear is the area where the yarn turns first reach the thimble and start turning around the thimble. It would suffice within the scope of the invention to just provide a conductive fibre there, or conductive fibres at the respective entering/exit points of the yarn turns at each thimble.

25 In a simple embodiment, there may be one conductive fibre at one first predetermined height to signal just when the cable needs to be replaced immediately, or at a known moment in the near future. Alternatively one can have multiple conductive fibres at this first predetermined height for this purpose. In particular, the one or more conductive fibres at the first predetermined height may be there to signal when it is time to order a new cable. The user may continue to use
 30 the cable for a certain period of time when one or more of these conductive fibres are not conductive anymore, which certain period of time depends on the use, actual time to the moment that the conductive fibre was not conductive anymore, and predicted life span of the cable. This may be displayed in a graph and/or table in the service manual.

The number of conductive fibres at the first predetermined height may be one, or two, or more than two. The number of conductive fibres at the second predetermined height may be one, or two, or more than two. The number of conductive fibres at the first and second predetermined height may be the same, or different. At one height, there may be one conductive fibre, while at the other height there may be multiple conductive fibres, e.g. two, three, four or more.

In an embodiment there may be conductive fibres at more than one or two predetermined heights, in particular at three or more predetermined heights. This increases the insight in the wear and remaining life span of the cable.

In an embodiment, there is at least one conductive fibre in the stack of main fibres, in order to signal whether a part of the main fibres have worn.

A service manual showing the predetermined periods of time, and remaining life spans, may be a paper manual or a digital manual which latter may be an off-line program on a computer, or smartphone, or other suitable digital device of a user or the supplier of the cable, and/or an on-line application on a web page.

The replacement period may be more than zero days, and depends on the design and life span of the cable, as well as the time that it took from the moment the cable came into use to the conductive fibre's failure. The replacement period may be specified in the service manual. This is in particular useful if the cable only comprises one or more conductive fibres at one height. In such an embodiment, there is no pre-warning indicating that a new cable should be ordered. It is advantageous in such an embodiment to position the conductive fibre at a predetermined height, corresponding to the wear of a portion of yarn turns that is still well within a safety limit.

Instead of inputting light at one end of an optical fibre, and observing whether light comes out at another end, one could also input light and observe at the same end. This can be advantageous when the cable is relatively long, such as cables used for the mooring of floating offshore structures. In such an embodiment, the optical fibre is provided with a mirror for reflecting light beyond at least one thimble. Preferably, such a mirror is a distributed Bragg reflector, such as a fibre Bragg grating. If no light is reflected by the distributed Bragg reflector, the optical fibre is broken between the end where the light is inputted and measured and the distributed Bragg reflector.

In a further embodiment, the measuring of the conductive fibre is done in an automated fashion. A source of power, such as a battery or a solar panel, is provided, as well as an electronic control circuit that comprises a wired or wireless transmitter, such as a WiFi transmitter or a Bluetooth transmitter, and an optical eye. The control circuit provides an electric pulse, which is transformed into light by a laser in the case of an optical fibre. The control circuit determines

whether the conductive fibre is still conductive, by measuring whether light, or electric current in the case of an electric conductive fibre, comes out at the other end of the conductive fibre and activates the optical eye. The result of the measurement is transmitted to an external computer via the transmitter. The control circuit may comprise a timer for performing the measurement at
 5 predetermined time intervals, or may perform the measurement on request via the external computer.

The thimble may be made of a plastic instead of a metal, or of a different metal than stainless steel, including but not limited to different steel alloys, aluminium alloys, magnesium alloys, and titanium.

10 The bearing surface may have one of several shapes, such as part of a cylinder, part of an ellipsoid, or another curved surface. The coating may comprise another fluoropolymer, such as a poly(perfluoroalkoxy alkane) (PFA), poly(fluorinated ethylene-propylene) (FEP), polyvinylidene fluoride (PVDF), polyethylenchlorotrifluoroethylene (ECTFE), and/or
 polyethylenetetrafluoroethylene (ETFE). In a variant the coating comprises micro chrome plating,
 15 tungsten disulphide (such as sold under the trade mark Dicronite® by Lubrication Sciences International), BAM (aluminium magnesium boride), ceramic coating, titanium nitride (TiN), and/or diamond-like carbon (DLC). Several bonding methods between the thimble and the coating are possible, depending on the type of coating and the material and pre-treatment of the bearing surface, including using primers, adhesives and using form fit. Instead of both, the bearing surface
 20 of just one thimble may have a friction reducing coating.

Applying a coating on the bearing surface is also advantageous when only main yarns are used. Tests have shown that in an embodiment with main yarns made of aramid fibres, applying a PTFE coating on a manually polished bearing surface results in an increase of the life span, in terms of the number of load cycles, of the first layer of yarns of approximately three to seven times the
 25 life span of a similar layer of yarns on a bearing surface of manually polished steel without a coating. If auxiliary yarns are applied according to the invention, a coating does improve life span, but the effect is less than in a cable without auxiliary yarns. Likewise, the effect of a coating on the main fibres is less in a cable with auxiliary yarns than in a cable without auxiliary yarns. It will be appreciated that, when a coating is present, the relevant friction coefficient is the friction
 30 coefficient between the auxiliary yarn and the coating material.

Instead of manually polishing the bearing surface, one may apply electro polishing to the bearing surface, which results in an even smoother surface.

It is possible to have a cable with both a friction reducing coating and a conductive fibre, as in the preferred embodiment, but it is also advantageous to have a cable comprising an auxiliary

yarn or sheet, and a thimble with a friction reducing coating as claimed, but without a conductive fibre, or a cable comprising an auxiliary yarn or sheet and one or more conductive fibres, but without a friction reducing coating, or a cable comprising an auxiliary yarn or sheet with no conductive fibres and no friction reducing coating.

CONCLUSIES

1. Kabel (1), omvattende een eerste kous (2) en een tweede kous (4), en ten minste één
hoofdgaren (6), waarbij

5 het hoofdgaren (6) vezels omvat van een eerste type,
de eerste kous (2) en de tweede kous (4) zijn voorzien bij tegenover elkaar gelegen
einden van de kabel (1),
het hoofdgaren (6) zich uitstrekt van de eerste kous (2) naar de tweede kous (4), om de
tweede kous (4) heen draait, zich uitstrekt van de tweede kous (4) naar de eerste kous (2),
10 en om de eerste kous (2) heen draait, zodanig dat het hoofdgaren (6) wikkelingen vormt
rond de eerste en tweede kousen (2, 4), en
iedere kous (2, 4) een draagoppervlak (40) omvat en een stapeling (19) houdt van lagen
(10) van wikkelingen van het hoofdgaren (6), **met het kenmerk, dat**
de kabel (1) vezels van een tweede type omvat, waarbij het tweede type afwijkt van het
15 eerste type,
een stapeling (119) die ten minste een eerste laag (13) omvat van de vezels van het
tweede type op het draagoppervlak (40) ligt van ten minste één van de eerste en tweede
kousen (2, 4), en
de stapeling (19) van wikkelingen van het hoofdgaren (6) is voorzien bovenop de
20 stapeling (119) van de vezels van het tweede type.
2. Kabel volgens conclusie 1, waarbij de vezels van het tweede type een wrijvingscoëfficiënt ten
opzichte van een materiaal van het draagoppervlak (40), in het bijzonder staal, hebben die lager
is dan een wrijvingscoëfficiënt ten opzichte van een materiaal van het draagoppervlak (40), in
25 het bijzonder staal, van de vezels van het eerste type, en/of waarbij de vezels van het tweede
type een elasticiteitsmodulus hebben die hoger is dan de elasticiteitsmodulus van de vezels van
het eerste type.
3. Kabel volgens conclusie 1, of 2, omvattende ten minste één hulpgaren (7), welke de vezels van
30 het tweede type omvat, waarbij het hulpgaren (7) zich uitstrekt van de eerste kous (2) naar de
tweede kous (4), om de tweede kous (4) heen draait, zich uitstrekt van de tweede kous (4) naar
de eerste kous (2), en om de eerste kous (2) heen draait, zodanig dat het hulpgaren (7)
wikkelingen vormt rond de eerste en tweede kousen (2, 4), en de eerste laag (13) van de vezels
van het tweede type de eerste laag (13) is van wikkelingen van het hulpgaren (7).

4. Kabel volgens conclusie 1, of 2, omvattende een blad (219) gemaakt van vezels van het tweede type, waarbij het blad (219) ten minste de eerste laag van de vezels van het tweede type omvat, en is voorzien op het draagoppervlak (4) van ten minste één van de eerste en tweede kousen
 5 (2, 4), waarbij in het bijzonder het blad (219) gemaakt van de vezels van het tweede type een niet-geweven blad, een geweven blad, een gevlochten blad, of een gebreid blad is.

5. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij de stapeling
 10 (119) van de vezels van het tweede type een meervoud van lagen (110) omvat, in het bijzonder ten minste vijf lagen, meer in het bijzonder ten minste tien lagen, meer in het bijzonder ten minste twintig lagen.

6. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij een totale stapelhoogte (h) is gedefinieerd als de afstand van de eerste laag (13) van de vezels van het
 15 tweede type naar een laatste laag (15) van wikkelingen van het hoofdgaren (6), en een stapelhoogte (h1) van de lagen van de vezels van het tweede type ten minste 1%, in het bijzonder ten minste 2%, meer in het bijzonder ten minste 5% is van de totale stapelhoogte (h).

7. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij een totale
 20 stapelhoogte (h) is gedefinieerd als de afstand van de eerste laag (13) van de vezels van het tweede type naar een laatste laag (15) van wikkelingen van het hoofdgaren (6), en een stapelhoogte (h1) van de lagen van de vezels van het tweede type minder dan 25%, in het bijzonder minder dan 15%, meer in het bijzonder minder dan 10% is van de totale stapelhoogte (h).
 25

8. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij het draagoppervlak (40) van ten minste één van de kousen is voorzien van een wrijvingsverminderende coating (42), die in het bijzonder een fluorpolymeer, meer in het bijzonder polytetrafluorethyleen, omvat.
 30

9. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij de kous (2) een metalen kous is, in het bijzonder een stalen kous.

10. Kabel volgens conclusie 9, waarbij het draagoppervlak (40) een oppervlakruwheid R_A heeft in het bereik van 0,1 – 3,0 μm .
11. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, omvattende ten
5 minste één geleidende vezel (8) voor het controleren van de kabel (1), waarbij de eerste geleidende vezel (8) is voorzien bij de eerste kous (2) in de stapeling (19) van lagen (10) van wikkelingen van het hoofdgaren (6) of in de stapeling (119) van de vezels van het tweede type.
12. Kabel volgens conclusie 11, waarbij de eerste geleidende vezel (8) is voorzien tussen de
10 stapeling (19) van lagen (10) van wikkelingen van het hoofdgaren (6) en de stapeling (119) van de vezels van het tweede type.
13. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, omvattende een meervoud van geleidende vezels (8, 18, 108, 118), waarbij ten minste twee van het meervoud
15 van geleidende vezels (8, 108) zijn voorzien bij de eerste kous (2) bij dezelfde laag (110) van wikkelingen van het hoofdgaren (6), of vezels van het tweede type, op afstand van elkaar voorzien in een breedterichting van de eerste kous (2).
14. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, verder omvattende
20 een kabelbedekking (28) die zich uitstrekt rond de kabel (1) vanaf de eerste kous naar de tweede kous (2, 4), en alle hoofdgarens (6) en vezels van het tweede type die zich uitstrekken tussen de eerste en de tweede kous (2, 4) bundelt in één compacte bundel (30) in een middendeel (32) van de kabel (1).
- 25 15. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij de vezels van het eerste type koolstof vezels, basalt vezels, polyamide vezels, polyester vezels, polypropyleen vezels, polyethyleen vezels, aramide vezels, LCAP vezels, of PBO vezels zijn.
16. Kabel volgens een willekeurige of meerdere van de voorgaande conclusies, waarbij de vezels
30 van het tweede type HMPE vezels zijn.
17. Werkwijze voor het vervaardigen van een eindloos gewikkelde kabel, omvattende de stappen van:

positioneren van een eerste kous en een tweede kous op een vooraf bepaalde afstand van elkaar, welke afstand overeen komt met een gewenste kabellengte,

verschaffen van ten minste een hoofdgaren die vezels van een eerste type omvat, and verschaffen van vezels van een tweede type, waarbij het tweede type afwijkt van het eerste type,

vormen van een stapeling die ten minste een eerste laag van de vezels van het tweede type op het draagoppervlak van ten minste een van de eerste en tweede kous omvat,

wikkelen van het hoofdgaren bovenop de stapeling van de vezels van het tweede type van de eerste kous naar de tweede kous, een halve slag rond de tweede kous, terug naar de eerste kous, en een halve slag rond de eerste kous,

herhalen van de voorgaande stap totdat een vooraf bepaald aantal lagen van wikkelingen van het hoofdgaren is voorzien in zowel de eerste kous als de tweede kous.

18. Werkwijze volgens conclusie 17, waarbij het vormen van een stapeling die ten minste een eerste laag van de vezels van het tweede type op het draagoppervlak van ten minste een van de eerste en tweede kous omvat

verschaffen van een hulpgaren dat de vezels van het tweede type omvat,

wikkelen van het hulpgaren van de eerste kous naar de tweede kous, een halve slag rond de tweede kous, terug naar de eerste kous, en een halve slag rond de eerste kous,

herhalen van de voorgaande stap totdat een vooraf bepaald aantal lagen van wikkelingen van het hulpgaren is voorzien in zowel de eerste kous als de tweede kous.

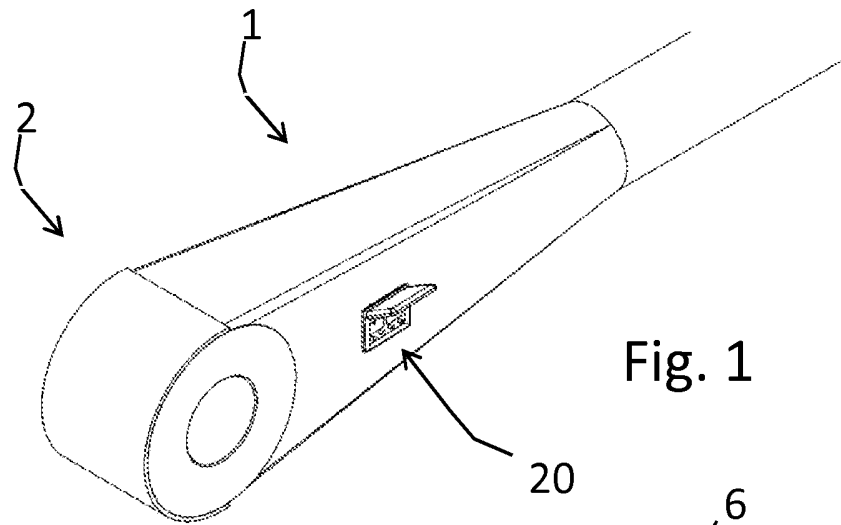


Fig. 1

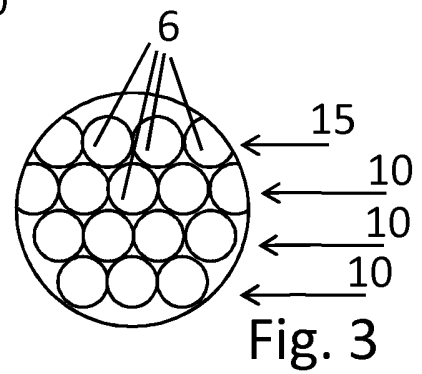


Fig. 3

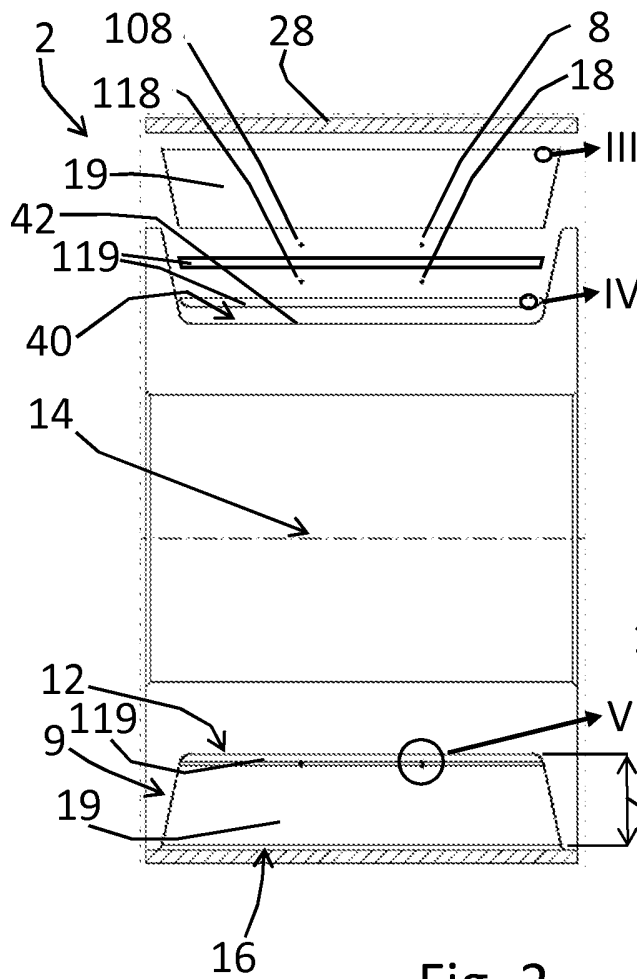


Fig. 2

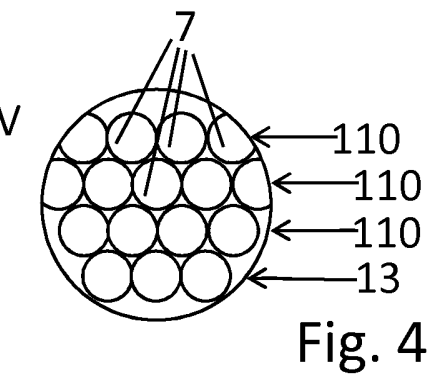


Fig. 4

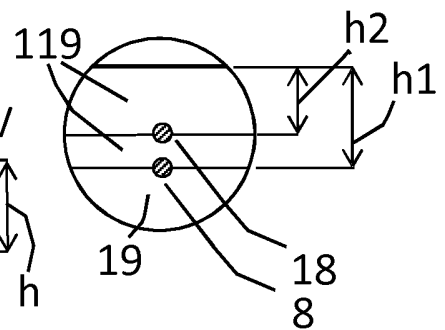
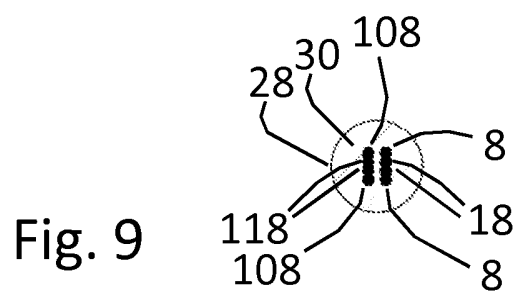
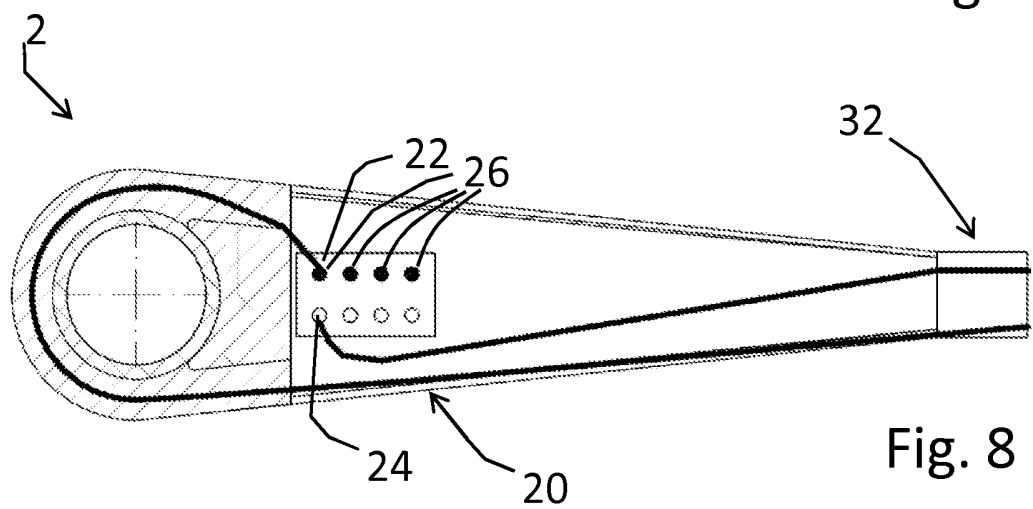
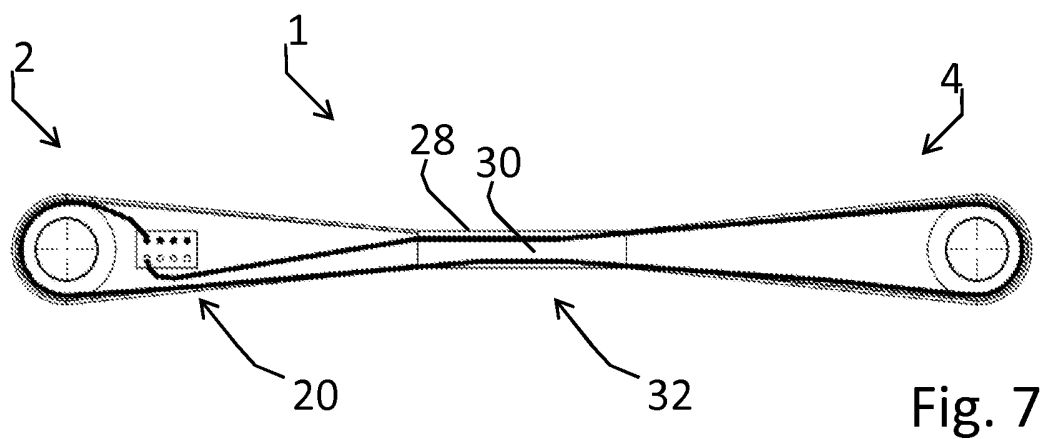
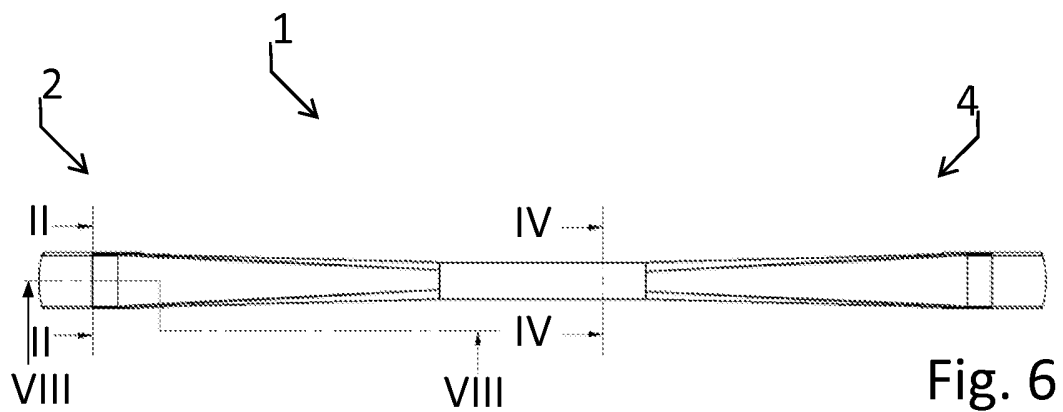


Fig. 5



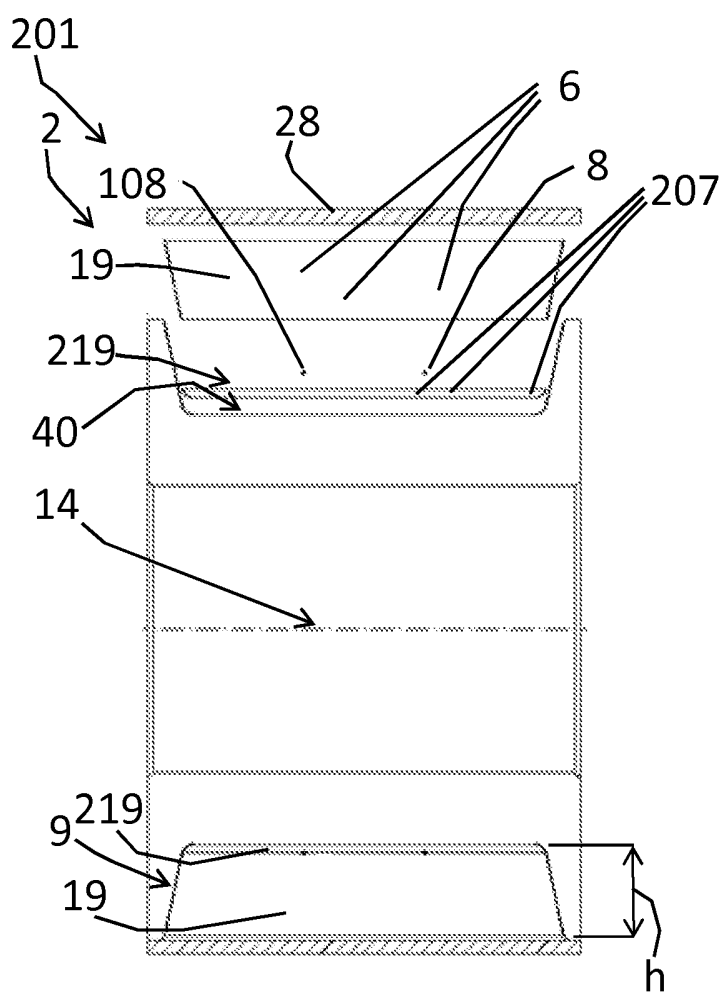


Fig. 10

ABSTRACT

A cable comprises a first and a second thimble (2, 4), and at least one main yarn (6) and an auxiliary yarn (7). The first and the second thimble are provided at opposite ends of the cable. The at least one main yarn (6) and the auxiliary yarn (7) each forms turns around the first and second
5 thimble (2, 4). Each thimble (2, 4) comprises a bearing surface (40), and holds a stack (19) of layers (10) of turns of the main yarn (6). A stack (119) of turns of the auxiliary yarn (7) comprising at least a first layer (13) of turns of the auxiliary yarn (7) lies on the bearing surface (40) of the respective thimble (2, 4).

Fig. 2

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE		KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE	
		FM_Hybride_NL	
Nederlands aanvraag nr.		Indieningsdatum	
2015822		19-11-2015	
		Ingeroepen voorrangsdatum	
Aanvrager (Naam)			
CABIN AIR GROUP B.V.			
Datum van het verzoek voor een onderzoek van internationaal type		Door de instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr.	
19-03-2016		SN65969	
I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)			
Volgens de internationale classificatie (IPC)			
D07B1/14;D07B1/18;F16G11/14			
II. ONDERZOChte GEBIEDEN VAN DE TECHNIEK			
Onderzochte minimumdocumentatie			
Classificatiesysteem		Classificatiesymbolen	
IPC		D07B;F16G	
Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen			
III.	☐	GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES (opmerkingen op aanvullingsblad)	
IV.	☐	GEBREK AAN EENHEID VAN UITVINDING (opmerkingen op aanvullingsblad)	

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2015822

A. CLASSIFICATIE VAN HET ONDERWERP
INV. D07B1/14 D07B1/18 F16G11/14
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)

D07B F16G

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	JP 2000 239983 A (TAKAMI KEIKO) 5 september 2000 (2000-09-05) * alinea [0032]; figuren 2,3,5 *	1,17
A	H A McKenna ET AL: "Handbook of fibre rope technology", HANDBOOK OF FIBRE ROPE TECHNOLOGY, 1 januari 2004 (2004-01-01), bladzijde 230-232,262, XP055263278, ENGLAND ISBN: 978-1-85573-606-1 Gevonden op het Internet: URL: http://www.sciencedirect.com/science/book/9781855736061 [gevonden op 2016-04-06] * 7.6.2, 8.4.12 *	1,17



Verdere documenten worden vermeld in het vervolg van vak C.



Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

*** Speciale categorieën van aangehaalde documenten**

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvraag vermeld

"E" eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwaarlijk is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"Z" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid

1 augustus 2016

Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type

Naam en adres van de instantie

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De bevoegde ambtenaar

Uhlig, Robert

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2015822

C. (Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	Anonymous: "End fittings/ cable terminations - FibreMax All fibres used to the max...", 18 november 2012 (2012-11-18), XP055263148, Gevonden op het Internet: URL: http://web.archive.org/web/20121118061139/http://www.fibremax.nl/products/end-fittings-cable-terminations/ [gevonden op 2016-04-06] * het gehele document *	1,17
A	JP 2014 218335 A (TOKYO SEIKO CO LTD) 20 november 2014 (2014-11-20) * alinea [0048]; figuren *	1,17
A	DE 39 24 379 A1 (GLEISTEIN & SOHN GMBH GEO [DE]) 31 januari 1991 (1991-01-31)	1,17
E	WO 2015/178769 A1 (CABIN AIR GROUP B V [NL]) 26 november 2015 (2015-11-26) * het gehele document *	1

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2015822

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
JP 2000239983	A	05-09-2000	GEEN
JP 2014218335	A	20-11-2014	GEEN
DE 3924379	A1	31-01-1991	GEEN
WO 2015178769	A1	26-11-2015	GEEN

WRITTEN OPINION

File No. SN65969	Filing date <i>(day/month/year)</i> 19.11.2015	Priority date <i>(day/month/year)</i>	Application No. NL2015822
International Patent Classification (IPC) INV. D07B1/14 D07B1/18 F16G11/14			
Applicant CABIN AIR GROUP B.V.			

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☒ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

	Examiner Uhlig, Robert
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WRITTEN OPINION

Application number
NL2015822

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing:
 - ☐ contained in the application as filed.
 - ☐ filed together with the application in electronic form.
 - ☐ furnished subsequently for the purposes of search.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	1-18
	No: Claims	
Inventive step	Yes: Claims	1-18
	No: Claims	
Industrial applicability	Yes: Claims	1-18
	No: Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Application number
NL2015822

Box No. VI Certain documents cited

☒ Certain published documents

see the Search Report

☐ Non-written disclosures

Box No. VII Certain defects in the application

see separate sheet

1 References

Reference is made to the following documents cited in the search report:

- D1 JP 2000 239983 A
- D2 H A McKenna ET AL: "Handbook of fibre rope technology",
HANDBOOK OF FIBRE ROPE TECHNOLOGY, (2004), XP055263278,
ISBN: 978-1-85573-606-1
- D3 Anonymous: "End fittings/ cable terminations - FibreMax All fibres used t
(2012-11-18), XP055263148
- D4 JP 2014 218335 A
- D6 WO 2015/178769 A1

RE Item VI

2 Certain Published Documents

Document D6 is considered to fall under "certain published documents" and consequently is not considered part of the prior art for the purpose of assessing novelty and inventive step for the present procedure.

Document D6 was published on 26.11.2015, filed on 19.05.2015 and is claiming the priority of 20.05.2014.

Annotation: Document D6 does not appear to disclose layer windings of different materials (=> EA document)

RE Item V

3 Independent Claim 1

- 3.1 Based on the documents mentioned in the search report, the subject-matter of claim 1, particularly when interpreted in its broadest sense and with regard how the wording is understood, appears to be new and inventive.
- 3.2 In terms of claim 1, document D1 can be said to disclose the following features of claim 1 (the references between inclined lines applying to this document), namely
een kabel (1), omvattende een eerste kous oog (2) en een tweede kous oog (4) /fig. 2/, en ten minste één hoofdgaren (6), waarbij het hoofdgaren (6)

vezels omvat van een eerste type, de eerste keus oog (2) en de tweede keus oog (4) zijn voorzien bij tegenover elkaar gelegen einden van de kabel (1) /fig. 2/, het hoofdgaren (6) zich uitstrekt van de eerste keus oog (2) naar de tweede keus oog (4), om de tweede keus oog (4) heen draait, zich uitstrekt van de tweede keus oog (4) naar de eerste keus oog (2), en om de eerste keus oog (2) heen draait, zodanig dat het hoofdgaren (6) wikkelingen vormt rond de eerste en tweede keus ogen (2, 4) /§ [0032], Fig. 3, ref. 4/, en ~~iedere keus (2, 4) een draagoppervlak (40) omvat en een stapeling (19) houdt van lagen (10) van wikkelingen van het hoofdgaren (6), met het kenmerk, dat de kabel (1) vezels van een tweede type omvat, waarbij het tweede type afwijkt van het eerste type, een stapeling (119) die ten minste een eerste laag (13) omvat van de vezels van het tweede type op het draagoppervlak (40) ligt van ten minste één van de eerste en tweede kousen (2, 4), en de stapeling (19) van wikkelingen van het hoofdgaren (6) is voorzien bovenop de stapeling (119) van de vezels van het tweede type /Fig. 5, ref. 4/.~~

- 3.3 The subject-matter of claim 1 appears to differ from this prior art in that
- a) the eyes comprise a thimble, and
 - b) the fibers of the second type lie on the bearing surface of at least one of the
- 3.4 The technical effects of these distinguishing features are that
- a) the wear at the attachment points of the load can be reduced, and
 - b) the fibers of the second type rub against the surface of the thimble.
- 3.5 Consequently, the partial technical objective problems to be solved by these distinguishing features may be regarded as to
- a) reduce the local stress to the endless rope at the load bearing points, and
 - b) selectively adapt the wear and/or friction property.
- 3.6 To provide thimbles is considered as belonging to the general knowledge of the skilled person (see D2, § 7.6.1) or is disclosed by the inventor (= CEO at Fibremax B.V.) himself in D3 (obvious alternative: thimbles - softloop) or is disclosed in D4 (Figs.).
- 3.7 However, the direct application of the teaching of D1 to any of the documents D2 to D4 would result in the jacket (5) of D1 lying on the bearing surface of at least one of the thimbles.

- 3.8 There is no prior art available disclosing that the jacket of a roundsling for manufacturing an endless rope with two eyes (= D1) can be removed and replaced by a jacket encircling together all convolutions spanning between the eyes (see e.g. D4, Fig. 1, ref. 5) in order to solve the above mentioned objective problem b). The jacket in D1 already provides some abrasion resistance
- 3.9 Consequently, based on the documents mentioned in the search report, claim 1 appears to involve an inventive step, as the solution of the present problem provided by claim 1 does not appear to be obvious.

4 Independent Claim 17

- 4.1 Based on the documents mentioned in the search report, the subject-matter of claim 17, particularly when interpreted in its broadest sense and with regard how the wording is understood, appears to be new and inventive.
- 4.2 The line of argument provided for claim 1 analogously applies to claim 17. Also document D4, Fig. 13, § [0048], does not appear to disclose to use two different fibers.

5 Dependent Claims

The dependent claims are regarded - from a formalistic point of view - as being new and inventive, as they refer directly or indirectly to independent claims 1 and 17 which are considered to be new and inventive.

RE Item VII

6 Formal/Further Objections

- 6.1 Although independent claim 1 is drafted in the two-part form, at least one feature is incorrectly placed in the characterising portion, as it is disclosed in document D1 in combination with the features placed in the preamble.
- 6.2 Independent claim 17 is not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art D1 or D4 being placed in the preamble and with the remaining features being included in the characterising part.

- 6.3 Documents D1 resp. D4, which may be considered to be the most relevant prior art document for the respective independent claim, are not identified in the description and their relevant content is not indicated.