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(54) Title: IMPACT ABSORBING DEVICE FOR DYNAMIC BARRIERS AGAINST ROCKFALLS

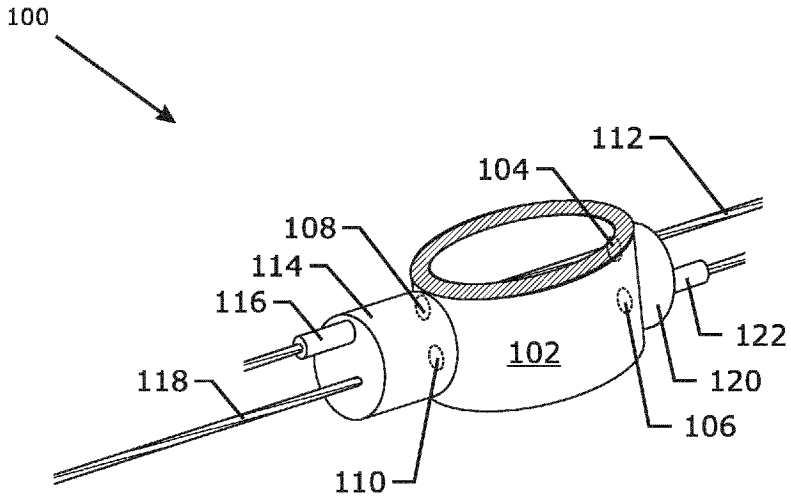

Fig. 1

(57) Abstract: An impact absorbing device (100) comprises at least one tube (102). This tube (102) has a wall that is provided with two holes (104, 106) at a first side and two holes (108, 110) at a second side. The device further comprises a first rope (112) and a second rope (118). The first rope (112) passes through the tube (102) or tubes starting from a first hole (104) at the first side and going to a first hole (108) at the second side. This first rope (112) is provided at its one end with a thickening (116) that prevents the first rope (112) from slipping back through the tube (102) or tubes. The second rope (118) passes through the tube (102) or tubes starting from a second hole (110) at the second side and going to a second hole (106) at the first side. The second rope (118) is provided at its one end with a thickening (122) that prevents the second rope (118) from slipping back through the tube (102) or tubes.

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Published:

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IMPACT ABSORBING DEVICE FOR DYNAMIC BARRIERS AGAINST ROCKFALLS

Description

Technical Field

[0001] The invention relates to an impact absorbing device and to a slope protection system with such an impact absorbing device in a dynamic barrier against rockfalls.

Background Art

[0002] Dynamic barriers against rockfalls are in general not designed to absorb high energies caused by e.g. large rocks falling. Therefore, energy absorbing devices are added to the screen or fence system. Kinetic and potential energy released by rockfall must be transformed in deformation, fracture, or heat caused by friction of elements of the impact absorbing devices.

[0003] Efficient impact absorbing devices must meet high demands.

[0004] Impact absorbing devices must first assure continuity of the screen or fence and thus prevent the screen or fence to be broken in two or more parts.

[0005] Secondly, impact absorbing devices must be able to absorb various levels of energy, since it is not known in advance how big the impact may be.

[0006] A third requirement is that the impact absorbing devices must be resistant to severe weather conditions. They should be resistant to corrosion, continue working under humid conditions or under varying temperatures.

[0007] A last and fourth requirement is that the impact absorbing devices must have a long life time since they are in general installed and used on locations that are not easy to reach.

[0008] Patent application KR-A-20150031259 discloses an impact absorbing mechanism where a rope is encircling a tube. Upon impact the released energy is transformed into deformation energy of the tube and in heat due

to friction between the rope and the tube. The deformation of the tube is only locally in the region of the encircling rope.

[0009] Patent applications KR-A-20120083874 and KR-A-20110130077 disclose a rockfall protection fence. Upon impact the tension on the rope is transferred to a device with a tube shaped part that can deform to absorb the transferred impact energy. This impact absorbing device needs to be located on a post.

[0010] Patent application US-A-2010 0327244 discloses another rockfall protection fence. Rope members go through posts in opposite directions and energy absorbers are provided to hold the ends of the ropes in place. Absorbers included in this patent are friction-resistant type. When tensile force overcomes their friction resistance, ropes slide through the absorber. Posts does not deform, but act as a lock.

Disclosure of Invention

[0011] It is a general object of the invention to avoid the drawbacks of the prior art.

[0012] It is a particular object of the invention to provide an impact absorbing device that has various composing elements that can be designed either in number or in dimensions or in both to allow for absorption of different levels of impact energy.

[0013] It is another object of the invention to provide an impact absorbing device that allows transforming the impact energy in deformation energy and in heat energy caused by friction.

[0014] Yet another object of the invention to provide an impact absorbing device that can be installed at various locations in a dynamic barrier against rockfalls.

[0015] According to a first aspect of the invention, there is provided an impact absorbing device with at least one tube. This tube or these tubes have a wall that is provided with two holes at a first side and two holes at a second side.

The device further comprises a first rope and a second rope.

The first rope passes through the tube or tubes starting from a first hole at the first side and going to a first hole at the second side of a first tube, and so on until all tubes have been passed through. The first rope is provided at its one end with a first thickening element such as a sleeve that prevents the first rope from slipping back or being pulled back through the tube or tubes. The first thickening element is fixed to the first rope and unable to slide along the first rope.

The second rope passes through the tube or tubes starting from a second hole at the second side and going to a second hole at the first side of a first tube and so on until all tubes have been passed through. The second rope is provided at its one end with a second thickening element such as a sleeve that prevents the second rope from slipping back or being pulled back through the tube or tubes. The second thickening element is fixed to the second rope and unable to slide along the second rope.

[0016] As will be explained hereinafter, this impact absorbing device allows to transform impact energy into energy needed to deform the tube or tubes, into energy needed to plastically elongate both ropes and into heat energy caused by friction of the ropes in the holes and with the stiff elements.

[0017] The tubes are preferably made of steel, aluminium or of another metallic alloy with a high level of deformation potential. These tubes or any of the rest of the parts can be made of neoprene, gum or other plastic material with similar properties. By selecting the proper tube material, by determining the number of tubes (one, two, three or more) and by designing the thickness of the tubes, one may obtain a large range of impact energy that can be absorbed.

[0018] In a preferable embodiment the first rope and the second rope are arranged substantially parallel to each other.

[0019] Most preferably, the first hole at the first side is positioned diametrically vis-à-vis the first hole at the second side. Similarly, the second hole at the first side is positioned preferably diametrically vis-à-vis the second hole at the second side.

The above design, namely parallel ropes and diametrically opposed holes, aims at obtaining the maximum possible deformation energy from the tubes.

[0020] The tube or tubes may have a circular cross-section, a rectangular cross-section or a rhombic cross-section.

[0021] Preferably the tubes do not have irregularities in the material that may cause weakening of the tubes and decrease in the deformation energy. More particularly, the tubes do not have welds.

[0022] The thickening element at the end of the ropes, e.g. a sleeve, a weld or a sling, may work together in combination with a stiff element. Stiff elements, e.g. stiff plates, are positioned between the first and/or the second thickenings and the at least one tube. The thickening at the rope end and the stiff element must work together such that after complete compression of the tube or tubes, the ropes still do not slip back through the tubes. The ropes must be blocked so that ultimately plastic elongation of the ropes can occur until fracture of the ropes. Fracture of the thickened rope ends is to be avoided. When an impact energy causes a tension force on the first and/or second rope, the first and/or said second thickenings transmit a compression force to the at least one tube and transform the impact energy into energy needed to deform the at least one tube by compression. The impact energy can also be partially transformed into energy needed to plastically elongate the ropes and into heat energy caused by friction of the ropes in the holes and with the possible stiff elements.

[0023] Generally, absorbing devices acting by friction are not regular in their behavior. Two devices with the same geometry and absorbing mechanism can have very different activation forces as well as different shape of the Force-displacement curve. This is related with the inaccuracy of (or difficulty on applying the same) the bolt pressure or small differences on the surface roughness. Energy absorbers acting by buckling have a more

regular behavior all along their characteristic curve, excepting the activation energy that could also vary for the same tube profile. On the contrary and as an advantage of the present invention, the present invention does not have these problems. Experimental tests have been carried out with the same geometry according to the present invention, and Force-Displacement curves obtained are identical one to each other.

[0024] According to a second aspect of the invention, there is provided a slope protection system as a dynamic barrier against rockfalls that comprises an impact absorbing device according to the first aspect of the invention. The impact absorbing devices can be also used for mudflow barriers, debris barriers or snow barriers as different dynamic barriers for several applications.

[0025] The dynamic barrier may have several posts and nets, screens or fences positioned and installed between the posts at the dynamic barrier. Perimeter ropes are hanging the nets, screens or fences to the posts. Supporting ropes are connecting the posts to anchors in the ground. The impact absorbing device may be positioned on one or more of the perimeter ropes, or on one or more of the supporting ropes or on both types of ropes, thus giving flexibility to locate the impact absorbing device at the positions where the needs may be the highest.

Brief Description of Figures in the Drawings

[0026] Figure 1 is a perspective view of an impact absorbing device according to the invention;

[0027] Figure 2 is a perspective view of a tube used in an impact absorbing device according to the invention;

[0028] Figure 3 is a perspective view of a preferable embodiment of the impact absorbing device according to the invention;

[0029] Figure 4 is a schematic view of a dynamic barrier equipped with several impact absorbing devices according to the invention.

Mode(s) for Carrying Out the Invention

[0030] Figure 1 is a perspective view of an impact absorbing device 100 according to the first aspect of the invention. The device 100 has one tube 102. This tube 102 has a first hole 104 and a second hole 106 at a first side and a first hole 108 and a second hole 110 at a second side. A first rope 112 passes through the first hole 104 at the first side and through the first hole 108 at the second side. Further on, the first rope also passes through a solid stiff block 114. At its end, the first rope 112 is provided with a sleeve 116. The sleeve 116 transmits the force exercised on the first rope 112 to the solid stiff block 114. Due to the fact that the sleeve 116 has a larger diameter than the diameter in the hole of the solid stiff block 114, the stiff block 114 prevents the first rope 112 from slipping back. In the same way as the first rope 112, a second rope 118 passes through a hole in the stiff block 114 at the second side, through a second hole 110 at the second side, through a second hole 106 at the first side, and finally through a hole of a stiff block 120 at the first side. The second rope 118 ends with a sleeve 122.

[0031] Upon impact on a screen or fence that is attached to the impact absorbing device 100, the forces on the screen or fence will be translated in pulling forces on the first rope 112 and the second rope 118. The sleeves 114 and 140 will transform these pulling forces on the ropes 112, 118 into compressive forces on the stiff blocks 114, 120. As these stiff blocks 114, 120 are not immediately deformable, the tube 102 will start to deform plastically and absorb at least part of the impact energy. Simultaneously heat is generated between the ropes 112, 118 and the stiff blocks 114, 120 and between the ropes 112, 118 and the tube 102. Depending upon the amount of impact energy, the ropes 112, 118 may start to deform plastically and absorb also part of the impact energy.

[0032] Figure 2 is a perspective view of a further improvement of a tube 200 used in an impact absorbing device according to a first aspect of the invention. The tube 200 has a first hole 202 and a second hole 204 at a first side and a first hole 206 and a second hole 208 at a second side. Hole 202 is

positioned diametrically vis-à-vis hole 206. Similarly, hole 204 is positioned diametrically vis-à-vis hole 208. The presence of the holes 202, 204, 206, 208 may weaken section A-A in the tube 200 to such an extent that deformation starts only in section A-A.

[0033] By selection of the proper material for the tube, by designing the outer diameter D and the thickness T, various levels of impact energy can be absorbed.
For a particular tube material, the energy absorbable by the tube could be doubled by increasing somewhat the diameter D and the thickness T.

[0034] Not only the dimensions of the tube may be varied, but also the number of tubes.

[0035] Figure 3 is a perspective view of a preferable embodiment of an impact absorbing device 300 according to a first aspect of the invention. The impact absorbing device 300 has two tubes 302 and 304. A first rope 306 passes through the two tubes 302, 304 and comprises a sleeve 308 at its one end at one side. This sleeve 308 has an external diameter that is larger than the hole through a stiff, solid plate 310 where the first rope 306 passes through. Similarly a second rope 312 passes through the tubes 302, 304 and ends with a sleeve 314 in contact with a stiff solid plate 316 at the other side.

[0036] Static tensile tests have been carried out separately on the ropes in order to measure the possible energy that can be absorbed by the ropes. This is done by recording a load displacement curve and by measuring the area under the curve.
Static compression tests have been carried out separately on the tubes in order to measure the energy that can be absorbed by the tubes themselves.

[0037] Finally some static tensile tests have been carried out on an impact absorbing device as shown in Figure 3. Test speed was set at the value

that is recommended by the ETAG for static tests on energy dissipators. . The outer diameter D of the two tubes and the thickness T of the tubes determined The displacement of the tubes, the displacement of the ropes and the displacement of the clamps in the test that were all recorded

The static tensile tests carried out on the impact absorbing device gives a good estimate of the total energy absorbable. This total energy can be divided into three components:
- a first part absorbed by the plastic deformation of the tubes, this first part is determined by the static compression tests on the tubes individually;
- a second part absorbed by the plastic deformation of the ropes, this second part is determined by the tensile tests carried separately on the ropes;
- a third part absorbed friction between the ropes and the holes, mainly the holes of the stiff plates, this third part can be derived by subtracting the first part and the second part from the total energy .

[0038] Figure 4 is a schematic view of how impact absorbing devices according to the first aspect of the invention are used and integrated into a dynamic barrier against rockfalls 400.

[0039] A dynamic barrier against rockfalls 400 comprises a number of poles 402, 404, 406 between which fences, nets or screens 408, 410 are hung. These fences 408, 410 may preferably be chain link fences. The fences 408, 410 are stretched and attached to the poles 402, 404, 406 with the help of perimeter ropes 412, 414, 416 and 418. At the left side, supporting ropes 420, 422 attach the left most pole 402 to a support or anchor 424. At the left side, supporting ropes 426, 428 connect the right most pole 406 to a support or anchor 430. The poles in-between may also be connected or attached to a support. Since the invention impact absorbing devices do not need to be connected to a post, there is quite some freedom to position them in the dynamic barrier against rockfalls 400. Impact absorbing devices 434, 436 may be positioned on the upper perimeter ropes 412 and 414. Alternatively or additionally, impact absorbing devices

432, 438 may be positioned on the supporting ropes 420, 428.

[0040] List of Reference Numbers

100	first embodiment of an impact absorbing device
102	tube
104	first hole at first side
106	second hole at first side
108	first hole at second side
110	second hole at second side
112	first rope
114	first stiff cylindrical element
116	sleeve for first rope
118	second rope
120	second stiff cylindrical element
122	sleeve for second rope
200	tube
202	first hole at first side
204	second hole at first side
206	first hole at second side
208	second hole at second side
300	second embodiment of impact absorbing device
302	first tube
304	second tube
306	first rope
308	sleeve for first rope
310	first stiff plate
312	second rope
314	sleeve for second rope
316	second stiff plate
400	dynamic barrier against rockfalls
402- 404 -406	pole
408 - 410	fence

412 – 414 – 416 – 418 perimeter rope
420 - 422 supporting rope
424 support
426 -428 supporting rope
430 support
432 – 434 – 436 – 438 energy absorbing device

Claims

1. An impact absorbing device,
said device comprising at least one tube,
said at least one tube having a wall that is provided with two holes at a first side and two holes at a second side,
said device further comprising a first rope and a second rope,
said first rope passing through said at least one tube starting from a first hole at the first side and going to a first hole at the second side,
said first rope being provided at its one end with a first thickening that prevents said first rope from slipping back through said at least one tube,
said first thickening element being fixed to said first rope and unable to slide along said first rope,
said second rope passing through said at least one tube starting from a second hole at the second side and going to a second hole at the first side,
said second rope being provided at its one end with a second thickening that prevents said second rope from slipping back through said at least one tube
said second thickening element being fixed to said second rope and unable to slide along said second rope.

2. An impact absorbing device according to claim 1,
wherein said first rope and said second rope are substantially parallel to each other.

3. An impact absorbing device according to claim 2,
wherein the first hole at the first side is positioned diametrically versus the first hole at the second side and wherein the second hole at the first side is positioned diametrically versus the second hole at the second side.

4. An impact absorbing device according to any one of the preceding claims, said device comprising two or more tubes.

5. An impact absorbing device according to any one or the preceding claims, wherein said at least one tube has a circular cross-section.

6. An impact absorbing device according to any one of claims 1 to 4, wherein said at least one tube has a rectangular cross-section.

7. An impact absorbing device according to any one of the preceding claims, wherein said tube has no welds.

8. An impact absorbing device according to any one of the preceding claims, wherein stiff plates are positioned between said first and/or second thickenings and said at least one tube.

9. An impact absorbing device according to any of claims 1 to 8, when an impact energy causes a tension force on said first or second rope, said first and/or second thickenings transmit a compression force to said at least one tube and transform the impact energy into energy needed to deform said at least one tube by compression.

10. A dynamic barrier against rockfalls comprising an impact absorbing device according to any one of the preceding claims.

11. A dynamic barrier against rockfalls according to claim 10, said dynamic barrier comprising:
- posts,
- nets positioned between said posts,
- perimeter ropes hanging said nets between said posts,
- supporting ropes connecting said posts to the anchors in the ground,
at least one impact absorbing device being positioned one said perimeter ropes or on said supporting ropes.

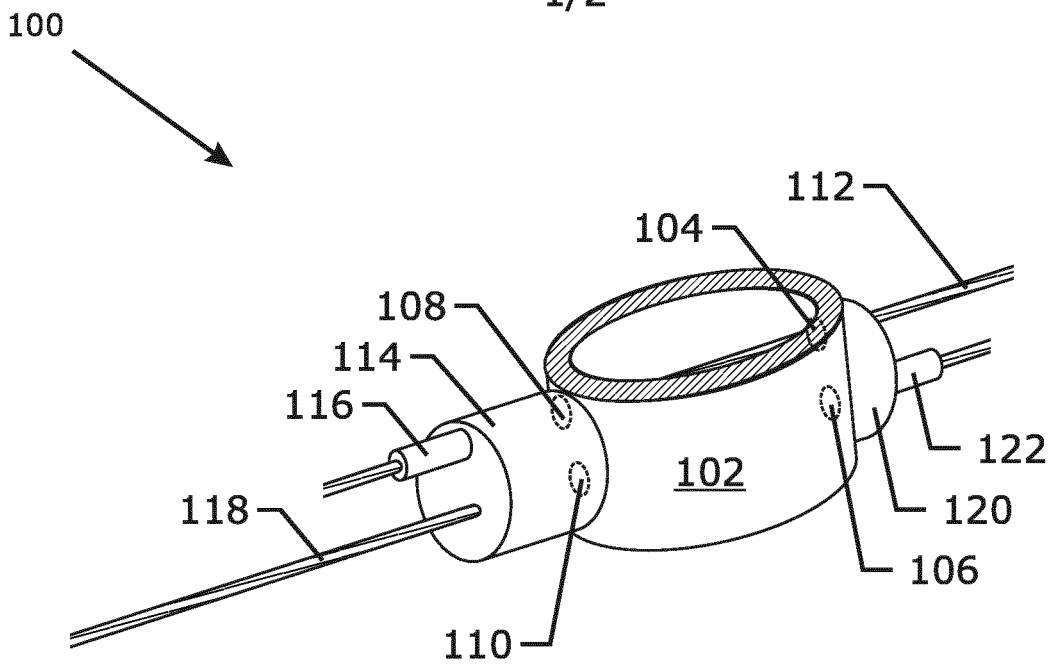
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Fig. 1

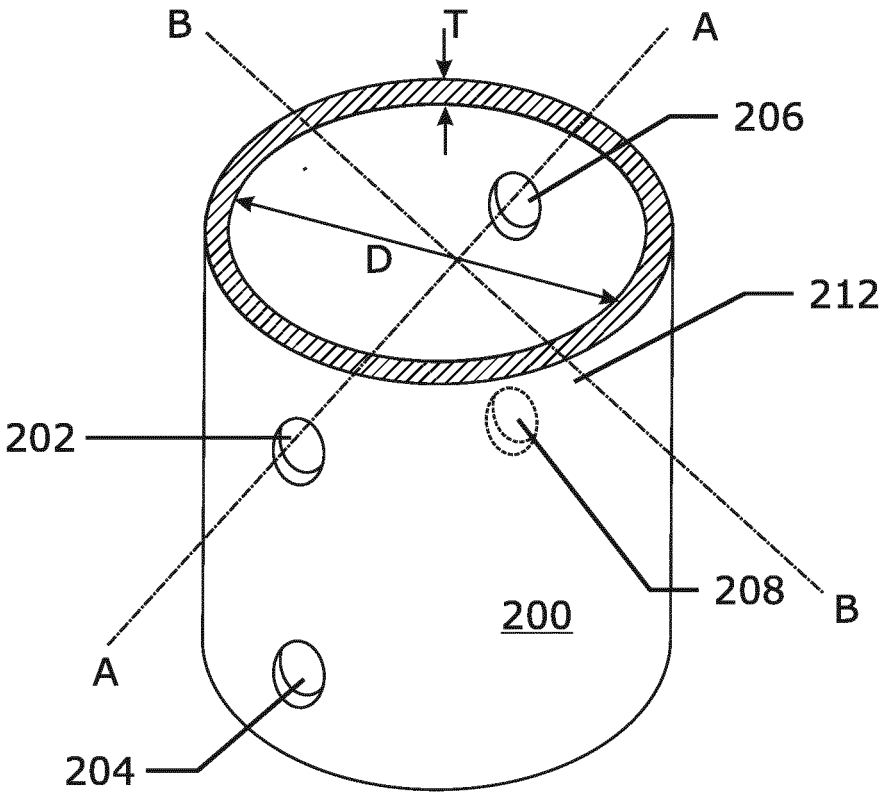
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Fig. 2

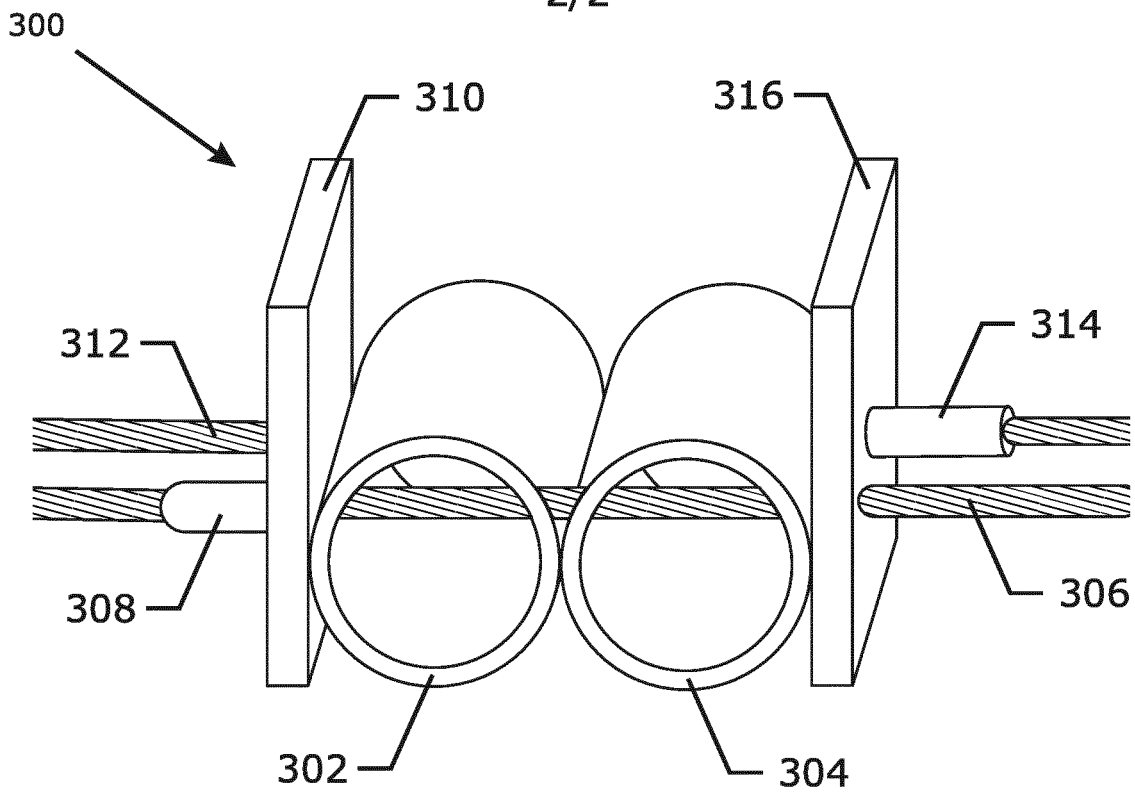
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Fig. 3

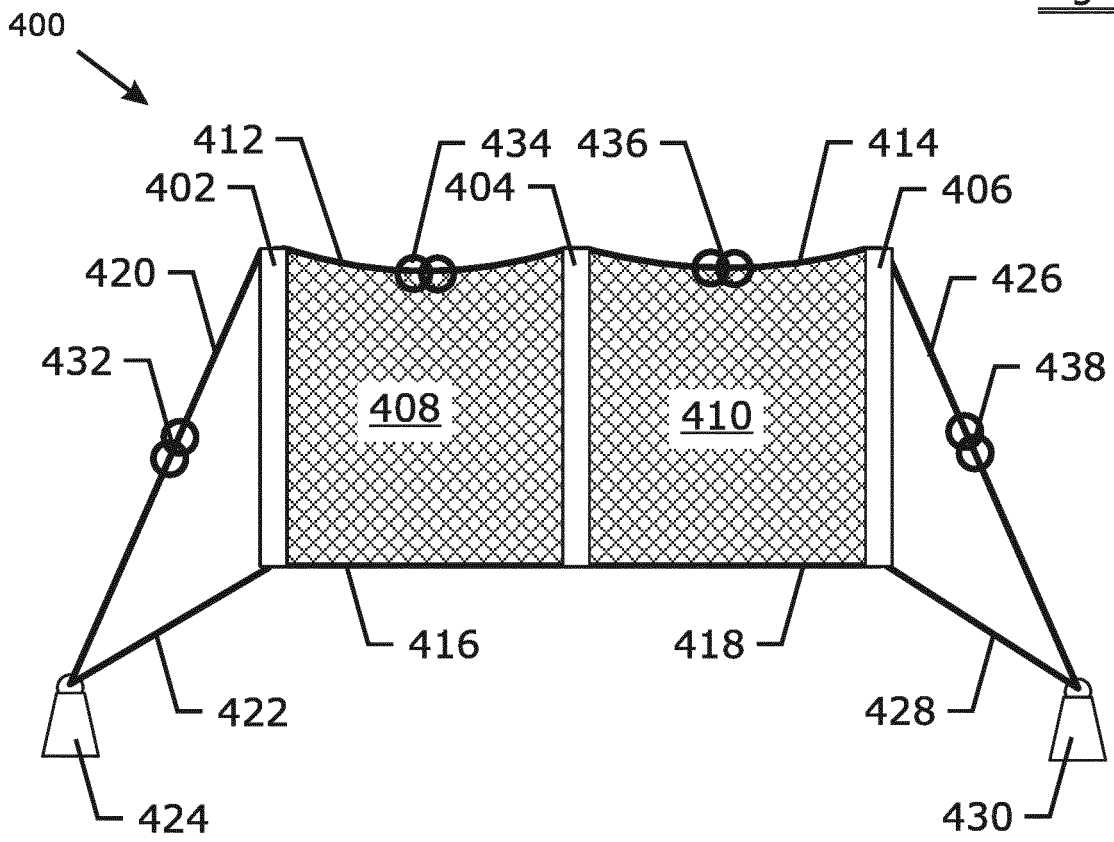
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Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/062102

A. CLASSIFICATION OF SUBJECT MATTER
INV. E01F7/04 E01F15/06 E04H17/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E01F E04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 205 908 105 U (DATONG POWER SUPPLY CO STATE GRID SHANXI ELECTRIC POWER CO LTD) 25 January 2017 (2017-01-25) paragraphs [0001] - [000300100015]; figures	1-5,9
A	US 2010/327244 A1 (NISHITA YOICHI [JP] ET AL) 30 December 2010 (2010-12-30) paragraph [0003005600580059061]; figures	1,10
A	KR 2012 0083874 A (DOYOUNG ENG CO LTD [KR]; UNIV KWANDONG IND FOUNDATION [KR]) 26 July 2012 (2012-07-26) cited in the application the whole document	1,10

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 July 2018	03/08/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Stern, Claudio

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/062102

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 518 953 A (HUNTER KENT [US] ET AL) 21 May 1985 (1985-05-21) column 3, line 26 - column 5, line 59; figures 2,8,10	1
A	US 600 964 A (O. HARLEY) 22 March 1898 (1898-03-22) the whole document	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/062102

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