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

(11) EP 3 626 880 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.03.2020 Bulletin 2020/13

(51) Int Cl.:
D07B 1/16 *(2006.01)* ***D07B 7/14*** *(2006.01)*

(21) Application number: **18250020.7**

(22) Date of filing: **19.09.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Bridon International Limited**
Doncaster DN4 5JQ, South Yorkshire (GB)

(72) Inventors:
- **Rommel, Hendrik**
  8200 Sint-Michiels (BE)
- **Wang, Pengzhu**
  Doncaster, DN4 7EA (GB)
- **Karedan, Joseph**
  Warmsworth
  Doncaster DN4 9JY (GB)

(74) Representative: **Zhang, Li**
NV Bekaert SA
IP Department - PC6030
Bekaertstraat 2
8550 Zwevegem (BE)

(54) **STEEL WIRE ROPE**

(57) The invention relates to a steel wire rope comprising a core element surrounded by at least one outer layer, said core element containing natural plant fibers, said at least one outer layer comprising a plurality of steel wire strands, wherein said core element in sheathed with a polymer having a thickness in a range from 0.2 to 2 mm.

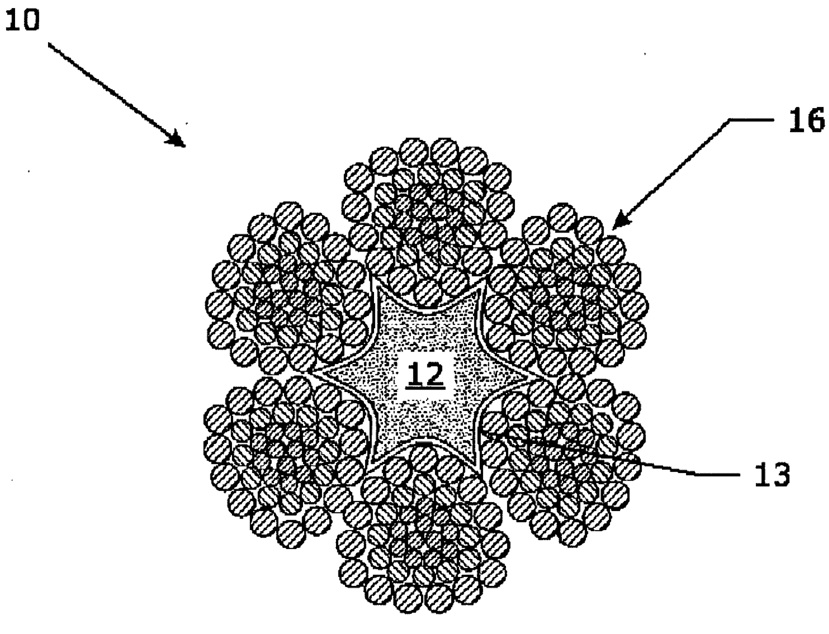

Fig. 1

EP 3 626 880 A1

Description

Technical Field

[0001] The invention relates to a steel wire rope comprising a fiber core element and an outer strand layer.

Background Art

[0002] In rope manufacture and use of steel wire ropes, core plays the role of supporting the outer strand layer of steel wire rope, keeping rope structural integrity, improving the flexibility of the wire rope. In addition, the core can store lubricant, thus keep the outer strand layer lubricated to reduce friction, abrasion and corrosion.

[0003] Fiber rope made from natural plant fibers, including hard fibers (e.g. Manila hemp, etc.) and soft fibers (sesame, sisal, cotton yarn, etc.) are widely used as the cores in the manufacture of steel wire ropes. One of the common disadvantage of natural fiber cores is its poor resistance corrosion due in wet environments. Organic cellulose a common building block of natural fiber core has strong water absorption ability and thus easily deteriorate and lose the original performance properties such as radial stiffness. If the rope core has poor resistance to crushing, the outer strand layer becomes unstable and the contact stress between adjacent strands will increase causing the steel wires to wear and eventually break. The hygroscopicity of fiber core will further increase the moisture content within the rope causing corrosion of the steel wires in the steel wire rope. Such corrosion will intensify the brittleness of the steel wire and lower the tensile strength of the steel wire rope. This would shorten the service life of the wire rope.

[0004] For applications where steel wire ropes are subjected to wet and acidic environments, the rope core is commonly made from synthetic fiber instead of natural plant fiber. However, sisal rope is widely used as core for steel wire ropes in some industrial and agricultural production. It has characteristics that are not possessed by synthetic fiber rope core and is irreplaceable in some industries.

Disclosure of Invention

[0005] It is a main object of the present invention to develop a steel wire rope having considerably increased resistance to corrosion of the fiber core and in particular suitable for critical applications, such as used in wet acidic mine shafts.

[0006] It is another object of the present invention to devise a steel wire rope having improved radial resistance and capacity for dynamic transverse impact pressures.

[0007] According to a first aspect of the present invention, there is provided a steel wire rope comprising a core element surrounded by at least one outer layer, said core element containing natural plant fibers, said at least one outer layer comprising a plurality of steel wire strands, wherein said core element is sheathed with a polymer having a thickness in a range from 0.2 to 2 mm.

[0008] Herewith, the steel wire rope can have a diameter in a range from 10 to 100 mm, e.g. from 30 mm to 60 mm, e.g. 30 mm, 40 mm, 50mm or 60 mm. The diameter of the core element is preferably from 30% to 60% of the diameter of the steel wire rope, and more preferably from 40% to 50% of the diameter of the steel wire rope. The sheath of the core element has a thickness in a range from 0.2 to 2 mm, preferably in a range from 0.3 to 1.5 mm and more preferably In a range from 0.5 to 1 mm. The thickness of the sheath on the core element can be selected depending on the diameter of the core and the steel wire rope.

[0009] The natural plant fiber referred in the present application can comprise, but not limited to hemp (e.g. Manila hemp, ramie or jute etc.) and soft fibers (sesame, sisal, cotton yam, etc.).

[0010] The core element can have any constructions known for fiber ropes. For instance, a rope construction of 3 strands, 4 strands, 1x4 or 1x6 strands. In such rope constructions, the ropes are made up of strands. The strands are made up of rope yarns, which contain natural plant fibers. Methods of forming yarns from fiber, strands from yarn and ropes from strands are known in the art.

[0011] In addition, the natural plant fiber rope can be preconditioned before further processing through e.g. pre-stretching, annealing, heat setting or compacting. The constructional elongation can also be removed during the rope production by sufficiently pre-tensioning the core before applying a sheath or during closing the outer wire strands onto the core.

[0012] The core element of the present invention can be lubricated with lubricant. The lubricant can have a weight in a range of 10 to 25 % of the total weight of said steel wire rope, which is less than normally used for fiber core element without sheath. For example, the lubricant can have a weight in a range of 10 to 12 % of the total weight of said steel wire rope.

[0013] The steel wire rope according to the present invention has at least one outer layer consists of steel wire strands, e.g. 6, 8, 12 or 16 steel wire strands. The steel wire strands can have any construction which is known in the prior art. The steel strand can have a triangular or round shape.

[0014] As another example, the core element can be surrounded by two outer layers and each outer layers consists of a plurality of steel wire strands. Preferably, the twist direction of the two outer layers are different.

[0015] The steel wire strands can be made from high-carbon steel. A high-carbon steel has a steel composition as follows: a carbon content ranging from 0.5 % to 2.15 %, a manganese content ranging from 0.10 % to 1.10 %, a silicon content ranging from 0.10 % to 1.30 %, sulfur and phosphor contents being limited to 0.15 %. preferably to 0.10 % or even lower; additional micro-alloying elements such as chromium (up to 0.20 % - 0.40 %), copper (up to 0.20 %) and vanadium (up to 0.30 %) may be added. All percentages are percentages by weight.

[0016] Alternatively, the steel wire strands can be made from low carbon steel (a carbon content ranging from 0.05 to 0.30 wt %), medium carbon steel or stainless steel.

[0017] According to the invention, the steel wire strands can be coated with zinc and/or zinc alloy. Preferably, the steel wires of the steel wire strands of the outer layer are coated individually with zinc and/or zinc alloy. More preferably, the coating is formed on the surface of the steel wires by galvanizing process. As an example, zinc aluminum alloy can be applied. In contrast to zinc, a zinc aluminum coating has a better overall corrosion resistance and is more temperature resistant, Still in contrast to zinc, there Is no flaking with the zinc aluminum alloy when exposed to high temperatures. A zinc aluminum coating may have an aluminum content ranging from 2 wt % to 12 wt %, e.g. ranging from 5 % to 10 %. A preferable composition lies around the eutectoid position: aluminum about 5 wt %. The zinc alloy coating may further have a wetting agent such as lanthanum or cerium in an amount less than 0.1 wt % of the zinc alloy. The remainder of the coating is zinc and unavoidable impurities. Another preferable composition contains about 10 % aluminum. This increased amount of aluminum provides a better corrosion protection than the eutectoid composition with about 5 wt % of aluminum. Other elements such as silicon and magnesium may be added to the zinc aluminum coating. More preferably, with a view to optimizing the corrosion resistance, a particular good alloy comprises 2 % to 10 % aluminum and 0.2 % to 3.0 % magnesium, the remainder being zinc.

[0018] The sheathed polymer on the core element can be any thermoplastic polymers. For instance, it can be selected from Arnitel®, Hytrel®, Polyethylene (PE), Polypropylene, (PP), Polyurethane (PU) or Polyvinyl chloride (PVC). As a preferred example, the core element can be coated with a polymer having copolyester elastomer containing soft blocks in the range of 10 to 70 wt %. Preferably, the hardness Shore D of the copolyester elastomer as measured according to ISO 868 is larger than 50. In a preferred embodiment, the copolyester elastomer contains soft blocks in the range of 10 to 40 wt %. In a more preferred embodiment, the copolyester elastomer contains soft blocks in the range of 20 to 30 wt %. In a most preferred embodiment, the copolyester elastomer contains 25 wt % soft blocks. The modulus and the hardness of the copolyester elastomer depend on the type and concentration of soft blocks in the copolyester elastomer. The advantage of using the copolyester elastomer containing soft and hard blocks in the manufacture of steel wire rope is that a hard transition layer established in-between the core and the outer layer. Less concentration of soft blocks in the copolyester elastomer can make the elastomer harder. Thus, the application of copolyester elastomer layer between the core and outer steel layer improves the fatigue resistance of the steel wire. Furthermore, the copolyester elastomer containing soft blocks is compatible with the inner fiber core element and the outer layer. Also, the material has outstanding resistance to flexural and bending fatigue both at high temperatures and sub-zero temperatures. This makes it particular suitable for applications such as crane ropes, which are subjected to a wide range of temperatures and also encounter very high levels of flexural fatigue and compression.

[0019] Suitably, the copolyester elastomer is a copolyesterester elastomer, a copolycarbonateester elastomer, and /or a copolyetherester elastomer; i.e. a copolyester block copolymer with soft blocks consisting of segments of polyester, polycarbonate or, respectively, polyether. Suitable copolyesterester elastomers are described, for example, in EP-0102115-B1. Suitable copolycarbonateester elastomers are described, for example, in EP-0846712-B1. Copolyester elastomers are available, for example, under the trade name Arnitel®, from DSM Engineering Plastics B.V. The Netherlands. Preferably copolyester elastomer is a copolyetherester elastomer.

[0020] Due to the compression force applied on the core element during rope closing, the sheathed core element of the invention steel wire rope can be compressed by the outer layer. The sheath also protects the core fibers from damage during rope closing compression. The sheathed core element may go in between the steel wire strands of the outer layer and have a natural star shape in cross-section or helical flute shape in three dimensions. The natural star shape in cross-section of the core element can be kept during the lifetime of the steel wire rope.

[0021] According to a second aspect of the invention, it is provided a method of manufacturing a steel wire rope, comprising the steps of:

(a) providing a core element, wherein said core element containing natural plant fibers;
(b) extruding said core element with a polymer having a thickness in a range from 0.2 to 2 mm; and
(c) twisting a plurality of steel wire strands around said core element to form an outer layer such that said steel wire rope is closed.

[0022] According to the invention, the extruding in step (b) is preferably a - jacket extrusion. The extruded polymer can be selected from Arnitel®, Hytrel®, Polyethylene (PE), Polypropylene (PP), Polyurethane (PU) or Polyvinyl chloride (PVC).

[0023] To the knowledge of the inventors, specialist equipment and skill is required to extrude polymers over natural plant fiber, in particular sisal, since the natural plant fiber is easy to burn. On the other hand, in order to sufficiently avoid penetration of liquid, e.g. water, the sheath should have good impermeable property. Moreover, the sheath on the core is desirable to survive during the lifetime of the rope. Due to the abrasion of the core element with the outer steel wire strands, the thickness of the sheath is preferably in a range from 0.2 to 2 mm and more preferably in a range from 0.5 to 1 mm. The extrusion process used to form the polymer sheath on the natural plant fiber core element is preferably a well-designed and concentric jacket extrusion. The advantage of applying jacket extrusion is to ensure a uniform and consistent thickness of the polymer layer around the fiber core element and along the length of the core, as the shape and diameter of a fiber core is less stable under tension than steel wire ropes. On the other hand, the applied temperature of molten polymer and residence time of fiber core to elevated temperature during the jacket extrusion process should be affordable to the natural plant fiber, thus avoiding the risk of burning of the natural plant fiber core element. The technique involves passing the fiber core through an extrusion head whilst overlaying the polymer over the fiber core at a predetermined draw down ratio and optimized line speed to result in a tight and concentric jacket over the fiber core.

[0024] According the invention, in step (c) said core element can undergo compression during rope closing such that said core element takes a natural star shape in cross-section or helical flute shape in three dimensions after rope closing.

[0025] The invention illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including", "containing", etc. shall be read expansively and without limitation. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

Brief Description of Figures in the Drawings

[0026] The invention will be better understood with reference to the detailed description when considered in conjunction with the non-limiting examples and the accompanying drawings, in which:

Fig. 1 is a cross-section of a steel wire rope according to a first embodiment of invention.

Fig. 2 is a cross-section of a steel wire rope according to a second embodiment of invention.

Mode(s) for Carrying Out the Invention

Steel wire rope 1

[0027] Fig. 1 is a cross-section of an invention steel wire rope according to a first embodiment. The invention steel wire rope 10 comprises a natural plant fiber core 12, a coated polymer layer 13, and an outer layer containing steel wire strands 16. The steel wire rope 10 as illustrated in Fig. 1 has a 6XV39(K3/9-12-15)-FC rope construction (the designation of the rope is according to BS EN 12385-2:2002 +A1:2008 Steel wire ropes - Safety - Part 2: Definitions, designation and classification, V stands for triangular and K for compaction). This refers to a rope design with an outer layer having six single triangular wire strands 16 and a fiber core (abbreviated as FC) 12. The triangular wire strand 16 has a K3/9-12-15 structure. The four layers of the outer steel wire strand 16 are preferably-twisted in the same direction, i.e. if it is a right hand rope, the 9 over 3, 12 over (3-9) and the 15 over 12 are all right hand (Z), so the rope is a Lang's lay rope.

[0028] As an example, a twisted 3 strands sisal rope 12 is used as the core of the steel wire rope. In a next step the sheathed polymer layer 13, such as Arnitel®, is extruded on the core 12 using a jacket extruder with the designed processing conditions. The technique involves passing the fiber core through an extrusion head whilst overlaying the polymer over the fiber core at a predetermined draw down ratio and optimized line speed to result in a tight and concentric jacket over the fiber core. The sheathed polymer has a thickness in a range from 0.2 to 2 mm, e.g. a thickness of 0.2 mm, 1 mm or 2 mm and preferably in a range of 0.5 to 1.5 mm.

[0029] The steel wire rope is obtained by twisting six steel wire strands 16 around the sheathed sisal rope core 12 to form an outer steel wire strand layer such that the steel wire rope is closed.

[0030] It should be noted that the sheathed core element undergoes compression during rope closing such that said core element takes a natural star shape in cross-section after rope closing, as shown in Fig.1.

Steel wire rope 2

[0031] Fig. 2 is a cross-section of an invention steel wire rope according to a second embodiment of the invention. The invention steel wire rope 20 comprises a sisal fiber core 22, an extruded thermoplastic jacket 23, and an outer layer containing steel wire strands 26. In this embodiment, the wire rope 20 has a rope construction of 6xK19(1-9-9)-FC. In contrast to the above first steel wire rope, the outer steel wire strand 26 in this second steel wire rope is a compacted independent wire rope and has a round shape. As shown in Fig. 2, the strand 26 has a 1-9-9 structure.

Claims

1. A steel wire rope comprising a core element surrounded by at least one outer layer, said core element containing natural plant fibers, said at least one outer layer comprising a plurality of steel wire strands, wherein said core element is sheathed with a polymer having a thickness in a range from 0.2 to

2 mm.

2. A steel wire rope according to claim 1, wherein said natural plant fibers are sisal.

3. A steel wire rope according to claim 1 or 2, wherein said core element is an independent sisal wire rope having a rope construction of 3 strands, 4 strands, 1x4 or 1x6 strands.

4. A steel wire rope according to claim 3, wherein the sheathed polymer is an extruded layer,

5. A steel wire rope according to any one of the preceding claims, wherein the sheathed polymer has a thickness in a range from 0.5 to 1 mm.

6. A steel wire rope according to any one of the preceding claims, wherein said core element is lubricated with lubricant having a weight in a range of 10 to 25 % of the total weight of said steel wire rope.

7. A steel wire rope according to any one of the preceding claims, wherein said at least one outer layer consists of 6, 8, 12 or 16 steel wire strands having a triangular or round shape.

8. A steel wire rope according to any one of the preceding claims, wherein said steel wire strands is made from low, medium and high carbon steel or stainless steel.

9. A steel wire rope according to any one of the preceding claims, wherein said core element is surrounded by two outer layers and each outer layers consists of a plurality of steel wire strands,

10. A steel wire rope according to any one of the preceding claims, wherein said steel wire strands are coated with zinc and/or zinc alloy.

11. A steel wire rope according to any one of the preceding claims, wherein said polymer is selected from Arnitel®, Hytrel®, Polyethylene (PE), Polypropylene (PP), Polyurethane (PU) or Polyvinyl chloride (PVC).

12. A steel wire rope according to any one of the preceding claims, wherein said sheathed core element is compressed by the outer layer and has a natural star shape in cross-section.

13. A method of manufacturing a steel wire rope, comprising the steps of:

(a) providing a core element, wherein said core element containing natural plant fibers;
(b) extruding said core element with a polymer having a thickness in a range from 0.2 to 2 mm; and
(c) twisting a plurality of steel wire strands around said core element to form an outer layer such that said steel wire rope is closed.

14. A method of manufacturing a steel wire rope according to claim 13, wherein said extruding in step (b) is a jacket extrusion.

15. A method of manufacturing a steel wire rope according to claim 13 or 14, wherein in step (c) said core element undergoes compression during rope closing such that said core element takes a natural star shape in cross-section after rope closing.

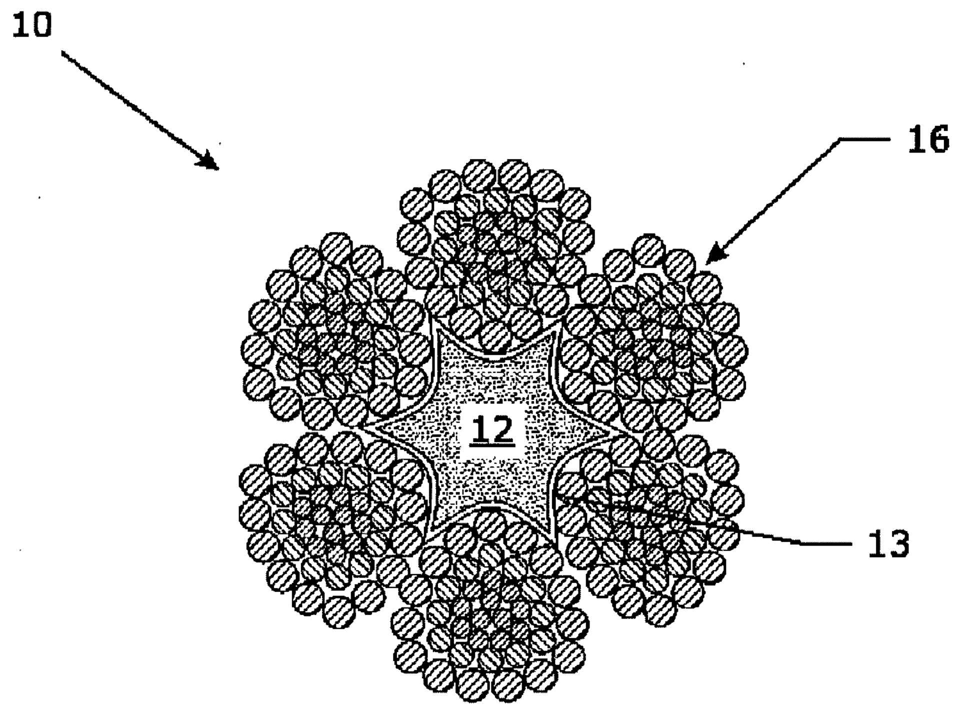

Fig. 1

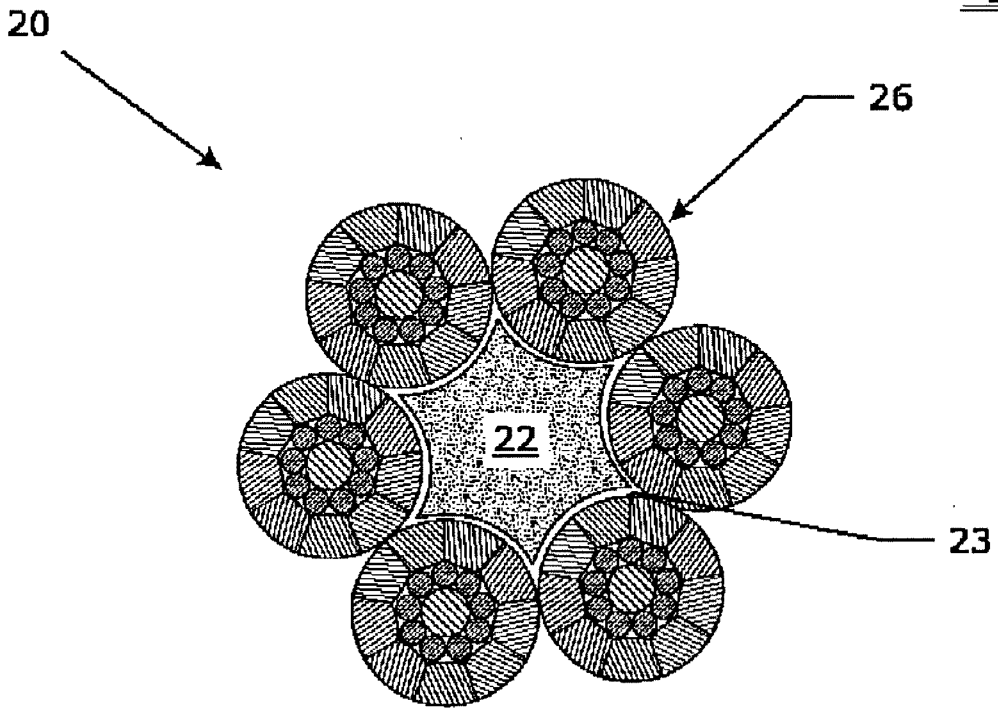

Fig. 2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 25 0020

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	KR 2004 0024283 A (KISWIRE LTD) 20 March 2004 (2004-03-20) * the whole document *	1,2,6-8, 10,11 4,10,13, 14	INV. D07B1/16 D07B7/14
X Y	US 3 018 607 A (ALFRED DIETZ ET AL) 30 January 1962 (1962-01-30) * column 1, line 9 - line 12; figures 1,2 * * column 2, lines 7-13,63-69 *	1,5,8, 10,12 4,5,10, 13-15	
X Y	US 2 184 502 A (METCALF FRANK R) 26 December 1939 (1939-12-26) * page 1, left-hand column, line 40 - page 2, right-hand column, line 17; figures 1,3 *	1,3,7,8, 10,12 4,5,10, 13-15	
X Y	US 2018/058003 A1 (LAUER BRUNO [DE]) 1 March 2018 (2018-03-01) * paragraphs [0008], [0009], [0013], [0042], [0044], [0048], [0049], [0051]; figures 3,4 *	1,8-12 10	
Y	US 2015/247285 A1 (AMILS XAVIER [BE] ET AL) 3 September 2015 (2015-09-03) * paragraphs [0033], [0041]; claims 1,6 *	4,13-15	TECHNICAL FIELDS SEARCHED (IPC) D07B
Y A	EP 0 357 883 A2 (AMSTED IND INC [US]) 14 March 1990 (1990-03-14) * column 4, line 10 - line 13; figures 5,7,9 * * page 3, line 55 - page 4, line 3; figure 3 *	4,13-15 1	
A	US 2 509 894 A (TOULMIN JR HARRY A ET AL) 30 May 1950 (1950-05-30) * column 1, lines 18-22,44,45 * * column 4, line 53 - line 65; claim 5 *	1	

-/--

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	1 March 2019	Uhlig, Robert

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 25 0020

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2 147 118 A (ELLSWORTH FRANK H ET AL) 14 February 1939 (1939-02-14) * page 1, line 23 - line 35; claim 1 * -----	1	
A	CH 274 803 A (CHRISTEN HAROLD A DR [CH]) 30 April 1951 (1951-04-30) * the whole document * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	1 March 2019	Uhlig, Robert

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

page 2 of 2

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 25 0020

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

01-03-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 20040024283 A	20-03-2004	NONE	
US 3018607 A	30-01-1962	NONE	
US 2184502 A	26-12-1939	NONE	
US 2018058003 A1	01-03-2018	CN 107429481 A	01-12-2017
		DE 102015103115 A1	08-09-2016
		DE 112016000184 A5	31-08-2017
		EP 3265607 A1	10-01-2018
		KR 20170122190 A	03-11-2017
		US 2018058003 A1	01-03-2018
		WO 2016138893 A1	09-09-2016
US 2015247285 A1	03-09-2015	AU 2013326492 A1	19-02-2015
		BR 112015007124 A2	04-07-2017
		CA 2880609 A1	10-04-2014
		CN 104685122 A	03-06-2015
		EP 2904143 A1	12-08-2015
		KR 20150059753 A	02-06-2015
		RU 2015116251 A	27-11-2016
		SG 11201502064Q A	28-05-2015
		US 2015247285 A1	03-09-2015
		WO 2014053601 A1	10-04-2014
		ZA 201500704 B	27-07-2016
EP 0357883 A2	14-03-1990	AU 610043 B2	09-05-1991
		BR 8904386 A	17-04-1990
		CA 1306392 C	18-08-1992
		DE 68925008 D1	18-01-1996
		DE 68925008 T2	15-05-1996
		EP 0357883 A2	14-03-1990
		ES 2080054 T3	01-02-1996
		NO 892489 A	07-03-1990
		US 4887422 A	19-12-1989
		ZA 8903969 B	25-04-1990
US 2509894 A	30-05-1950	NONE	
US 2147118 A	14-02-1939	NONE	
CH 274803 A	30-04-1951	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- EP 0102115 B1 **[0019]**
- EP 0846712 B1 **[0019]**