



- (51) International Patent Classification:
D02G 3/12 (2006.01) *C03B 35/18* (2006.01)
- (21) International Application Number:
PCT/EP2016/052116
- (22) International Filing Date:
2 February 2016 (02.02.2016)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
15155699.0 19 February 2015 (19.02.2015) EP
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- (81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*

(54) Title: SPUN METAL FIBER YARN

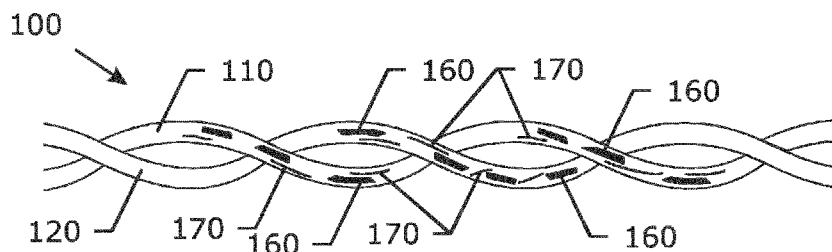


Fig. 1

(57) Abstract: The spun metal fiber yarn (100) comprises staple fibers (160) out of a first alloy and staple fibers (170) out of a second alloy. The first alloy is a stainless steel alloy. The second alloy is a NiCr alloy or a NiCrFe alloy. The NiCr or NiCrFe alloy comprises at least 40% by weight of nickel and at least 14% by weight of chromium.

Spun metal fiber yarn**Description****Technical Field**

[0001] The invention relates to a spun metal fiber yarn and to a heat resistant separation fabric comprising such spun metal fiber yarn. The heat resistant separation fabric material can be used as tool covering in the processing of glass products, e.g. for the car industry, where the fabric is in contact with glass at a temperature above the softening point of glass.

Background Art

[0002] In most operations where glass plates are bent, the glass plate is heated to a temperature of between 680°C and 700°C, although operations are known where the glass plates are brought to higher temperature, e.g. 720°C or even 780°C or even higher. In order to prevent damage to the tooling (e.g. bending molds, transport rollers) brought into contact with the heated glass plate, the tooling is normally covered by means of a heat resistant separation material, mostly a cloth made out of fibers.

[0003] WO2011/116992A2 discloses a heat resistant separation fabric for use as tool covering in the production of car glass. Such heat resistant separation materials can be knitted fabrics, made from yarns spun with stainless steel fibers. Alloys such as AISI 316 or AISI 316L, AISI 347, or other alloys out of the AISI 300 type can be used.

[0004] WO2014/166793A1 discloses a woven tape for use as heat resistant separation material. The woven tape comprises a first set of yarns in a first direction of the woven tape. This first set of yarns comprises yarns comprising stainless steel fibers. This first set of yarns has a material density, which is the number of yarns per meter of the first set of yarns in the first direction multiplied by their linear density. The woven tape comprises a second set of yarns in the second direction of the woven tape. This second set of yarns comprises yarns comprising fibers out of NiCr alloy or NiCrFe alloy, comprising at least 40% by weight of nickel and at least 14% by weight of chromium. This second set of yarns has a material density which is the number of yarns per meter of the second set of yarns in the second direction multiplied by their linear density. The weave of the woven tape is a twill weave or a satin weave. The material density of the second set of yarns is higher than the material density of the first set of yarns.

[0005] FR2868439 discloses a hybrid yarn comprising metal, mineral and carbon-rich filaments such as aramid fibers; and textile structures derived from such hybrid yarn. The hybrid yarn exhibits a high thermal resistance and is used for handling glass at the forming temperature thereof.

[0006] Polymer fibers such as poly(p-phenylene-2,6-benzobisoxazole)-fibers (PBO fibers) or aramid fibers (including para-aramid fibers) are limited in use temperature when used in fabrics for tool covering in glass processing. Aramid fibers can be used in applications up

to 350°C; PBO fibers can be used in applications up to 450°C, or exceptionally in applications in which 500°C is reached during a short period in time.

Disclosure of Invention

- 5 [0007] The primary objective of the invention is to provide a spun metal fiber yarn comprising metal fibers for use in the production of heat resistant separation fabrics that have a long lifetime in multiple time use at high temperatures of more than 680°C. With multiple time use is meant that the fabrics are mounted on and demounted from the tooling multiple times.
- 10 [0008] It is a specific benefit of at least some embodiments of inventive heat resistant separation fabrics that car glass quality is improved thanks to lower sagging of the inventive heat resistant separation material on tooling covered with it.
- [0009] The first aspect of the invention is a spun metal fiber yarn. The metal fiber yarn
15 comprises, and preferably consists out of,
- staple fibers out of a first alloy. The first alloy is a stainless steel alloy; and
- staple fibers out of a second alloy. The second alloy is a NiCr alloy or a NiCrFe alloy. The NiCr or NiCrFe alloy comprises at least 40% by weight of nickel and at least 14% by weight of chromium.
- 20 With a NiCr alloy comprising at least 40% by weight of nickel and at least 14% by weight of chromium, is meant an alloy that comprises at least 40% by weight of nickel and at least 14% by weight of chromium.
- With a NiCrFe alloy comprising at least 40% by weight of nickel and at least 14% by weight of chromium, is meant an alloy that comprises at least 40% by weight of nickel, at
25 least 14% by weight of chromium and also iron, preferably at least 5% by weight of iron, more preferably at least 10% by weight of iron.
- [0010] In preferred embodiments, the spun metal fiber yarn consists out of metal fibers. It means that the spun metal fiber yarn does not comprise other fibers than metal fibers.
- 30 [0011] The yarn can be used to produce heat resistant separation fabrics (e.g. knitted, woven or braided fabrics) for use as tool covering in the production process of glass products, e.g. of car glass, where the tool covering is in contact with glass at a temperature above the softening point of glass. Surprisingly, heat resistant separation fabrics made with the yarn of the invention have shown to have in conditions where they are mounted and
35 dismounted numerous times on tooling used in car glass production, excellent lifetime at temperatures over 680°C°, and for some embodiments of the invention even at temperatures over 750°C.
- Such mounting and dismounting and multiple times use is e.g. important when small series of car glass is produced; and the type of tool covering needs to be replaced when
40 other types of car glass needs to be produced.

[0012] In preferred embodiments the NiCr alloy or NiCrFe alloy comprises at least 50% by weight of nickel, more preferably at least 55% by weight of nickel. Preferably, such alloy comprises less than 70% by weight of nickel. Preferably, the alloy comprises at least 20% by weight of chromium. Preferably, the alloy comprises less than 30% by weight of chromium, more preferably less than 25% by weight of chromium.

[0013] An example of a suitable alloy for the second alloy is UNS N06601, and/or its equivalent designation 2.4851 according EN10088-1:2005. This alloy has nickel content between 58 and 63 % by weight and chromium content between 21.0 and 25.0 % by weight.

[0014] Another example of a suitable alloy for the second alloy comprises more than 50 % by weight of nickel (e.g. between 50 and 57 % by weight, e.g. between 53 and 56 % by weight), about 23 % by weight of chromium, about 16 % by weight of molybdenum, at maximum 3% by weight of iron, about 1.6 % by weight of copper, at maximum 0.08 % by weight of silicon and at maximum 0.01 % by weight of carbon. An example of this alloy is commercially available as Hastelloy C2000.

[0015] Another example of a suitable alloy for the second alloy comprises between 44 and 56 % by weight of nickel, between 20 and 24 % by weight of chromium, about 3 % by weight of iron, between 8 and 10 % by weight of molybdenum and between 10 to 15 % by weight of cobalt. An example of this alloy is commercially available as Inconel 617.

[0016] In preferred embodiments, the equivalent diameter of the staple fibers out of a first alloy is between 6.5 and 22 μm , preferably between 8 and 12 μm . With equivalent diameter of the staple fibers is meant the diameter of a circle that has the same cross sectional area as the cross section of the fiber that is not necessarily having a circular cross section.

[0017] In preferred embodiments, the equivalent diameter of the staple fibers out of a second alloy is between 6.5 and 22 μm , preferably between 8 and 12 μm .

[0018] In a preferred embodiment, the staple fibers out of the first alloy and the staple fibers out of the second alloy have substantially the same equivalent diameter.

[0019] Preferably, the staple fibers out of the first alloy and/or the staple fibers out of the second alloy are manufactured using the known bundled drawing technology, as is e.g. described in in US-A-2050298.

[0020] In a preferred embodiment, the spun metal fiber yarn comprises an intimate blend of staple fibers. The intimate blend comprises staple fibers out of the first alloy and staple fibers out of the second alloy.

The spun metal fiber yarn of the invention can be a plied yarn, e.g. a two-ply or a three-ply yarn. One ply, two plies and/or more preferably each of the plies of the yarn can comprise an intimate blend of staple fibers, wherein the intimate blend comprises staple fibers out of the first alloy and staple fibers out of the second alloy. Preferably all plies of the plied yarn have the same fiber composition. In a preferred embodiment, the spun

metal fiber yarn consists out of an intimate blend of staple fibers out of the first alloy and staple fibers out of the second alloy.

[0021] In preferred embodiments, the spun metal fiber yarn is a plied yarn. The plied yarn comprises at least one ply comprising or consisting out of a single yarn out of staple fibers out of the first alloy; and at least one ply comprising or consisting out of a single yarn out of staple fibers out of the second alloy.

[0022] In preferred embodiments, the spun metal fiber yarn comprises or consists out of a core-sheath metal fiber yarn. The core of the yarn comprises or consists out of staple fibers out of the first alloy; and the sheath comprises or consists out of staple fibers out of the second alloy.

In a further preferred embodiment, the spun metal fiber yarn comprises two or more plied core-sheath metal fiber yarns, wherein the core of each of the core-sheath metal fiber yarn comprises or consists out of staple fibers out of the first alloy; and the sheath comprises or consists out of staple fibers out of the second alloy.

[0023] A preferred metal fiber yarn comprises a strand. The strand comprises or consists out of staple fibers out of the first alloy. The strand is wrapped with a strand comprising or consisting out of staple fibers out of the second alloy.

In a further preferred embodiment, the spun metal fiber yarn comprises or consists out of a plied yarn. In the plied yarn, each of the yarns comprise a strand, wherein the strand comprises or consists out of staple fibers out of the first alloy; and wherein the strand is wrapped with a strand comprising or consisting out of staple fibers out of the second alloy.

[0024] Preferred yarn counts of the spun metal fiber yarn are between 7.5 and 4.25 Nm (meaning between 133 tex and 235 tex), more preferably between 9 Nm and 5 Nm (meaning between 110 tex and 200 tex). Preferably, such yarns are two ply or three ply yarns.

[0025] In a preferred embodiment, the first alloy is an austenitic stainless steel alloy, comprising preferably more than 16 % by weight of chromium, more preferably more than 17% by weight of chromium and preferably less than 28% by weight of chromium. Preferably, the first alloy comprises more than 6% by weight of nickel, more preferably more than 9% by weight of nickel, even more preferably more than 12% by weight of nickel, even more preferably more than 15% by weight of nickel. Preferably, the first alloy comprises less than 25 % by weight of nickel.

[0026] In a preferred embodiment, the first alloy comprises between 17 to 18 % by weight of chromium, between 12 to 15% of nickel, between 2 and 2.5% by weight of molybdenum,

less than 0.1 % by weight of nitrogen and less than 0.03 % of carbon. The indicated limiting values for chromium content and for nickel content of the first alloy may be combined while staying within the scope of the invention.

[0027] In a preferred embodiment, the first alloy is a stainless steel alloy of the 300 series according to ASTM A313. Preferred examples are 316, 316L and 347 (according to ASTM A313). The use of alloy 347 according to ASTM A313 as first alloy has shown to provide inventive spun metal fiber yarns that in heat resistant separation fabrics result in surprisingly low sagging values when used at higher temperatures, e.g. at 780°C, in glass panel processing.

[0028] In a preferred embodiment, in the yarn, the weight ratio of fibers out of the second alloy to the weight ratio of the fibers out of the first alloy is at least 0.5, more preferably at least 0.6.

[0029] In a preferred embodiment, in the yarn, the weight ratio of fibers out of the first alloy to the fibers out of the second alloy is between 20/80 and 80/20, preferably between 30/70 and 70/30, more preferably between 60/40 and 40/60, e.g. 50/50.

[0030] The second aspect of the invention is a heat resistant separation fabric for use as tool covering in the production of glass products at temperatures over 680°C, more preferably over 740°C. The heat resistant separation fabric can e.g. be a knitted fabric, preferably a weft knitted fabric; or can e.g. be sleeve, preferably a knitted sleeve, e.g. for covering a roller. The heat resistant separation fabric comprises or consists out of spun metal fiber yarns as in any embodiment of the first aspect of the invention. Preferably, the heat resistant separation fabric has a specific weight between 500 and 1800 g/m², more preferably between 700 and 1300 g/m².

[0031] In a preferred embodiment, the heat resistant separation fabric comprises or consists out of a knitted (e.g. a weft knitted fabric), a woven or a braided fabric.

[0032] In an exemplary embodiment, the heat resistant separation fabric is a weft knitted fabric comprising or consisting out of spun metal fiber yarns as in the first aspect of the invention, for covering a mold for bending glass plates at elevated temperatures of at least 680°C, e.g. of at least 740°C. For such an application, preferably the first alloy is alloy 316 according to ASTM A 313; or the first alloy is alloy 316L according to ASTM A 313; or the first alloy comprises between 17 to 18 % by weight of chromium, between 12 to 15% of nickel, between 2 and 2.5% by weight of molybdenum, less than 0.1 % by weight of nitrogen and less than 0.03 % of carbon.

[0033] In another exemplary embodiment, the heat resistant separation fabric is a sleeve, preferably a knitted sleeve, more preferably a weft knitted sleeve, for covering a roller. For such an application, preferably the first alloy is alloy 316 according to ASTM A 313; or the first alloy is alloy 316L according to ASTM A 313; or the first alloy is alloy 347 according to ASTM A 313; or the first alloy comprises between 17 to 18 % by weight of

chromium, between 12 to 15% of nickel, between 2 and 2.5% by weight of molybdenum, less than 0.1 % by weight of nitrogen and less than 0.03 % of carbon.

[0034] In a preferred embodiment, all fibers in the heat resistant separation fabric are metal fibers.

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[0035] The third aspect of the invention is a method of using a heat resistant separation fabric as in the second aspect of the invention. The method comprises the step of covering tooling in glass production with the heat resistant separation fabric. In use the temperature of the heat resistant separation materials is higher than 680°C, preferably higher than 700°C, more preferably higher than 720°C. The tooling covered with the heat resistant separation fabric is brought in contact with glass panels. Such tooling can e.g. be rollers for the transport of glass panels or molds for bending glass panels.

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Brief Description of the Drawings

15 [0036] Figure 1 shows an example of a spun yarn according to the invention.
Figure 2 shows another example of a spun yarn according to the invention.
Figure 3 shows another example of a spun yarn according to the invention.
Figure 4 shows another example of a spun yarn according to the invention.

20 Mode(s) for Carrying Out the Invention

[0037] Figure 1 shows a metal fiber yarn **100** that has been spun out of 50% by weight 12 µm equivalent diameter fibers **160** out of alloy 347 (according to ASTM A 313) and 50% by weight 12 µm equivalent diameter fibers **170** out of alloy UNS N06601. Both metal fiber types have been made by means of bundled drawing. The bundles of fibers of continuous length made via bundled drawing have been transformed into staple fibers by means of stretch breaking. By blending stretch broken slivers of fibers of both alloys, an intimate blend with a precise blend ratio is obtained. The yarns have been spun by means of ring spinning, on a long staple type ring spinning frame. The yarns have been ply twisted into a two ply yarn **100** (the two plies are indicated by reference **110** and **120**) of count 11/2 Nm (90*2 tex). The plied yarn has been knitted into a single jersey fabric of 780 g/m² that has been tested; this is sample A for the comparative testing.

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The behavior of sample A has been compared with a sample of the same yarn and fabric construction but where the spun yarns consisted for 100% out of 12 µm equivalent diameter fibers out of alloy 347 (sample B for the comparison); and with a sample of the same yarn and fabric construction but where the spun yarns consisted for 100% out of 12 µm equivalent diameter fibers out of alloy UNS N06601 (sample C for the comparison).

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[0038] Inventive sample A showed the benefit that it can be removed from a tooling after use in hot glass processing, and be put on again and re-used. A comparison was made at 680°C. Sample C tears very easily when the tooling has cooled down and the fabric is to

be removed from the tooling, making it extremely difficult and in most cases impossible to reuse the sample. Sample B showed much less lifetime in multiple use than sample A.

[0039] Sample A showed excellent behaviour at high temperature. After keeping the sample during 24 hours at 750°C, the sample still showed a good appearance and good performance characteristics, such as strength and elongation of the sample in tensile loading.

[0040] The samples have been tested in cyclic impact loading mode at a temperature of 680°C. In the test method, a fabric sample is attached onto a metal plate. The plate with the sample is heated up to the test temperature - here 680°C – and a knife blade is pressed with a preset force of 60 N onto the fabric, simulating contact of glass plates with the fabric in use of the fabric. After 2000 cycles, the wear and damage of the fabric is visually observed. Inventive sample A showed a remarkably slower wear and less damage in the cyclic impact loading test than sample B; and then sample C.

[0041] Samples A, B and C have been compared in sagging simulation. Sagging is the heat resistant separation fabric coming somewhat loose from the surface of the tooling when the tooling is brought in use at high temperature. Sagging is believed to be caused by creep phenomena in the fibers. Sagging can cause quality problems in glass that is contacted by a sagging fabric. In sagging simulation, a fabric is clamped in a ring. The ring with the clamped sample is put in an oven at high temperature (here 680°C), a plunger is pushed into the fabric until a specific force is attained, after which the plunger is withdrawn. This is repeated 500 times. Sagging is expressed as the increase in distance the plunger has to travel before it touches the fabric and force is build up. Sample A shows significantly less sagging compared to sample B: Sample B showed a result of 32.4 mm, whereas sample A showed a result of 30.3 mm. Sample C showed a result of 38.4 mm. Experience has shown that for excellent performance, fabrics should have a result below 31 mm on this test set up.

Sagging of sample A was measured at a temperature of 780°C as well. Surprisingly, a more than excellent result of 26.3 mm was obtained. Better (lower) sagging values result in better quality glass panels made with the inventive heat resistant separation fabrics.

[0042] Yarns have been spun out of blends of 12 µm equivalent diameter fibers out of a 316L-related alloy; and out of 12 µm equivalent diameter fibers out of alloy UNS N06601. The 316L-related alloy has the same specification as alloy 313L (according to ASTM A 313) but with a modified nickel content (between 12 and 15 % by weight), a modified chromium content (between 17 and 18 % by weight) and a modified molybdenum content (between 2 and 2.5 % by weight). Both metal fiber types have been made by means of bundled drawing, as is e.g. described in in US-A-2050298. The bundles of fibers of continuous length have been transformed into staple fibers by means of stretch breaking. By blending stretch broken slivers of fibers of both alloys, an intimate blend of both fibers with precise blend ratio is obtained. Two different spun metal fiber yarns have been

made. The first yarn was spun from an intimate blend consisting out of 60% by weight of fibers out of the 316L-related alloy and 40% by weight of fibers out of alloy UNS N06601. The second yarn has been spun from an intimate blend consisting out of 80% by weight of fibers out of the 316L-related alloy and 20% by weight of fibers out of alloy UNS N06601. The yarns have been spun by means of ring spinning, on a long staple type ring spinning frame. The yarns have been ply twisted into a two ply yarn of count 11/2 Nm (90*2 tex). The plied yarns have been knitted into single jersey fabrics of 780 g/m² that have been tested, these are samples D (fabric made with the first yarn, comprising the 60/40 blend ratio) and E (fabric made with the second yarn, comprising the 80/20 blend ratio).

The fabrics D and E showed improved wear resistance and could be heated to 680° and cooled down multiple times without damage to the fabric. Also wear resistance in impact loading showed to be very good.

Samples D and E showed excellent sagging results at the test temperature of 680°C: 25.8 mm for sample D and 26.6 mm for sample E; which are better results than fabrics out of yarns with single fiber composition 316L-related alloy or with single fiber composition alloy UNS N06601.

[0043] Sample D has been analyzed via SEM (Scanning Electron Microscopy) after heating it to 780°C in air. Surprisingly, it was observed that the fibers out of the stainless steel alloy had not been much attacked by the heating in air.

The SEM images on 100% stainless steel fiber fabric (made with yarns consisting out of the same stainless steel fibers as the stainless steel fibers of the first alloy present in sample D) that had undergone the same treatment (same temperature of 780°C, same duration, same atmosphere) showed that the fibers had been corroded to a large extent, showing a scaly oxide surface. The fabric, yarn and fibers had become brittle, making them unsuitable.

Surprisingly, it seems that in the inventive yarn the presence of fibers of the second alloy protects the fibers of the first alloy when the yarn is brought to high temperature.

[0044] Figure 2 shows another example of the first aspect of the invention. A spun two ply yarn **200** consists out of two plies **212**, **214**. The first ply **212** consists out of a single yarn out of 12 µm equivalent diameter fibers **262** out of 316L stainless steel alloy. The second ply **214** consists out of 12 µm equivalent diameter fibers **272** out of alloy UNS N06601. Both plies have a count 11 Nm (90 tex).

[0045] Another example of the first aspect of the invention is a core-sheath metal fiber yarn as can be spun by means of friction spinning, e.g. using the DREF-spinning system. Figure 3 shows the cross section **300** of such a yarn. The core **330** of the spun yarn consists out of 12 µm equivalent diameter fibers **364** out of 316L stainless steel alloy. The sheath **340**

consists out of 12 μm equivalent diameter fibers **374** out of alloy UNS N06601. Although other weight percentages of both fiber types are possible, the 180 tex (Nm 5.5) yarn was spun using equal quantities of both fiber types.

- 5 [0046] Figure 4 shows yet another example of the first aspect of the invention: the yarn **400** comprises a first strand **416** consisting out of 12 μm equivalent diameter fibers **466** out of 316L stainless steel alloy. This first strand **416** is wrapped with a strand **426** consisting out of 12 μm equivalent diameter fibers **476** out of alloy UNS N06601. In the example, both strands **416**, **426** have the same linear weights.

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- [0047] The listed examples have all been made with fibers of 12 μm equivalent diameter. The invention is not limited to fibers of this equivalent diameter. The use of the invention is not limited to the metal alloys of the specific examples described in the section *Mode(s) for Carrying Out the Invention*. Also other yarn counts can be made besides the yarn counts
- 15 of the specific examples.

Claims

1. Spun metal fiber yarn, comprising
 - staple fibers out of a first alloy, wherein the first alloy is a stainless steel alloy; and
 - staple fibers out of a second alloy, wherein the second alloy is a NiCr alloy or a NiCrFe alloy,wherein the NiCr or NiCrFe alloy comprises at least 40% by weight of nickel and at least 14% by weight of chromium.
2. Spun metal fiber yarn as in claim 1, wherein the spun metal fiber yarn comprises an intimate blend of staple fibers, wherein said intimate blend comprises
 - staple fibers out of said first alloy; and
 - staple fibers out of said second alloy.
3. Spun metal fiber yarn as in claim 1, wherein the spun metal fiber yarn is a plied yarn, wherein the plied yarn comprises
 - at least one ply comprising or consisting out of a single yarn out of staple fibers out of said first alloy;
 - and at least one ply comprising or consisting out of a single yarn out of staple fibers out of said second alloy.
4. Spun metal fiber yarn as in claim 1, wherein the spun metal fiber yarn comprises or consists out of a core-sheath metal fiber yarn;
wherein the core of the yarn comprises or consists out of staple fibers out of said first alloy;
and wherein the sheath comprises or consists out of staple fibers out of said second alloy.
5. Spun metal fiber yarn as in claim 1, wherein the yarn comprises a strand, wherein said strand comprises or consists out of staple fibers out of said first alloy;
and wherein said strand is wrapped with a strand comprising or consisting out of staple fibers out of said second alloy.
6. Spun metal fiber yarn as in any of the preceding claims,
wherein the first alloy is an austenitic stainless steel alloy, comprising more than 16% by weight of chromium;
and wherein the first alloy comprises more than 6% by weight of nickel.
7. Spun metal fiber yarn according to any of the preceding claims, wherein the first alloy is a stainless steel alloy of the 300 series according to ASTM A313.
8. Spun metal fiber yarn as in any of the preceding claims, wherein the stainless steel alloy is alloy 347 according to ASTM A313.

9. Spun metal fiber yarn as in any of the preceding claims, wherein in the yarn the weight ratio of fibers out of the second alloy to the weight ratio of the fibers out of the first alloy is at least 0.5.
- 5 10. Spun metal fiber yarn as in any of the claims 1 - 8, wherein in the yarn the ratio by weight of fibers out of the first alloy to the fibers out of the second alloy is between 20/80 and 80/20.
11. Heat resistant separation fabric for use as tool covering in the production of glass products at temperatures over 680°C; wherein the heat resistant separation fabric comprises or consists
10 out of spun metal fiber yarns as in any of the preceding claims.
12. Heat resistant separation fabric as in claim 11, wherein the heat resistant separation fabric comprises or consists out of a knitted, a woven or a braided fabric.
- 15 13. Heat resistant separation fabric as in claims 11 or 12, wherein the separation fabric is a sleeve for covering a roller.
14. Method of using a heat resistant separation fabric as in any of the claims 11 to 13, comprising the step of covering tooling in glass production with the heat resistant separation fabric;
20 wherein in use the temperature of the heat resistant separation fabric is higher than 680°C; and wherein the tooling covered with the heat resistant separation fabric is brought in contact with glass panels.

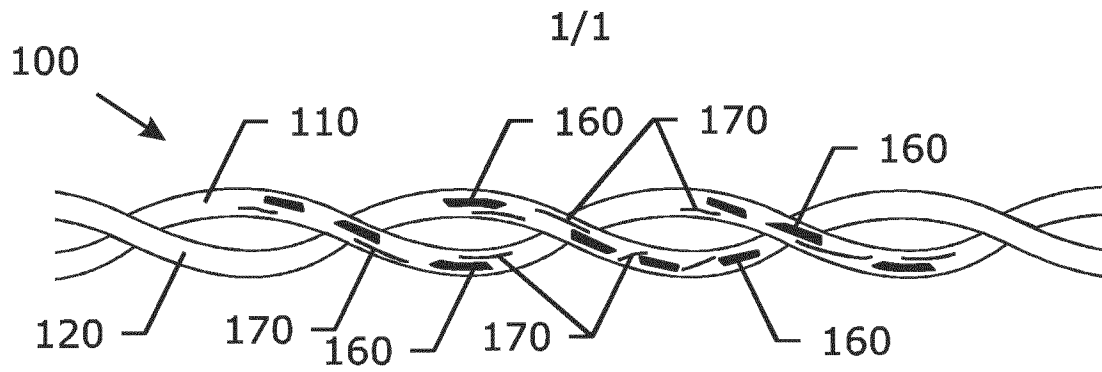


Fig. 1

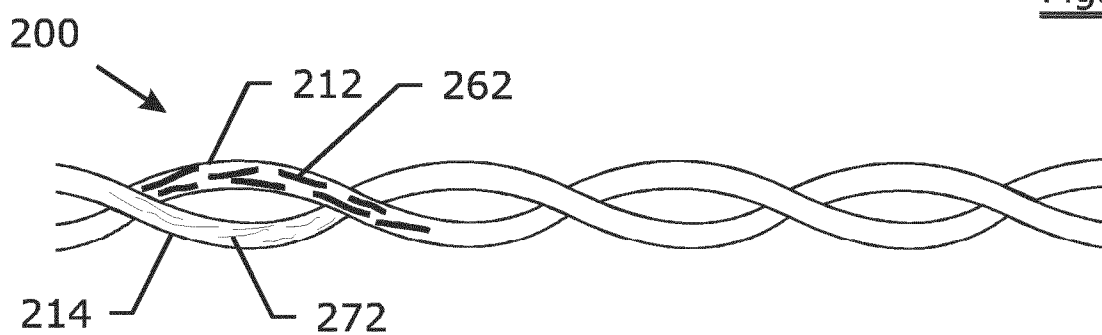


Fig. 2

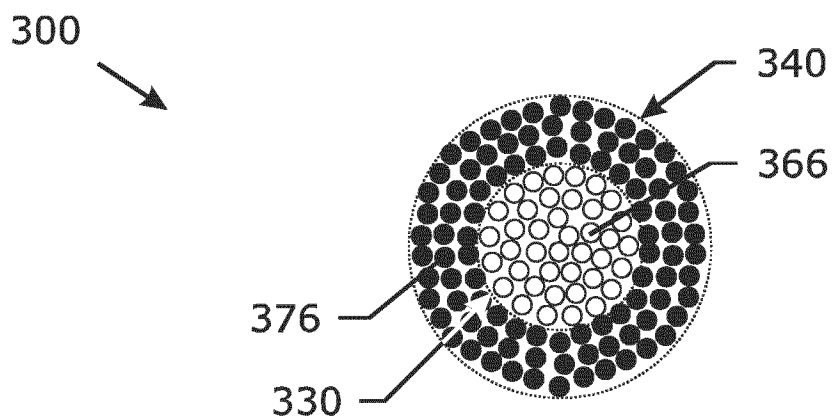


Fig. 3

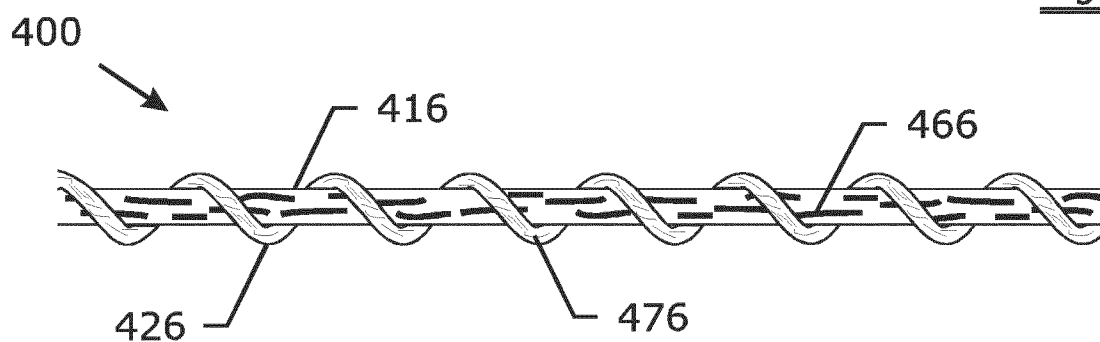


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/052116

A. CLASSIFICATION OF SUBJECT MATTER
INV. D02G3/12 C03B35/18
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)
D02G C03B D03D D04B A41D H05B B60N D04C

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/166793 A1 (FNV BEKAERT SA [BE]) 16 October 2014 (2014-10-16) cited in the application paragraph [0001]; claim 1 paragraph [0007] - paragraph [0009] paragraph [0015] - paragraph [0018] paragraph [0028] - paragraph [0031] paragraph [0043] -----	1-14
A	FR 2 868 439 A1 (SAINT GOBAIN QUARTZ SAS [FR]) 7 October 2005 (2005-10-07) cited in the application page 1, line 8 - line 11 page 2, line 4 - line 21 page 4, line 30 - page 6, line 20 ----- -/-	1-5, 11, 14



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

7 April 2016

Date of mailing of the international search report

18/04/2016

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/052116

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/174698 A1 (BEKAERT SA NV [BE]) 28 November 2013 (2013-11-28) paragraph [0001] paragraph [0012] paragraph [0028] paragraph [0036] paragraph [0039] -----	1,11,14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/052116

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