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(54) STRAPPING MACHINE AND METHOD FOR SECURING A PIECE OF METAL STRAP IN A LOOP AROUND ONE OR MORE OBJECTS

(57) A strapping machine comprising:
- a feeding device for feeding a strap (3) around one or more objects and subsequently retracting the strap to draw it tightly around said objects;
- a welding device for forming a welded joint between a first section at the leading end of the strap and an overlapping second section at the trailing end of a piece (3a) of the strap fed around said objects to thereby secure this piece in a loop around the objects;
- a support member (24) for supporting said overlapping strap sections during the formation of the joint, a recess (25) being provided in an upper support surface (26) on the support member; and
- a pressing element (27) with a shape adapted to the shape of said recess, the pressing element and support member being configured to form a permanent bulge (30) on the first strap section by a press forming action between the pressing element and the support member.

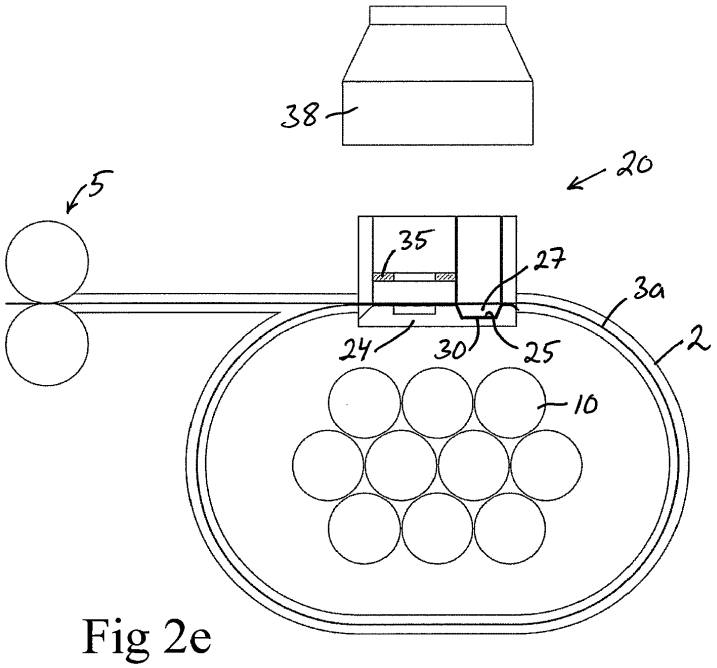

Fig 2e

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Description

FIELD OF THE INVENTION AND PRIOR ART

[0001] The present invention relates to a strapping machine according to the preamble of claim 1. The invention also relates to a method according to the preamble of claim 9 for securing a piece of metal strap in a loop around one or more objects.

[0002] Automatic strapping machines for applying a metal strap in a loop around an object or a bundle of objects, drawing the strap tightly around the object/bundle and thereafter joining overlapping sections of the strap in order to secure the strap around the object/bundle are known in many different configurations. WO 2017/129679 A1 discloses a strapping machine where a welding device is used for forming a welded joint between overlapping sections of a metal strap to thereby secure the metal strap in a loop around an object or a bundle of objects. This known strapping machine comprises a gripping device for gripping and locking a first strap section at the leading end of the strap after the application of a piece of the strap in a loop around the object/bundle and before the strap is retracted in order to draw it tightly around the object/bundle, wherein the gripping device is configured to grip the strap at an area that will form part of the final strap loop on the object/bundle and that will be subjected to tensile stress when the strap loop has been released from the strapping machine. This is the normal gripping position for a gripping device of a strapping machine to be used for strapping an object or a bundle of objects with a strap of metallic material.

SUMMARY OF THE INVENTION

[0003] The object of the present invention is to achieve a new and favourable strapping machine of the above-mentioned type.

[0004] According to the invention, this object is achieved by means of a strapping machine having the features defined in claim 1.

[0005] The strapping machine of the present invention comprises:

- a welding device for forming a welded joint between a first strap section at a leading end of a piece of metal strap arranged in a loop around one or more objects to be strapped and an overlapping second strap section at a trailing end of said strap piece to thereby secure this strap piece in a loop around said one or more objects;
- a strapping unit which comprises a support member for supporting said overlapping first and second strap sections during the formation of the welded joint, wherein a recess is provided in an upper support surface on the support member; and
- a feeding device for feeding the strap through the strapping unit, in a loop around an object receiving space configured for receiving one or more objects to be strapped and then back into the strapping unit and subsequently retracting the strap to draw it tightly around one or more objects received in the object receiving space.

According to the invention, the strapping unit comprises a pressing element, which has a shape adapted to the shape of the recess in the support member so as to allow the pressing element to be received in this recess. The strapping unit further comprises an actuating device which is configured to move the pressing element and the support member in relation to each other between a first mutual position, in which the pressing element is positioned at a distance from the recess in the support member, and a second mutual position, in which the pressing element is received in said recess, wherein the pressing element and the support member are configured to form a permanent bulge on the first strap section at a position between the leading end of said strap piece and said welded joint by a press forming action between the pressing element and the support member when the pressing element and the support member are moved in relation to each other by the actuating device from said first mutual position to said second mutual position with a part of the first strap section received in the space between the pressing element and the support member.

[0006] The permanent bulge formed on the first strap section will together with the pressing element and the recess in the support member, and as long as the pressing element and the support member are made to remain in the above-mentioned second mutual position, ensure that the first strap section is locked to the strapping unit with a positive locking effect and thereby prevented from slipping in the longitudinal direction of the strap when the feeding device retracts the strap and draws it tightly against the object or bundle of objects to be strapped. Hereby, the leading end of the strap is locked to the strapping unit in an efficient and reliable manner. Furthermore, the bulge formed on the first strap section will be located between the leading end of the strap and the welded joint between the first and second strap sections, i.e. on a part of the strap piece that will not be subjected to any tensile stress when the strap piece has been released from the strapping unit. Thus, the weakening deformation caused by the pressing element and the support member on the strap piece at the area of the bulge will not have any negative effect on the strength of the loop formed by the strap piece, in contrast to the previously mentioned normal case when the strap is gripped and subjected to a weakening deformation on the opposite side of the welded joint, i.e. on a part of the strap piece that will be subjected to tensile stress when the strap piece has been released from the strapping unit. In the latter, previously known case, the weakening deformation on the strap piece caused by the gripping of the first strap section will have a negative effect on the strength of the loop formed by the strap piece.

[0007] When the strap piece has been released from the strapping unit, the bulge formed on the strap piece by the pressing element will be pressed against an outer surface on the object/bundle and act as a spacer between the object/bundle and the loop formed by the strap piece. Hereby, the bulge will contribute to an increased tensional force in the loop and thereby an improved strapping effect. The gap formed between the loop and the outer surface of the object/bundle by the bulge will also facilitate a cutting of the loop in connection with a later destrapping operation when the metal strap is to be removed from the object/bundle.

[0008] Further advantageous features of the strapping machine according to the present invention will appear from the description following below and the dependent claims.

[0009] The invention also relates to a method having the features defined in claim 9.

[0010] Further advantageous features of the method according to the present invention will appear from the description following below and the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] With reference to the appended drawings, a specific description of embodiments of the invention cited as examples follows below. In the drawings:

Fig 1 is an outline diagram of a strapping machine according to an embodiment of the present invention,

Figs 2a-2i are partly cut outline diagrams of parts included in the strapping machine of Fig 1, as seen at different stages during the process of securing a strap piece in a loop around a bundle of objects,

Fig 3 is a schematic illustration of a support member and a pressing element included in the strapping machine of Fig 1, as seen with the pressing element located in a retracted position at a distance from an associated recess in the support member,

Fig 4 is a schematic illustration of the support member and pressing element, as seen with the pressing element in an advanced position received in the recess in the support member,

Fig 5 is a schematic lateral view of a strap piece secured in a loop around a bundle of objects,

Fig 6 is a planar view from above of the strap piece of Fig 5,

Fig 7 is a planar view from above of a part of a strap secured in a loop around one or more objects to be strapped, illustrating a heating area on the strap before the strap loop has been released from the remaining part of the strap,

Fig 8 is a planar view corresponding to Fig 7, as seen when the strap loop has been released from the remaining part of the strap,

Fig 9 is a cut according to the line IX-IX in Fig 8,

Fig 10 is a planar view from above of a part of a strap secured in a loop around one or more objects to be strapped, illustrating a break line on the strap before the strap loop has been released from the remaining part of the strap,

Fig 11 is a cut according to the line XI-XI in Fig 10,

Fig 12 is a planar view from above of a part of a strap secured in a loop around one or more objects to be strapped, illustrating an alternative type of break line on the strap before the strap loop has been released from the remaining part of the strap, and

Fig 13 is a cut according to the line XIII-XIII in Fig 12.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0012] Some of the parts included in a strapping machine 1 according to an embodiment of the present invention are very schematically illustrated in Fig 1. The strapping machine 1 comprises:

- a guide track 2 for guiding an elongated strap 3 of metallic material in a loop around a space 4 configured for receiving one or more objects 10 to be strapped;
- a strapping unit 20 for securing the strap 3 around said one or more objects 10;
- a feeding device 5 for feeding the strap 3 from a supply coil 6, through the strapping unit 20, into said guide track 2, along the guide track in a loop around said object receiving space 4 and then back into the strapping unit 20 and subsequently retracting the strap 3 to draw it tightly around one or more objects 10 received in said space 4; and
- an accumulator 9 for temporarily accumulating a part of the strap 3 when the binding element is retracted by the feeding device 5 and then releasing the accumulated part of the strap when the strap thereafter is fed forwards by the feeding device 5.

[0013] The guide track 2 may for instance have the form of a rail with a longitudinal opening facing said object receiving space 4. As an alternative, the strap may also be feed in a loop around the object or objects to be strapped without using any guide track. This may be accomplished by feeding the strap through a bending device that is configured to bend the strap in such a manner that it will move in free space, without contact with any guide track or the similar, in an essentially circular path around the object or objects 10 to be strapped, wherein a funnel-shaped guiding element may be arranged at the end of said path in order to catch the leading end of the strap and guide it into the strapping unit.

[0014] The object or objects 10 to be strapped may be positioned in the object receiving space 4 before, during or after the feeding of the strap 3 in a loop around this space 4.

[0015] As an alternative to the use of an accumulator 9, the slackening of the strap 3 when the strap is retracted by the feeding device 5 may be taken up or avoided by rotating the supply coil 6 in a reversed direction.

[0016] In the illustrated embodiment, the feeding device 5 comprises two rotatable feed rollers 5a, 5b, which are located opposite each other and configured to be in contact with opposite sides of a part of the strap 3 received in the nip between the feed rollers. At least one of the feed rollers 5a, 5b is rotatably driven by an actuator (not shown) in the form of a reversible drive motor in order to move the strap 3 in its longitudinal direction. The drive motor is preferably an electric motor, but it could as an alternative be a hydraulic or pneumatic motor. The feeding device 5 may also comprise any other suitable type of actuator for feeding and retracting the strap 3.

[0017] Some of the parts included in the above-mentioned strapping unit 20 are very schematically illustrated in Figs 2a-2i. The strapping unit 20 comprises a welding device 21 (see Fig 2a) for forming a welded joint 8 (see Figs 2h and 2i) between a first strap section 7a at a leading end of a piece 3a of metal strap arranged in a loop around one or more objects 10 to be strapped and an overlapping second strap section 7b at a trailing end of said strap piece 3a to thereby secure this strap piece 3a in a loop around said one or more objects 10. The welding device 21 is configured to form the welded joint 8 as a lap joint with the second strap section 7b overlapping the first strap section 7a.

[0018] The welding device 21 may be any suitable type of welding device. In the illustrated embodiment, the welding device 21 is a laser welding device provided with a laser welding head 22, wherein said welded joint 8 between the first and second strap sections 7a, 7b is formed by means of a laser beam 23 (see Fig 2g) emitted from the laser welding head. The welding device 21 comprises means of conventional type for directing and focusing the emitted laser beam 23 onto a desired target area.

[0019] The strapping unit 20 further comprises a support member 24 for supporting said overlapping first and second strap sections 7a, 7b during the formation of the welded joint 8. The support member 24 is configured to be located between the first strap section 7a and an outer surface of the object or objects 10 to be strapped during the formation of the welded joint 8. A recess 25 is provided in an upper support surface 26 on the support member 24. When the welded joint 8 has been formed, the support member 24 is moved laterally out of the area between the strapped object/objects 10 and the strap loop 11 (see Figs 2h and 2i) formed around the object/objects to thereby release the strap loop from the strapping unit 20.

[0020] In the examples illustrated in Figs 7-12, the welded joint 8 has an elliptical shape, as seen in a planar view. However, the welded joint 8 between the overlapping binding element sections 7a, 7b may of course also have any other suitable configuration.

[0021] The strapping unit 20 also comprises a pressing element 27, which has a shape adapted to the shape of the recess 25 in the support member 24 so as to allow the pressing element 27 to be received in this recess 25. The pressing element 27 has an upper surface 28 which is flush or at least essentially flush with the upper support surface 26 on the support member 24 when the pressing element 27 is received in the recess 25 in the support member, as illustrated in Fig 2a.

[0022] An actuating device 29 (very schematically illustrated in Fig 1) included in the strapping unit 20 is configured to move the pressing element 27 and the support member 24 in relation to each other between a first mutual position (see Figs 2c, 2d and 3), in which the pressing element 27 is located outside and at a distance from the recess 25 in the support member 24, and a second mutual position (see Figs 2a, 2b, 2e-2h and 4), in which the pressing element 27 is received in said recess 25. The pressing element 27 and the support member 24 are configured to form a permanent bulge 30 (see Figs 2e-2i, 4, 5 and 9) on the first strap section 7a by a press forming action between the pressing element 27 and the support member 24 when the pressing element 27 and the support member 24 are moved in relation to each other by the actuating device 29 from said first mutual position to said second mutual position with a part of the first strap section 7a received in the space between the pressing element 27 and the support member 24, wherein this bulge 30 is formed at a position between the leading end 12 of said strap piece 3a and the welded joint 8 to be formed by the welding device 21.

[0023] In the embodiment illustrated in Figs 2a-2i, the actuating device 29 is configured to achieve said relative movement between the pressing element 27 and the support member 24 by moving the pressing element 27 in relation to the support member 24. In this case, the pressing element 27 is moved downwards towards the support member 24 in order to achieve the movement from the first mutual position to the second mutual position and upwards away from the support member 24 in order to achieve the movement from the second mutual position to the first mutual position, wherein the support member 24 remains in a fixed position during the movements of

the pressing element 27. As an alternative, the actuating device 29 may be configured to achieve said relative movement between the pressing element 27 and the support member 24 by moving the support member 24 in relation to the pressing element 27 or by moving the pressing element 27 as well as the support member 24 in relation to each other.

[0024] The pressing element 27 is also moveable horizontally by means of the actuating device 29 in order to allow the pressing element to be moved laterally out of the bulge 30 when the first and second strap sections 7a, 7b have been secured to each other by the welding device 21 and the strap loop 11 thereby formed is to be released from the strapping unit 20. According to a first alternative, the pressing element 27 is formed as a single-part element and moveable out of the bulge 30 by a displacement in a horizontal direction. According to another alternative, the pressing element 27 is divided into two parts, which are located opposite each other and moveable out of the bulge 30 by being displaced laterally in opposite directions away from each other.

[0025] The support member 24 may comprise first and second support jaws located opposite each other in the manner shown in WO 2017/129679 A1, wherein the support jaws are moveable in relation to each other between an advanced supporting position, in which the support jaws form a support for the first strap section 7a, and a retracted releasing position, in which the support jaws are retracted from each other in order to allow the first and second strap sections 7a, 7b, after having been joined to each other, to pass through a gap between the support jaws. Each support jaw may be fixed to a pivot arm, which in its turn is pivotally mounted to a housing 36 of the strapping unit 20. Thus, in this case, the support jaws are pivotable between the supporting and releasing positions. As an alternative, the support jaws could be linearly moveable between the supporting and releasing positions. The support jaws are moveable between the supporting and releasing positions by means of the actuating device 29. As an alternative, the support member 24 is formed as a single-part member and moveable between the supporting and releasing positions by a displacement in a horizontal direction.

[0026] The actuating device 29 may be electrically, pneumatically or hydraulically driven and may comprise one or more electrically, pneumatically or hydraulically driven actuators.

[0027] The strapping unit 20 illustrated in Figs 2a-2i comprises a squeezing device 34 for squeezing the second strap section 7b against the first strap section 7a with the second strap section 7b overlapping the first strap section 7a, wherein the squeezing device 34 is configured to keep the second strap section 7b squeezed against the first strap section 7a during the moment when the welded joint 8 between the first and second strap sections 7a, 7b is formed by the welding device 21. In the illustrated example, the squeezing device 34 comprises a squeezing member 35 which is configured to cooperate with the support member 24 and which is moveably mounted to the housing 36 of the strapping unit 20. The first and second strap sections 7a, 7b are receivable in a space between the squeezing member 35 and the support member 24 and the squeezing member 35 is moveable in relation to the support member 24 between a retracted first position (see Figs 2a-2f, 2i and 3), in which the squeezing member 35 is retracted from the support member 24, and an advanced second position (see Figs 2g, 2h and 4), in which the squeezing member 35 is pressed against the support member 24 in order to squeeze together the first and second strap sections 7a, 7b. The squeezing member 35 is provided with a passage 37, through which a laser beam 23 from the laser welding head 22 of the welding device 21 may be directed towards an area on the second strap section 7b, in order to form the welded joint 8 between the first and second strap sections 7a, 7b, when the squeezing member 23 is in said second position and keeps the first and second strap sections 7a, 7b squeezed together between the squeezing member 35 and the support member 24. The squeezing member 35 is moveable between said first and second positions by means of an actuator (not shown), which may be electrically, pneumatically or hydraulically driven. The actuator is with advantage a hydraulic cylinder.

[0028] The support member 24, the pressing element 27 and the squeezing device 34 may of course also have any other suitable design in addition to the designs illustrated in Figs 2a-2i.

[0029] The strapping machine 1 further comprises an electronic control device 60 (very schematically illustrated in Fig 1) for controlling the operation of the strapping machine. The electronic control device 60 is connected to the welding device 21 and configured to control the welding device to direct and focus the laser beam 23 of the welding device onto a desired part of the strap 3. The electronic control device 60 is also connected to the feeding device 5, the actuating device 29 and the actuator of the squeezing device 34 and configured to control the operation thereof.

[0030] The electronic control device 60 is configured to control the feeding device 5 to stop the feeding of the strap 3 when the leading end 12 of the strap during its second passage over the support member 24 has passed over the recess 25 in the support member from a first end 25a (see Fig 3) of the recess to an opposite second end 25b thereof and has reached a final position beyond said second end 25b of the recess. The pressing element 27 and the support member 24 are thereafter moved in relation to each other, by a vertical movement downwards of the pressing element 27 and/or a vertical movement upwards of the support member 24, until the pressing element 27 has been received in the recess 25 and a permanent bulge 30 has been formed on the first strap section 7a. The strap 3 is thereafter retracted in order to draw it tightly around one or more objects 10 positioned in the object receiving space 4 of the strapping unit 20, wherein a part 15 (see Fig 4) of the second strap section

7b is pressed, under the effect of the tensional force in the strap 3, towards the upper support surface 26 on the support member 24 and tightly against a part 16 of the first strap section 7a located between said second end 25b of the recess 25 in the support member and the leading end 12 of the strap. Said part 16 of the first strap section 7a is hereby clamped between the support member 24 and the second strap section 7b during the tightening of the strap 3. The positive locking between the bulge 30 and the support member 24 and pressing element 27 will together with the clamping force exerted by said part 15 of the second strap section 7b on said part 16 of the first strap section 7a achieve a gripping and locking effect on the first strap section 7a and keep the first strap section locked to the support member 24 during the tightening of the strap 3.

[0031] The distance D between the above-mentioned first and second ends 25a, 25b of the recess 25 is at least 10 mm, preferably at least 15 mm. The recess 25 has a depth d of at least 5 mm, preferably at least 6 mm.

[0032] In the example illustrated in Figs 2a-2i, 3 and 4, the recess 25 and the pressing element 27 have a cross-sectional shape in the form of an isosceles trapezoid, as seen in a vertical plane. However, the recess 25 and the pressing element 27 may also have any other suitable cross-sectional shape.

[0033] The electronic control device 60 may be configured to control the welding device 21 to direct a laser beam 23 (see Fig 2h) onto an area 14 (see Figs 7, 10 and 12) extending across the strap 3 at the trailing end of the second strap section 7b, i.e. at the end of the second strap section 7b facing the feeding device 5, in order to reduce the tensile strength of the strap 3 at the trailing end of the second strap section 7b, wherein electronic control device 60 is configured to control the feeding device 5 to retract the strap 3 in order to subject said area 14 to tensile stress and thereby cause the strap to be broken off at the trailing end of the second strap section 7b. Hereby, the strap loop 11 arranged around the object or objects 10 to be strapped is released from the remaining part 3b of the strap. As an alternative, the electronic control device 60 may be configured to control the welding device 21 to cut off the strap 3 at the trailing end of the second strap section 7b by means of a laser beam 23 which cuts across the strap 3 in the entire thickness thereof, to thereby release the part 3a of the strap fed in a loop around said space 4 from the remaining part 3b of the strap.

[0034] The laser welding head 22 may comprise one or more computer-controlled scanning mirrors for controlling the direction and movement of the laser beam 23 emitted from the laser welding head. As an alternative, the direction and movement of the laser beam 23 may be controlled by computer-controlled movements of the entire laser welding head 22. The laser welding head 22 is provided with a focusing lens 38, through which the laser beam 23 leaves the laser welding head.

[0035] In the illustrated embodiment, the welding device 21 further comprises a laser source 39 (see Fig 2a) for generating the laser power required for producing the laser beam 23 used for forming the welded joint 8 between the first and second strap sections 7a, 7b and for releasing the strap loop 11 from the remaining part 3b of the strap. The laser source 39 can be of any type commonly used for welding. In the illustrated example, the laser source 39 is connected to the laser welding head 22 via an optical fibre cable 40, which is configured to guide the laser power generated by the laser source 39 to the laser welding head 22. The optical fibre cable 40 is in a conventional manner connected to the laser welding head 22 by means of an optical connector 41 comprising focusing optics. The focal point of the laser beam 23 emitted from the laser welding head 22 may be adjusted by computer-controlled movements of one or more optical members included in the focusing optics of the optical connector 41.

[0036] The electronic control device 60 may be configured to control the welding device 21 to reduce the tensile strength of the strap 3 at the trailing end of the second strap section 7b by heating the above-mentioned area 14 at the trailing end of the second strap section 7b under the effect of said laser beam 23 and without cutting or penetrating into the strap 3. In order to heat the area 14 at the trailing end of the second strap section 7b, the welding device 21 is made to sweep the laser beam 23 over the area 14 (schematically illustrated with dotted lines in Fig 7), which extends between the longitudinal edges 17a, 17b of the strap 3. In order to make sure that the laser beam 23 will heat the area 14 in question without cutting into the strap 3, the focal point of the laser beam 23 is adjusted, for instance by means of the above-mentioned focusing optics of the optical connector 41, in such a manner that the laser beam is out of focus when hitting the area 14 at the trailing end of the second strap section 7b. When the area 14 has been rapidly heated by the laser beam 23, the feeding device 5 is operated to pull the strap 3 backwards with such a force that the strap 3, under the effect of the tensile stress produced in the strap between the feeding device 5 and the second strap section 7b, is broken off at the heated area 14.

[0037] As an alternative, the electronic control device 60 may be configured to control the welding device 21 to reduce the tensile strength of the strap 3 at the trailing end of the second strap section 7b by forming one or more depressions 18, 18' (see Figs 10-13) across the strap 3 at the trailing end of the second strap section 7b under the effect of the laser beam 23 so as to thereby provide a break line 19 across the strap 3 at the trailing end of the second strap section 7b. In this case, the laser beam 23 is made to cut into the strap 3, but without cutting through it. The depressions 18, 18' may for instance have a depth corresponding to approximately half the thickness of the strap 3. The laser beam 23 is preferably prevented from reaching any of the longitudinal edges 17a, 17b of the strap 3 when forming the depressions 18, 18'. The break line 19 may be formed by several shorter de-

pressions 18 arranged in line with each other across the strap 3 at the trailing end of the second strap section 7b, as illustrated in Figs 10 and 11, or by one longer depression 18' extending across the strap 3 at the trailing end of the second strap section 7b, as illustrated in Figs 12 and 13. When the break line 19 has been formed by the laser beam 23, the feeding device 5 is operated to pull the strap 3 backwards with such a force that the strap 3, under the effect of the tensile stress produced in the strap between the feeding device 5 and the second strap section 7b, is broken off at the break line 19.

[0038] The electronic control device 60 may be implemented by one single electronic control unit or by two or more mutually cooperating electronic control units.

[0039] An operating sequence for securing a strap 3 in the form of a strap in a loop around a bundle of objects 10 by means of the above-described strapping machine 1 will now be described with reference to Figs 2a-2i.

[0040] In a first step, a motor of the feeding device 5 is operated in a first direction in order to feed the strap 3 forwards from the supply coil 6, through the strapping unit 20, in a loop around the object receiving space 4 of the strapping machine 1 and then back into the strapping unit 20. The leading end 12 of the strap is first moved over the support member 24 and the pressing element 27, thereafter in a loop around the object receiving space 4 and then into a space between the pressing element 27 and the recess 25 in the support surface 26 on the support member 24, wherein the feeding of the strap 3 is stopped when the leading end 12 of the strap has passed over said recess 25 from the first end 25a thereof to the opposite second end 25b thereof and has reached a final position beyond the second end 25b of the recess.

[0041] During the feeding of the strap 3, the squeezing member 35 is in its retracted first position.

[0042] In the illustrated example, the pressing element 27 is positioned in the recess 25 in the support member 24 before the initial feeding of the leading end 12 of the strap through the strapping unit 20 and maintained in the recess 25 until the leading end 12 of the strap has passed over the upper surface 28 of pressing element 27 and the upper support surface 26 on the support member 24, as illustrated in Figs 2a and 2b. Thus, in this case the upper surface 28 of pressing element 27 is flush or at least essentially flush with the upper support surface 26 on the support member 24 when the leading end 12 of the strap is fed through the strapping unit 20 before being fed around the object receiving space 4. The actuating device 29 thereafter effects a relative movement between the pressing element 27 and the support member 24 in order to cause the pressing element 27 to be positioned at a distance from the recess 25 in the support member 24, wherein the strap 3 is lifted by the pressing element 27 from the upper support surface 26 on the support member 24, as illustrated in Fig 2c.

[0043] When the strap 3 has been fed through the guide track 2 in a loop around the object receiving space 4, the leading end 12 of the strap 3 will leave the guide track 2 and pass through the gap between the pressing element 27 and the support member 24 (see Fig 2d), whereupon the leading end 12 of the strap 3 actuates a stop member (not shown) and the motor of the feeding device 5 is stopped. The actuating device 29 thereafter effects a relative movement between the pressing element 27 and the support member 24 in order to cause the pressing element 27 to be received in the recess 25 (see Fig 2e) and thereby form a permanent bulge 30 on the first strap section 7a by a press forming action between the pressing element 27 and the support member 24. Thereafter, the motor of the feeding device 5 is reversed in order to pull the strap 3 backwards and thereby tighten the strap 3 around the objects 10 received in the object receiving space 4, as illustrated in Fig 2f. As illustrated in Figs 2e and 2f, the strapping unit 20 and the guide track 2 are moveable in relation to the objects 10 and configured to move towards the objects 10 when the strap 3 is tightened around the objects. During the retraction of the strap 3, a part 15 of the second strap section 7b is pressed, under the effect of the tensional force in the strap 3, towards the upper support surface 26 on the support member 24 and tightly against a part 16 of the first strap section 7a located between the second end 25b of the recess 25 in the support member and the leading end 12 of the strap, whereby this part 16 of the first strap section 7a is clamped between the support member 24 and the second strap section 7b, as illustrated in Fig 4. During the retraction of the strap 3, the second strap section 7b comes into contact with the upper surface 28 of the pressing element 27 and thereby prevents the pressing element 27 from moving vertically out of the recess 25 in the support member 24. Hereby, the pressing element 27 will remain in the recess 25 during the tightening of the strap 3 without requiring that the pressing element 27 and the support member 24 are pressed against each other under the effect of the actuating device 29.

[0044] When the strap 3 has been drawn tightly around the objects 10, the motor of the feeding device 5 is stopped and the squeezing member 35 is moved to its advanced second position in order to squeeze together the first and second strap sections 7a, 7b between the squeezing member 35 and the support member 24 (see Fig 2g). The welding device 21 is then operated to focus a laser beam 23 onto the mutually overlapping strap sections 7a, 7b in order to form a welded joint 8 between the strap sections 7a, 7b. The strap 3 is thereby secured in a loop around the objects 10. Thereafter, the welding device 21 is operated to direct a laser beam 23 onto an area 14 across the strap 3 at the trailing end of the second strap section 7b in order to reduce the tensile strength of the strap 3 at the trailing end of the second strap section 7b, as illustrated in Fig 2h. The part of the strap extending between the squeezing member 35 and the feeding device 5 is with advantage held in a slacked state during the moment when the laser beam 23 is directed onto said area 14. Thereafter, the feeding device 5 is configured

to retract the strap 3 in order to subject said area 14 to tensile stress and thereby cause the strap to be broken off at the trailing end of the second strap section 7b. Finally, the squeezing member 35 is returned to its retracted first position and the pressing element 27 and support member 24 are removed from the bulge 30 on the first strap section 7a in order to release the strap loop 11 from the strapping unit 20. Hereby, the bulge 30 will come into contact with the objects 10 and will thereby act as a spacer between the objects 10 and the strap loop 11, as illustrated in Figs 2i and 5.

[0045] The intended welding area on the first and second strap sections 7a, 7b is with advantage preheated by means of a laser beam emitted from the laser welding head 22 of the welding device 21 before the formation of the welded joint 8. The welding area is preferably preheated to such a temperature that possible layers of paint and/or wax on the first and second strap sections 7a, 7b are removed by vaporization at the intended welding area. The pre-heating temperature is preferably also so adapted that the metallic material of the first and second strap sections 7a, 7b is subjected to metallurgical changes which result in improved welding conditions.

[0046] The welding area on the first and second strap sections 7a, 7b is with advantage also postheated by means of a laser beam emitted from the laser welding head 22 of the welding device 21 after the formation of the welded joint 8, wherein the post-heating temperature is so adapted that the metallic material of the first and second strap sections 7a, 7b is subjected to metallurgical changes which influence the strength of the welded joint 8 in a favourable manner.

[0047] In order to make sure that the laser beam will heat the welding area without cutting into the strap 3 in connection with the pre-heating and post-heating, the focal point of the laser beam is adjusted, for instance by means of the above-mentioned focusing optics of the optical connector 41, in such a manner that the laser beam is out of focus when hitting the second strap section 7b during the pre-heating step and the post-heating step. The pre-heating and post-heating laser beam is directed onto an outer surface of the second strap section 7b, wherein heat energy is transmitted from the second strap section 7b to the first strap section 7a by thermal conduction.

[0048] The invention is of course not in any way restricted to the embodiments described above. On the contrary, many possibilities to modifications thereof will be apparent to a person with ordinary skill in the art without departing from the basic idea of the invention such as defined in the appended claims. The strapping machine according to the present invention may for instance be design for co-operation with a compacting machine in order to strap a coil of wire compacted by the compacting machine. In the latter case, several strapping units are mounted to the compacting machine and used simultaneously in order to apply strap loops at different positions around the compacted coil of wire, wherein each strap loop extends along the inside of the coil through a central axial opening therein and along the outside of the coil.

Claims

1. A strapping machine for securing a piece (3a) of metal strap in a loop (11) around one or more objects, the strapping machine (1) comprising:

- a strapping unit (20) provided with:

  a welding device (21) for forming a welded joint (8) between a first strap section (7a) at a leading end of a piece (3a) of metal strap arranged in a loop around one or more objects (10) to be strapped and an overlapping second strap section (7b) at a trailing end of said strap piece (3a) to thereby secure this strap piece (3a) in a loop around said one or more objects (10), and

  a support member (24) for supporting said overlapping first and second strap sections (7a, 7b) during the formation of the welded joint (8); and

- a feeding device (5) for feeding the strap (3) through the strapping unit (20), in a loop around an object receiving space (4) configured for receiving one or more objects (10) to be strapped and then back into the strapping unit (20) and subsequently retracting the strap (3) to draw it tightly around one or more objects (10) received in the object receiving space (4);

characterized in:

- **that** a recess (25) is provided in an upper support surface (26) on the support member (24);
- **that** the strapping unit (20) comprises a pressing element (27), which has a shape adapted to the shape of the recess (25) in the support member (24) so as to allow the pressing element (27) to be received in this recess (25); and
- **that** the strapping unit (20) comprises an actuating device (29) which is configured to move the pressing element (27) and the support member (24) in relation to each other between a first mutual position, in which the pressing element (27) is positioned at a distance from the recess (25) in the support member (24), and a second mutual position, in which the pressing element (27) is received in said recess (25), wherein the pressing element (27) and the support member (24) are configured to form a permanent bulge (30) on the first strap section (7a) at a position between the leading end (12) of said strap piece

(3a) and said welded joint (8) by a press forming action between the pressing element (27) and the support member (24) when the pressing element (27) and the support member (24) are moved in relation to each other by the actuating device (29) from said first mutual position to said second mutual position with a part of the first strap section (7a) received in the space between the pressing element (27) and the support member (24).

2. A strapping machine according to claim 1, **characterized in that** the pressing element (27) has an upper surface (28) which is flush or at least essentially flush with the upper support surface (26) on the support member (24) when the pressing element (27) is received in said recess (25).

3. A strapping machine according to claim 1 or 2, **characterized in that** the actuating device (29) is configured to achieve said relative movement between the pressing element (27) and the support member (24) by moving the pressing element (27) in relation to the support member (24).

4. A strapping machine according to claim 1 or 2, **characterized in that** the actuating device (29) is configured to achieve said relative movement between the pressing element (27) and the support member (24) by moving the support member (24) in relation to the pressing element (27).

5. A strapping machine according to any of claims 1-4, **characterized in that** the recess (25) has a depth (d) of at least 5 mm, preferably at least 6 mm.

6. A strapping machine according to any of claims 1-5, **characterized in that** the strapping machine (1) comprises a squeezing device (34) for squeezing the second strap section (7b) against the first strap section (7a), wherein the squeezing device (34) is configured to keep the second strap section (7b) squeezed against the first strap section (7a) during the moment when the welded joint (8) between the first and second strap sections (7a, 7b) is formed by the welding device (21).

7. A strapping machine according to any of claims 1-6, **characterized in that** the welding device (21) is a laser welding device.

8. A strapping machine according to claim 7 in combination with claim 6, **characterized in:**

- **that** the squeezing device (34) comprises a squeezing member (35) which is configured to co-operate with the support member (24), wherein the first and second strap sections (7a, 7b) are receivable in a space between the squeezing member (35) and the support member (24) and wherein the squeezing member (35) is moveable in relation to the support member (24) between a retracted first position, in which the squeezing member (35) is retracted from the support member (24), and an advanced second position, in which the squeezing member (35) is pressed against the support member (24) in order to squeeze together the first and second strap sections (7a, 7b); and
- **that** the squeezing member (35) is provided with a passage (37), through which a laser beam (23) from a laser welding head (22) of the laser welding device (21) may be directed towards an area on the second strap section (7b) when the squeezing member (35) is in said second position and keeps the first and second strap sections (7a, 7b) squeezed together between the squeezing member (35) and the support member (24).

9. A method for securing a piece (3a) of metal strap in a loop (11) around one or more objects, the method comprising the steps of:

- feeding the strap (3) through a strapping unit (20) of a strapping machine (1) and in a loop around an object receiving space (4) of the strapping machine, wherein the leading end (12) of the strap is first fed over a support member (24) and a pressing element (27) of the strapping unit (20), thereafter in a loop around said object receiving space (4) and then into a space between the pressing element (27) and a recess (25) in an upper support surface (26) on the support member (24), the feeding of the strap being stopped when the leading end (12) of the strap has passed over said recess (25) from a first end (25a) thereof to an opposite second end (25b) thereof and has reached a final position beyond said second end (25b) of the recess;
- pressing a part of a first strap section (7a) at the leading end of the strap (3) into the recess (25) in the support member (24) by effecting a relative movement between the pressing element (27) and the support member (24) and thereby causing the pressing element (27) to be received in said recess (25) and a permanent bulge (30) to be formed on the first strap section (7a) by a press forming action between the pressing element (27) and the support member (24);
- retracting the strap (3) to draw it tightly around one or more objects (10) positioned in said object receiving space (4), wherein a part (15) of a second strap section (7b) at the trailing end of the piece (3a) of strap fed in a loop around the

object receiving space (4) is pressed, under the effect of the tensional force in the strap (3), towards the upper support surface (26) on the support member (24) and tightly against a part (16) of the first strap section (7a) located between said second end (25b) of the recess (25) in the support member and the leading end (12) of the strap to thereby clamp this part (16) of the first strap section (7a) between the support member (24) and the second strap section (7b); and
- forming, by means of a welding device (21) included in the strapping unit (20), a welded joint (8) between said first and second strap sections (7a, 7b) to thereby secure said strap piece (3a) in a loop (11) around said one or more objects.

10. A method according to claim 9, **characterized in that** said relative movement between the pressing element (27) and the support member (24) is effected by moving the pressing element (27) towards the support member (24).

11. A method according to claim 9, **characterized in that** said relative movement between the pressing element (27) and the support member (24) is effected by moving the support member (24) towards the pressing element (27).

12. A method according to any of claims 9-11, **characterized in:**

- **that** the pressing element (27) is positioned in the recess (25) in the support member (24) before the initial feeding of the leading end (12) of the strap through the strapping unit (20) and maintained in this recess (25) until the leading end (12) of the strap has passed over the pressing element (27) and the upper support surface (26) on the support member (24); and
- **that** a relative movement between the pressing element (27) and the support member (24) is thereafter effected in order to cause the pressing element (27) to be positioned at a distance from the recess (25) in the support member (24) to thereby lift the strap (3) from the upper support surface (26) on the support member (24) and allow the leading end (12) of the strap to pass into the space between the pressing element (27) and the upper support surface (26) on the support member (24) when the leading end of the strap returns to the strapping unit (20) after having passed around the object receiving space (4).

13. A method according to claim 12, **characterized in that** the last-mentioned relative movement between the pressing element (27) and the support member (24) is effected by moving the pressing element (27) away from the support member (24).

14. A method according to claim 12, **characterized in that** the last-mentioned relative movement between the pressing element (27) and the support member (24) is effected by moving the support member (24) away from the pressing element (27).

15. A method according to any of claims 9-14, **characterized in that** the distance (D) between the first end (25a) of the recess (25) and the second end (25b) of the recess (25) is at least 10 mm, preferably at least 15 mm.

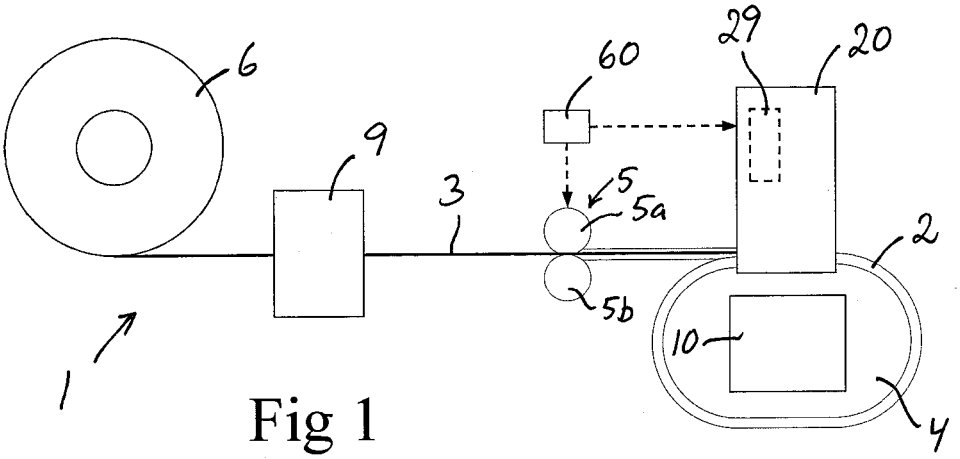
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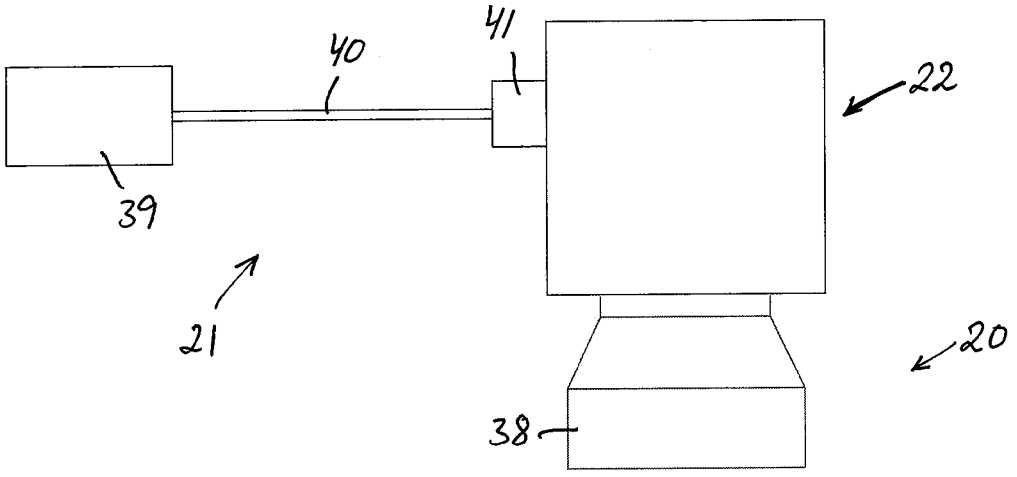
Fig 1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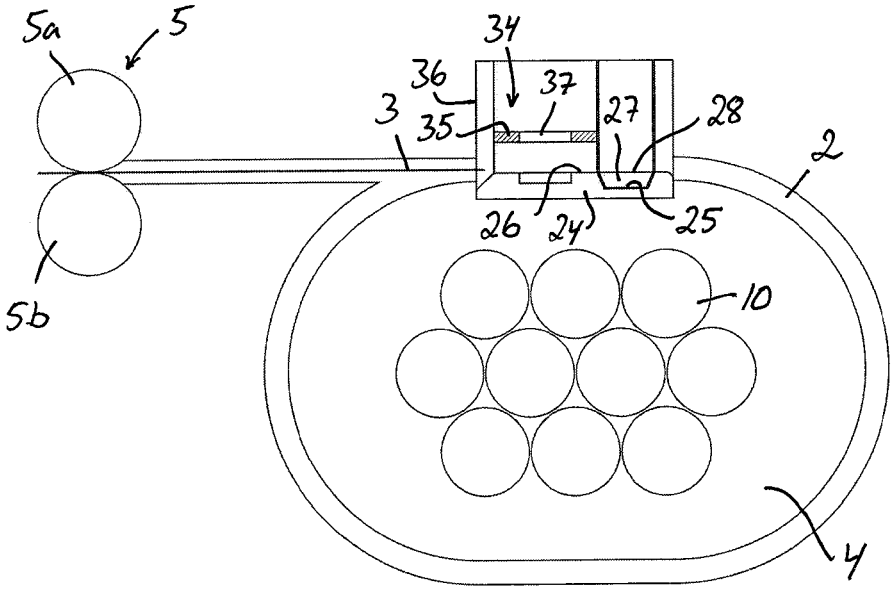
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5b
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Fig 2a

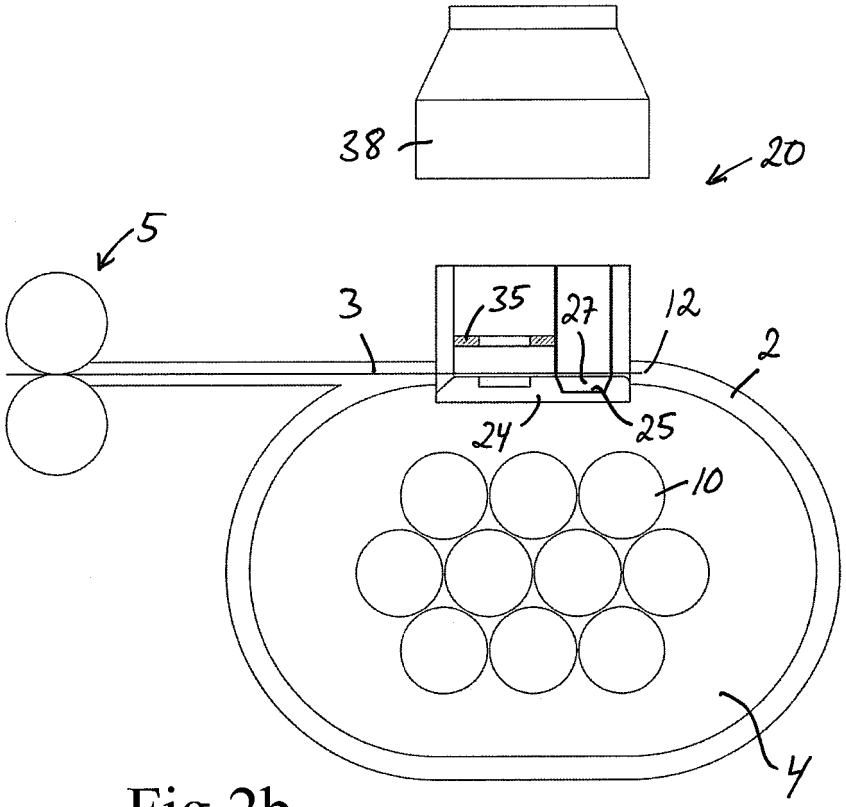


Fig 2b

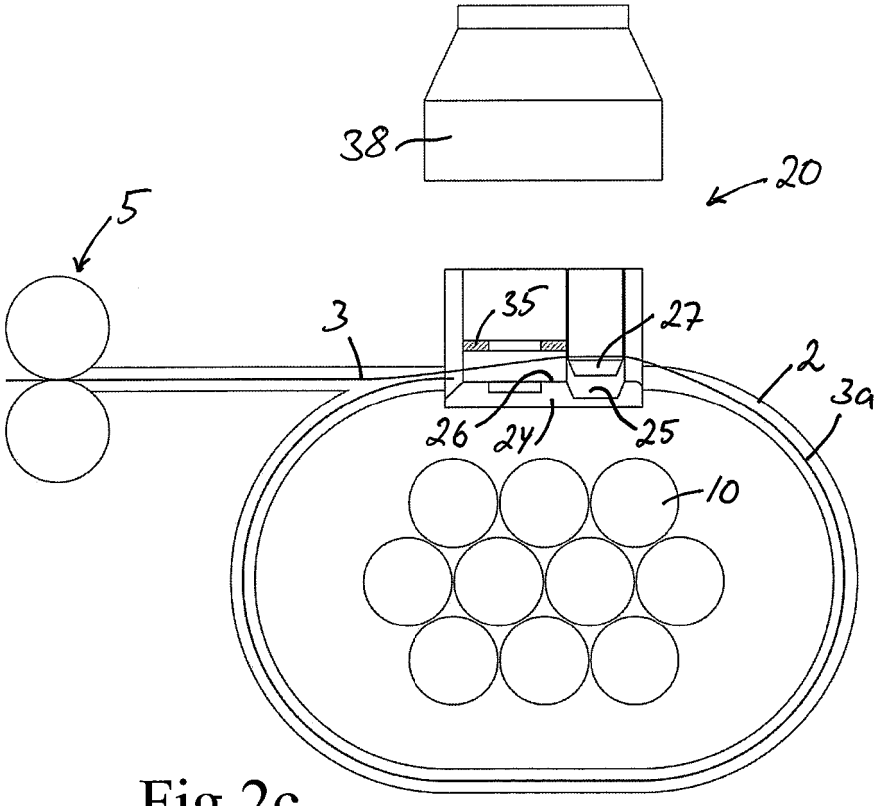


Fig 2c

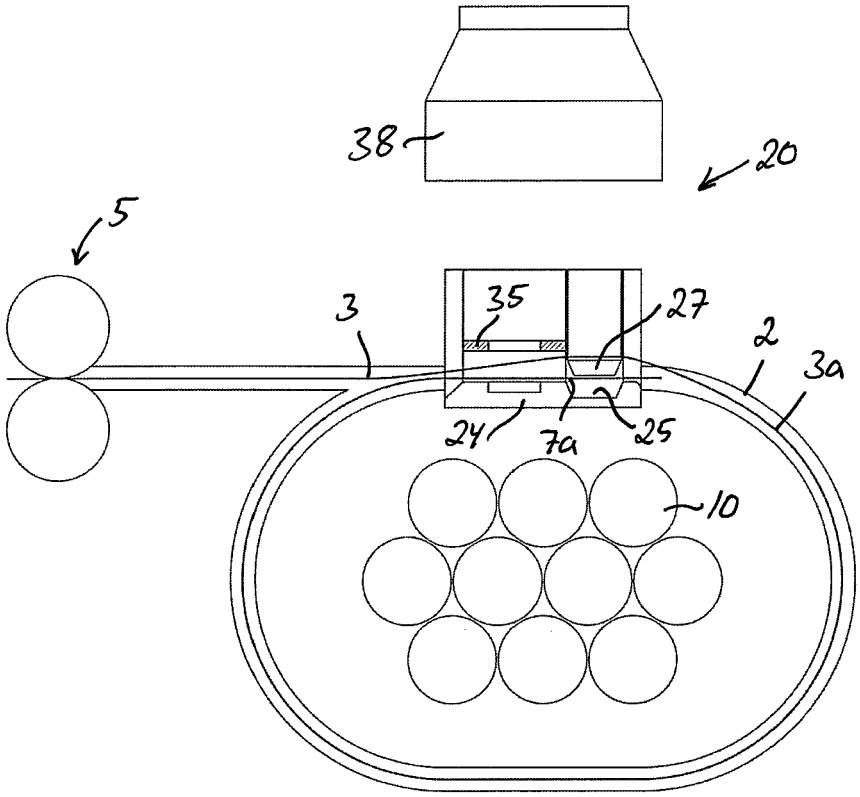


Fig 2d

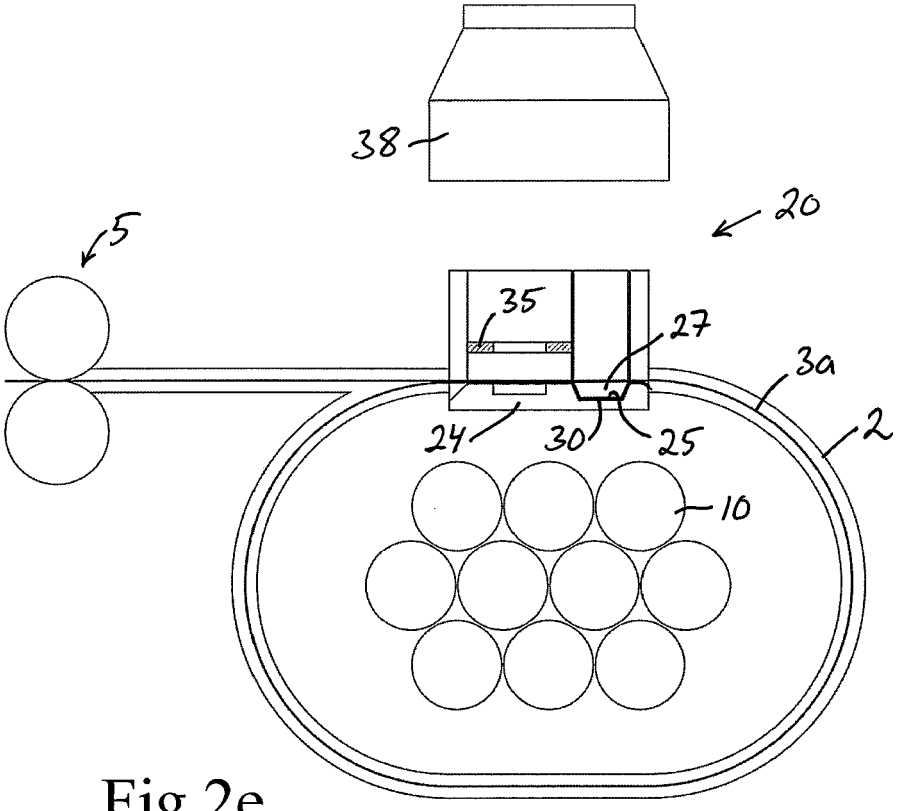


Fig 2e

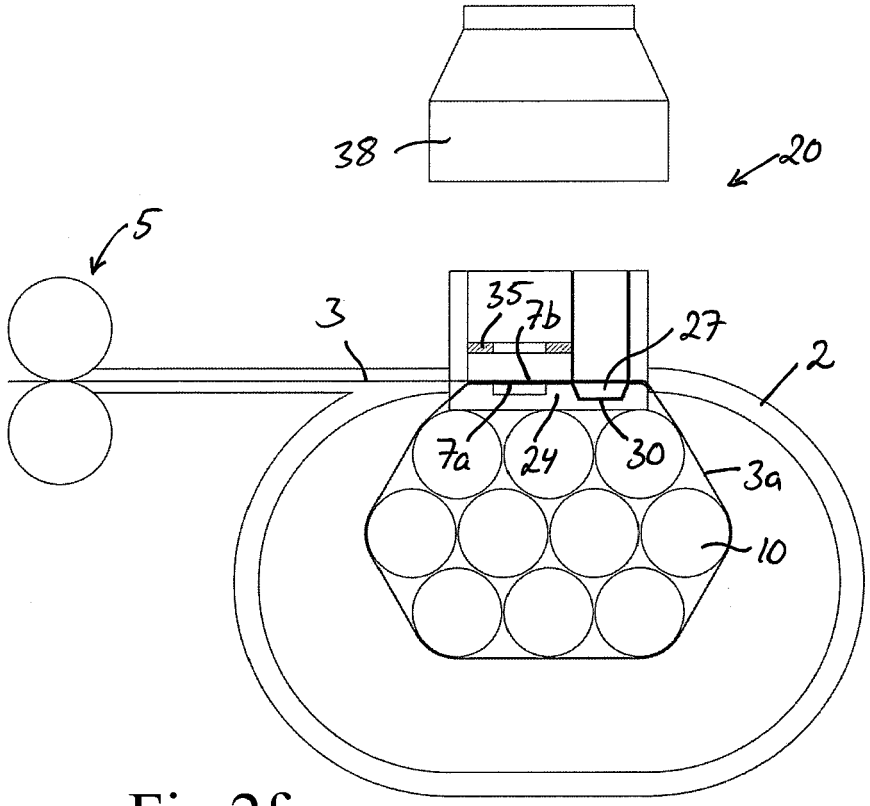


Fig 2f

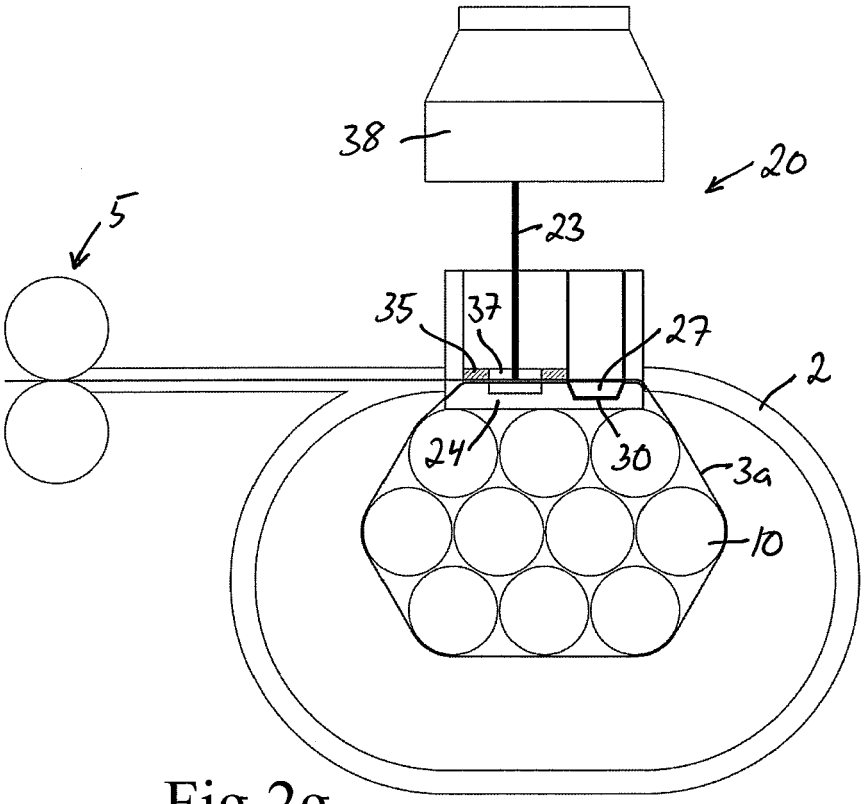


Fig 2g

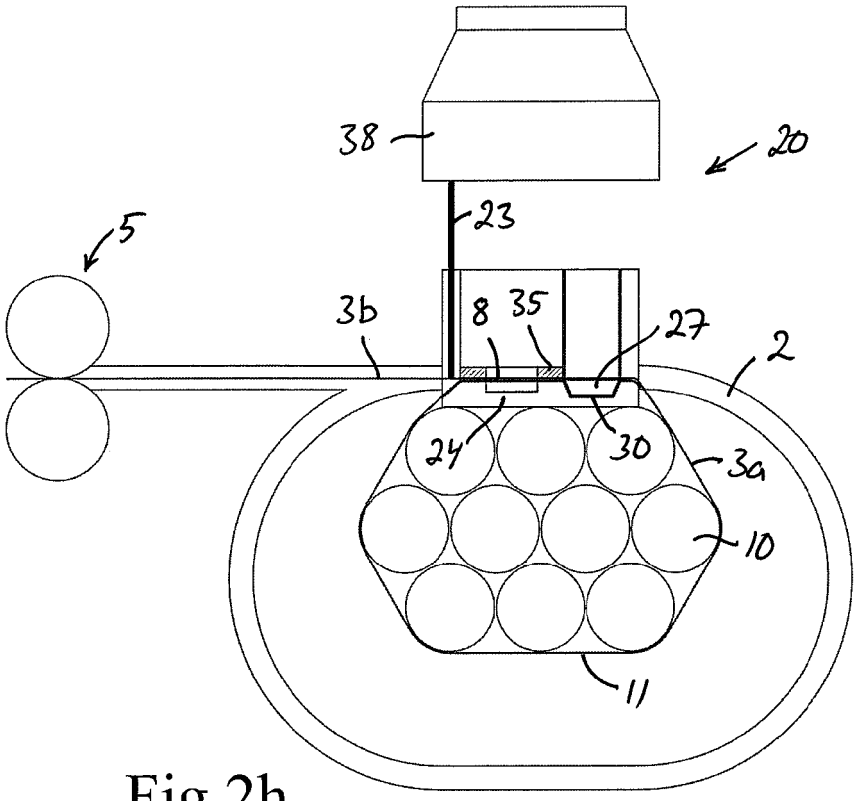


Fig 2h

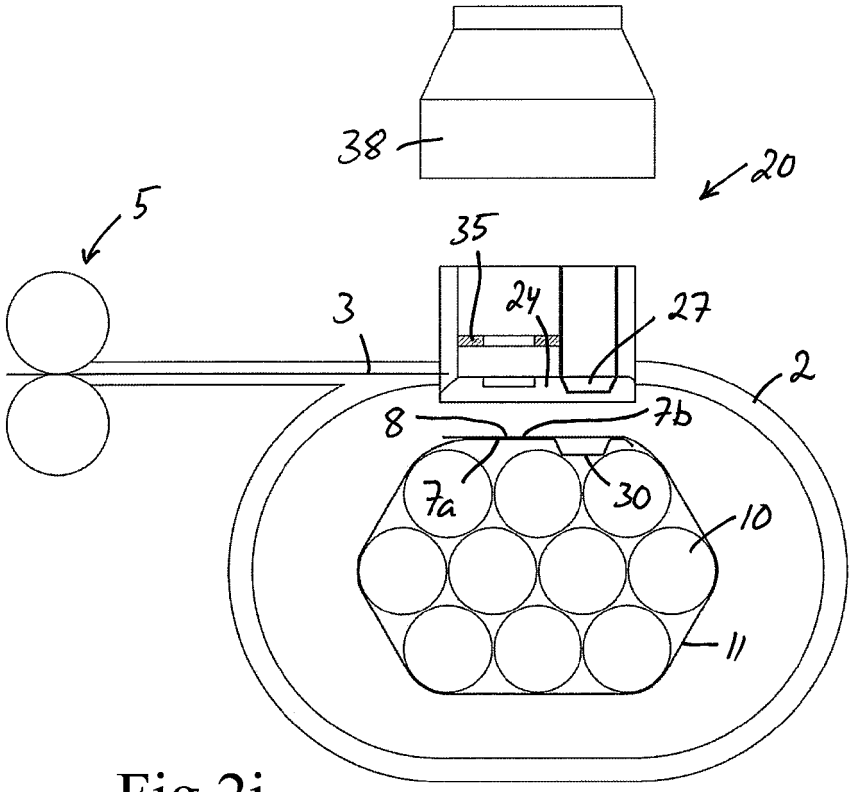
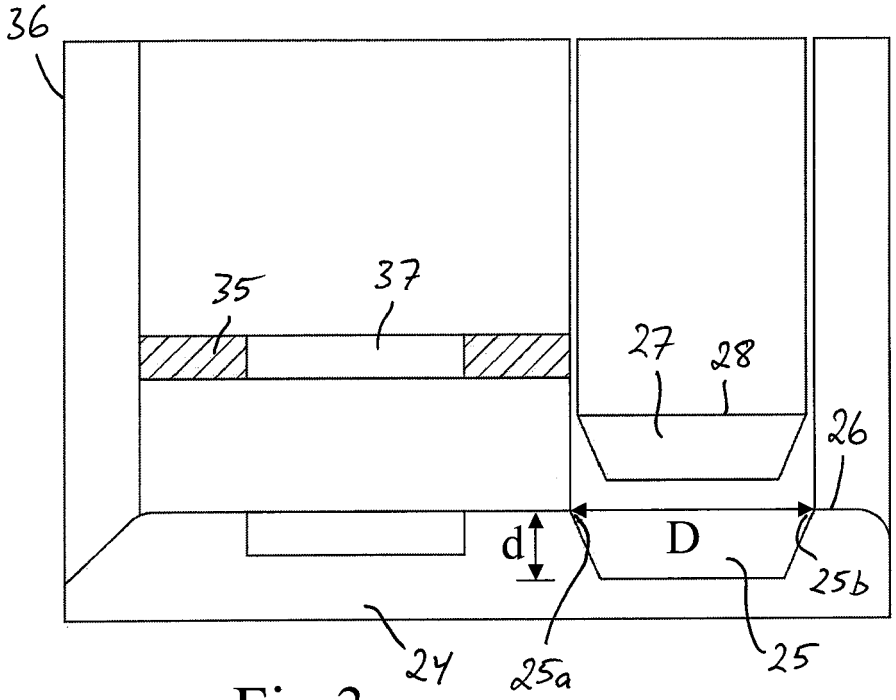


Fig 2i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28
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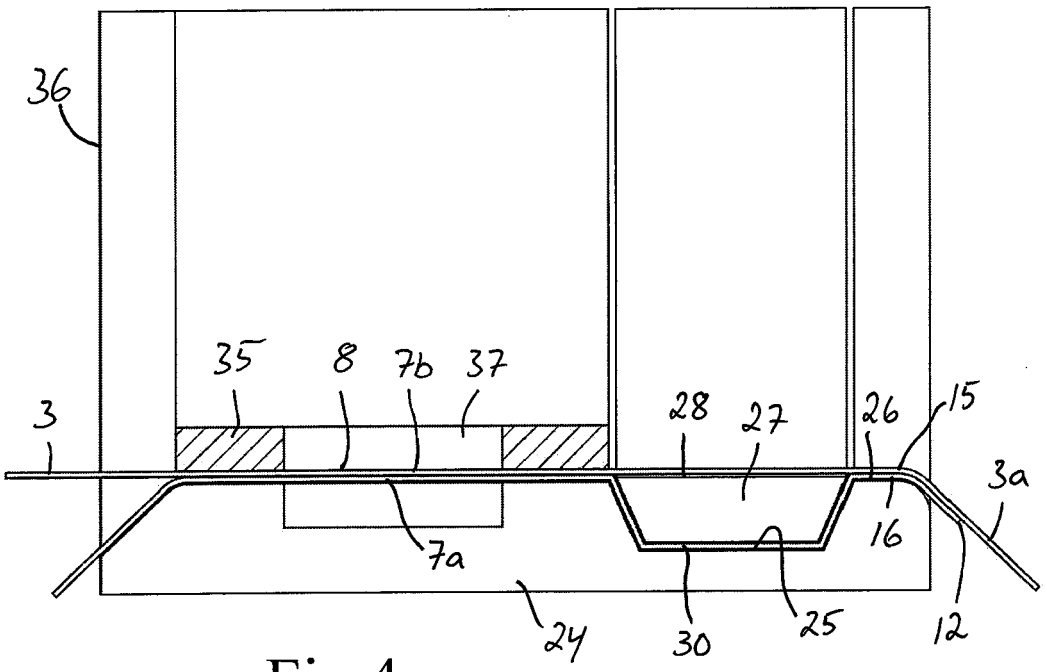
d
D
25b
24
25a
25

Fig 3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3a
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7a
24
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25
12

Fig 4

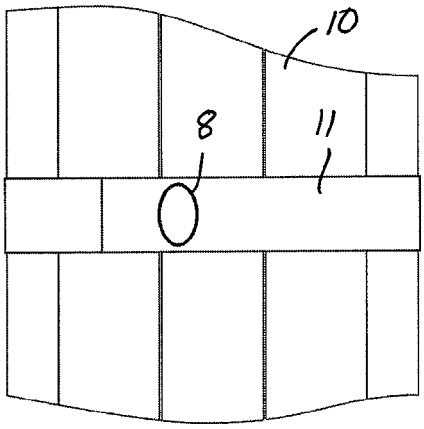

Fig 6

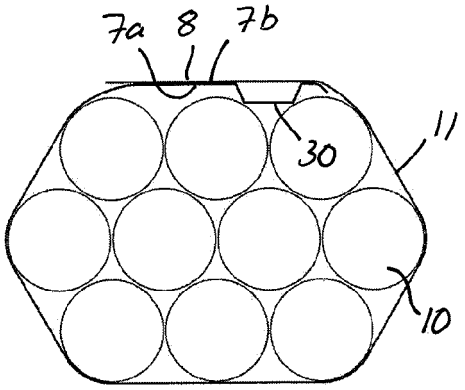

Fig 5

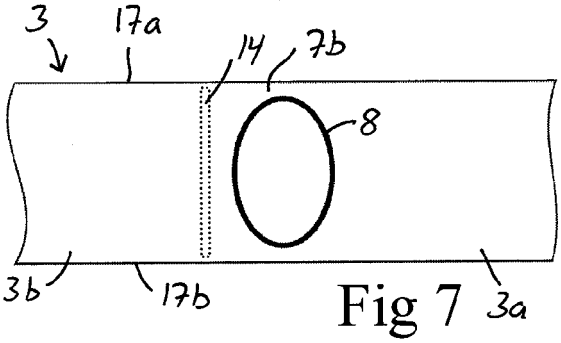

Fig 7

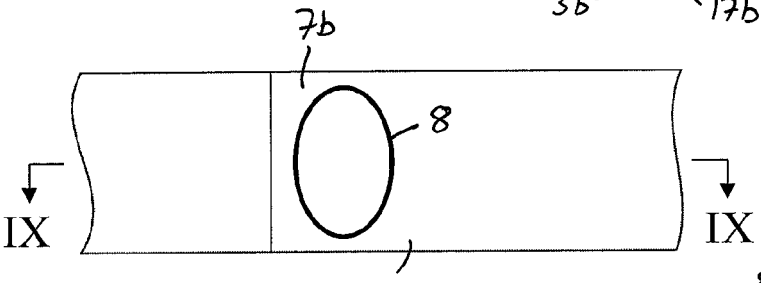

Fig 8

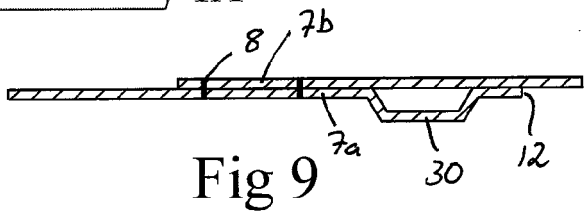

Fig 9

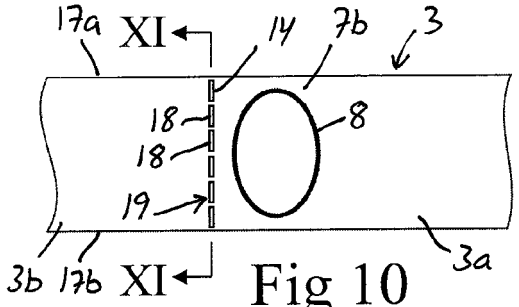

Fig 10

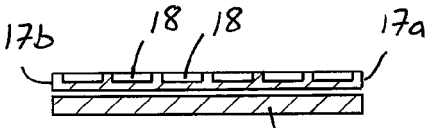

Fig 11

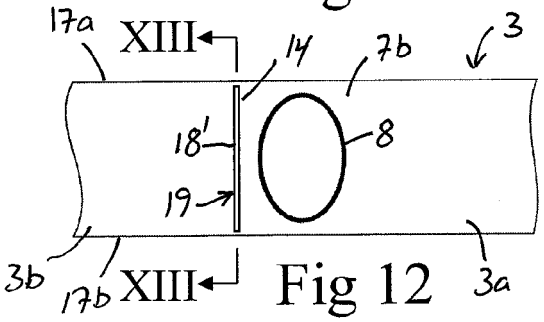

Fig 12

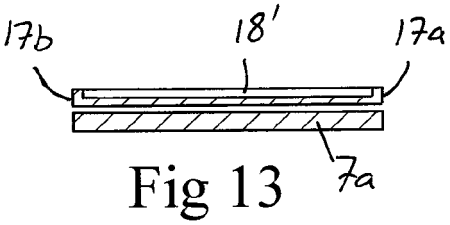

Fig 13

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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 1768

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	WO 2017/129679 A1 (SUND BIRSTA AB [SE]) 3 August 2017 (2017-08-03)	1,4,9,11	INV. B65B13/32
A	* the whole document *	2,3,5-8, 10,12-15	

Y	EP 0 399 599 A1 (AKZO NV [NL]) 28 November 1990 (1990-11-28)	1,4,9,11	
A	* figures 1b,1c *	2,3,5-8, 10,12-15	

TECHNICAL FIELDS SEARCHED (IPC)

B65B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 August 2018	Ungureanu, Mirela

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
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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

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16-08-2018

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

REFERENCES CITED IN THE DESCRIPTION

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