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(54) **METHOD AND APPARATUS FOR FORMING A TUBULAR PIECE, A TUBULAR PIECE AND A LADDER**

(57) The present disclosure concerns a method and an apparatus for forming a tubular piece (2), a tubular piece (2), a method for manufacturing a ladder (6), and such a ladder (6). The disclosure is based on the idea of providing a punch (4) comprising at least two parts (4', 4") and having protuberances (4b) thereon. The tubular piece (2) is inserted onto the punch (4), and a tapered wedge (5) placed between the parts (4', 4'") of the punch is pulled, such that the separate parts are pushed against the inner surface (2a) of the tubular piece (2). The protuberances (4b) on the punch deform the wall of the tubular piece (2), thus forming a corresponding embossed pattern (2c) on the outer surface (2b) of the tubular piece (2).

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Description

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to a method and apparatus for forming tubular pieces, and more particularly such tubular pieces to be used as rungs of a ladder. The present disclosure further concerns the such a tubular piece and an associated ladder.

BACKGROUND OF THE DISCLOSURE

[0002] Tubular pieces have generally been used as rungs for ladders. Moreover, it is generally desirable to have an embossed pattern on the surface of the rung, so as to improve the grip, thus making the ladder safer.

[0003] Known methods for achieving an embossed pattern on a tubular piece for a rung include, e.g. forming an embossed pattern on sheet metal, and then rolling the sheet into a tubular piece. However, this does not result in truly closed tubular profile, unless the piece is subsequently welded, or otherwise attached to close the profile in a subsequent process. A closed profile is desirable, because the structural strength thereof is much higher as compared to a corresponding non-closed profile.

[0004] Another alternative is to take an already tubular piece and punch holes therethrough, i.e. in from one side and out from one side. However, this results in holes being formed in the tubular piece, resulting in a weakened structural strength. Moreover, this will damage any possible coating, such as a galvanization layer, making the piece more susceptible to corrosion.

BRIEF DESCRIPTION OF THE DISCLOSURE

[0005] An object of the present disclosure is to provide a method and apparatus for forming tubular pieces, in which the structural integrity of the tubular piece is maintained, and such a tubular piece. It is a further object of the present disclosure to provide a method for manufacturing a ladder having such tubular pieces as rungs, and such a ladder.

[0006] The object of the disclosure is achieved by a method and an apparatus for forming a tubular piece, a tubular piece, a method for manufacturing a ladder, and such a ladder, which are characterized by what is stated in the independent claims. The preferred embodiments of the disclosure are disclosed in the dependent claims.

[0007] The disclosure is based on the idea of providing a punch comprising at least two parts and having protuberances thereon. The punch is inserted into the tubular piece to be formed (or the tubular piece is inserted onto the punch), and a tapered wedge placed between the parts of the punch is pulled, such that the separate parts of the punch are pushed against the inner surface of the tubular piece. The protuberances on the punch deform the wall of the tubular pieces, thus forming a corresponding embossed pattern on the outer surface of the tubular piece.

[0008] An advantage of the disclosure is that the structural integrity of the tubular piece is maintained, resulting in a higher structural strength as compared to forming which breaks the structure of the piece, and additionally, a possible coating is maintained unbroken, resulting in improved resistance to environmental stress.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In the following the disclosure will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

Fig. 1a schematically illustrates an apparatus for forming tubular piece according to an embodiment of the present disclosure with a tapered wedge in an extracted position, as seen as a partially cut plane view

Fig. 1b schematically illustrates the apparatus of Fig. 1a with the tapered wedge in a retracted position, as seen as a partially cut plane view;

Fig. 2a schematically illustrates a tubular piece according to an embodiment of the present disclosure as seen along the longitudinal direction thereof;

Fig. 2b schematically illustrates a detailed view of an elevated portion of the tubular piece of Fig. 2a;

Fig. 2c schematically illustrates a tubular piece according to an embodiment of the present disclosure as seen along a direction transverse to the longitudinal direction of the tubular piece, and

Fig. 3 illustrates a ladder according to an embodiment of the present disclosure as seen as a perspective view.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0010] According to a first aspect of the present disclosure a method for forming a tubular piece is provided.

[0011] In the method a tubular piece 2 is positioned on top of a punch 4, such that the punch 4 resides within the tubular piece 2. The tubular piece 2 is then held on top of the punch 4 in a longitudinally and rotationally secured manner. Moreover, the punch 4 comprises at least two separate parts 4', 4". Most suitably, the at least two separate parts 4', 4" are of a longitudinally extending shape and longitudinally separated from each other, so as to allow relative movement therebetween in a direction transverse to the longitudinal.

[0012] The method further comprises a following step of drawing a longitudinal, tapered wedge 5 positioned between the separate parts 4', 4" of the punch 4 so as

to push the separate parts 4', 4" of the punch 4 towards an inner circumferential surface 2a of the tubular piece 2. Drawing of the punch 4 is suitably carried out by drawing it from an extracted position (i.e. initial position of the wedge) to a retracted position.

[0013] This results in that protuberances 4a on a tooling portion 4b of the punch 4 facing the inner circumferential surface 2a of the tubular piece 2 deforms a wall of the tubular piece 2, such that a corresponding embossed pattern 2c is formed on the outer circumferential surface 2b of the tubular piece 2.

[0014] Naturally, the tubular piece 2 may then be removed off from the punch 4. Suitably, the wedge 5 is returned to its initial position before removal of the tubular piece 2. In addition, if any grippers are used to secure the tubular piece 2 in place during drawing of the wedge 5, they may naturally be released before withdrawal of the tubular piece 2.

[0015] In the context of this disclosure, the tooling portion 4a of the punch 4 is used to describe the portion of the punch 4 that is intended to be inserted into the tubular piece 2, or onto which the tubular piece 2 is intended to be inserted.

[0016] In an embodiment of the first aspect according to the present disclosure, in that the embossed pattern 2c comprises one or more elevated portions 2d elevated at a distance *h* of between 1,0 mm - 2,0 mm from a surrounding non-elevated portion of the outer circumferential surface 2b of the tubular piece 2 surrounding and adjacent to the respective elevated portion 2d. Preferably, the elevated portions 2d are elevated at a distance h of between 1,1 mm - 1,5 mm from a surrounding non-elevated portion of the outer circumferential surface 2b of the tubular piece 2 surrounding and adjacent to the respective elevated portion 2d. More preferably, the elevated portions 2d are elevated at a distance *h* of between 1,2 mm - 1,5 mm from a surrounding non-elevated portion of the outer circumferential surface 2b of the tubular piece 2 surrounding and adjacent to the respective elevated portion 2d.

[0017] Elevated portions 2d dimensioned accordingly have been found to provide improved properties in terms of grip, when the tubular pieces 2 achieved are used as rungs of a ladder 7.

[0018] Naturally, the protuberances 4b on the tooling portion 4a of the punch may be dimensioned accordingly, so as to achieve desired dimensions of the elevate portions 2d on the tubular piece 2 of given material and material thickness.

[0019] In an embodiment of the first aspect according to the present disclosure, the embossed pattern 2c may comprise multiple elevated portions 2d having a frustum shape, preferably a frusto-conical shape.

[0020] Such a frustum shape has been found to provide improved properties in terms of grip, when the tubular pieces 2 achieved are used as rungs of a ladder 7.

[0021] Naturally other shapes, such as spherical, frusto-spherical, polygonal, or frusto-polygonal shapes, for example, may be used.

[0022] In an embodiment of the first aspect according to the present disclosure, the sides of the one or more elevated portions 2d have a taper angle α of between 45° - 65°, preferably between 50° - 60°, and most preferably of 55° with respect to an axis perpendicular to a tangent of a middle point of the elevated portion.

[0023] Again, such a tapered shape has been found to provide improved properties in terms of grip, when the tubular pieces 2 achieved are used as rungs of a ladder 7.

[0024] In an embodiment of the first aspect according to the present disclosure, a plurality of embossed patterns 2c are formed on the outer circumferential surface 2b of the tubular piece 2. Suitably, each embossed pattern 2c formed on the tubular piece extends along the longitudinal direction thereof, and preferably, the embossed patterns 2c on the tubular piece are circumferentially spaced apart from each other.

[0025] In an embodiment of the first aspect according to the present disclosure, each of the separate parts 4', 4" of the punch 4 comprises a respective tooling portion 4a comprising protuberances 4b facing towards the inner circumferential surface 2a of the tubular piece 2, such that drawing the wedge 5 causes the punch to form the wall of the tubular piece such that at least two corresponding embossed patterns are formed on the outer circumferential surface of the tubular piece, preferably on the opposite sides thereof. That is, each separate part 4', 4" forms a respective embossed pattern 2c. In this way multiple embossed patterns 2c are formed with a single draw of the tapered wedge 5.

[0026] In an embodiment of the first aspect according to the present disclosure, the method may further comprise, subsequent to the drawing of the wedge 5, returning the wedge 5 to an initial position thereof, and thereafter, rotating the tubular piece 2 about its longitudinal axis. Furthermore, the wedge 5 may be subsequently drawn between the separate parts 4', 4" of the punch 4 so as to push the separate parts 4', 4" again towards the inner circumferential surface 2a of the tubular piece 2.

[0027] This results in that the protuberances 4b on the tooling portion 4a of the punch 4 facing the inner circumferential surface 2a of the tubular piece 2 further form the wall of the tubular piece 2 such that a corresponding subsequent embossed pattern 2c is formed on the outer circumferential surface 2b of the tubular piece 2, circumferentially spaced apart from the preceding embossed pattern 2c.

[0028] Naturally, this sequence of returning the wedge 5 to its initial position, rotating the tubular piece 2 and redrawing the wedge 5 may repeated multiple times, to achieve multiple embossed patterns 2c circumferentially spaced apart from each other.

[0029] In an embodiment of the first aspect according to the present disclosure, the method further comprises, prior to positioning the tubular piece 2 on top of the punch 4, pressing the separate parts 4', 4" of the punch towards each other. This facilitates fitting a distal end of the tooling

portion 4a within the tubular piece 2.

[0030] In an embodiment of the first aspect according to the present disclosure, the method further comprises, during drawing of the wedge 5, holding a distal portion of the punch extending out of the tubular piece, so as prevent oscillation or vibration of the punch.

[0031] In an embodiment of the first aspect according to the present disclosure the method may further comprise, following the forming of one or more embossed patterns 2c, pressing the tubular 2 piece so as to deform the cross-sectional shape thereof. Preferably, but not necessarily, the cross-sectional shape of the tubular piece 2 is formed so as to achieve a tear-drop shaped cross section.

[0032] Such a tear-drop shaped cross-sectional profile has been found particularly advantageous, when the tubular piece 2 is us to be used as rungs of a roof ladder (i.e. when the ladder is inclined), because this allows an increased support area on side of the rung for the user to engage. Additionally, such a rotationally non-symmetric shape prevents the tubular piece 2 from rotating, with respect to a rail of a ladder, to which it is attached so as to form a rung of said ladder.

[0033] Alternatively, or additionally, the method may further comprise, following the forming of one or more embossed patterns 2c, pressing both longitudinal end portions of the tubular piece 2, so as to reduce the diameter thereof. If this is done in addition to forming the cross-sectional profile, as discussed above, the pressing of the longitudinal end portions is most suitably carried out most subsequently. Reducing the diameter of the longitudinal end portions facilitates attaching the tubular piece 2 to a rail of an ladder, as it forms a stopper surface, thus locking the movement of the rail in the longitudinal direction towards an opposing longitudinal end portion of the tubular piece 2 (i.e. rung).

[0034] It should be noted that the first aspect of the present disclosure encompasses any combination of the embodiments, or variants thereof, as discussed above.

[0035] According to a second aspect of the present disclosure, a method of manufacturing a ladder 6 is provided, which ladder comprises a pair of rails 7 and a plurality of rungs.

[0036] Particularly, in such a method the rungs have been formed as tubular pieces 2 in accordance with the first aspect of the present disclosure. Furthermore, the method comprises inserting longitudinal end portions of the rungs through corresponding openings in the rails 7.

[0037] Subsequently the rungs are fixed to the rails 7.

[0038] Preferably this is done by flattening the longitudinal end portions of the rungs now protruding through the rails. Suitably, in such a case, the rungs have been formed as tubular pieces 2 having their cross-sectional shape formed so as to achieve rotationally non-symmetric shape (such as a tear-drop shaped cross section), and their longitudinal end portions being shaped so as to reduce the diameter thereof. This ensures, that the rungs are secured to the rails 7 in a longitudinal direction of the rungs by being clamped between the flattened end portion and the stopper surface formed by the increase of diameter in the cross-sectional shape of the rung. Moreover, the rotationally non-symmetrical cross-sectional profile prevents the rung from rotating about its longitudinal axis.

[0039] In an embodiment according to the second aspect of the present disclosure, the ladder has an intended top end and an intended bottom end, such that the intended top end is to be installed higher than the intended bottom end. The rungs provided as tubular pieces 2 are formed to have a teardrop shaped cross-sectional profile, as discussed above in context of the first aspect of the present disclosure. Notably, the rungs are rotationally oriented about their respective longitudinal axis, such that the bulge of the teardrop shaped cross-sectional profile is oriented towards the intended bottom of the ladder. In other words, the blunt side is pointing towards the intended bottom of the ladder.

[0040] This provides an increased contact area under a user's foot particularly for ladders that are to be used as roof ladders on roofs having a relative slight inclination such that the ladders will be walked on, as opposed to climbing.

[0041] Alternatively, the rungs may be oriented such that the bulge of the teardrop shaped cross-sectional profile is oriented towards the intended top of the ladder, i.e. the blunt side of the rung is pointing towards the intended top of the ladder. Such an arrangement is more suitable for wall ladders and roof ladders for roof having a relatively steep inclination, such that the ladders will be climbed, as opposed to walking.

[0042] It should be noted that the second aspect of the present disclosure encompasses any combination of the embodiments, or variants thereof, as discussed above.

[0043] According to a third aspect of the present disclosure, an apparatus 1 for forming a tubular piece 2 is provided.

[0044] The apparatus 1 comprises a frame 3 and a punch 4 formed of at least two separate parts 4', 4". The punch 4 is attached to the frame 3 in a longitudinally and rotationally secured manner, such that a movement of the separate parts 4', 4" with respect to each other in a direction transverse to the longitudinal is allowed.

[0045] Furthermore, the punch 4 comprises at least a longitudinal tooling portion 4a having a plurality of protuberances 4b. The tooling portion 4a is configured to be inserted into the tubular piece 2 such that the protuberances 4b on the tooling portion 4a face towards an inner circumferential surface of the tubular piece 2a. In other words, the tooling portion 4a is configured such that a tubular piece 2 may be inserted thereon so that the protuberances 4b on the tooling portion 4a face towards an inner circumferential surface of the tubular piece 2a.

[0046] The apparatus 1 further comprises a longitudinal wedge 5 positioned between the at least two separate parts 4', 4" of the punch and extending longitudinally therebetween.

[0047] The apparatus 1 further comprises a drawing device 6 coupled to the frame 1 and the punch 4. The drawing device 6 is configured to draw the wedge 5 along a longitudinal direction between the at least two separate parts 4', 4" of the punch 4, so as to cause the at least two separate parts 4', 4" of the punch 4 to move away from each other in a direction transverse to the longitudinal. Preferably, but not necessarily, the drawings device 6 is also configured to return the wedge 5 into its initial position.

[0048] This consequently causes the protuberances 4b to press against the inner circumferential surface 2a of the tubular piece 2, and forms the wall thereof such that an embossed pattern 2c corresponding to the protuberances 4b is formed on the outer circumferential surface 2b of the tubular piece 2, when in use.

[0049] For the purpose of completeness, it should be noted that the longitudinal direction of the punch 4, and the wedge 5 are parallel, along with that of the tubular piece 2, when being placed onto the punch 4.

[0050] Preferably, but not necessarily, the apparatus 1 may comprise a first gripper 1a for holding a distal end of the punch 4 projecting out of the tubular piece 2 when the tubular piece is formed 2. Particularly, the first gripper 1a follows the movement of the separate parts 4', 4" away and towards each other while holding the distal end of the punch 4 firmly. This helps support the punch 4 and reduces undesired vibration of the punch 4 and the wedge 5 extendgin therefrom.

[0051] Preferably, but not necessarily, the apparatus 1 may comprise a second gripper 1b for pressing the separate parts 4', 4" of the punch towards each other prior to positioning the tubular piece 2 on top of the punch 4. This facilitates fitting a distal end of the tooling portion 4a within the tubular piece 2. The second gripper 1b may also be used when withdrawing the tubular piece 2 off from the punch 4 after the tubular piece has been withdrawn past the position of the second gripper 1b. This facilitates removal of the tubular piece 2, protects the working surface 4a form damage caused by the tubular piece 2 sliding past.

[0052] The apparatus may further comprise a guider (not illustrated) for supporting the wedge 5 extending out from the punch 4 and preventing excessive oscillation of the wedge during the drawing thereof. For example, such a guider may be provided as a gripper allowing sliding contact between itself and the wedge 5.

[0053] Preferably, but not necessarily, the apparatus 1 may be equipped with an arrangement for rotating the tubular piece 2 between subsequent draws of the wedge 5. This may be done, e.g., with a robotic arm configured for manipulating the tubular piece 2. Such a robotic arm may additionally be used for inserting the tubular piece 2 onto the punch 4 and removing it therefrom. Naturally, such a robotic arm may be provided as a separate entity within the same manufacturing sell, for example.

[0054] It should be noted that the third aspect of the present disclosure encompasses any combination of the embodiments, or variants thereof, as discussed above.

[0055] According to a fourth aspect of the present disclosure, a tubular piece is provided. Particularly, such a tubular piece 2 is formed by the method according to the first aspect of the present disclosure.

[0056] According to a fifth aspect of the present disclosure, a ladder is provided. Particularly, such a ladder is formed by the method according to the second aspect of the present disclosure. Fig. 1a schematically illustrates an apparatus 1 for forming tubular piece 2 according to an embodiment of the present disclosure.

[0057] Particularly, the apparatus 1 has a frame 3 having a punch 4 attached to it. The punch extends in a longitudinal direction and has two separate parts 4', 4", the mutual movement of which is allowed in a direction transverse to the longitudinal. A tooling portion 4a extending out of the frame 3 is configured to be inserted into the tubular piece 2, and has protuberances 4b thereon. In the embodiment of Fig. 1a, the tooling portion 4a is arrange on the two separate parts 4', 4", i.e. each of the parts have protuberances 4b thereon.

[0058] The device further comprises a longitudinally extending wedge 5, the movement of which is allowed in the longitudinal direction. The wedge 5 is positioned between the separate parts of 4', 4" of the punch 4, and in the initial position of Fig. 1a, extends through and beyond the punch 4.

[0059] The apparatus further comprises a drawing device 6 coupled to the frame 3. The drawing device 6 is configured to draw the wedge 5 along a longitudinal direction towards the frame 3, i.e. to its retracted position so as so as to cause the at least two separate parts 4', 4" of the punch 4 to move away from each other in a direction transverse to the longitudinal. In the embodiment of Fig. 1 the drawings device is implemented with a hydraulic actuator. The drawings device 6 is also configured to return the wedge 5 back to its initial, i.e. extracted position.

[0060] The apparatus 1 of Fig. 1a further comprises a first gripper 1a for holding a distal end of the punch 4 projecting out from the tubular piece 2, after the tubular piece 2 has been placed onto the punch 4. Additionally, the apparatus of Fig. 1a further comprises a second gripper 1b for pressing the separate parts 4', 4" of the punch towards each other prior to positioning the tubular piece 2 on top of the punch 4. The second gripper 1b may also be used to press the separate parts 4', 4" of the punch towards each when the tubular piece 2 is withdrawn, after it has been withdrawn past the second gripper 1b.

[0061] Fig. 1b schematically illustrates the apparatus of Fig. 1a with the wedge 5 being drawn into the retracted position, as seen as a partially cut plane view.

[0062] Fig. 2a schematically illustrates a tubular piece according to an embodiment of the present disclosure as seen along the longitudinal direction thereof. Particularly, a plurality of longitudinally extending embossed patterns 2c are formed on the outer circumference of the tubular piece 2, rotationally spaced apart from each oth-

er. Furthermore, the cross-sectional profile of the he tubular piece 2 has been formed into a rotationally non-symmetrical, tear-drop shape.

[0063] Fig. 2b schematically illustrates a detailed view of an elevated portion of the tubular piece encircled in Fig. 2a. Particularly, the elevated portions 2d have a frusto-conical shape with an elevation of h from a surrounding non-elevated portion of the outer circumferential surface 2b of the tubular piece 2 surrounding and adjacent to the respective elevated portion 2d. Moreover, the elevated portion 2d has a taper angle α.

[0064] Fig. 2c schematically illustrates a tubular piece 2 of Fig. 2a as seen along a direction transverse to the longitudinal direction of the tubular piece 2. Most notably, this clearly illustrates the manner in which the embossed patterns 2c extends longitudinally along the tubular piece 2.

[0065] Fig. 3 illustrates a ladder according to an embodiment of the present disclosure as seen as a perspective view. Particularly, a plurality of tubular pieces 2 have provided between a pair of rails 7, in a well-known manner.

Claims

1. A method for forming a tubular piece (2), comprising the following succession of steps:

   positioning a tubular piece (2) on top of a punch (4), such that the punch (4) resides within the tubular piece (2);
   holding the tubular piece (2) on top of the punch in a longitudinally and rotationally secured manner,
   wherein the punch (4) comprises at least two separate parts (4', 4"),
   characterized in that the method further comprises a following step of drawing a longitudinal, tapered wedge (5) positioned between the separate parts (4', 4") of the punch (4) so as to push the separate parts (4', 4") of the punch (4) towards an inner circumferential surface (2a) of the tubular piece (2),
   wherein protuberances (4b) on a tooling portion (4a) of the punch (4) facing the inner circumferential surface (2a) of the tubular piece (2) deforms a wall of the tubular piece (2) such that a corresponding embossed pattern (2c) is formed on the outer circumferential surface (2b) of the tubular piece (2).

2. The method according to Claim 1, **characterized in that** the embossed pattern (2c) comprises one or more elevated portions (2d) elevated at a distance (h) of between 1,0 mm - 2,0 mm, preferably between 1,1 mm -1,5 mm, and more preferably between 1,2 - 1,5 mm from a surrounding non-elevated portion of the outer circumferential surface (2b) of the tubular piece (2) surrounding and adjacent to the elevated portion (2d).

3. The method according to Claim 1 or 2, **characterized in that** the embossed pattern (2c) comprises multiple elevated portions (2d) having a frustum shape, preferably a frusto-conical shape.

4. The method according to any of the preceding Claims wherein the sides of the one or more elevated portions (2d) have a taper angle (α) of between 45° - 65°, preferably between 50° - 60°, and most preferably of 55° with respect to an axis perpendicular to a tangent of a middle point of the elevated portion

5. The method according to any of the preceding Claims, **characterized in that** a plurality of embossed patterns (2c) are formed on the outer circumferential surface (2b) of the tubular piece (2), wherein each embossed pattern (2c) formed on the tubular piece extends along the longitudinal direction thereof, and preferably, the embossed patterns (2c) on the tubular piece are circumferentially spaced apart from each other.

6. The method according to any of the preceding Claims, **characterized in that** the each of the separate parts (4', 4") of the punch comprises a respective tooling portion (4a) comprising protuberances (4b) facing towards the inner circumferential surface (2a) of the tubular piece (2), such that drawing the wedge (5) causes punch to form the wall of the tubular piece such that at least two corresponding embossed patterns are formed on the outer circumferential surface of the tubular piece, preferably on the opposite sides thereof.

7. The method according to any of the preceding Claims, **characterized by** further comprising, subsequent to the drawing of the wedge (5), a following succession of steps:

   returning the wedge (5) to an initial position thereof,
   rotating the tubular piece (2) about its longitudinal axis, and
   performing a subsequent draw of the wedge (5) between the separate parts (4', 4") of the punch (4) so as to push the separate parts (4', 4") towards the inner circumferential surface (2a) of the tubular piece (2),
   wherein the protuberances (4b) on the tooling portion (4a) of the punch (4) facing the inner circumferential surface (2a) of the tubular piece (2) form the wall of the tubular piece (2) such that a corresponding subsequent embossed pattern (2c) is formed on the outer circumferential sur-

face (2b) of the tubular piece (2), circumferentially spaced apart from the preceding embossed pattern (2c).

8. The method according to any of the preceding Claims, **characterized by** further comprising, prior to positioning the tubular piece (2) on top of the punch (4), pressing the separate parts (4', 4") of the punch towards each other, so as to facilitate fitting a distal end of the tooling portion (4a) within the tubular piece (2).

9. The method according to any of the preceding Claims **characterized by**, during drawing of the wedge (5), holding a distal portion of the punch extending out of the tubular piece, so as prevent oscillation or vibration of the punch.

10. The method according to any of the preceding Claims, **characterized by**, following the forming of one or more embossed patterns (2c), further comprising either or both of the following steps:

pressing the tubular (2) piece so as to deform the cross-sectional shape thereof, preferably so as to achieve a tear-drop shaped cross section, and
pressing both longitudinal end portions of the tubular piece (2), so as to reduce the diameter thereof.

11. A method of manufacturing a ladder (6) comprising a pair of rails (7) and a plurality of rungs **characterized in that** the rungs are provided as tubular pieces (2) formed in accordance with any of the preceding Claims 1 - 11,
wherein the method further comprises:

inserting longitudinal end portions of the rungs through corresponding openings in the rails (7), and
fixing the rungs to the rails (7), preferably by flattening the longitudinal end portions of the rungs protruding through the rails.

12. The method according to Claim 11, **characterized in that** the ladder (6) has an intended top end and an intended bottom end, such that the intended top end is to be installed higher than the intended bottom end,
wherein the rungs are provided as tubular pieces (2) formed in accordance with Claim 10, such that the tubular pieces (2) have a teardrop shaped cross-sectional profile, and
wherein the rungs are rotationally oriented about their respective longitudinal such that either:

- a bulge of the teardrop shaped cross-sectional profile is oriented towards the intended bottom end of the ladder, or
- the bulge of the teardrop shaped cross-sectional profile is oriented towards the intended top end of the ladder.

13. An apparatus (1) for forming a tubular piece (2), comprising:

a frame (3),
a punch (4) formed of at least two separate parts (4', 4"), wherein the punch (4):

- is attached to the frame (3) in a longitudinally and rotationally secured manner, such that a movement of the separate parts (4', 4") with respect to each other in a direction transverse to the longitudinal is allowed
- comprises at least a longitudinal tooling portion (4a) having a plurality of protuberances (4b), said tooling portion (4a) is configured to be inserted into the tubular piece (2) such that the protuberances (4b) on the tooling portion (4a) face towards an inner circumferential surface of the tubular piece (2a) **characterized in that** the apparatus (1) further comprises:

a longitudinal wedge (5) positioned between the at least two separate parts (4', 4") of the punch and extending longitudinally therebetween, and
a drawing device (6) coupled to the frame (1) and the punch (4), configured to draw the wedge (5) along a longitudinal direction between the at least two separate parts (4', 4") of the punch (4), so as to cause the at least two separate parts (4', 4") of the punch (4) to move away from each other in a direction transverse to the longitudinal, wherein pressing the protuberances (4b) against the inner circumferential surface (2a) of the tubular piece (2) forms the wall thereof such that an embossed pattern (2c) corresponding to the protuberances (4b) is formed on the outer circumferential surface (2b) of the tubular piece (2), when in use.

14. A tubular piece, **characterized in that** the tubular piece is formed by the method according to any of the preceding Claims 1-10

15. A ladder, **characterized in that** the ladder is manufactured by the method according to Claim 11 or 12.

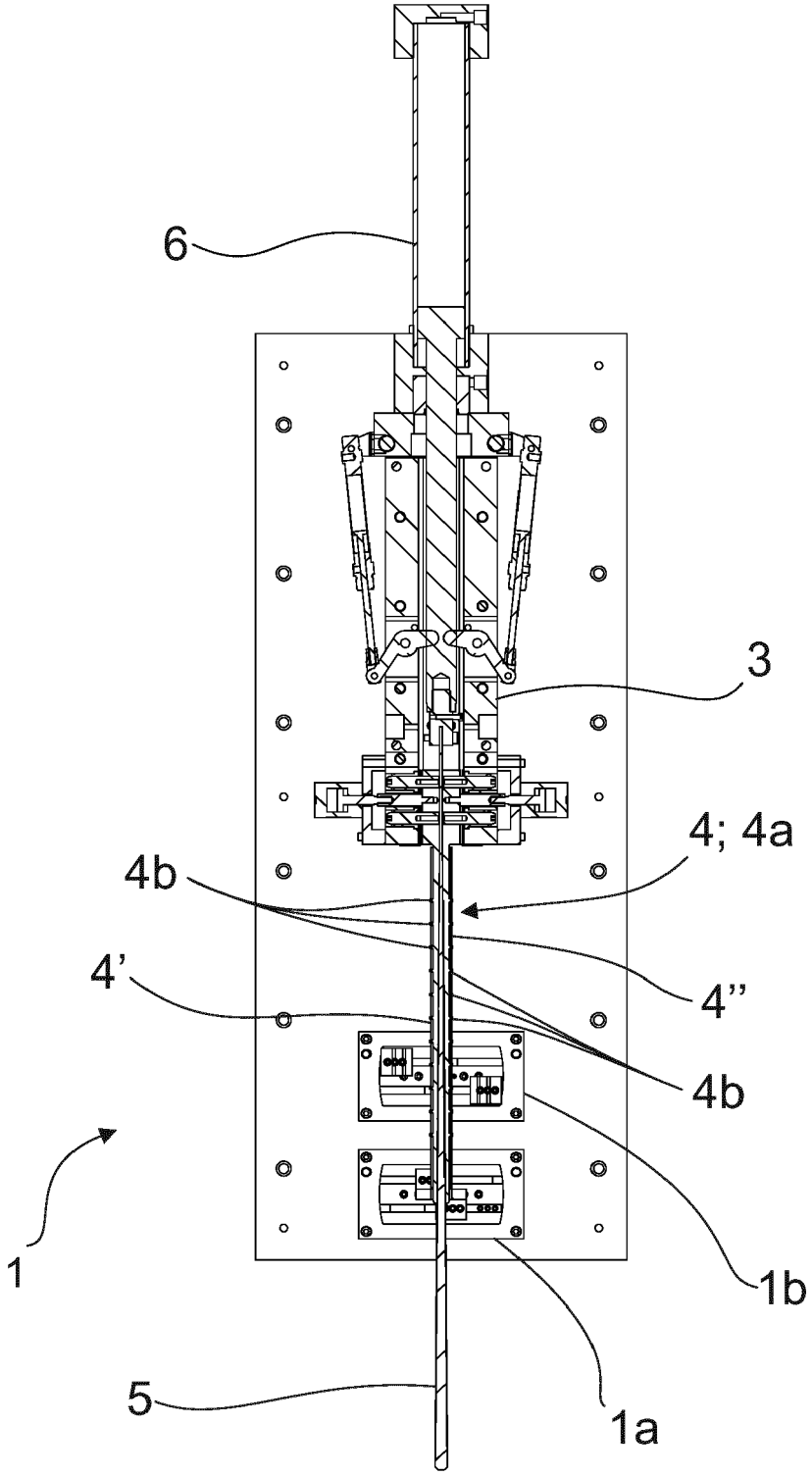

Fig. 1a

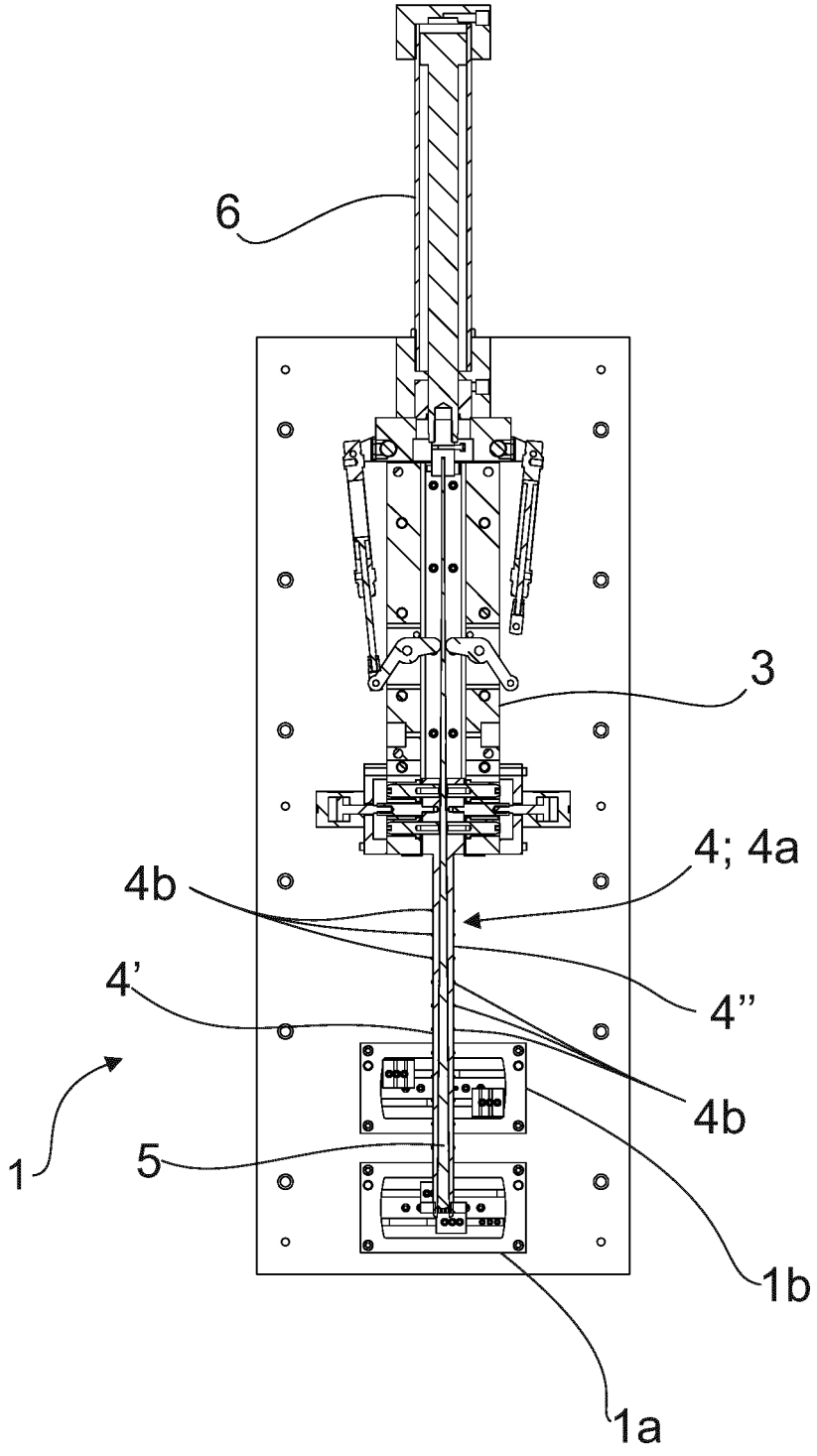

Fig. 1b

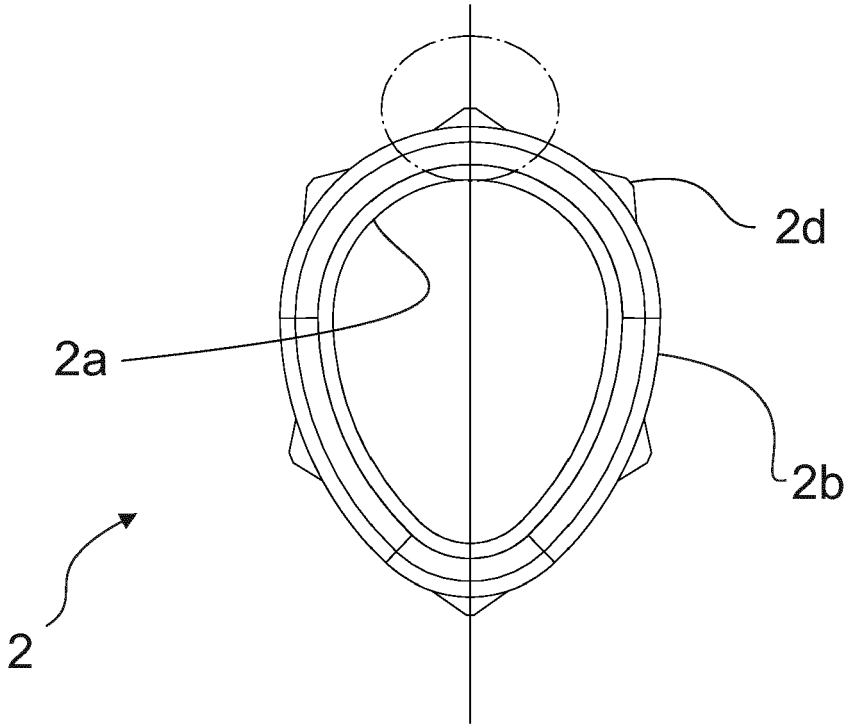

Fig. 2a

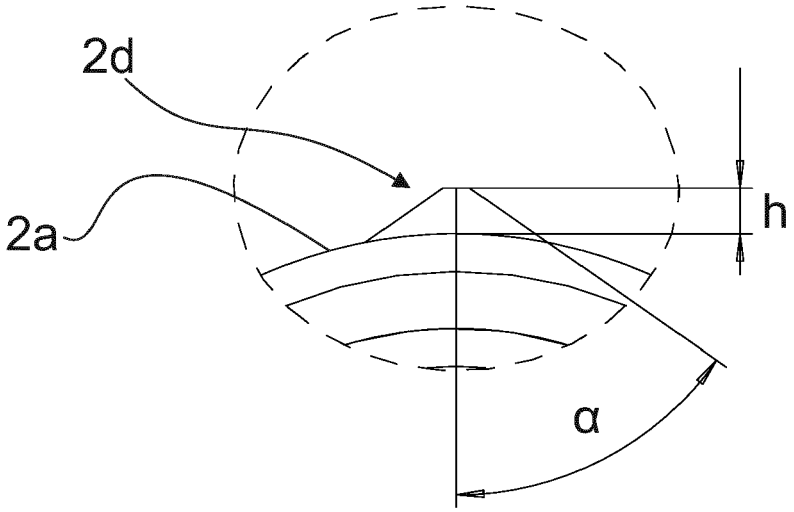

Fig. 2b

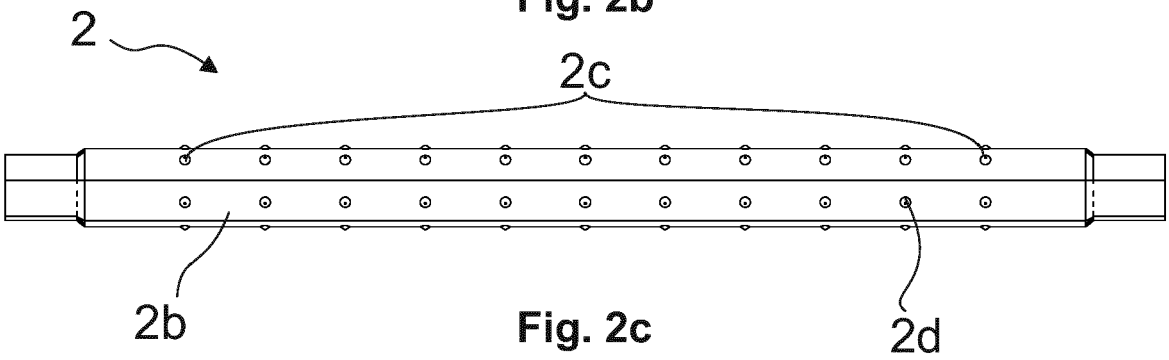

Fig. 2c

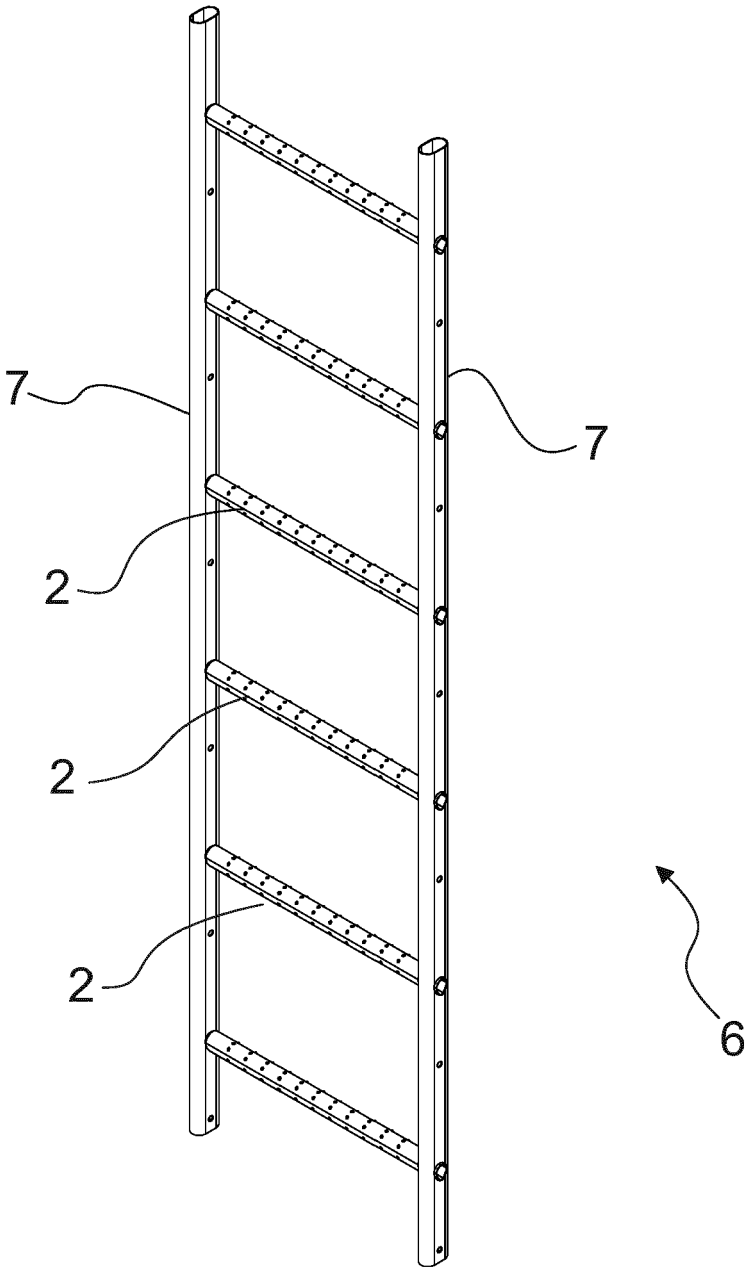

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 August 2020	Vesterholm, Mika

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