(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 November 2020 (12.11.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/225735 A1

(51) International Patent Classification:
E21D 21/00 (2006.01)

(21) International Application Number:
PCT/IB2020/054269

(22) International Filing Date:
06 May 2020 (06.05.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2019/02816 06 May 2019 (06.05.2019) ZA

(72) Inventor; and

(71) Applicant: **HOLFELD, Barry Graeme** [ZA/ZA]; 1207 Schooner Avenue, Laser Park Ext. 9, Roodepoort, 2040 Johannesburg (ZA).

(74) Agent: **DESSINGTON & DESSINGTON INC.**; Dessington IP, 1st Floor, 20 Baker St, Rosebank, 2196 Johannesburg (ZA).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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

(54) **Title:** AN INFLATABLE ROCK BOLT

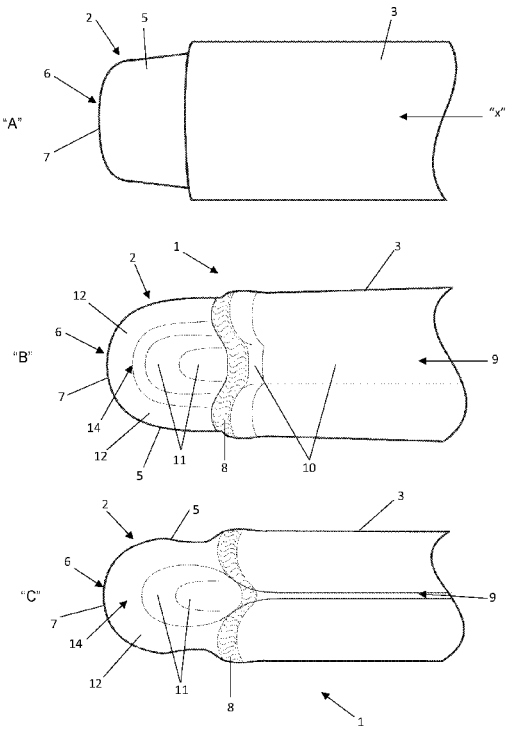

FIGURE 1

(57) **Abstract:** The invention relates to an inflatable rock bolt (1) and a method of manufacture. A cap (2) is welded onto an end of the pipe (3). A fold (9) is formed from a first side of the rock bolt (1), extending along a length of the pipe (3). A bottom (10) of the fold (9) is formed to extend from the pipe (3) into a sidewall (5) of the cap (2) and outwardly towards the first side to a position separated by a ridge (12) from a first portion (13) of the end wall that remains outside the fold (9), with a second portion (14) of the end wall drawn into the fold (9).

WO 2020/225735 A1

[Continued on next page]

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

AN INFLATABLE ROCK BOLT

FIELD OF THE INVENTION

The invention relates to an inflatable rock bolt of the kind that includes a sealed tubular (metal pipe) body formed with at least one longitudinal fold to provide a reduced and substantially circular cross-sectional profile for insertion into a drill hole and to, in use, be expanded into frictional engagement with a wall of the drill hole by introducing a pressurised fluid into an interior of the body.

BACKGROUND TO THE INVENTION

These inflatable rock bolts generally have a sealed tube with a longitudinal channel formed by a fold, which reduces the cross-sectional dimension of the tube (sufficiently for the required purpose). A check valve at one end remains outside a drill hole into which the rock bolt is inserted and allows the tube to be inflated or expanded. The pressurised fluid is usually water. On expansion of the body through outward deformation of the fold, the surface of the tube engages in the hole.

An improved version of such a rock bolt is disclosed in PCT/2016/053817 and PCT/2016/054864. The first of these two International applications teaches a beneficial construction of what is preferably an inner end of the rock bolt.

OBJECT OF THE INVENTION

It is an object of the present invention to provide an inflatable rock bolt with a sealed inner end having a configuration that provides improved durability to the stress placed on the folded regions of material during the expansion operation in use.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the invention, there is provided an inflatable rock bolt comprising:

a pipe with a cap welded in sealing engagement onto an end of the pipe in a pre-formed condition;

the cap having a sidewall that extends from a rim of the cap to a closed end provided by an end wall of the cap;

the rock bolt provided with a fold formed from a first side of the rock bolt and extending along a length of the pipe;

a bottom of the fold located adjacent an opposite, second side of the rock bolt where it extends along the length of the pipe; and

the bottom of the fold extending from the pipe into the sidewall of the cap and outwardly towards the first side of the rock bolt to a position separated by a ridge from a first portion of the end wall that remains outside the fold, with a second portion of the end wall drawn into the fold.

The invention provides for the second portion of the end wall to be arranged at a forward region of the fold with the first portion of the end wall in an oppositely disposed position at a front of the rock bolt.

The invention further provides for a rock bolt as defined, in which:

a greater portion of the end wall of the cap to be maintained substantially in a pre-formed condition as the first portion with an adjacent lesser portion curved rearwardly and pressed toward the fold as the second portion.

The invention still further provides for a rock bolt as defined, in which:

the ridge extends from a front of the rock bolt as a substantially U-shaped ridge formed around the fold at the cap of the rock bolt;

the closed end of the cap is pressed outwardly in line with the fold where it is formed into a forward most section of the U-shaped ridge;

an edge of the ridge is located on one side of an axis of the pipe as it exists in a pre-formed condition of the pipe;

the end wall of the cap transitions from the sidewall uniformly through a curve to the closed end of the cap which is substantially flat [relative to the transition curve]; and

the sidewall of the cap includes a substantially cylindrical region at the rim that locates with a press-fit into the pre-formed pipe.

In accordance with a second aspect of the invention, there is provided a method of making an inflatable rock bolt which includes the steps of:

providing a length of pre-formed pipe with at least one open end,

welding a cap to the open end, and

thereafter deforming the pipe and the cap into a folded form to provide a fold that extends along the pipe,

characterised in that the fold is formed by a tool that is sized with a working edge that stops sufficiently short of an end wall at a closed end of the cap to:

- maintain a first portion of the end wall that is in line with the fold on an outside of the fold; and
- draw a second portion of the end wall in a curve rearwardly toward and into the fold.

The invention further provides for a method as defined, in which the fold is formed to:

- provide a substantially U-shaped ridge that extends from a front of the rock bolt around the fold at the cap with an edge of the ridge located to one side of an axis of the pipe as it exists in a pre-formed condition of the pipe.

The invention still further provides for a method as defined, in which:

the fold is formed with the first portion as a greater portion of the end wall and the second portion as a lesser potion of the end wall; and

the rock bolt is pressed closed around the fold in a second forming operation.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description of a preferred embodiment, made by way of example only, with reference to the accompanying illustrations, in which:

Figure 1	shows three inner ends of pre-formed, intermediate and final formed rock bolts from a position facing the fold;
Figure 2	shows a perspective view of the intermediate and final formed rock bolts;
Figure 3	shows a side view of the rock bolt ends in Figure 2 from a position lateral to the fold; and
Figure 4	shows the pre-formed and final formed rock bolt ends marked with an axis of the pre-formed rock bolt.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the accompanying drawings, a rock bolt (1) having a cap (2) at an inner end manufactured in accordance with the invention is shown. The rock bolt (1) is illustrated in progressive forming conditions labelled as follows in the Figures:

"A"	pre-formed condition;
"B"	intermediate condition; and
"C"	formed condition.

The rock bolt (1) is made from a length of pipe (3) initially having a circular cross-section in the pre-formed condition. The pipe (3) is made from a suitable metal. The cap (2) is used to seal an open end of the pipe (3) that will be located inside a drilled rock bolt hole (not shown). It is only this inner end of the rock bolt (1) that is shown in the Figures.

The construction and components used at the opposite, outer end of the rock bolt (1) may be varied and will be within the understanding of a person skilled in the art. Examples are set out in the second of the two PCT applications referred to in the "Background" above.

The cap (2) is fabricated from a suitably ductile metal and has a sidewall or skirt (5) that extends from a rim (not shown) of the cap (2) to a closed end (6). The sidewall (5) extends forwardly from the pipe (3) with a slight inward taper. The closed end of the cap (2) in this embodiment is substantially flat and provides an end wall (7) to the front of the sidewall (5). The end wall (7) transitions substantially uniformly through a curve at an annular outer region from the sidewall (5) and into a central region of the closed end (6) which is, in this embodiment, substantially flattened (relative to the transition curve).

The sidewall (5) of the cap (2) has an outer diameter on a substantially cylindrical region at the rim (not shown). This short region (not shown) of the sidewall (5) adjacent the rim is be provided with a substantially parallel wall for press-fitting with a friction or interference fit into the pre-formed pipe (3). The pipe (3) with the cap (2) so fitted is shown as "A" in Figure 1. It will then be welded (8) at a junction along an edge at the end of the pipe (3). By securing the cap (2) to the pipe (3) in this manner the open and operatively inner end of the rock bolt (1) is sealed.

Once the cap (2) is welded in place, the pre-formed rock bolt is subjected to a subsequent metalworking process, in which the pipe (3) and the cap (2) are formed into an intermediate condition of the rock bolt (1) with convoluted or folded shape

as shown as “B” in Figures 1, 2, and 3. The configuration referred to involves an initial, first step of press-forming the longitudinal fold or channel (9) to reduce the cross-sectional dimension of a post-formed rock bolt (1) shown as “C” in Figures 1, 2 and 3.

In accordance with the invention, the fold (9) is formed from a first side “x” of the rock bolt (1) and extending along a length of the pipe (3). A bottom (10) of the fold (9) located adjacent an opposite, second side “y” of the rock bolt (1) where it extends along the length of the pipe (3).

The fold (9) is formed so that the bottom (10) extends from the pipe (3) into the sidewall (5) and with a concave curve into a forward region (11) outwardly towards the first side “x” of the rock bolt (1) to a position separated by a front region of a U-shaped ridge (12) from a first portion (13) of the end wall (7) that remains outside the fold (9), with a second portion (14) of the end wall (7) drawn toward and/or into the forward region (11) of the fold (9).

In the current embodiment, a greater portion of the end wall (7) is maintained substantially in a pre-formed condition [apart from being pressed slightly forwardly in the forming of a front of the U-shaped ridge (12)] as the first portion (13) with an adjacent lesser portion of the end wall (7) curved rearwardly and pressed toward and/or into the fold (9) as the second portion (14).

After the welding has been completed the pipe (3) and cap (2) still have a circular outline or profile in cross-section. In the first forming step, the pipe (3) and cap (2) assembly is placed in a trough-shaped cavity of a first die. A pressing tool in a hydraulic press is then used to deform the pipe (3) and cap (2) assembly into the intermediate condition, which is accompanied by some lateral bulging or outward distortion to either side of the fold as well as the forward displacement of the end wall (7) where the U-shaped ridge (12) takes form.

The tool is in the shape of an elongate blade with a straight working edge (parallel to the pipe) that is curved between two planar sides. In use, the working edge directly contacts the outer surface of the pipe (3) and cap (2) assembly. The first die is supported in a hydraulic press that is used to bias the tool into engagement with the outer surface of the pipe. The tool deforms the pipe (3) and cap (2) assembly radially inwardly to form the relatively deep fold or channel (9) as shown.

In accordance with previous versions of the rock bolt, a fold was formed to extend through the cap and past its closed end to reduce the profile of the cap in line with the forming process to which the length of pipe was subjected.

The modification which brings about the current invention involves, in the first forming operation, the use of a tool that is sized with a folding or working edge that stops sufficiently short of the closed end (6) of the cap (2). At the relevant end which locates over the cap (2), the tool will be radiused from the working edge (which is provided parallel to the pipe) to an end of the tool that is perpendicular to or inclined away from the working edge. It is this radiused portion of the tool that is pressed down in the required position to form the fold in the cap (2).

It follows that the pre-formed rock bolt needs to be placed in a predetermined position in the hydraulic press so that the fold is formed by the pressing tool with the upwardly curved or radiused end of the working edge located to stop short of the closed end (6) of the cap (2). The arrangement avoids providing a lateral compression force that would act in line with the material across the cap end wall (7) and particularly in the central flat region thereof. Instead, the tool engages the cap of pre-formed rock bolt where a lateral bending force can be applied to the sidewall (5).

The forming process of the invention provides for the following features:

- A substantially U-shaped ridge (12) is formed around the fold (9) at the cap (2) of the rock bolt (1) – see “B” and “C” in Figure 1;

- A greater, first portion (13) of the end wall (7) that is in line with the fold (9) is maintained substantially in a pre-formed condition and outside of the fold (9) with an adjacent lesser, second portion (14) formed rearwardly and pressed toward and/or into the fold (9) – see "B" and "C" Figure 3; and
- An edge "e" of the ridge (12) is located to the first side "x" of an axis "a" of the pipe (3) as it exists in a pre-formed condition of the pipe (3). This is shown as "A" and "C" in the comparison of Figure 4.

In the result, the second portion (14) of the end wall is arranged at the forward region (11) of the fold (9) with the first portion (13) of the end wall in an oppositely disposed position at the front of the rock bolt (1) on an outside of the fold (9). The section at the bottom of the "U" of the U-shaped ridge (12) separates the first portion (13) from the second portion (14) of the end wall.

The forces exerted by the tool in the first forming step are such that when the fold (9) is formed, the outer surface of the pipe (3) and cap (2) assembly is no longer generally of circular form. The rock bolt (1) in intermediate form is then subjected to a second step of the forming process. This operation involves placing the rock bolt (1) into a second die set which includes upper and lower dies that together define an elongate die cavity of circular cross-section and which locates over the pipe (3) and the cap (2). The second die set is closed using hydraulic pressure with the intermediate condition rock bolt in the die cavity. In the result, a rock bolt is formed with a body that, except for the fold (9), has a substantially circular axial profile. This configuration of the finished product (post-formed rock bolt) is suited for insertion into a round drill hole and presents further capacity for expansion over the intermediate form.

The cap (2) remains connected with leak-proof seal provided by the weld to the pipe (3). The pipe (3) then has an elongate longitudinally extending channel (9) which extends into a region occupied by the sidewall (5) of the cap (2).

In the second forming operation, the rock bolt (1) is pressed closed around the fold (9). The post-formed rock bolt shown “C” in Figures 1, 2, 3 and 4 is thus formed with the fold (9) having a substantially closed or abutting configuration where it extends along the majority of the pipe length. This is not the case in the region of the cap (2) as illustrated in the drawings of the current embodiment. The outer diameter of the cap (2) is smaller than that of the pipe (3) into which it fits and is welded in place. In the first forming step, the material in the region of the cap (2) inside of the fold (9) is pressed close to an outside of portion of the cap (2) around the fold (9) at and around the second side “y” of the rock bolt (1). When the two dies of the set are closed onto the rock bolt (1) in the second forming step, the cap is not closed over the fold to the same extent as the larger diameter pipe wall.

In use, the rock bolt is inserted into a drill hole and expanded from a formed, folded condition towards a pre-formed condition, wherein the fully pre-formed condition represents a (substantially) maximal expansion which is in excess of that required for the rock bolt to engage in the drill hole. In practice, the wall of the drill hole is usually engaged with the rock bolt resembling the intermediate condition shown as “B” in Figures 1, 2 and 3. In situ conditions and the particular embodiment of the rock bolt used will determine the form that the expanded rock bolt takes.

The configuration of the cap formed in the manner illustrated and described serves to provide a configuration that involves folded regions of material that afford improved durability to the stress placed on the material in those regions during expansion of the rock bolt.

The forming process involves a smaller component of lateral compression in the region of the end wall of the cap. The majority of the deformation involves bending of the sidewall of the cap (similar to the sidewall of the pipe). The sidewall of the cap is more suitably arranged to accommodate bending than the end wall which has a large component of material provided substantially at a right angle to the pressing tool. The bending at the end wall of the cap involves having the material

pressed or drawn by the pressing tool, rearwardly towards and/or into the fold to form the substantially U-shaped ridge around the front of the rock bolt.

This folded configuration has been found to mitigate weakening of the material in the cap around the fold or folded regions and deter against any leaks forming when the rock bolt is expanded.

The terms used to describe the forming of the components and the cap sidewall and end wall are indicative and/or instructive of the process and components. These terms and description will be understood by a person suitably skilled in the art and will allow the invention to be implemented as a modification or improvement over the teaching of PCT/IB2016/053817.

While the invention is described and illustrated with respect to a configuration having a single fold providing the longitudinal channel for the reduced dimension of the rock bolt, it may also be employed where more than one such channel is formed along the pipe.

The capped and folded configuration of a rock bolt end in accordance with the invention is particularly suited for the inner or leading end of a rock bolt that is, in use, located into and towards the bottom of a drilled hole. This is not however a limitation and the invention may well be employed at both ends of a rock bolt. A pressurised fluid inlet may be provided through the wall of the pipe adjacent the outer end that protrudes from the drill hole.

A person skilled in the art will appreciate that a number of variations may be made to the features of the embodiments described without departing from the scope of the invention.

CLAIMS

1. An inflatable rock bolt comprising:

a pipe with a cap welded in sealing engagement onto an end of the pipe in a pre-formed condition;

the cap having a sidewall that extends from a rim of the cap to a closed end provided by an end wall of the cap;

the rock bolt provided with a fold formed from a first side of the rock bolt and extending along a length of the pipe;

a bottom of the fold located adjacent an opposite, second side of the rock bolt where it extends along the length of the pipe; and

the bottom of the fold extending from the pipe into the sidewall of the cap and outwardly towards the first side of the rock bolt to a position separated by a ridge from a first portion of the end wall that remains outside the fold, with a second portion of the end wall drawn into the fold.

2. A rock bolt as claimed in claim 1, in which the second portion of the end wall is arranged at a forward region of the fold with the first portion of the end wall in an oppositely disposed position at a front of the rock bolt.

3. A rock bolt as claimed in claim 1, in which the ridge extends from a front of the rock bolt as a substantially U-shaped ridge formed around the fold at the cap of the rock bolt.

4. A rock bolt as claimed in claim 3, in which the closed end of the cap is pressed outwardly in line with the fold where it is formed into a forward most section of the U-shaped ridge.

5. A rock bolt as claimed in claim 3, in which an edge of the ridge is located on one side of an axis of the pipe as it exists in a pre-formed condition of the pipe.

6. A rock bolt as claimed in claim 1, in which the end wall of the cap transitions from the sidewall uniformly through a curve to the closed end of the cap which is substantially flat.

7. A rock bolt as claimed in claim 1, in which the sidewall of the cap includes a substantially cylindrical region at the rim that locates with a press-fit into the pre-formed pipe.

8. A rock bolt as claimed in claim 1, in which a greater portion of the end wall of the cap to be maintained substantially in a pre-formed condition as the first portion with an adjacent lesser portion curved rearwardly and pressed toward the fold as the second portion.

9. A method of making an inflatable rock bolt which includes the steps of:

providing a length of pre-formed pipe with at least one open end,

welding a cap to the open end, and

thereafter deforming the pipe and the cap into a folded form to provide a fold that extends along the pipe,

characterised in that the fold is formed by a tool that is sized with a working edge that stops sufficiently short of an end wall at a closed end of the cap to:

- maintain a first portion of the end wall that is in line with the fold on an outside of the fold; and
- draw a second portion of the end wall in a curve rearwardly toward and into the fold.

10. A method as claimed in claim 9, in which the fold is formed to:

- provide a substantially U-shaped ridge that extends from a front of the rock bolt around the fold at the cap with an edge of the ridge located to one side of an axis of the pipe as it exists in a pre-formed condition of the pipe.

11. A method as claimed in claim 9, in which the fold is formed with the first portion as a greater portion of the end wall and the second portion as a lesser potion of the end wall.

12. A method as claimed in claim 9, in which the rock bolt is pressed closed around the fold in a second forming operation.

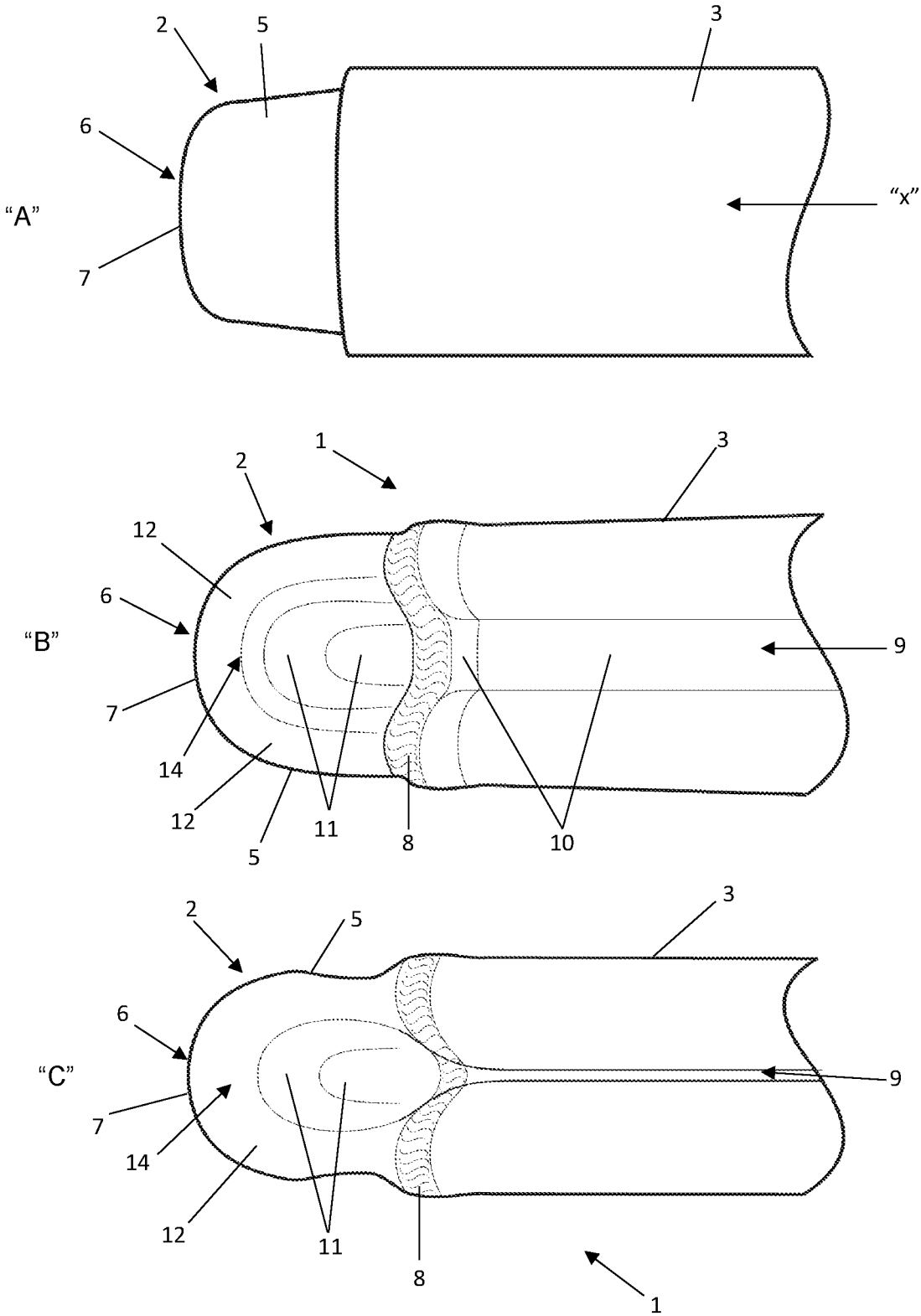

FIGURE 1

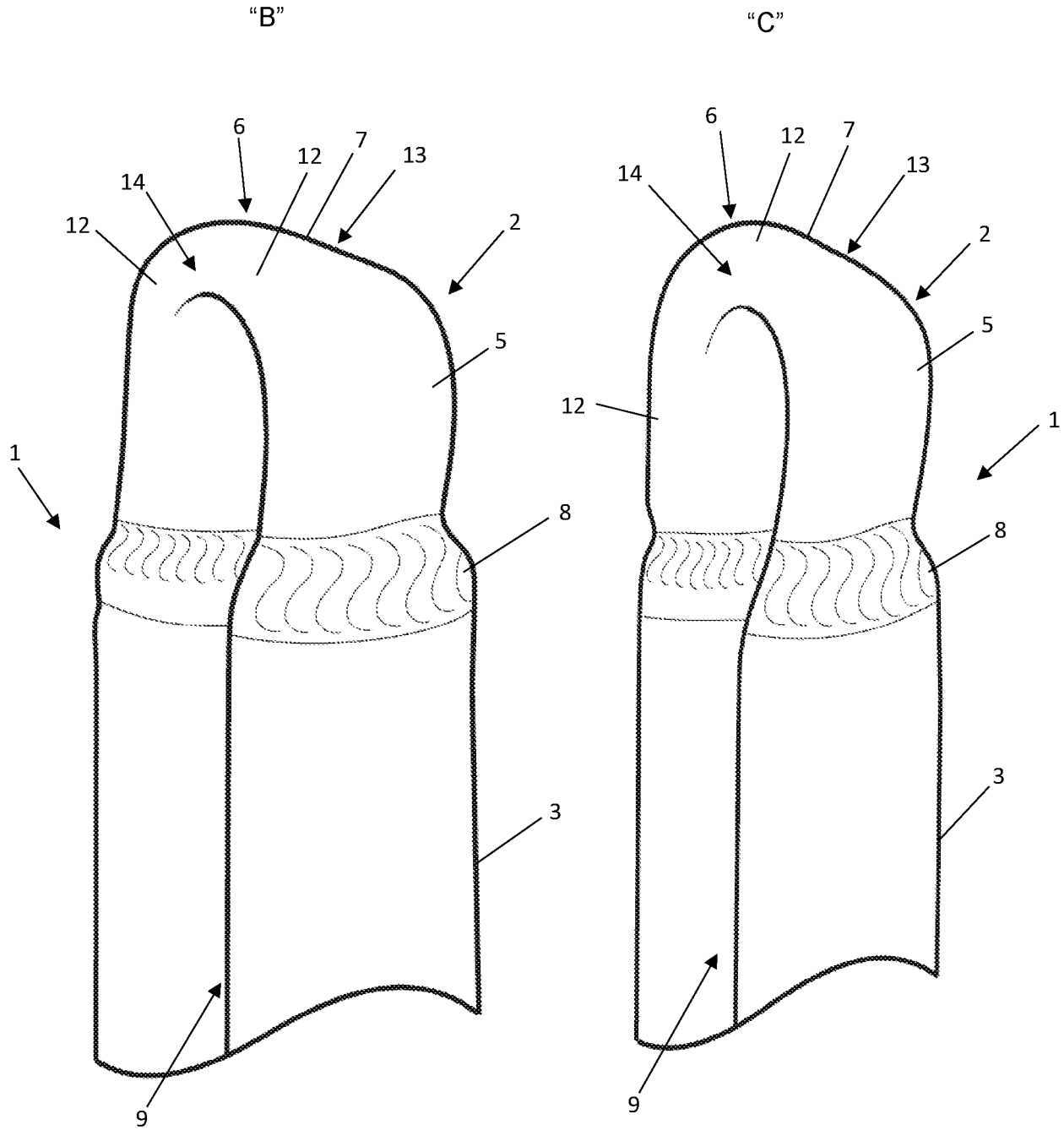

FIGURE 2

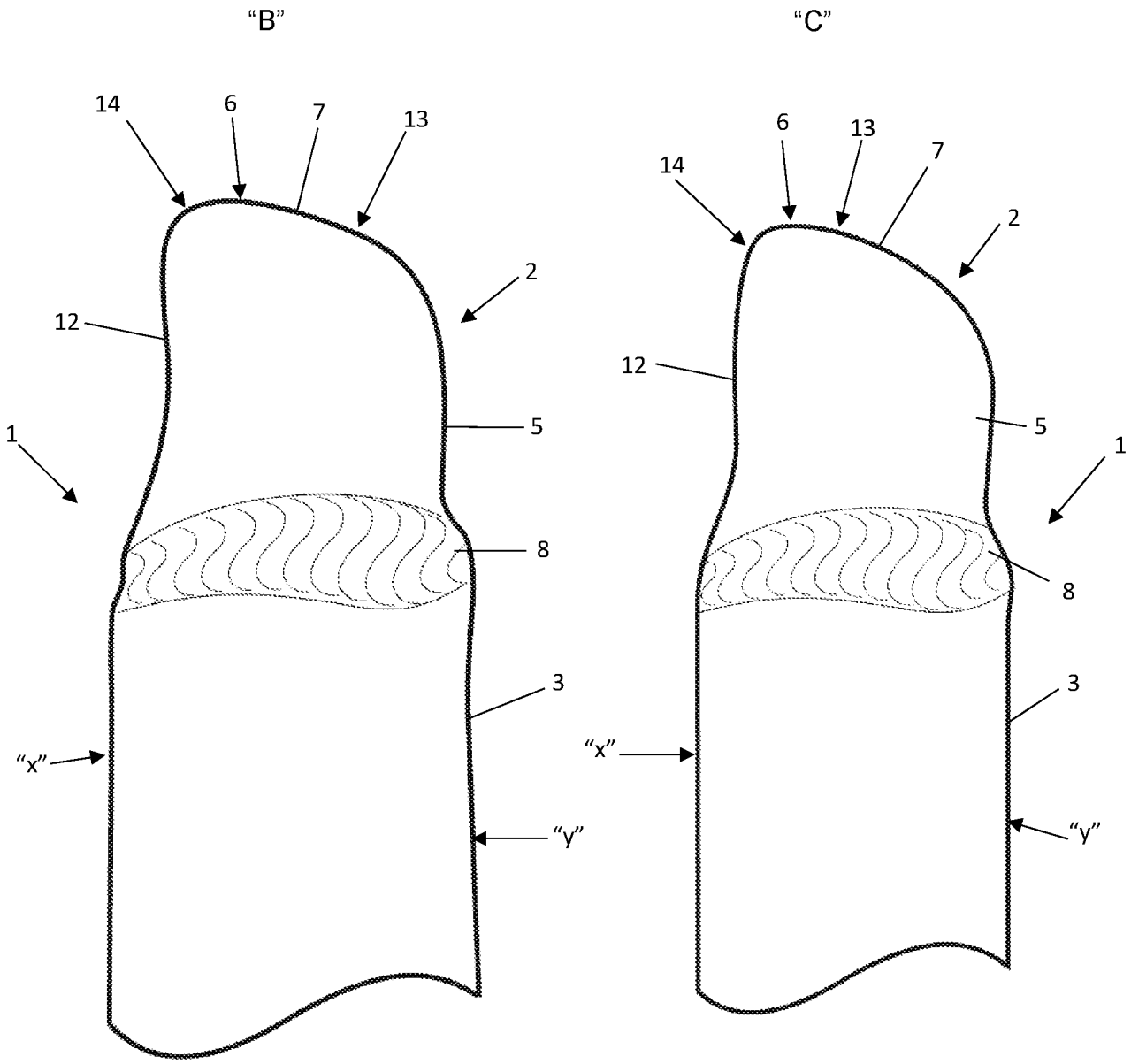

FIGURE 3

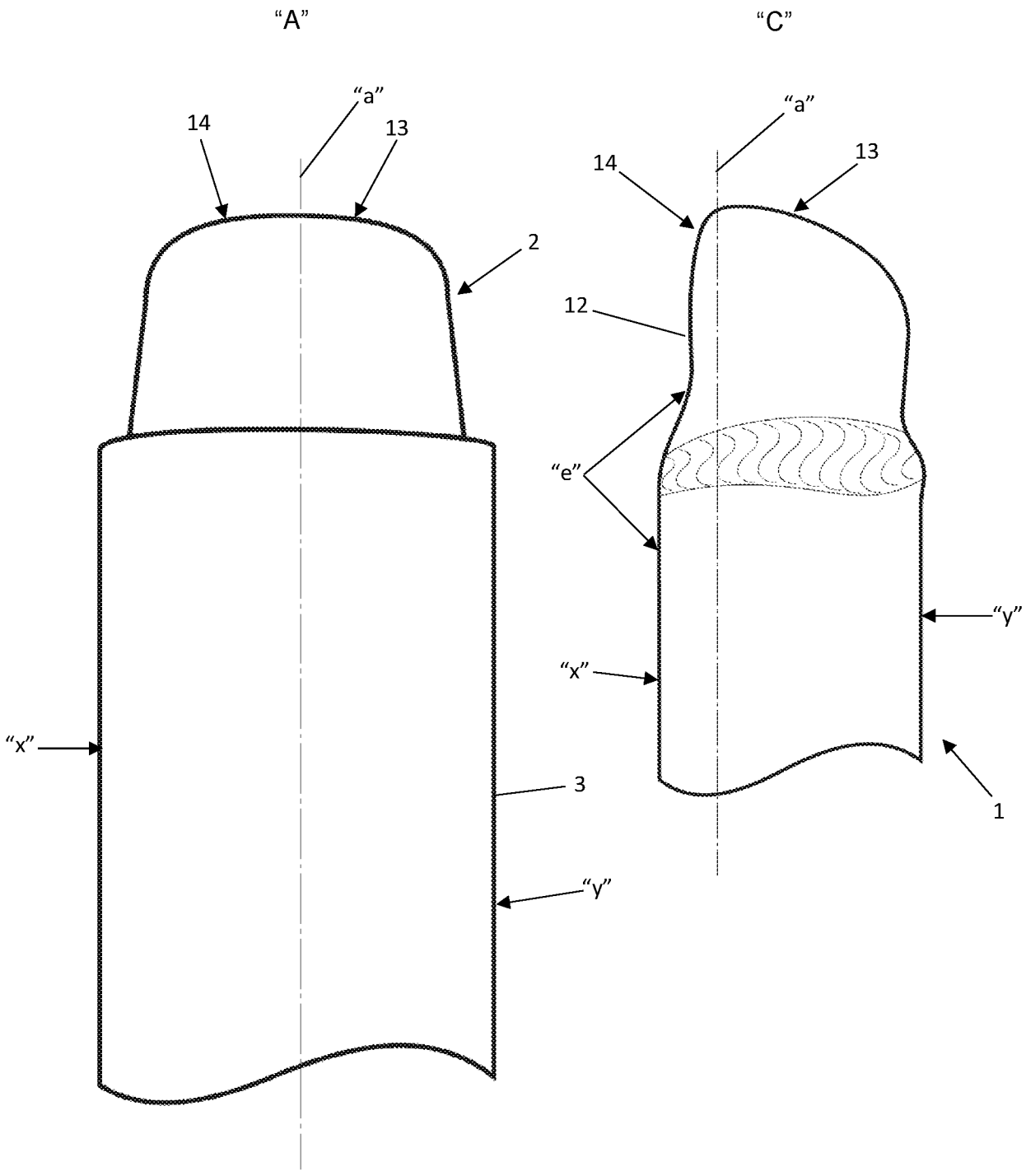

FIGURE 4