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(54) **Title**: EXPANDABLE TIE BACK SEAL ASSEMBLY

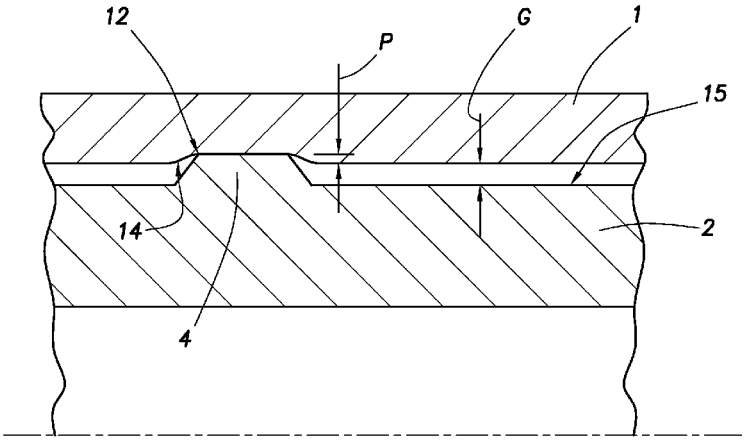

FIG.2A

(57) **Abstract**: Disclosed are apparatus and methods for completing a wellbore, using expandable tubular to form a sealed connection. More particularly, embodiments of the present invention relate to forming a seal between a radially expanded tubular and a receptacle, wherein annular-shaped, radially extending protrusions are present between the tubular and the receptacle to form a durable sealed connection therebetween.

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during replacement down-time, will accumulate. Accordingly, there is a need in the art for a highly durable tie back seal without elastomers that provides a reliable seal.

[0008] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each claim of this application.

SUMMARY

[0009] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

[0010] Embodiments disclosed herein generally relate to methods and apparatus for completing a well. Particularly, the present disclosure relates to a method and apparatus for completing a wellbore that involve the expansion of tubular. More particularly, embodiments disclosed herein relate to a tie back seal system, wherein the first tubular contains a polished bore receptacle configured to seal with the second tubular, thereby providing a sealed connection therebetween.

[0011] Disclosed herein is method of completing a well, having a cased wellbore section, the method comprising:

hanging a first metallic tubular member in the cased wellbore section at a subterranean location;

thereafter placing a second metallic tubular member in the cased wellbore section, such that a portion of the second tubular member is telescoped into the first tubular member, and such

that a portion of the outer surface of the second tubular member is adjacent to a portion of the inner surface of the first tubular member;

forming a plurality of metallic annular protrusions on one of the adjacent surface portions before the second tubular member is telescoped into the first tubular member; and

expanding the second tubular member until the protrusions form annular metallic seals with the adjacent surface portion of the other tubular member via plastic deformation of the adjacent surface portion and/or the protrusions,

wherein the protrusions and adjacent surface portions are configured such that when radially outermost ends of the protrusions first make contact with the adjacent surface portion of the other tubular member during expansion of the second tubular member, gaps are present on opposite axial sides of each protrusion, said gaps being at least partially closed upon further expansion of the second tubular member

[0012] Also disclosed herein is a wellbore tubing connection for use in connecting tubing at a subterranean location, comprising:

first and second metallic tubular members;

an end portion of the second tubular member being telescopically receivable in an end portion of the first tubular member to form an overlapping area in which the inner surface of the end portion of the first tubular member is adjacent to the outer surface of the end portion of the second tubular member; and

a plurality of preformed annular-shaped, radially extending metallic protrusions on one of the adjacent surfaces of one of the tubular members,

wherein the protrusions and end portions are configured such that:

with the end portion of the second tubular member telescoped in the end portion of the first tubular member, expanding the second tubular member causes the protrusions form annular metallic seals with the adjacent surface of the end portion of the other tubular member via plastic deformation of the adjacent surface portion and/or the protrusions, and

when radially outermost ends of the protrusions first make contact with the adjacent surface of the end portion of the other tubular member during expansion of the second tubular member, gaps are present on opposite axial sides of each protrusion, said gaps being at least partially closed upon further expansion of the second tubular member.

[0013] Also disclosed herein is a tie back seal system. The system includes tubular members receptive for forming a tie back seal assembly therein. The tie back seal assembly includes two telescoping tubular with the overlapping slip fit portions, at least one which is made from plastically deformable metallic material. The interior tubular having radially extending annular protrusions thereon, which when the tubular are plastically deformed to form a tie back seal, the protrusions engage the interior of the outer tubular to improve the sealing and durability of the seal system.

[0014] Further disclosed herein is a method of sealing a tie back to a tubular. The method includes: positioning a metal deformable tubular member of the tie back within an outer tubular member; expanding the deformable tubular in a radial direction to contact the outer tubular. The expanding causing the protrusions to engage the outer tubular creating annular contact areas comprising plastic deformation of the interior wall of outer tubular member.

[0015] Further disclosed herein is a tie back system and method wherein axially spaced protrusions on the outer surface of interior tubular member have a generally triangular or trapezoidal shaped cross section.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The drawings are incorporated into and form a part of the specification to illustrate at least one embodiment and/or example of the principles of the present disclosure. Together with the written description, the drawings serve to explain the principles of the present disclosure. The drawings are not to be construed as being in any way limiting. Advantages and

features of various embodiments of the principles disclosed herein will be apparent from a consideration of the following written description and accompanying drawings, in which:

[0017] **Figure 1** shows an embodiment of a tie back seal system configuration according to principles disclosed herein, illustrated in a longitudinal section prior to expansion;

[0018] **Figure 1A** is an enlarged cross section from **Figure 1**;

[0019] **Figure 2** shows an embodiment of a tie back seal system configuration according to principles disclosed herein, illustrated in longitudinal section subsequent to expansion; and

[0020] **Figure 2A** is an enlarged cross section from **Figure 2**.

DETAILED DESCRIPTION

[0021] Embodiments of the principles disclosed herein generally relate to methods and apparatus for completing a well, and particularly to completing a wellbore through the expansion of one or more tubular members. More particularly, embodiments of the principles disclosed herein relate to the concurrent expansion of a first and second tubular, wherein the first tubular contains a polished bore receptacle for forming a tie back seal, configured to sealingly receive a portion of the second tubular, thereby providing a sealable connection therebetween.

[0022] Referring more particularly to the drawings, wherein like reference characters are used throughout the various figures to refer to like or corresponding parts, there is shown in the figures, an embodiment of a tie back seal system according to principles disclosed herein.

[0023] Turning first to **Figures 1** and **1A**, one embodiment of a metal to metal tie back seal configuration used to form a seal between well tubing 5 and well tubing 6 is shown. The well tubing 6 has been run (installed) into a cased portion of the wellbore (not shown) and hung mounted in the wellbore. The mounting is not shown but methods of hanging the tubing 6 in the wellbore are well known in the industry. The tubing 5 has been lowered into the wellbore and the lower end inserted in a downhole direction DH into the upper end of the tubing 6.

[0024] In this embodiment, the telescoped or overlapping portion of well tubing 5 comprises a tie back seal mandrel 2. The telescoped or overlapping portion of well tubing 6 comprises a tie back seal receptacle 1. The receptacle can be in the form of a polished bore receptacle. For descriptive purposes, the cone 3 of an expander tool is illustrated in **Figure 1** in position to be moved through the tie back seal assembly to deform the seal mandrel 2 into sealing engagement with the tie back receptacle 1.

[0025] Tie back seal mandrel 2 comprises a tubular member made from deformable metallic material. Mandrel 2 has an outer diameter and wall thickness which when compared to the well tubing 5 is smaller and thinner, respectively. The wall thickness of the tie back receptacle 1 is thinner than the wall thickness of the well tubing 6.

[0026] A plurality of radially extending metallic protrusions or ridges 4 are formed on the reduced diameter outer surface of the seal mandrel 2. These protrusions can be integrally formed on the tubular members, for example, by casting and/or machining. Ridges 4 are axially spaced apart a distance D. Ridges 4 are annular shaped in that they extend continuously around the circumference of the seal mandrel 2 outer surface. In other words, each protrusion is endless or ring shaped as contrasted with the spiral pattern with ends that is present in a threaded connection. As illustrated in detail in **Figure 1A**, these protrusions 4 have a tapered cross section which in this embodiment is generally triangular or trapezoid shaped in cross-section with the opposed sidewalls 7 inclined toward each other at an angle A in the range of about 30° to about 60°. The outer apexes of each of the ridges 4 are flattened to form an annular outer wall

8. Wall 8 appears linear and parallel to the longitudinal axis of the seal mandrel 2 when viewed in cross section as in Figure 1A, such that the wall 8 defines a cylindrical shape to form a cylindrical contact area with the tie back receptacle 1. However, it is envisioned that the wall 8 could define a surface that appears concave or convex when viewed in a cross section corresponding with that of **Figure 1A**.

[0027] **Figures 2** and **2A** graphically illustrate the metal to metal tie back seal configuration after it has been made up by the cone of expander tool 3. As is illustrated, the cone 3 of the expander tool can elastically contact the tie back receptacle 1 or deform the tie back mandrel 2 and tie back receptacle 1 in the area of contact. The protrusions 4 can deform and/or be embedded in the inner wall of the tie back receptacle 1 to form an annular contact area which acts as a metallic annular seal.

[0028] As illustrated in diagram form in **Figure 2A**, it is anticipated that protrusions 4 can cause plastic deformations 12 to occur in the inner wall 14 of the tie back receptacle 1 as the expansion process is performed. In **Figure 2A**, the deformations 12 penetrate a distance "P" into the internal surface 14. It is also believed that the protrusions 4 can likewise be plastically deformed during the expansion process. As a result of the engagement between the protrusions 4 and the deformations 12, a plurality of circumferentially extending annular metal to metal contact areas are created, forming a plurality annular seals spaced along the length of the seal assembly. Also, as illustrated in **Figure 2A**, a gap "G" may be formed at the interface between the internal surface 14 of the tie back receptacle 1 and the external surface 15 of the seal mandrel 2. The gap "G" may be present along all or portions of the interface where the protrusions are not present.

[0029] The interaction between the protrusions 4 and interior wall surface of the tie back receptacle 14 can be altered by the selection of materials for the tubing sections. By forming the receptacle from relatively hard material and the mandrel with a lesser hardness,

more deformation of the protrusions would be expected. The dimensions of the sections and cone can be selected to vary the expansion process and amount of deformation in the sealing area.

[0030] In another embodiment, the protrusions illustrated in **Figure 1A**, are formed on the interior wall of the tie back receptacle, instead of or in addition to the protrusions on the tie back receptacle.

[0031] The embodiments disclosed herein are capable of considerable modification, alteration, and equivalents in form and function, as will occur to those ordinarily skilled in the pertinent arts and having the benefit of this disclosure.

[0032] Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an", as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent(s) or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

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Claims:

1. A method of completing a well, having a cased wellbore section, the method comprising:

hanging a first metallic tubular member in the cased wellbore section at a subterranean location;

thereafter placing a second metallic tubular member in the cased wellbore section, such that a portion of the second tubular member is telescoped into the first tubular member, and such that a portion of the outer surface of the second tubular member is adjacent to a portion of the inner surface of the first tubular member;

forming a plurality of metallic annular protrusions on one of the adjacent surface portions before the second tubular member is telescoped into the first tubular member; and

expanding the second tubular member until the protrusions form annular metallic seals with the adjacent surface portion of the other tubular member via plastic deformation of the adjacent surface portion and/or the protrusions,

wherein the protrusions and adjacent surface portions are configured such that when radially outermost ends of the protrusions first make contact with the adjacent surface portion of the other tubular member during expansion of the second tubular member, gaps are present on opposite axial sides of each protrusion, said gaps being at least partially closed upon further expansion of the second tubular member.

2. The method according to claim 1, wherein forming the annular protrusions comprises integrally forming the annular protrusions on said one of the adjacent surface portions.

3. The method according to claim 1 or claim 2, wherein the annular protrusions each have a tapered cross sectional shape.

4. The method according to any one of claims 1 to 3, wherein the annular protrusions are axially spaced on said one of the adjacent surface portions.

5. The method according to any one of the preceding claims, wherein the annular protrusions each have opposite side walls inclined toward each other at an angle of between about 30 degrees and about 60 degrees.

6. The method according to any one of the preceding claims, wherein the annular protrusions each have a generally trapezoidal cross-sectional shape.

7. The method according to claim 1, wherein the annular protrusions each have an outer annular wall for contacting the adjacent surface portion of the other tubular member.

8. The method according to any one of claims 1 to 5, wherein the annular protrusions each have a generally triangular cross-sectional shape.

9. The method according to claim 1, wherein a plurality of metallic annular protrusions are integrally formed on the adjacent surface portions of both the first and second tubular members.

10. A wellbore tubing connection for use in connecting tubing at a subterranean location, comprising:

first and second metallic tubular members;

an end portion of the second tubular member being telescopically receivable in an end portion of the first tubular member to form an overlapping area in which the inner surface of the end portion of the first tubular member is adjacent to the outer surface of the end portion of the second tubular member; and

a plurality of preformed annular-shaped, radially extending metallic protrusions on one of the adjacent surfaces of one of the tubular members,

wherein the protrusions and end portions are configured such that:

with the end portion of the second tubular member telescoped in the end portion of the first tubular member, expanding the second tubular member causes the protrusions

form annular metallic seals with the adjacent surface of the end portion of the other tubular member via plastic deformation of the adjacent surface portion and/or the protrusions, and

when radially outermost ends of the protrusions first make contact with the adjacent surface of the end portion of the other tubular member during expansion of the second tubular member, gaps are present on opposite axial sides of each protrusion, said gaps being at least partially closed upon further expansion of the second tubular member.

11. The connection according to claim 10, wherein the annular protrusions are integrally formed on said one of the adjacent surfaces.

12. The connection according to claim 10 or claim 11, wherein the annular protrusions each have a tapered cross sectional shape.

13. The connection according to any one of claims 10 to 12, wherein the annular protrusions are axially spaced on said one of the adjacent surfaces.

14. The connection according to any one of claims 10 to 13, wherein the plurality of protrusions each have opposite side walls inclined toward each other at an angle of between about 30 degrees and about 60 degrees.

15. The connection according to any one of claims 10 to 14, wherein the plurality of protrusions each have a generally trapezoidal cross-sectional shape.

16. The connection according to any one of claims 10 to 15, wherein the plurality of protrusions each have an outer annular wall for contacting the adjacent surface of the end portion of the other tubular member.

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17. The connection according to any one of claims 10 to 14, wherein the plurality of protrusions each have a generally triangular cross-sectional shape.

18. The connection according to any one of claims 10 to 17, wherein a plurality of the metallic annular protrusions are integrally formed on the adjacent surfaces of both the first and second tubular members.

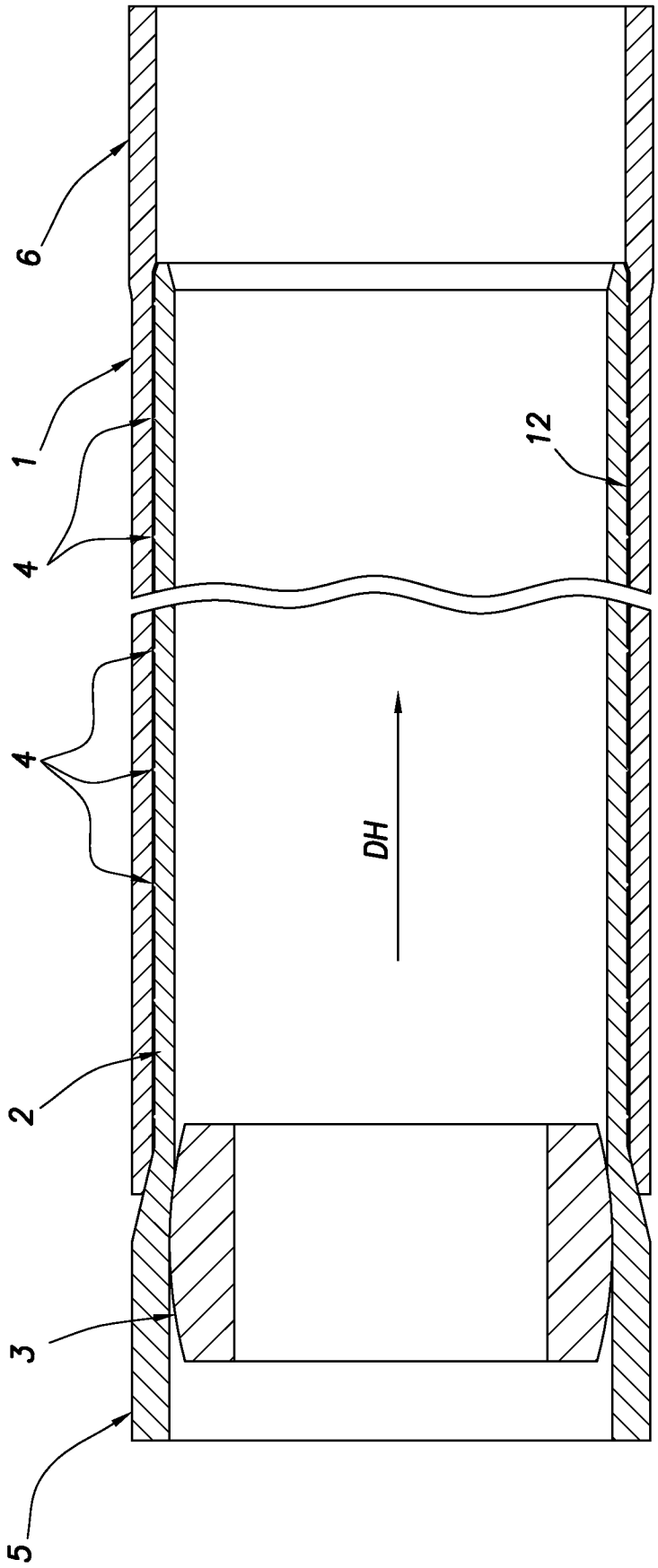

FIG. 1

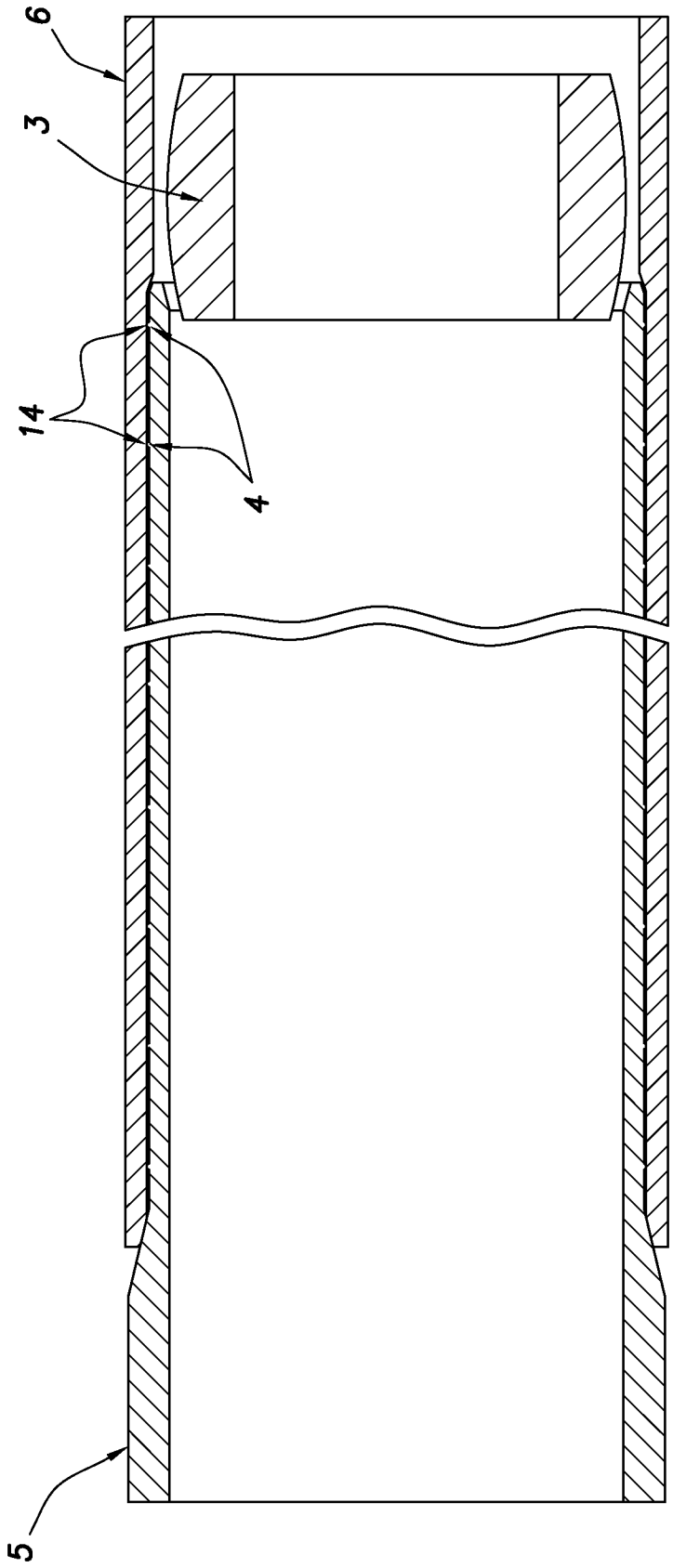

FIG.2

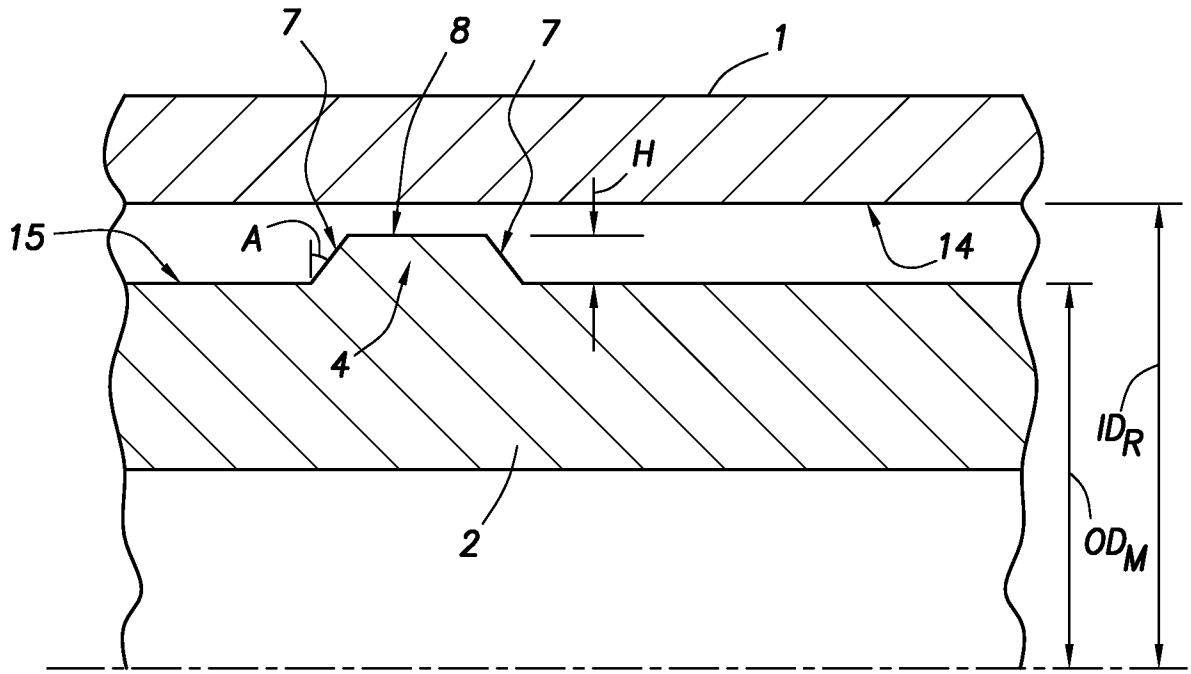

FIG. 1A

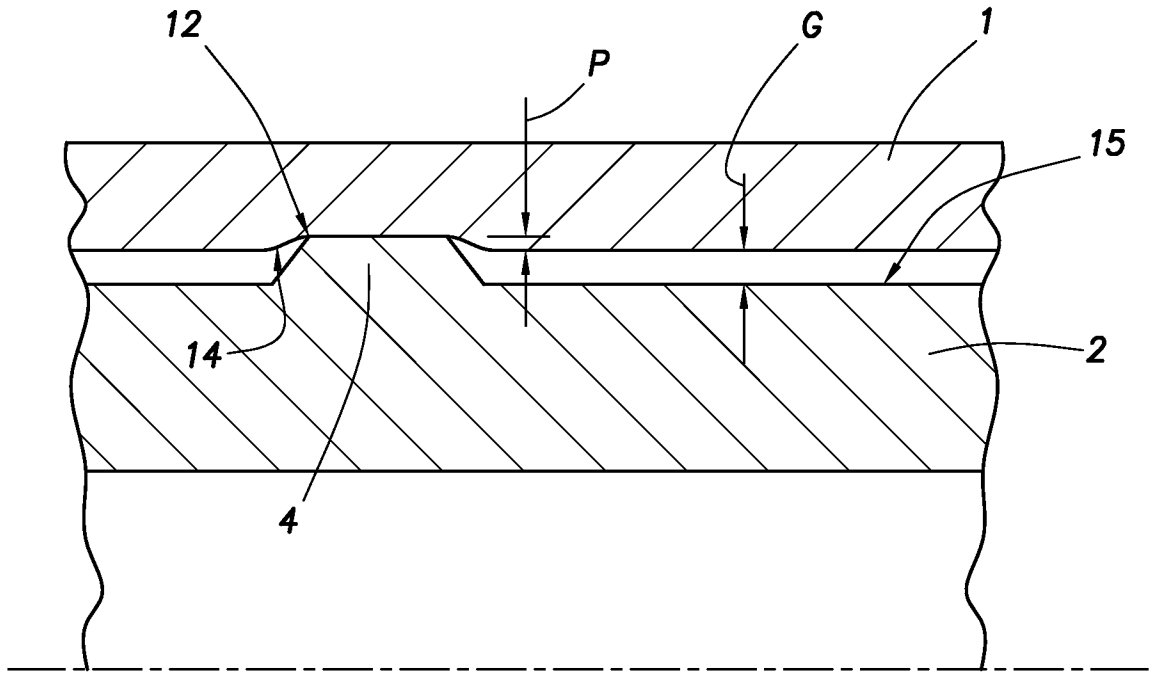

FIG. 2A