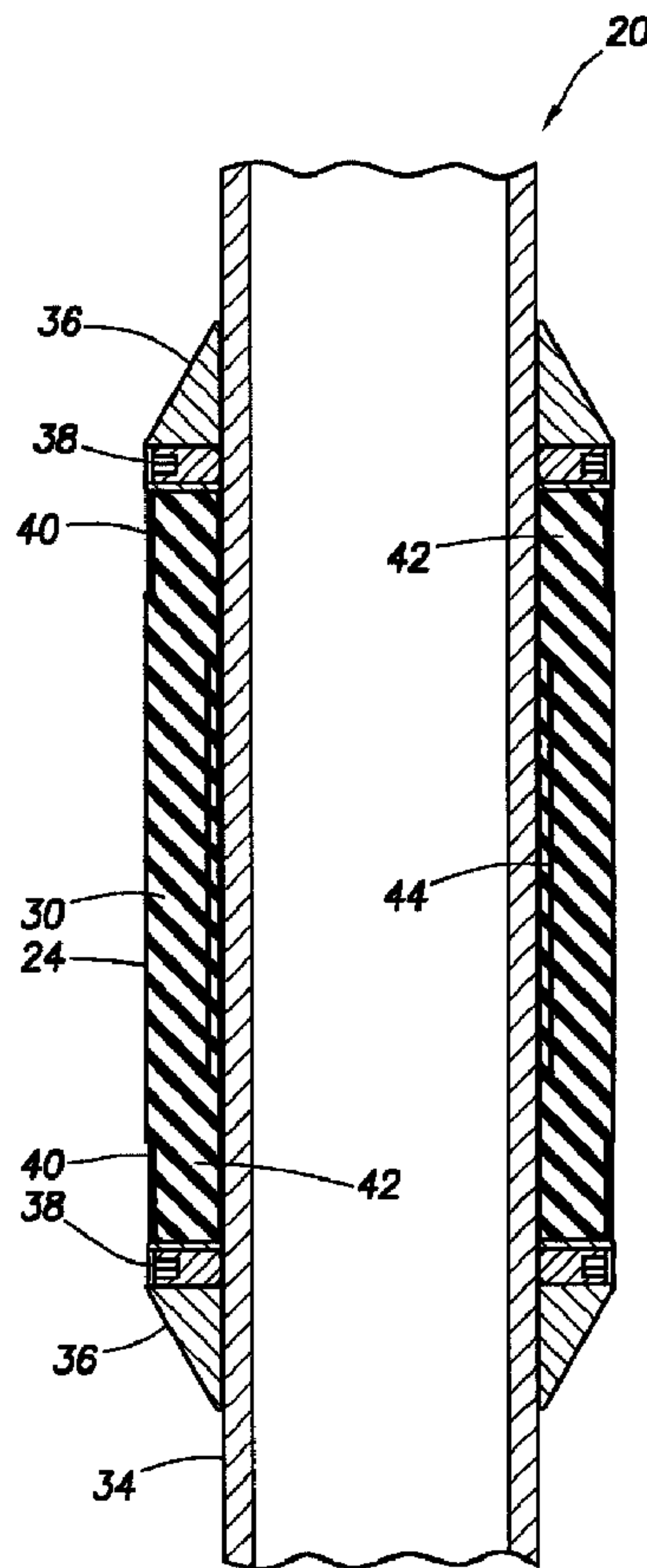




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(54) **Titre : PACKER GONFLANT COMPORTANT DES ELEMENTS DE RENFORT ET ANTI-EXTRUSION**
 (54) **Title: SWELLABLE PACKER WITH REINFORCEMENT AND ANTI-EXTRUSION FEATURES**



(57) **Abrégé/Abstract:**

A packer assembly for use in a subterranean well can include a seal element which swells in the well, a reinforcement in the seal element, and an extrusion barrier which displaces outward in response to swelling of an end portion of the seal element, the

(57) Abrégé(suite)/Abstract(continued):

reinforcement being longitudinally spaced apart from the end portion of the seal element. A method of constructing a packer assembly can include positioning a reinforcement in a seal element which swells in response to contact with a fluid, the positioning including longitudinally spacing opposite ends of the reinforcement away from opposite end portions of the seal element, and installing extrusion barriers which radially outwardly overlie the seal element end portions.

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(54) Title: SWELLABLE PACKER WITH REINFORCEMENT AND ANTI-EXTRUSION FEATURES

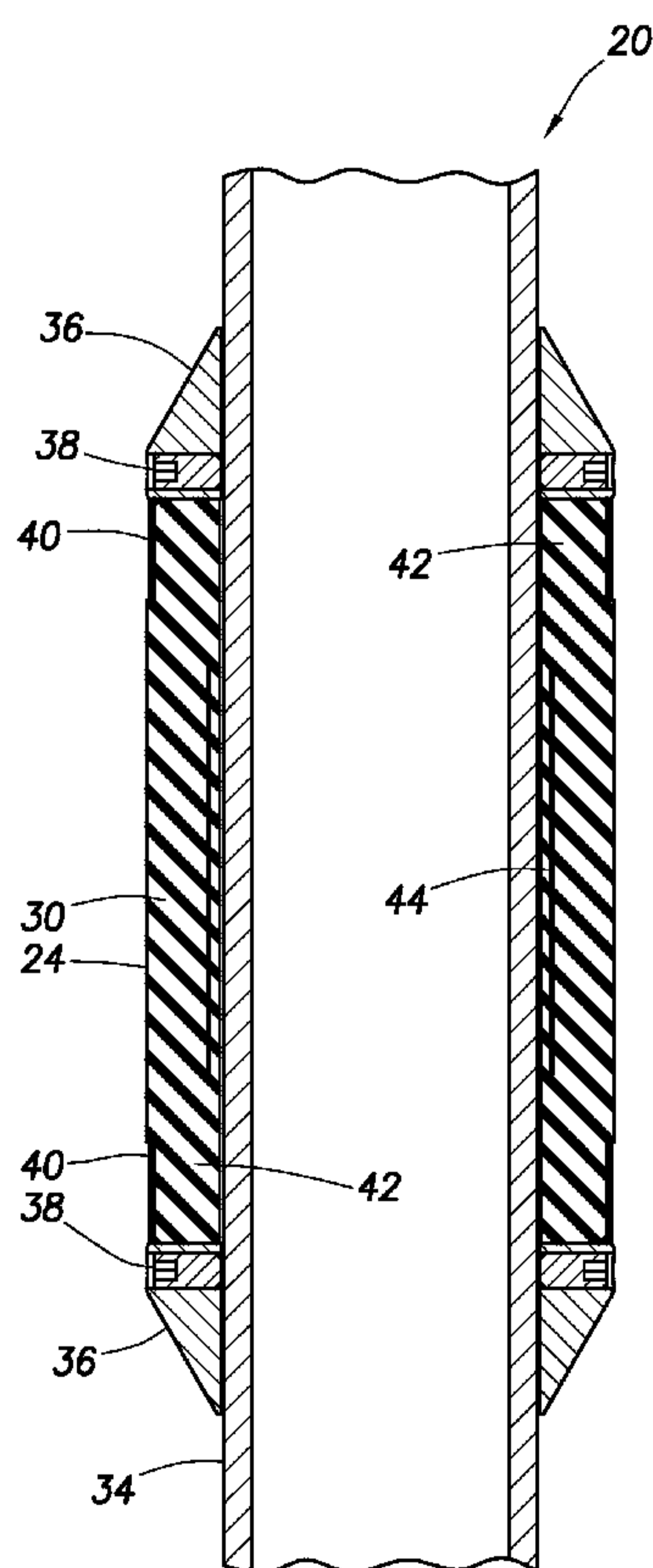


FIG. 3

(57) Abstract: A packer assembly for use in a subterranean well can include a seal element which swells in the well, a reinforcement in the seal element, and an extrusion barrier which displaces outward in response to swelling of an end portion of the seal element, the reinforcement being longitudinally spaced apart from the end portion of the seal element. A method of constructing a packer assembly can include positioning a reinforcement in a seal element which swells in response to contact with a fluid, the positioning including longitudinally spacing opposite ends of the reinforcement away from opposite end portions of the seal element, and installing extrusion barriers which radially outwardly overlie the seal element end portions.



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**SWELLABLE PACKER WITH REINFORCEMENT AND ANTI-
EXTRUSION FEATURES**

10

TECHNICAL FIELD

This disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in one example described below, more particularly provides a swellable packer with reinforcement and anti-
15 extrusion features.

BACKGROUND

Swellable packers are known in the art as annular barriers which swell to seal off annular spaces in wells
20 (such as, between a production tubing and a casing or wellbore wall, etc.). Swellable packers include seal elements which, after swelling, are subjected to pressure differentials across the seal elements in the annular spaces. Therefore, it will be readily appreciated that
25 improvements are continually needed in the arts of constructing and utilizing swellable packers.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representative partially cross-sectional view of a well system and associated method which can embody principles of this disclosure.

FIGS. 2 & 3 are representative elevational and cross-sectional views of a packer assembly which may be used in the system and method of FIG. 1, FIG. 3 being taken along line 3-3 of FIG. 2.

FIG. 4 is a representative perspective view of an end ring and extrusion barrier of the packer assembly.

FIG. 5 is a representative perspective view of an extrusion barrier portion of the packer assembly.

DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a system for use with a well, and an associated method, which system and method can embody principles of this disclosure. However, it should be clearly understood that the system and method are merely one example of an application of the principles of this disclosure in practice, and a wide variety of other examples are possible. Therefore, the scope of this disclosure is not limited at all to the details of the system and method described herein and/or depicted in the drawings.

In the FIG. 1 example, a tubular string 12 is positioned in a wellbore 14 lined with casing 16 and cement 18. In other examples, the wellbore 14 could be uncased or open hole, at least in a section where a packer assembly is connected in the tubular string 12.

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The packer assembly 20 is used to seal off an annulus 22 formed radially between the tubular string 12 and the wellbore 14. If the wellbore 14 is uncased or open hole, then an annular seal element 24 of the packer assembly 20 can sealingly engage an inner wall 26 of an earth formation 28 penetrated by the wellbore 14. However, it should be clearly understood that the scope of this disclosure is not limited to any particular surface or wall being sealingly contacted by the seal element 24.

10 The seal element 24 comprises a material 30 which swells when it is contacted by a particular fluid or fluids. Swelling of the material 30 causes the seal element 24 to extend radially outward into sealing contact with the wellbore 14.

15 Preferably, the swellable material 30 swells when it is contacted with a particular activating agent (e.g., oil, gas, other hydrocarbons, water, acid, other chemicals, etc.) in the well. The activating agent may already be present in the well, or it may be introduced after installation of the packer assembly 20 in the well, or it may be carried into the well with the packer assembly, etc. The swellable material 30 could instead swell in response to exposure to a particular temperature, or upon passage of a period of time, or in response to another stimulus, etc.

25 Thus, it will be appreciated that a wide variety of different ways of swelling the swellable material 30 exist and are known to those skilled in the art. Accordingly, the scope of this disclosure is not limited to any particular manner of swelling the swellable material 30. Furthermore, 30 the scope of this disclosure is also not limited to any of the details of the well system 10 and method described

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herein, since the principles of this disclosure can be applied to many different circumstances.

The term "swell" and similar terms (such as "swellable") are used herein to indicate an increase in volume of a swellable material. Typically, this increase in volume is due to incorporation of molecular components of the activating agent into the swellable material itself, but other swelling mechanisms or techniques may be used, if desired. Note that swelling is not the same as expanding, although a seal material may expand as a result of swelling.

For example, in some conventional packers, a seal element may be expanded radially outward by longitudinally compressing the seal element, or by inflating the seal element. In each of these cases, the seal element is expanded without any increase in volume of the seal material of which the seal element is made. Thus, in these conventional packers, the seal element expands, but does not swell.

The activating agent which causes swelling of the swellable material 30 is in this example preferably a hydrocarbon fluid (such as oil or gas). In the well system 10, the swellable material 30 swells when a fluid 32 comprises the activating agent (e.g., when the fluid enters the wellbore 14 from the formation 28 surrounding the wellbore, when the fluid is circulated to the packer assembly 20 from the surface, when the fluid is released from a chamber carried with the packer assembly, etc.). In response, the seal element 24 seals off the annulus 22.

The activating agent which causes swelling of the swellable material 30 could be comprised in any type of fluid. The activating agent could be naturally present in the well, or it could be conveyed with the packer assembly

20, conveyed separately or flowed into contact with the swellable material 30 in the well when desired. Any manner of contacting the activating agent with the swellable material 30 may be used in keeping with the principles of this disclosure.

Various swellable materials are known to those skilled in the art, which materials swell when contacted with water and/or hydrocarbon fluid, so a comprehensive list of these materials will not be presented here. Partial lists of swellable materials may be found in U.S. Patent Nos. 3385367, 7059415 and 7143832.

As another alternative, the swellable material 30 may have a substantial portion of cavities therein which are compressed or collapsed at the surface condition. Then, after being placed in the well at a higher pressure, the material 30 is expanded by the cavities filling with fluid.

This type of apparatus and method might be used where it is desired to expand the swellable material 30 in the presence of gas rather than oil or water. A suitable swellable material is described in U.S. Published Application No. 2007-0257405.

Preferably, the swellable material 30 used in the seal element 24 swells by diffusion of hydrocarbons into the swellable material, or in the case of a water swellable material, by the water being absorbed by a super-absorbent material (such as cellulose, clay, etc.) and/or through osmotic activity with a salt-like material. Hydrocarbon-, water- and gas-swellable materials may be combined, if desired.

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It should, thus, be clearly understood that any swellable material which swells when contacted by a predetermined activating agent may be used in keeping with the principles of this disclosure. The swellable material 30 could also swell in response to contact with any of multiple activating agents. For example, the swellable material 30 could swell when contacted by hydrocarbon fluid, or when contacted by water.

Referring additionally now to FIGS. 2 & 3, elevational and cross-sectional views of the packer assembly 20 are representatively illustrated. The packer assembly 20 may be used in the system 10 and method of FIG. 1, or the packer assembly may be used in other systems or methods.

In the FIGS. 2 & 3 example, the seal element 24 is longitudinally retained on a base pipe 34 by end rings 36. In this example, the end rings 36 are secured to the base pipe 34 with set screws 38, but other techniques (such as welding, clamping, etc.) may be used as desired. The scope of this disclosure is not limited to any particular details of the end rings 36, or to any particular manner of securing the end rings on the base pipe 34.

Extrusion barriers 40 radially outwardly overlie opposite end portions 42 of the seal element 24. When the seal element end portions 42 swell, the extrusion barriers 40 are bent outward, so that they bridge extrusion gaps formed between the end rings 36 and the wellbore 14. This prevents extrusion of the seal element 24 through the extrusion gaps due to differential pressure across the seal element.

A reinforcement 44 is embedded in the seal element 24. In this example, the reinforcement 44 is in the form of a metal sleeve embedded or molded into the seal element 24.

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However, in other examples, the reinforcement 44 could be made of other material(s), and the reinforcement could be otherwise shaped. Thus, the scope of this disclosure is not limited to any particular details of the reinforcement 44 as depicted in the drawings or described herein.

The reinforcement 44 prevents buckling of the seal element 24 and helps to retain the seal element on the base pipe 34. For example, when swelling of the seal element 24 begins, the swellable material 30 radially between the reinforcement 44 and the base pipe 34 will also swell, thereby causing the seal element to grip the base pipe.

Note that the reinforcement 44 extends longitudinally in the seal element 24, but does not extend an entire length of the seal element. Instead, the reinforcement 44 is longitudinally spaced apart from the end portions 42 of the seal element.

In this manner, swelling of the seal element end portions 42 are not restricted at all by the reinforcement 44. The seal element end portions 42 can readily swell outward to sealingly contact the wellbore 14, and to outwardly extend the extrusion barriers 40 at opposite ends of the seal element 24.

Referring additionally now to FIGS. 4 & 5, an end ring 36 and extrusion barrier 40 are representatively illustrated, apart from the remainder of the packer assembly 20. In FIG. 4, it may be seen that the extrusion barrier 40 includes longitudinally extending and circumferentially distributed leaves or petals 46 formed on the end ring 36.

The extrusion barrier 40 also includes longitudinally extending and circumferentially distributed leaves or petals 48 formed on a sleeve 50 received in the petals 46 on the end ring 36. The petals 46, 48 are arranged, so that each

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petal extends across a gap between petals underlying or overlying that petal, thereby forming a complete barrier to extrusion of the seal element 24 when it swells.

As depicted in FIG. 3, the extrusion barriers 40
5 radially outwardly overlie the end portions 42 of the seal element 24. Thus, when the seal element end portions 42 swell, the extrusion barriers 40 will be readily displaced outward by the seal element end portions, so that the extrusion barriers contact the wellbore 14 and bridge the
10 extrusion gaps between the end rings 36 and the wellbore.

It may now be fully appreciated that the above disclosure provides significant advancements to the arts of constructing and utilizing swellable packers in wells. In an example described above, the seal element 24 of the packer
15 assembly 20 has a reinforcement 44 therein, but the reinforcement does not hinder swelling of end portions 42 of the seal element, and allows the extrusion barriers 40 to readily displace to close off extrusion gaps.

A packer assembly 20 for use in a subterranean well is
20 described above. In one example, the packer assembly 20 can include a seal element 24 which swells in the well, a reinforcement 44 in the seal element 24, and an extrusion barrier 40 which displaces outward in response to swelling of an end portion 42 of the seal element 24. The
25 reinforcement 44 is longitudinally spaced apart from the end portion 42 of the seal element 24.

The reinforcement 44 may comprise a metal sleeve. The seal element 24 can be disposed both radially inward and outward relative to the reinforcement 44.

30 The end portion 42 of the seal element 24 may underlie the extrusion barrier 40. The extrusion barrier 40 can comprise multiple circumferentially distributed petals 46,

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48 secured to an end ring 36, the end ring 36 preventing longitudinal displacement of the seal element 24 relative to a base pipe 34.

The reinforcement 44 may be longitudinally spaced apart from the extrusion barrier 40. The seal element 24 may swell in response to contact with a fluid 32.

A method of constructing a packer assembly 20 for use in a subterranean well is also described above. In one example, the method can comprise: positioning a reinforcement 44 in a seal element 24 which swells in the well, the positioning including longitudinally spacing opposite ends of the reinforcement 44 away from opposite end portions 42 of the seal element 24; and installing extrusion barriers 40 which radially outwardly overlie the seal element end portions 42.

Also described above is a well system 10, which can include a packer assembly 20 disposed in a subterranean well. The packer assembly 20 may include a seal element 24 which swells in response to contact with a fluid 32, a reinforcement 44 in the seal element 24, and an extrusion barrier 40 which overlies an end portion 42 of the seal element 24. The reinforcement 44 is longitudinally spaced apart from the end portion 42 of the seal element 24.

Although various examples have been described above, with each example having certain features, it should be understood that it is not necessary for a particular feature of one example to be used exclusively with that example. Instead, any of the features described above and/or depicted in the drawings can be combined with any of the examples, in addition to or in substitution for any of the other features of those examples. One example's features are not mutually exclusive to another example's features. Instead, the scope

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of this disclosure encompasses any combination of any of the features.

Although each example described above includes a certain combination of features, it should be understood
5 that it is not necessary for all features of an example to be used. Instead, any of the features described above can be used, without any other particular feature or features also being used.

It should be understood that the various embodiments
10 described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of this disclosure. The embodiments are described merely as examples of useful applications of the principles
15 of the disclosure, which is not limited to any specific details of these embodiments.

In the above description of the representative examples, directional terms (such as "above," "below," "upper," "lower," etc.) are used for convenience in
20 referring to the accompanying drawings. However, it should be clearly understood that the scope of this disclosure is not limited to any particular directions described herein.

The terms "including," "includes," "comprising," "comprises," and similar terms are used in a non-limiting
25 sense in this specification. For example, if a system, method, apparatus, device, etc., is described as "including" a certain feature or element, the system, method, apparatus, device, etc., can include that feature or element, and can also include other features or elements. Similarly, the term
30 "comprises" is considered to mean "comprises, but is not limited to."

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Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the disclosure, readily appreciate that many modifications, additions, 5 substitutions, deletions, and other changes may be made to the specific embodiments, and such changes are contemplated by the principles of this disclosure. For example, structures disclosed as being separately formed can, in other examples, be integrally formed and *vice versa*.

10 Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the invention being limited solely by the appended claims and their equivalents.

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WHAT IS CLAIMED IS:

1. A packer assembly for use in a subterranean well,
the packer assembly comprising:

5 a seal element which swells in the well;

a reinforcement in the seal element; and

an extrusion barrier which displaces outward in
response to swelling of an end portion of the seal element,
the reinforcement being longitudinally spaced apart from the
10 end portion of the seal element.

2. The packer assembly of claim 1, wherein the
reinforcement comprises a metal sleeve.

15 3. The packer assembly of claim 1, wherein the seal
element is disposed both radially inward and outward
relative to the reinforcement.

20 4. The packer assembly of claim 1, wherein the end
portion of the seal element underlies the extrusion barrier.

25 5. The packer assembly of claim 1, wherein the
extrusion barrier comprises multiple circumferentially
distributed petals secured to an end ring, the end ring
preventing longitudinal displacement of the seal element
relative to a base pipe.

6. The packer assembly of claim 1, wherein the reinforcement is longitudinally spaced apart from the extrusion barrier.

5 7. The packer assembly of claim 1, wherein the seal element swells in response to contact with a fluid.

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8. A method of constructing a packer assembly for use in a subterranean well, the method comprising:

positioning a reinforcement in a seal element which swells in the well, the positioning including longitudinally spacing opposite ends of the reinforcement away from
5 opposite end portions of the seal element; and

installing extrusion barriers which radially outwardly overlie the seal element end portions.

10 9. The method of claim 8, wherein the positioning further comprises longitudinally spacing the reinforcement away from the extrusion barrier.

15 10. The method of claim 8, wherein the reinforcement comprises a metal sleeve.

20 11. The method of claim 8, wherein the positioning further comprises disposing the seal element both radially inward and outward relative to the reinforcement.

12. The method of claim 8, wherein the extrusion barrier displaces outward in response to swelling of the seal element end portions.

25 13. The method of claim 8, wherein the extrusion barriers each comprise multiple circumferentially distributed petals secured to an end ring, the end rings preventing longitudinal displacement of the seal element relative to a base pipe.

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14. The method of claim 8, wherein the seal element swells in response to contact with a fluid.

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15. A well system, comprising:

a packer assembly disposed in a subterranean well, the packer assembly including a seal element which swells in response to contact with a fluid, a reinforcement in the seal element, and an extrusion barrier which overlies an end
5 portion of the seal element,

wherein the reinforcement is longitudinally spaced apart from the end portion of the seal element.

10 16. The system of claim 15, wherein the reinforcement comprises a metal sleeve.

17. The system of claim 15, wherein the seal element is disposed both radially inward and outward relative to the
15 reinforcement.

18. The system of claim 15, wherein the extrusion barrier comprises multiple circumferentially distributed petals secured to an end ring, the end ring preventing
20 longitudinal displacement of the seal element relative to a base pipe.

19. The system of claim 15, wherein the reinforcement is longitudinally spaced apart from the extrusion barrier.

25

20. The system of claim 15, wherein the extrusion barrier displaces outward in response to swelling of the end portion of the seal element.

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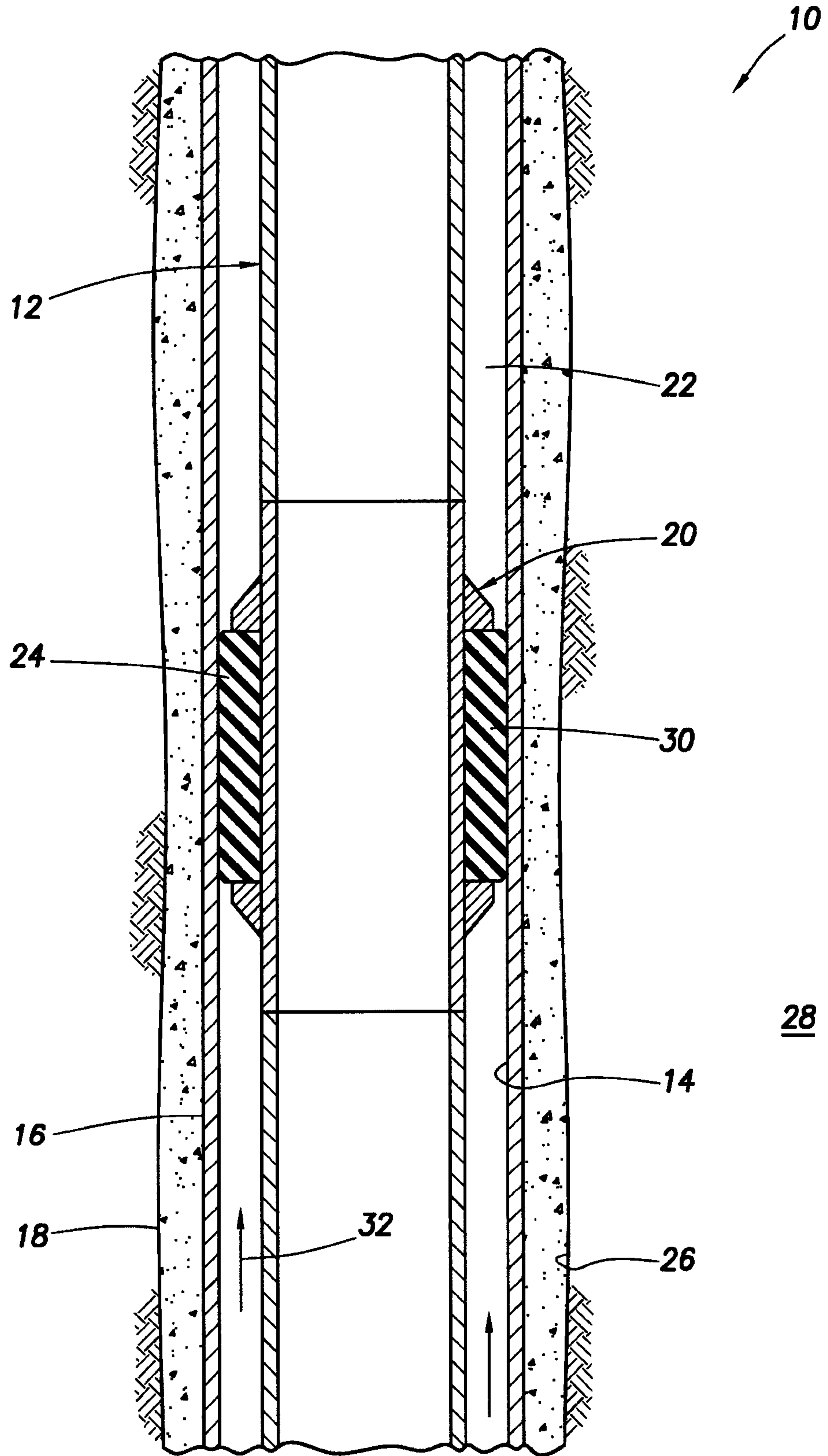


FIG. 1

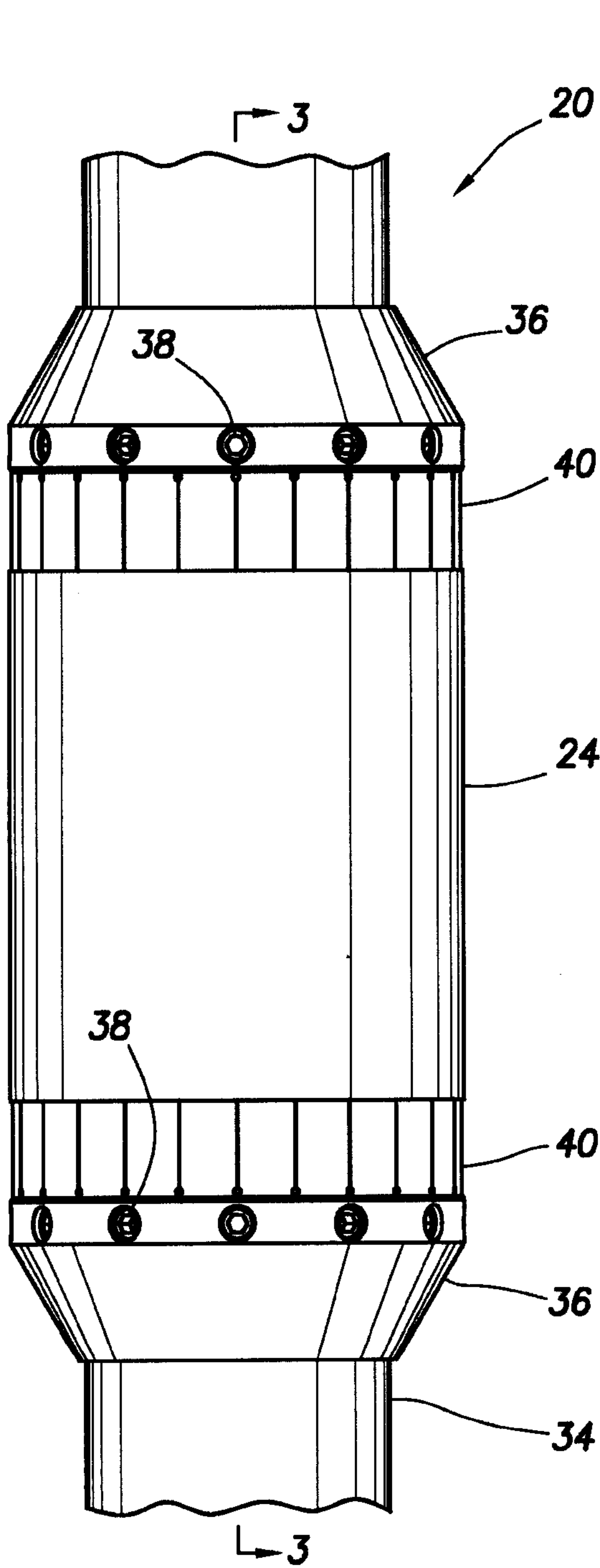


FIG. 2

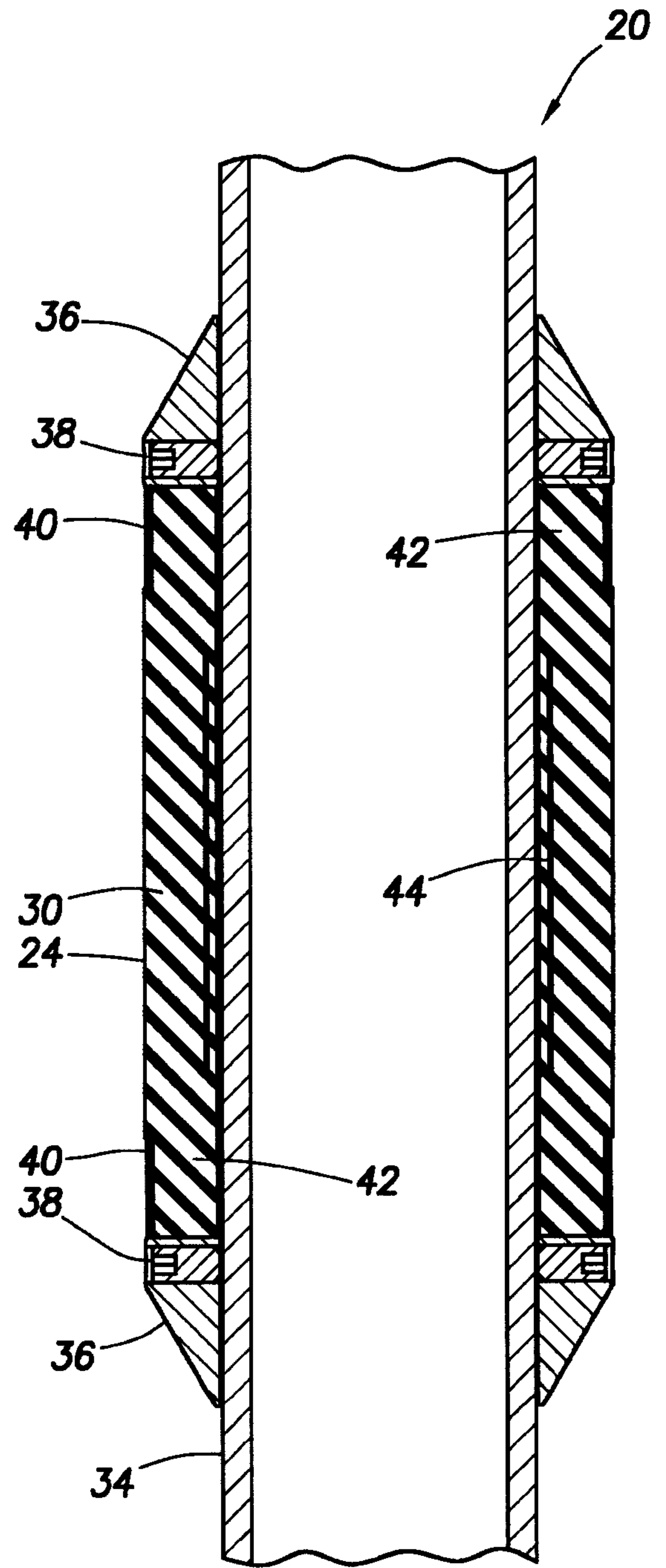


FIG. 3

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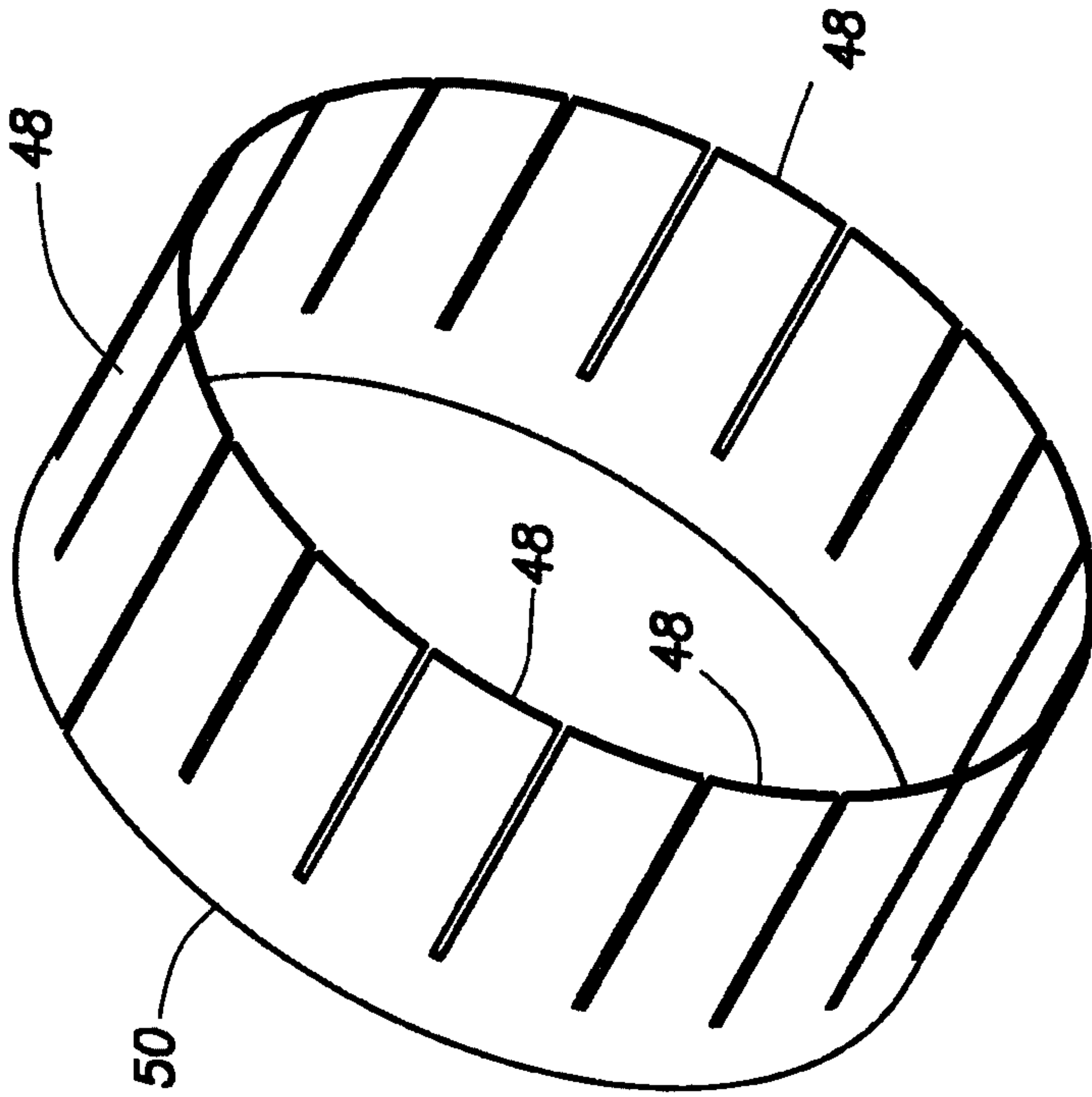


FIG. 5

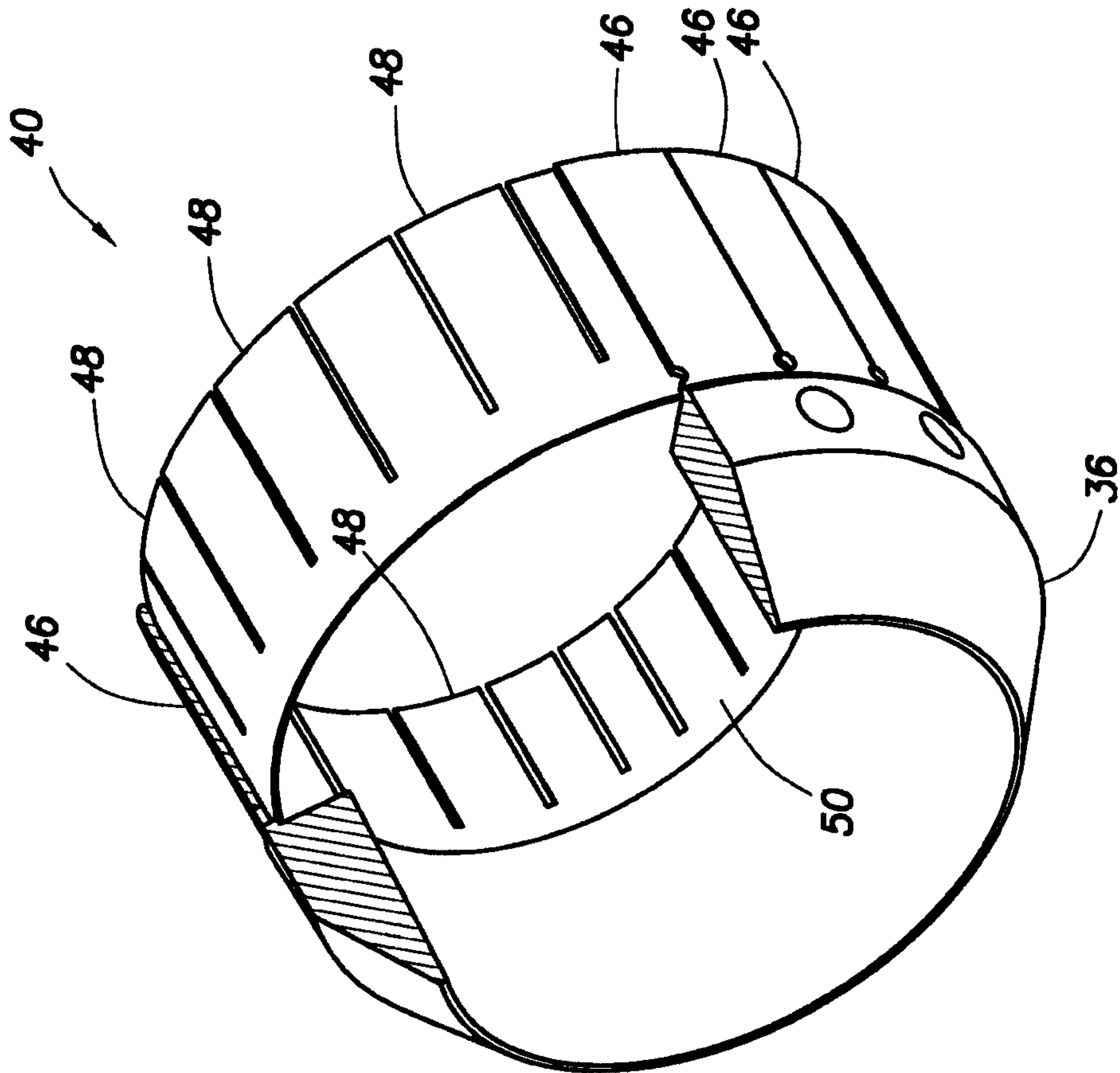


FIG. 4

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