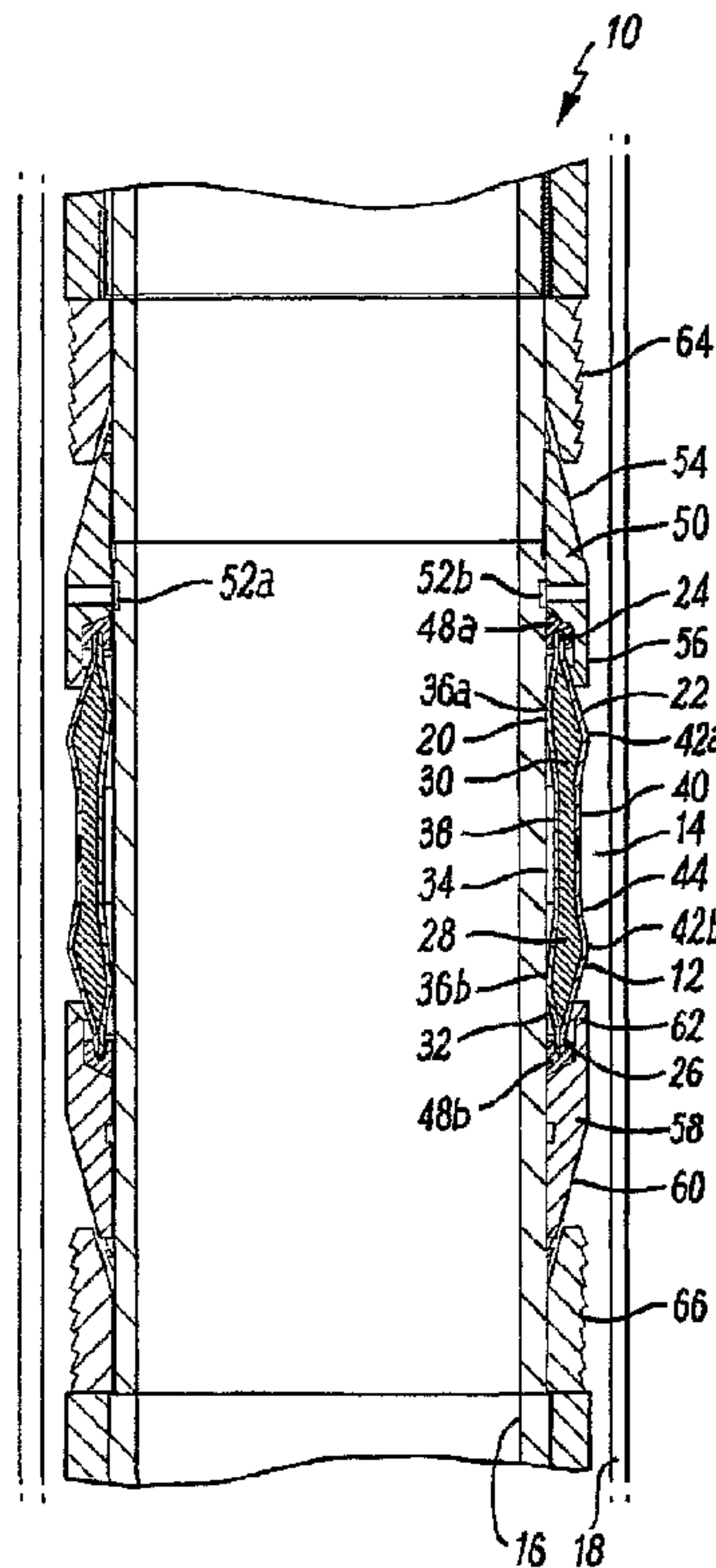




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 (72) Inventeurs/Inventors:
 MARTIN, DAVID, GB;
 SINCLAIR, EWAN, GB
 (73) Propriétaire/Owner:
 CALEDYNE LIMITED, GB
 (74) Agent: TEITELBAUM & MACLEAN

(54) Titre : JOINT D'ETANCHEITE AMELIORE
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(57) **Abrégé/Abstract:**

An annular sealing element (12) to seal between metal surfaces for use in flanges, joints, packers and the like, located in oil and gas exploration and production equipment. The sealing element has inner and outer metal deformable surfaces (20, 22) joined at ends (24, 26), defining an interior volume (30) which is entirely filled with a plastic deformable material (28). The surfaces are arranged such that on compression of the element (12) from the ends (24, 26), the element will deform in a controlled manner on a cantilever principle. The volume of filler (28) and the interior volume (30) remain substantially equal during compression so that delamination does not occur. Thus the sealing element provides a seal combining the flexibility of elastomer seals with the integrity of a metal to metal seal.

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[GB/GB]; Viewfield, Meikle Wattle, Inverurie AB51 5DE
(GB). **SINCLAIR, Ewan** [GB/GB]; 36 Clifton Road, Ab-
erdeen AB24 4RR (GB).

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(74) Agent: **KENNEDYS PATENT AGENCY LIMITED**;
Floor 5, Queens House, 29 St Vincent Place, Glasgow G1
2DT (GB).

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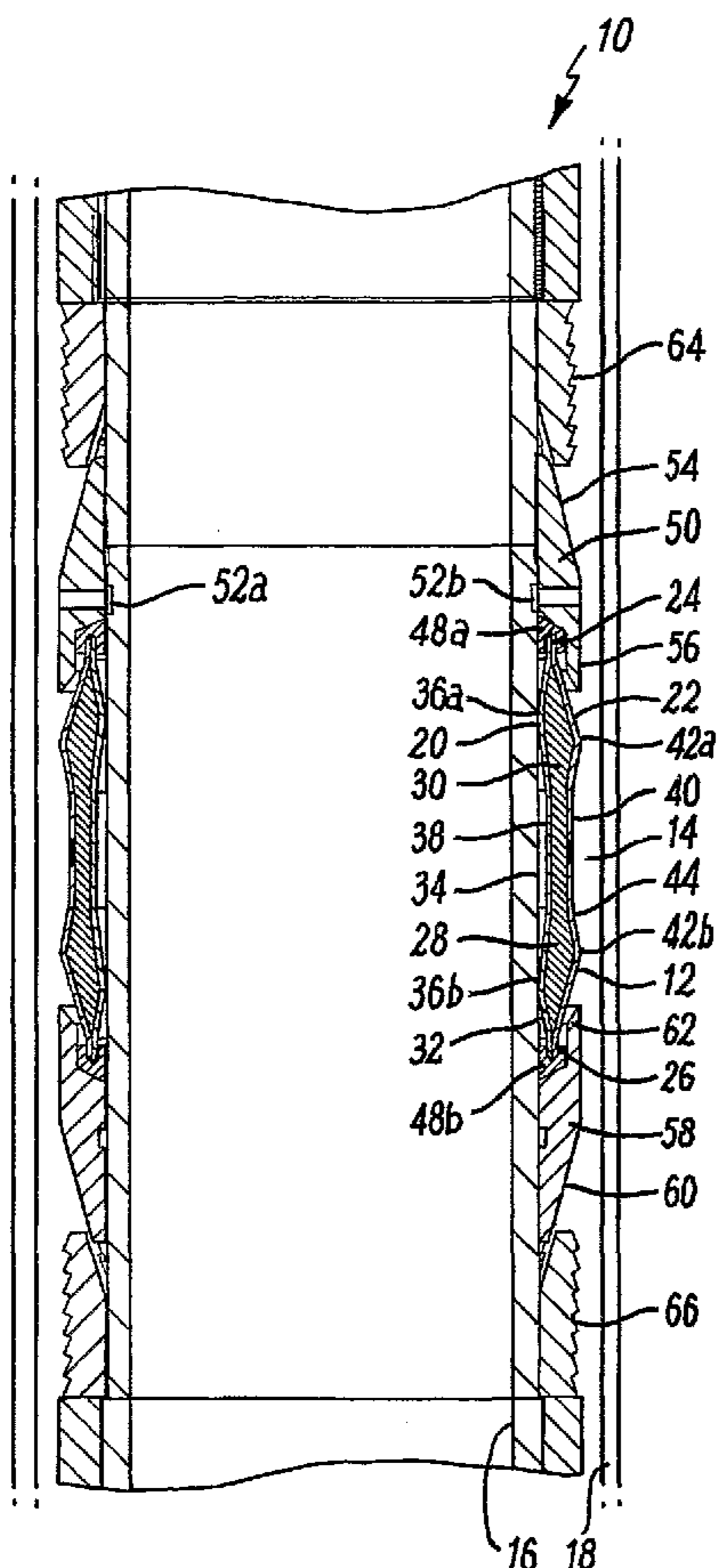
(71) Applicant (*for all designated States except US*): **CALE-
DYNE LIMITED** [GB/GB]; Unit 14, The Technology
Centre, Claymore Drive, Bridge of Don, Aberdeen AB23
8GD (GB).

(72) Inventors; and

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(75) Inventors/Applicants (*for US only*): **MARTIN, David**

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1 **Improved Seal**

2

3 The present invention relates to seals used between metal
4 surfaces and in particular, though not exclusively, to an
5 annular seal for use in flanges, joints and packers
6 located in oil and gas exploration and production
7 equipment.

8

9 Typical annular seals used to prevent the passage of
10 fluid between two surfaces are elastomeric o-rings. The
11 material makes them flexible enough to mould into any
12 deformities in the metal surface, while their
13 compressibility aids in providing a large sealing area.
14 However, these seals can go beyond their operational
15 limits when used within well bores during oil and gas
16 exploration and production, due to the extremes of
17 pressure, temperature and the harsh substances which are
18 used. In order to overcome these problems, metal to
19 metal seals have been developed to provide increased seal
20 strength and reduce seal degradation.

21

22 These metal to metal seals have found application in
23 flanges, for example. When API 6A or similar flanges are

1 manufactured, the groove has an exact geometry and
2 surface finish. The sealing ring is a solid metal ring,
3 which is compressed against the seal ring grooves to make
4 the metal-to-metal seal. This is typically achieved by
5 tightening the bolts on the flange. As there is no or
6 little flexibility in the seal, side loading can reduce
7 or remove any seal formed between the groove and flange.
8 Furthermore, older flanges, which are subject to
9 corrosion, can leak. As there is no compliance within the
10 solid metal ring, once a leak appears the seal cannot be
11 re-seated without re-tightening the bolts. In sub-sea
12 applications, it is very expensive to monitor each flange
13 and tighten the bolts as part of a maintenance programme.
14

15 To overcome this problem, seals incorporating the
16 strength of metals together with the flexible
17 characteristics of elastomers have been developed. EP
18 1136734, DE 3633335 and DE 3712814 all disclose flange
19 ring seals using metal and elastomeric parts. These
20 seals generally comprise a metal insert in the
21 elastomeric material. While this design provides a seal
22 with improved rigidity, the seal against the flange is
23 made by the elastomer, which has the inherent
24 disadvantage of seal degradation.

25
26 In packers, it is known to position an elastomeric sleeve
27 around a tubing, the sleeve being limited by upper and
28 lower retainers. In order to provide an annular seal
29 and/or anchor the tubing in a well bore, one or both of
30 the retainers are moved toward the other. This results in
31 compression of the sleeve so that it deforms radially
32 outwardly to fill the space between the tubing and a bore
33 hole wall or tubular and adhere to the bore hole wall or

1 tubular. Various arrangements have been provided in an
2 attempt to ensure a sufficient portion of the sleeve
3 contacts the borehole or tubular wall to effect a good
4 seal while maintaining the sleeve within the retainers
5 during compression. In addition, the surface of the seals
6 have been modified to improve adhesion to the borehole
7 wall. Further, metal to metal seals as described above,
8 have been incorporated.

9
10 WO 02/04783 to Moyes discloses a deformable member
11 comprising a generally hollow cylindrical body defining a
12 wall, the wall includes three circumferential lines of
13 weakness in the form of grooves, with two grooves
14 provided in an outer surface of the member wall, and the
15 other groove provided in an inner surface. The member is
16 deformed outwardly to provide a seal, by folding about
17 the lines of weakness. The member is typically made of a
18 tough malleable material such as carbon steel. A
19 disadvantage of this seal is that by introducing lines of
20 weakness to help the seal deform, the whole structure is
21 weakened. As a result thick sections are required to
22 prevent the element from collapsing under pressure
23 differentials.

24
25 US 5,988,276 to Oneal discloses a compact retrievable
26 well packer which also utilises deformable cylindrical
27 members to form the annular seal and also to lock the
28 well packer in situ. As with Moyes, thick sections are
29 required to prevent the sealing element from collapsing
30 under pressure differentials.

31
32 US 5,961,123 to Ingram et al discloses a seal arrangement
33 which is designed to prevent the seal from extruding

1 uphole or downhole when subjected to extremes of
2 differential pressure. In this arrangement the seal
3 material is bounded at either end by metal back-up rings,
4 these rings may be attached to the seal or, as disclosed
5 in US 5,961,123, be attached to one of the retainers.
6 This seal has the typical disadvantages of elastomeric
7 based seals which can be degraded easily by heat and
8 chemicals used downhole.

9

10 US 5,775,429 to Arizmendi et al discloses a seal
11 including a deformable sheath having a body and first and
12 second ends for defining an interior volume proximate to
13 a tool surface. The tool surface is the tubing. A
14 material located within the interior volume is
15 deformable, when the sheath second end is moved toward
16 the sheath first end. The sheath is typically a
17 relatively thin walled tubular member formed from
18 materials like stainless steel or titanium. The filler
19 material within the interior volume plastically deforms
20 to advantageously allow the seal to be used oval shaped
21 bore holes. Unfortunately this seal does not perform well
22 in practice. As the filler material is restrained by the
23 tubing, volumetric changes in the seal distort the seal
24 and reduce the effectiveness of contact with the bore
25 hole wall or tubular. These volumetric changes occur as
26 the sheath ends are brought together before the seal
27 meets the bore hole wall or tubular and is pressurised.

28

29 It is an object of at least one embodiment of the present
30 invention to provide a sealing element which is flexible,
31 like an elastomer seal, but is fully metal to metal.

32

1 It is a further object of at least one embodiment of the
2 present invention to provide a sealing element having a
3 fully enclosed filler material to provide improved
4 sealing properties of the element.

5

6 It is a yet further object of at least one embodiment of
7 the present invention to provide a sealing element which
8 deforms in a controlled manner on a cantilever principle.

9

10 According to a first aspect of the present invention
11 there is provided a sealing element for providing a seal
12 between a first and a second surface, the element
13 comprising an inner deformable surface, an outer
14 deformable surface, the inner and outer surfaces being
15 joined at opposed first and second ends, providing a body
16 defining an interior volume entirely bounded by the said
17 surfaces and said ends, a deformable filler material
18 within said interior volume, wherein the element deforms
19 in a predetermined manner to seal between the first and
20 second surfaces when said ends are brought toward each
21 other.

22

23 By entirely enclosing the deformable filler material
24 within the element, the material acts as a filler within
25 a continuous body. This allows the shape of the volume of
26 the element to change as the ends are brought together
27 but minimises any change in the said interior volume. By
28 minimising any change in the interior volume until
29 pressure is applied across the seal, the seal will deform
30 in a predetermined manner. As discussed hereinbefore, as
31 a disadvantage with respect to the seal of US 5,775,429,
32 delamination of the filler from the said surfaces will
33 occur unless the volume change is minimised. This feature

1 of the seal helps prevent the seal collapsing when
2 pressure is applied across the seal, between the inner
3 and outer surfaces.

4
5 Preferably, the inner and outer deformable surfaces are
6 sleeves, the element thereby being annular. Such an
7 arrangement can provides a seal around a mandrel or
8 tubing. Alternatively the arrangement can provide an
9 annular seal for a flange. Preferably the inner and outer
10 surfaces are deformable metal sleeves. Preferably the
11 inner and outer surfaces define a first shape containing
12 the interior volume. Following deformation the inner and
13 outer surface define a second shape. Preferably the
14 second shape is a cantilever structure arranged
15 longitudinally between the ends. Preferably the first and
16 second shapes are predetermined. The first and second
17 shapes may be annular having a polygon in longitudinal
18 cross-section. Advantageously the polygon is symmetrical
19 across the horizontal plane. In a first embodiment the
20 polygon has ten sides. In a preferred embodiment the
21 polygon has fifteen sides. The shape of the polygon, but
22 not the number of sides, varies as the sealing element is
23 deformed. Preferable the outer surface defines at least
24 two peaks and at least one trough. Preferably also the
25 inner surface defines at least two peaks and at least one
26 trough. In a preferred embodiment the outer surface
27 defines two peaks and one trough and the inner surface
28 defines three peaks and two troughs.

29
30 Preferably the deformable filler material has a first
31 volume. Advantageously the first volume equals the
32 interior volume and both remain substantially equal as
33 the ends are brought together. The deformable filler

1 material may be an elastomer, plastic or other flexible
2 material. Advantageously the filler material is a
3 plastic. Use of a plastic is possible as the filler
4 material will allow the seal to have a higher temperature
5 rating than an elastomer, but being entirely encased in
6 metal will not extrude as can be seen with elastomers and
7 such plastics which have unsuitable mechanical
8 properties.

9

10 Preferably the outer surface includes a plurality of
11 outer ridges. The outer ridges bite into the second
12 surface. This is advantageous when the second surface is a
13 wall of the well bore, in a well which is open hole, or a
14 tubing wall for a well which is cased. Preferably the
15 outer ridges are arranged circumferentially around the
16 outer surface. Advantageously a sealant material is
17 applied to at least a portion of the outer surface. More
18 preferably the portion is between the outer ridges. The
19 sealant material may be Teflon® or the like. The sealant
20 material provides a seal in the event that the primary
21 metal seal of the outer surface fails to work.

22

23 Optionally at least one metal insert is located on at
24 least a portion of the outer surface. More preferably the
25 portion is between the outer ridges. Preferably the metal
26 insert is a ductile inert metal. More preferably, the
27 metal insert is gold. The metal insert could be the
28 primary seal, instead of the deformable surfaces or the
29 sealant material. The ductile insert could deform to
30 accommodate any scratches or other discontinuities, which
31 the outer surface may not.

32

1 According to a second aspect of the present invention
2 there is provided a method of providing a seal between a
3 first and a second surface, the method comprising the
4 steps:

5 (a) providing a sealing element according to the first
6 aspect, having a first interior volume and a first
7 shape with a filler having a first volume
8 substantially equal to the first interior volume;

9 (b) arranging the element adjacent the first surface and
10 opposite the second surface;

11 (c) moving one or both ends of the sealing element
12 toward the opposing end;

13 (d) deforming the sealing element in a controlled manner
14 to provide a second shape while keeping the first
15 interior volume and the first volume substantially
16 equal;

17 (e) contacting the sealing element on the first and
18 second surfaces to provide the seal; and

19 (f) further moving one or both ends of the sealing
20 element toward the opposing end to provide a
21 pressure across the sealing element between the
22 inner and outer surfaces.

23

24 By keeping the volumes substantially equal, delamination
25 of the filler material from the inner and outer surfaces
26 is prevented. By avoiding delamination this helps prevent
27 the sealing element collapsing when the pressure is
28 applied across the sealing element in step (f).

29

30 Preferably, the sealing element forms a cantilever
31 structure during deformation.

32

1 Preferably the method includes the step of deforming the
2 outer and inner surfaces of the sealing element.

3

4 Preferably also the method includes the step of abutting
5 ridges of the sealing element onto at least the second
6 surface. Advantageously the step includes the ridges
7 biting into the second surface.

8

9 Preferably the method further includes the step of
10 abutting a sealing material of the sealing element to at
11 least the second surface to improve the sealing
12 characteristics.

13

14 Preferably the method further includes the step of
15 abutting a metal insert of the sealing element to at
16 least the second surface to improve the sealing
17 characteristics.

18

19 According to a third aspect of the present invention
20 there is provided apparatus for providing a seal between
21 a first and a second surface within in a well bore, the
22 apparatus comprising a substantially tubular body upon
23 which is located the first surface; a sealing element
24 located around the tubular body, comprising an inner
25 deformable surface, an outer deformable surface, the
26 inner and outer surfaces being joined at opposed first
27 and second ends, providing a sealing body defining an
28 interior volume entirely bounded by the said surfaces and
29 said ends, a deformable filler material within said
30 interior volume; at least one actuating element arranged
31 around and longitudinally moveable relative to the body;
32 the actuating element including means for affixing an end
33 of the sealing element; wherein the sealing element

1 deforms in a predetermined manner to seal between the
2 first and second surfaces when said ends are brought
3 toward each other by movement of the actuating element.

4
5 Preferably the apparatus comprises a packer or other
6 downhole tool. More preferably the apparatus comprises a
7 retrievable packer. Alternatively the apparatus
8 comprises an expansion joint or other travelling seal.

9
10 Preferably the at least one actuating element is a cone.
11 The cone having a bore therethrough for passage of the
12 sealing body. Preferably there are two cones, one located
13 at each end of the sealing element. Preferably also at
14 least one cone is releasably retained to the tubular
15 body. The cone may be retained by shear pins.

16
17 Alternatively the at least one actuating element is a
18 threaded ring. By tightening the ring against an end,
19 the sealing element is pre-loaded.

20
21 Preferably, the inner and outer deformable surfaces are
22 sleeves, the element thereby being annular. Such an
23 arrangement provides a seal around a mandrel or tubing.
24 Preferably the inner and outer surfaces are deformable
25 metal sleeves. Preferably the inner and outer surfaces
26 define a first shape containing the interior volume.
27 Following deformation the inner and outer surface define
28 a second shape. Preferably the second shape is a
29 cantilever structure arranged longitudinally between the
30 ends. Preferably the first and second shapes are
31 predetermined. The first and second shapes may be annular
32 having a polygon in longitudinal cross-section.
33 Advantageously the polygon is symmetrical on the across

1 the horizontal plane. In a first embodiment the polygon
2 has ten sides. In a preferred embodiment the polygon has
3 fifteen sides. The shape of the polygon, but not the
4 number of sides, varies as the sealing element is
5 deformed. Preferable the outer surface defines at least
6 two peaks and at least one trough. Preferably also the
7 inner surface defines at least two peaks and at least one
8 trough. In a preferred embodiment the outer surface
9 defines two peaks and one trough and the inner surface
10 defines three peaks and two troughs.

11

12 Preferably the deformable filler material has a first
13 volume. Advantageously the first volume equals the
14 interior volume and both remain substantially equal as
15 the ends are brought together. The deformable filler
16 material may be an elastomer or a plastic. Advantageously
17 the filler material is a plastic. Use of a plastic is
18 possible as the filler material will not be affected by
19 heat, being entirely encased in metal.

20

21 Preferably the outer surface includes a plurality of
22 outer ridges. The outer ridges bite into the second
23 surface in the well bore. The second surface may be a
24 wall of the well bore, when the well is open hole, or
25 tubing wall when the well is cased. Preferably the outer
26 ridges are arranged circumferentially around the outer
27 surface. Advantageously a sealant material is applied to
28 at least a portion of the outer surface. More preferably
29 the portion is between the outer ridges. The sealant
30 material may be Teflon® or the like. The sealant material
31 provides a seal in the event that the primary metal seal
32 of the outer surface fails to work.

33

1 Optionally at least one metal insert is located on at
2 least a portion of the outer surface. More preferably the
3 portion is between the outer ridges. Preferably the metal
4 insert is a ductile inert metal. More preferably, the
5 metal insert is gold. The metal insert could be the
6 primary seal, instead of the deformable surfaces or the
7 sealant material. The ductile insert could deform to
8 accommodate any scratches or other discontinuities, which
9 the outer surface may not.

10

11 According to a fourth aspect of the present invention
12 there is provided a method of anchoring an apparatus to
13 an inner surface of a well bore, the method comprising
14 the steps:

15

- 16 (a) providing an apparatus according to the third
17 aspect, having a first interior volume and a first
18 shape with a filler having a first volume
19 substantially equal to the first interior volume;
- 20 (b) running the apparatus on a work string in the well
21 bore;
- 22 (c) moving one or both ends of the sealing element
23 toward the opposing end;
- 24 (d) deforming the sealing element in a controlled manner
25 to provide a second shape while keeping the first
26 interior volume and the first volume substantially
27 equal;
- 28 (e) contacting the sealing element on the first and
29 second surfaces; and
- 30 (f) further moving one or both ends of the sealing
31 element toward the opposing end to provide a
32 pressure across the sealing element between the

1 inner and outer surfaces thereby anchoring the
2 apparatus to the second surface.

3

4 Preferably, the sealing element forms a cantilever
5 structure during deformation.

6

7 Preferably the method includes the step of deforming the
8 outer and inner surfaces of the sealing element.

9

10 Preferably also the method includes the step of abutting
11 ridges of the sealing element onto the second surface.

12 Advantageously the step includes the ridges biting into
13 the second surface.

14

15 Preferably the method further includes the step of
16 abutting a sealing material of the sealing element to the
17 second surface to improve the sealing characteristics.

18

19 According to a fifth aspect of the present invention
20 there is provided a flange ring seal for location in a
21 groove of a mating plate of a flange, the seal comprising
22 an inner deformable surface, an outer deformable surface,
23 the inner and outer surfaces being joined at opposed
24 first and second ends, providing a sealing body defining
25 an interior volume entirely bounded by the said surfaces
26 and said ends, a deformable filler material within said
27 interior volume; wherein an end is arranged to locate in
28 the groove of the flange and wherein the seal deforms in
29 a predetermined manner an opposing mating plate is
30 brought against the mating plate to seal between the
31 plates.

32

33 Preferably, the inner and outer deformable surfaces are

1 sleeves, thus forming the ring. Preferably the inner and
2 outer surfaces are deformable metal sleeves. Preferably
3 the inner and outer surfaces define a first shape
4 containing the interior volume. Following deformation the
5 inner and outer surface define a second shape. Preferably
6 the second shape is a cantilever structure arranged
7 longitudinally between the ends. Preferably the first and
8 second shapes are predetermined. The first and second
9 shapes may be annular having a polygon in longitudinal
10 cross-section. Advantageously the polygon is symmetrical
11 on the across the horizontal plane. In a first embodiment
12 the polygon has ten sides. In a preferred embodiment the
13 polygon has fifteen sides. The shape of the polygon, but
14 not the number of sides, varies as the sealing element is
15 deformed. Preferable the outer surface defines at least
16 two peaks and at least one trough. Preferably also the
17 inner surface defines at least two peaks and at least one
18 trough. In a preferred embodiment the outer surface
19 defines two peaks and one trough and the inner surface
20 defines three peaks and two troughs.

21

22 Preferably the deformable filler material has a first
23 volume. Advantageously the first volume equals the
24 interior volume and both remain substantially equal as
25 the ends are brought together. The deformable filler
26 material may be an elastomer or a plastic. Advantageously
27 the filler material is a plastic. Use of a plastic is
28 possible as the filler material will not be affected by
29 heat, being entirely encased in metal.

30

31 Embodiments of the present invention will now be
32 described, by way of example only, with reference to the
33 following drawings of which:

1

2 Figure 1 is a cross-sectional view a packer tool
3 incorporating a sealing element according to an
4 embodiment of the present invention, with the element un-
5 set;

6

7 Figure 2 is a cross-sectional view through the tool of
8 Figure 1, now shown in the set position;

9

10 Figure 3 is a cross-sectional view a packer tool
11 incorporating a sealing element according to a further
12 embodiment of the present invention, with the element un-
13 set;

14

15 Figure 4 is a cross-sectional view through the tool of
16 Figure 4, now shown in the set position;

17

18 Figure 5 is a part cross-sectional view of a portion of
19 the outer surface of a sealing element according to a
20 further embodiment of the present invention;

21

22 Figure 6 is a part cross-sectional view of an expansion
23 joint incorporating a sealing element according to a
24 further embodiment of the present invention; and

25

26 Figure 7(a) is a schematic cross-sectional view through
27 mating flanges incorporating a sealing element, shown in
28 detail in Figure 7(b), according to a further embodiment
29 of the present invention.

30

31 Referring initially to Figure 1, there is illustrated a
32 downhole tool, generally indicated by reference numeral
33 10, according to an embodiment of the present invention.

1 Downhole tool 10 is a packer, being an apparatus for
2 providing a seal between a first and a second surface
3 within in a well bore. Located on the tool 10, is a
4 sealing element 12, according to an embodiment of the
5 present invention. Tool 10 operates by filling the space
6 14 between the tool body 16 and a bore hole wall, such as
7 a casing 18, to provide a seal between the tool 10 and
8 the casing 18.

9
10 Sealing element 12 comprises a generally cylindrical
11 sleeve which surrounds the tool body 16. Element 12 is
12 formed as two concentric metal sleeves, an inner sleeve
13 20 and an outer sleeve 22. The sleeves are joined at
14 upper 24 and lower 26 ends. Between the sleeves 20,22 is
15 located a filler 28. The filler is entirely contained
16 within the sealing element 12 and bounded on all sides by
17 the metal sleeves 20,22. Thus an interior volume 30
18 defined by the metal sleeves 20,22 contains an equal
19 volume of the filler 28.

20
21 The sleeves 20,22 are made of a deformable metal. The
22 metal is typically stainless steel and the thickness of
23 the sleeve 20,22 is selected to ensure that the steel is
24 deformable under pressure. The sleeves are pinched
25 together at the ends 24,26. The filler 28 is also of a
26 deformable material. The filler may be a plastic or
27 elastomer. However, as the filler 28 is entirely encased
28 in metal, it is not affected by heat and thus a plastic,
29 such as Teflon[®], is preferable.

30
31 The inner sleeve 20 provides an inner surface 32 facing
32 an outer surface 34 of the tool body 16. Inner surface 20
33 is geometrically arranged to provide two symmetrical

1 peaks 36a,b running circumferentially around the surface
2 20. Peaks 36a,b rest on the surface 34 of the tool body
3 16. A trough 38 lies between the two peaks 36a,b. Trough
4 38 has symmetrical sloping side walls with a flat base
5 lying parallel to the surface 34 of the tool body 16.

6
7 The outer sleeve 22 has a similar geometrical arrangement
8 on its outer surface 40 to that of the inner surface 32.
9 However peaks 42a,b are somewhat closer together
10 providing a narrower trough 44. The bases of each trough
11 38,44 are approximately equal in length.

12
13 When viewed together in cross-section, the surfaces 32,40
14 provide a polygon having ten sides. Each side is
15 substantially linear. The polygon is symmetrical on a
16 plane perpendicular to the well bore. The geometrical
17 arrangement of the sealing element 12 is selected so that
18 when the ends 24,26 are brought together the element 12
19 will deform in a controlled manner. The peaks 36,42 and
20 troughs 38,44 will act like fold lines on the sleeves
21 20,22 and the element 12 will form a cantilever
22 structure, best seen in Figure 2.

23
24 In Figure 2, the ends 24,26 have been brought together by
25 the longitudinal displacement of the end 24 towards the
26 element 12. Trough 38 has been forced radially outwards
27 and meets trough 44. With the sleeves 20,22 meeting, the
28 filler material is contained in two chambers 46a,b. The
29 peaks 36,42 are now more acute so that the element 12
30 bridges the space 40. It should be noted that the element
31 12 provides a cantilever structure which supports the
32 seal 12 and allows the tool 10 to be anchored to the
33 casing 18 by the slips 66. The filler 28 supports the

1 seal 12 to prevent the seal from collapsing with pressure
2 applied from the end 24. The interior volume 30 and the
3 volume of the filler 28 remain substantially the same
4 between the two positions, Figure 1 and Figure 2. The
5 filler 28 has remained in contact with the continuous
6 surface formed by the sleeves 20,22 and defining the
7 interior volume 30. As delamination has not occurred, the
8 filler 28 helps prevent the seal 12 collapsing when
9 pressure is applied across the seal between the surfaces
10 32,40 when the seal 12 is in contact with the casing 18.

11

12 Returning to Figure 1, sealing element 12 is mounted upon
13 tool body 16. The ends 24,26 locate into opposed fixings
14 48a,b. The fixings 48a,b hold the sleeves 20,22 together
15 to provide the interior volume 30 where the filler 28 is
16 located. At the upper end 24 of the seal 12 is located an
17 upper cone 50, which is formed as a sleeve having a
18 sloping surface 54. Cone 50 fits over the tool body 16
19 and is held against the body by shear pins 52a,b. The
20 cone 50 has an outer sloping section 54 and a lower lip
21 56. Lip 56 provides an overhang across the seal 12 and
22 the seal 12 rests upon it. The lip 56 covers the fitting
23 48a, thereby protecting the end 24 of the seal during
24 operation.

25

26 At the lower end 26 of the seal 12 is located a lower
27 cone 58. Cone 58 includes a sloping surface 60 and a lip
28 62 in an identical manner to cone 50. Cone 58 is bolted
29 to the tool body 16 so that it cannot move during
30 operation of the tool 10. Located outside the cones 50,58
31 are slips 64,66 as are known in the art.

32

1 In use, tool 10 is mounted on a work string (not shown)
2 and run into a well bore. The seal 12 is not set, as
3 illustrated in Figure 1, so that seal 12 lies toward the
4 body 16 and a space 14 exists between the tool 10 and the
5 casing 18 within the well bore. In this unset
6 configuration the tool 10 can be run without interfering
7 with any other operations performed in the well bore.
8 When the tool 10 has reached a location within the well
9 bore where an annular seal is required between the tool
10 10 and the casing, the tool 10 can be set. This is
11 achieved by moving the cone 50 towards the lower sleeve
12 58. It will be appreciated by those skilled in the art
13 that either or both cones 50,58 could be moved. It will
14 also be known by those in the art that various actuation
15 mechanisms such as weight-setting and hydraulic actuation
16 can be used to cause movement of the cone 50. Shear pins
17 52a,b are sheared in the actuation to allow the cone 50
18 to move along the tool body 16. If cone 50 is the lower
19 cone, then holding the cone in position will provide
20 actuation by the relative movement of the work string and
21 the tool 10 through the cone.

22

23 Effectively, cone 50 is moved towards sleeve 58. The
24 compression applies pressure longitudinally onto the seal
25 12. The pressure causes the peaks 36,42 to move away from
26 each other while the troughs 38,44 move toward each
27 other. It is the geometrical arrangement of the peaks and
28 troughs which cause the seal 12 to deform in this
29 controlled manner. Deformation is complete when the
30 troughs meet. This is illustrated in Figure 2. During the
31 deformation, the polygon has changed in shape, but the
32 interior volume 30 and the volume of the filler 28 have
33 remained substantially equal and constant throughout.

1
2 Continued pressure forces the outer peaks 42 against the
3 casing 38 while the inner peaks meet the surface 34 of
4 the tool body 16. A seal is thus formed between the tool
5 16 and the casing 38. Additionally the seal 12 now
6 anchors the tool 10 against the casing 38 at this
7 location. The seal 12 is set. The seal 12 provides a
8 cantilever structure from the overhangs at lips 56,62.
9 The filler 28 located now in the two chambers 46a,b
10 supports the seal and prevents any collapsing as
11 additional force is applied from the cone 50, and across
12 the seal from the casing 18. Slips 64,66 have been forced
13 up the slopes 54,60 to provide additional anchorage to
14 the tool 10.

15

16 Sealing element 12 has ridges 68 located upon its outer
17 surface 40. The ridges 68 bite into the casing 38 in
18 order to effect the seal. A sealant material, Teflon®, is
19 located between the ridges 68 to provide an improved seal
20 if the primary metal seal of the ridges 68 fail. This is
21 described with reference to Figure 6.

22

23 The tool 10 can be retrieved from the well bore, by
24 moving the ends 24,26 apart via movement of one or both
25 of the cones 50,58. Separation of the ends 24,26 pulls
26 the seal longitudinally and the seal 12 returns close to
27 its original shape. A space 14 is thus created between
28 the tool 10 and the casing 18 so that the work string can
29 be pulled from the hole.

30

31 Referring now to Figure 3, there is illustrated a sealing
32 element, generally indicated by reference numeral 112,
33 according to a preferred embodiment of the present

1 invention. Like parts to the sealing element 12 of
2 figures 1 and 2 have been given the same reference
3 numeral with the addition of one hundred. Sealing element
4 112 operates in an identical manner to sealing element 12
5 in providing a seal between two surfaces. For ease of
6 interpretation, ends are shown held in opposed fixings
7 148a,b as described hereinbefore with reference to
8 figures 1 and 2.

9
10 Sealing element 112 comprises a continuous cylindrical
11 annulus which may be described as a torus. The element
12 112 is formed from two metal sleeves, a first 120 being
13 arranged inside and coaxial with a second 122. The
14 sleeves, 120,122 are joined at upper 124 and lower 126
15 ends by having adjacent sides of the sleeves meeting over
16 a short distance. The ends 124,126 of the sleeves 120,122
17 are held together by the fixing elements 148a,b. A
18 resultant interior volume 130 is created which is
19 entirely bounded by the sleeves 120,122 and the ends
20 124,126. The interior volume 130 is completely filled
21 with a filler 128. The filler 128 contacts the sleeves
22 120,122 and ends 124,126. Each sleeve 120, 122 is formed
23 of a metal continuous metal strip. The metal is preformed
24 into a shape calculated to deform in a predetermined
25 manner when the ends 124,126 are brought together. The
26 inner sleeve 120, in longitudinal cross-section, has a
27 surface 132 which is symmetrically shaped through a
28 horizontal plane equidistant from the ends 124,126. The
29 surface 132 forms a series of peaks and troughs. There
30 are two troughs 138a,b which comprise opposing sloping
31 surfaces, bounding a single peak 136 which is a plateau
32 bounded by the sloping surfaces of the troughs 138a,b.
33 The outer sleeve 122 has a profile 134 in reverse to the

1 inner sleeve 120 with respect to the element 112. There
2 are not distinct peaks 142a,b, opposing the troughs
3 138a,b. These have been levelled to provide a sharp
4 sloping surface into the trough 144 opposite the peak
5 138. Each surface 132,134 is made up of a series of
6 straight sections so that the metal of the sleeve can be
7 bent along fold lines to create the shape required. In
8 longitudinal cross-section through the torus, a polygon
9 is created which defines the interior volume 30 and the
10 volume of filler 128.

11

12 By mirroring the profiles of the sleeves 120,122, when
13 the ends 124,126 are brought together the interior volume
14 130 remains substantially constant while the shape of the
15 sleeves 120,122 ie. the polygon, deforms in a manner to
16 accentuate the peaks and troughs. As the interior volume
17 130 remains substantially constant the filler 128 will
18 deform with the element 112, but will remain in contact
19 with the entire inside surface of the sleeves 120,122 at
20 all times. In this way delamination is prevented which
21 would otherwise cause air pockets in the seal, weakening
22 its ability to withstand both longitudinal pressure
23 applied from the ends 124,126 and transverse pressure
24 applied horizontally between the sleeves 120,122.

25

26 Reference is now made to Figure 4 of the drawings which
27 illustrates the seal 112 of Figure 3 when the ends
28 124,126 have been brought toward each other. This
29 represents the seal 112 in the 'set' position. Like parts
30 to those of Figure 3 have been given the same reference
31 numeral to aid clarity. It can be seen that the peaks
32 142a,b now sit proud of the fixing elements 148a,b. As
33 the peaks 136,138,142 are plateau like, they provide

1 planar surfaces to improve the sealing properties of the
2 element 112. The area of contact of the sealing element
3 112 is thus predetermined by the dimension of the peaks
4 136,138,142 in the shape of the original sleeves 120,122.
5 Further the arrangement of opposing peaks and troughs,
6 with a trough 144/peak 136 on the horizontal plane
7 bounded by symmetrically arranged peaks 142 and troughs
8 138, provides a cantilever structure which strengthens
9 the sealing element 112.

10

11 As described herein with reference to figures 1 and 2 the
12 peaks 142a,b on the outer sleeve 122 may include ridges
13 or other material to improve the grip of the sealing
14 element 112 when these positions contact a surface within
15 a well bore. Such additional features are illustrated
16 with reference to Figure 5.

17

18 Figure 5 shows a part cross-sectional view through the
19 outer sleeve 22 of a sealing element 12. Like parts to
20 those of Figures 1 and 2 have been given the same
21 reference numeral to aid clarity. Outer surface 40 of
22 the sleeve 22 has a number of ridges 68a,b located
23 thereon. The ridges 68 are protrusions extending from
24 the surface. While they are illustrated as triangular in
25 cross-section, it will be understood that a variety of
26 forms could be used as long as they provide a 'bite' for
27 the seal 12 against the second surface (not shown).

28

29 Located between the ridges 68a,b on a portion 70 of the
30 surface is a sealant material 72. The material 72 can be
31 a coating or may be a treatment applied to the surface
32 70. The coating could be metal, plastic or another
33 material which will conform to the second surface on

1 contact. While the material 72 is shown as only located
2 between the ridges 68 it will be understood that the
3 ridges could additionally or independently be coated.
4 Teflon® or the like, would be a suitable material 72.

5
6 A further feature of the surface 40 is in the provision
7 of a groove 74 for an insert 76. At discrete locations
8 over the surface 40, grooves 74 in the form of indents
9 can be arranged. Into each groove 74 an insert 76 is
10 fitted. It will be appreciated that any suitable
11 technique may be used for attaching the insert 76 to the
12 groove 74. The insert 76 is a metal, which is preferably
13 a ductile, inert metal, such as gold. In use, the insert
14 76 would be the primary seal, instead of the outer
15 surface 40 or the sealant material 72. The ductile
16 insert 76 will deform to accommodate any scratches or
17 other discontinuities, which the outer surface 40 may
18 not.

19
20 A further example application of use of the sealing
21 element of the present invention, is in an expansion
22 joint. Figure 6 illustrates an expansion joint,
23 generally indicated by reference numeral 310, as may be
24 found in a tool string run in a well bore. The joint 310
25 operates by allowing one portion, such as a sleeve 313 to
26 move axially relative to the mandrel 315. A seal 312 is
27 located between the moving parts with a pressure
28 differential between the outside and the tubing string.
29 The seal 312 is as described hereinbefore with reference
30 to Figures 1-4. The seal 312 is held on a mandrel 315,
31 within a seal bore 317. Alternatively, the seal could be
32 held on a housing, with a moveable mandrel. The seal 312
33 is activated by applying a pre-load to deform it

1 slightly. A threaded ring 319 is used to apply the pre-
2 load, but other methods could be equally be used. The
3 surface of the seal bore 317 is treated in such a manner
4 that friction and wear are minimised. This could be done
5 with tungsten carbide coating or other such methods,
6 which are well understood. In use, the seal 312 slides
7 within the seal bore 317, maintaining a dynamic seal
8 during axial movement of the mandrel 315 within the
9 stationary seal bore 317.

10

11 Reference is now made to Figures 7(a) and 7(b),
12 illustrating a sealing element, generally indicated by
13 reference numeral 412, being used as a flange sealing
14 ring. When flanges 421a,b are brought together to join
15 adjacent pipe sections 423a,b, a seal is needed to
16 prevent the escape of fluid from the pipe bore 425. Each
17 flange 421a,b includes a circular groove 427a,b located
18 on the surface 429a,b of the flange plate 431a,b. The
19 seal 412 is sized to locate within the grooves 427a,b.
20 Indeed the grooves 427a,b are profiled to match the outer
21 surface of the ends 424,426 of the seal 412. Sealing
22 between the flanges 421a,b is achieved at the first
23 surface, being a combination of the inner edges 433a,b of
24 the grooves 427a,b respectively, and the second surface,
25 being a combination of the outer edges 435a,b of the
26 grooves 427a,b respectively.

27

28 Sealing element 412 is as described with reference to
29 Figures 1-4, comprising an annular body. Element 412 is
30 formed as two concentric metal sleeves, an inner sleeve
31 420 and an outer sleeve 422. The sleeves are joined at
32 upper 424 and lower 426 ends. Joining is by welding of
33 the sleeves 420,422. Between the sleeves 420,422 is

1 located a filler 428. The filler is entirely contained
2 within the sealing element 412 and bounded on all sides
3 by the metal sleeves 420,422. Thus an interior volume 430
4 defined by the metal sleeves 420,422 contains an equal
5 volume of the filler 428.

6

7 Inner sleeve 420 is geometrically arranged to provide two
8 symmetrical peaks 436a,b running circumferentially around
9 the surface 432. A trough 438 lies between the two peaks
10 436a,b. Trough 438 has symmetrical sloping side walls
11 with a flat base 439. The outer sleeve 422 has a similar
12 geometrical arrangement on its outer surface 440 to that
13 of the inner surface 432. However peaks 442a,b are
14 somewhat closer together providing a narrower trough 444
15 without a flat base.

16

17 As is seen in Figures 7(a) and (b) geometrical
18 arrangement of the sealing element 412 is selected so
19 that when the ends 424,426 are brought together the
20 element 412 will deform in a controlled manner. The
21 peaks 436,442 and troughs 438,444 act like fold lines on
22 the sleeves 420,422 forming a cantilever structure, which
23 supports the seal. The filler 428 supports the seal 412
24 to prevent the seal from collapsing with pressure applied
25 from the ends 424. The interior volume 430 and the volume
26 of the filler 428 remain the same during compression of
27 the seal 412. The filler 428 remains in contact with the
28 continuous surface formed by the sleeves 420,422.

29 Delamination does not occur, thus the filler 428 helps
30 prevent the seal 412 collapsing when pressure is applied
31 across the seal.

32

1 The principal advantage of the present invention is that
2 by entirely enclosing a filler material within two
3 sleeves, volumetric changes in the sealing element are
4 minimised and the seal will deform in a controlled
5 manner.

6

7 A further advantage of an embodiment of the present
8 invention is that it provides a sealing element, which by
9 forming a cantilever structure on deforming, produces a
10 strong seal which can be used to anchor tools in a well
11 bore.

12

13 A yet further advantage of an embodiment of the present
14 invention is that it provides a sealing element which
15 does not collapse under pressure differentials. This is
16 done without the need to thicken the sleeves as it is
17 achieved by the 'rubber pressure' of the filler within
18 the sealing element.

19

20 A still further advantage of an embodiment of the present
21 invention is that it provides a sealing element which
22 does not use elastomers, thus heat and chemicals
23 typically found in well bores will not affect the
24 operation of the seal.

25

26 A still further advantage of an embodiment of the present
27 invention is that it provides a sealing element which has
28 the benefits of flexibility, like an elastomer seal, but
29 is fully metal-to metal.

30

31 A yet further advantage of at least one embodiment of the
32 present invention is that it provides a sealing element

1 which can be used in dynamic applications where it must
2 slid while maintaining a seal.

3

4 It will be appreciated by those in the art that various
5 modifications may be made to the invention
6 hereindescribed without departing from the scope thereof.
7 For example, the overall size of the sealing element can
8 be varied to suit the tool used. The applications
9 describe use in a packer, joint and flange mating but the
10 sealing element could equally be applied to a range of
11 subsea/downhole tools and equipment where a seal and/or
12 anchoring is required.

13

1 CLAIMS

2
3 1. An annular sealing element for a downhole tool for
4 providing a seal between a first and a second
5 surface, the element comprising:

6 an inner sleeve providing an inner deformable
7 surface and arranged concentric with an outer sleeve
8 providing an outer deformable surface, each of the
9 inner and outer sleeves being formed of a material
10 liable to plastic deformation, the inner and outer
11 sleeves being joined at respective junctions of
12 opposed first ends and second ends, providing a body
13 defining an interior volume entirely bounded by the
14 said surfaces and said ends, a deformable filler
15 material within said interior volume, wherein the
16 filler material is a plastic;

17 wherein the inner and outer sleeves each
18 comprise a plurality of fold lines;

19 wherein the element deforms in a predetermined
20 manner when said first ends are brought toward said
21 second ends by deformation of the inner and outer
22 sleeves about their respective fold lines, to
23 thereby seal between the first and second surfaces;

24 wherein the inner and outer sleeves define a
25 first shape containing said interior volume, and
26 following deformation the inner and outer sleeves
27 define a second shape, which is a cantilever
28 structure arranged longitudinally between the ends,
29 and

30 wherein the first and second shape are annular
31 having a polygon in longitudinal cross-section.
32

- 1 2. A sealing element as claimed in Claim 1, wherein the
2 inner and outer surfaces are deformable metal
3 sleeves.
4
- 5 3. A sealing element as claimed in Claim 1 or 2,
6 wherein the polygon is symmetrical to a horizontal
7 plane, equidistant from the ends.
8
- 9 4. A sealing element as claimed in Claim 1, 2 or 3,
10 wherein the deformable filler material has a first
11 volume which equals the interior volume and both
12 remain substantially equal as the ends are brought
13 together.
14
- 15 5. A sealing element as claimed in any one of Claims 1
16 to 4, wherein the outer surface includes a plurality
17 of outer ridges.
18
- 19 6. A sealing element as claimed in any one of Claims 1
20 to 5, wherein a sealant material is applied to at
21 least a portion of the outer surface.
22
- 23 7. A sealing element as claimed in any one of Claims 1
24 to 6, wherein at least one metal insert is located
25 in at least a portion of the outer surface.
26
- 27 8. A sealing element as claimed in any one of Claims 1
28 to 7, wherein each of the outer and inner sleeves is
29 rigid.
30
- 31 9. A sealing element as claimed in any one of Claims 1
32 to 8, wherein the ends of the outer and inner

- 1 sleeves are located in abutment and held together by
2 respective fixing elements.
3
- 4 10. A sealing element as claimed in any one of Claims 1
5 to 9, wherein the outer and inner sleeves contain
6 the deformable filler when said ends of the sleeves
7 are brought toward each other.
8
- 9 11. A sealing element as claimed in any one of Claims 1
10 to 10, wherein the filler is adapted to prevent the
11 sealing element from collapsing under applied
12 pressure.
13
- 14 12. A sealing element as claimed in any one of Claims 1
15 to 11, wherein the inner and outer sleeves are
16 pinched together at the first ends and the second
17 ends.
18
- 19 13. A sealing element as claimed in any one of Claims 1
20 to 12, wherein the element deforms in a
21 predetermined manner to sealingly contact the first
22 and second surfaces at the respective fold lines of
23 the inner and outer sleeves.
24
- 25 14. A sealing element as claimed in any one of Claims 1
26 to 13, wherein the first and second surfaces
27 comprise respective opposing outer and inner
28 surfaces of coaxial tubular members, and wherein the
29 element is disposed longitudinally between the first
30 and second surfaces and deforms in a predetermined
31 manner to sealingly contact the first and second
32 surfaces at the respective fold lines of the inner
33 and outer sleeves.

- 1 15. A sealing element as claimed in any one of Claims 1
2 to 14, wherein the inner sleeve comprises at least
3 two troughs and at least one peak, and wherein the
4 inner and outer sleeves are asymmetrical.
5
- 6 16. A method of providing a seal between a first and a
7 second surface, the method comprising the steps:
8 (a) providing a sealing element according to any one
9 of Claims 1 to 15, having a first interior
10 volume and a first shape, and wherein the filler
11 has a first volume substantially equal to the
12 first interior volume;
13 (b) arranging the element adjacent the first surface
14 and opposite the second surface;
15 (c) moving one or both ends of the sealing element
16 toward the opposing end;
17 (d) deforming the inner and outer sleeves and the
18 plastic filler material of the sealing element
19 in a controlled manner to provide a second shape
20 while keeping the first interior volume and the
21 first volume substantially equal, wherein the
22 sealing element forms a cantilever structure
23 during deformation;
24 (e) contacting the sealing element on the first and
25 second surfaces to provide the seal, and
26 (f) further moving one or both ends of the sealing
27 element toward the opposing end to provide a
28 pressure across the sealing element between the
29 inner and outer surfaces.
30
- 31 17. A method as claimed in Claim 16, wherein the method
32 includes the step of deforming the outer and inner

- 1 surfaces of the sealing element.
2
- 3 18. A method as claimed in any one of Claims 16 to 17,
4 wherein the method includes the step of abutting
5 ridges of the sealing element onto at least the
6 second surface.
7
- 8 19. A method as claimed in any one of Claims 16 to 18,
9 wherein the method includes the step of abutting a
10 sealing material of the sealing element to at least
11 the second surface.
12
- 13 20. A method as claimed in any one of Claims 16 to 19,
14 wherein the method includes the step of abutting a
15 metal insert of the sealing element to at least the
16 second surface.
17
- 18 21. A method as claimed in any one of claims 16 to 20,
19 wherein the method is a method of anchoring an
20 apparatus to an inner surface of a well bore and
21 providing a seal between the first and second
22 surfaces, the inner surface of the well bore
23 defining the second surface, and
24 wherein the step of providing the sealing element
25 comprises providing an apparatus including the
26 sealing element, and
27 wherein the step of arranging the element adjacent
28 the first surface and opposite the second surface
29 comprises running the apparatus on a work string in
30 the well bore and so arranging the element, and
31 further wherein the step of further moving one or
32 both ends of the sealing element towards the

- 1 opposing end also anchors the apparatus to the
2 second surface.
3
- 4 22. A method as claimed in any one of claims 16 to 21,
5 wherein the first and second surfaces comprise
6 respective opposing outer and inner surfaces of
7 coaxial tubular members.
8
- 9 23. A method as claimed in claim 22, wherein the first
10 surface comprises an outer cylindrical surface
11 having a smaller diameter relative to the second
12 surface.
13
- 14 24. An apparatus for providing a seal between a first
15 and a second surface within in a well bore,
16 comprising:
17 a substantially tubular body upon which is
18 located the first surface;
19 a sealing element according to claims 1 to 15
20 located around the tubular body;
21 at least one actuating element arranged around
22 and longitudinally moveable relative to the tubular
23 body, the actuating element including means for
24 contacting an end of the sealing element;
25 wherein the sealing element deforms in a
26 predetermined manner to seal between the first and
27 second surfaces when said ends are brought toward
28 each other by movement of the actuating element.
29
- 30 25. The apparatus as claimed in Claim 24, wherein the at
31 least one actuating element is a cone, the cone
32 having a bore therethrough for passage of the
33 tubular body.

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26. The apparatus as claimed in Claim 24, wherein the at least one actuating element is a threaded ring.

27. The apparatus as claimed in Claims 24, 25 or 26, wherein the first surface comprises an outer cylindrical surface and the second surface comprises an opposing inner cylindrical surface.

28. An annular sealing element for providing a seal between first and second metallic cylindrical surfaces, comprising:

a metallic inner sleeve providing an inner deformable surface, an outer metallic sleeve providing an outer deformable surface, the inner and outer sleeves being joined together at upper and lower junctions at opposite ends of the sleeves to provide a body defining an elongated annular volume entirely bounded by the said surfaces and said junctions, and a deformable solid plastic filler material within said volume;

wherein the inner and outer sleeves each comprise a plurality of fold lines, and

wherein the element deforms about the fold lines in a predetermined manner when the inner and outer sleeves are compressed at the opposite ends, to thereby form a metal-to-metal seal between the first and second surfaces.

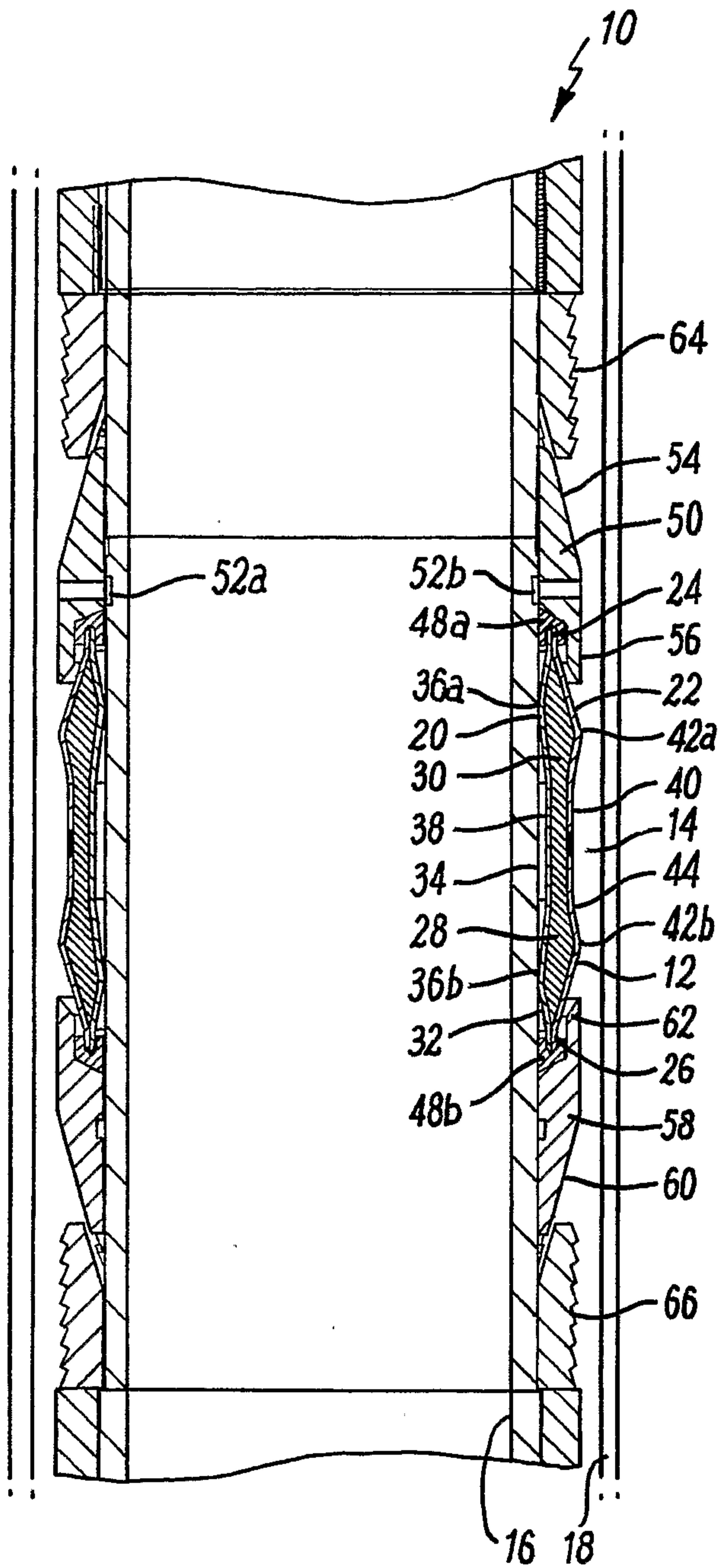


FIG. 1

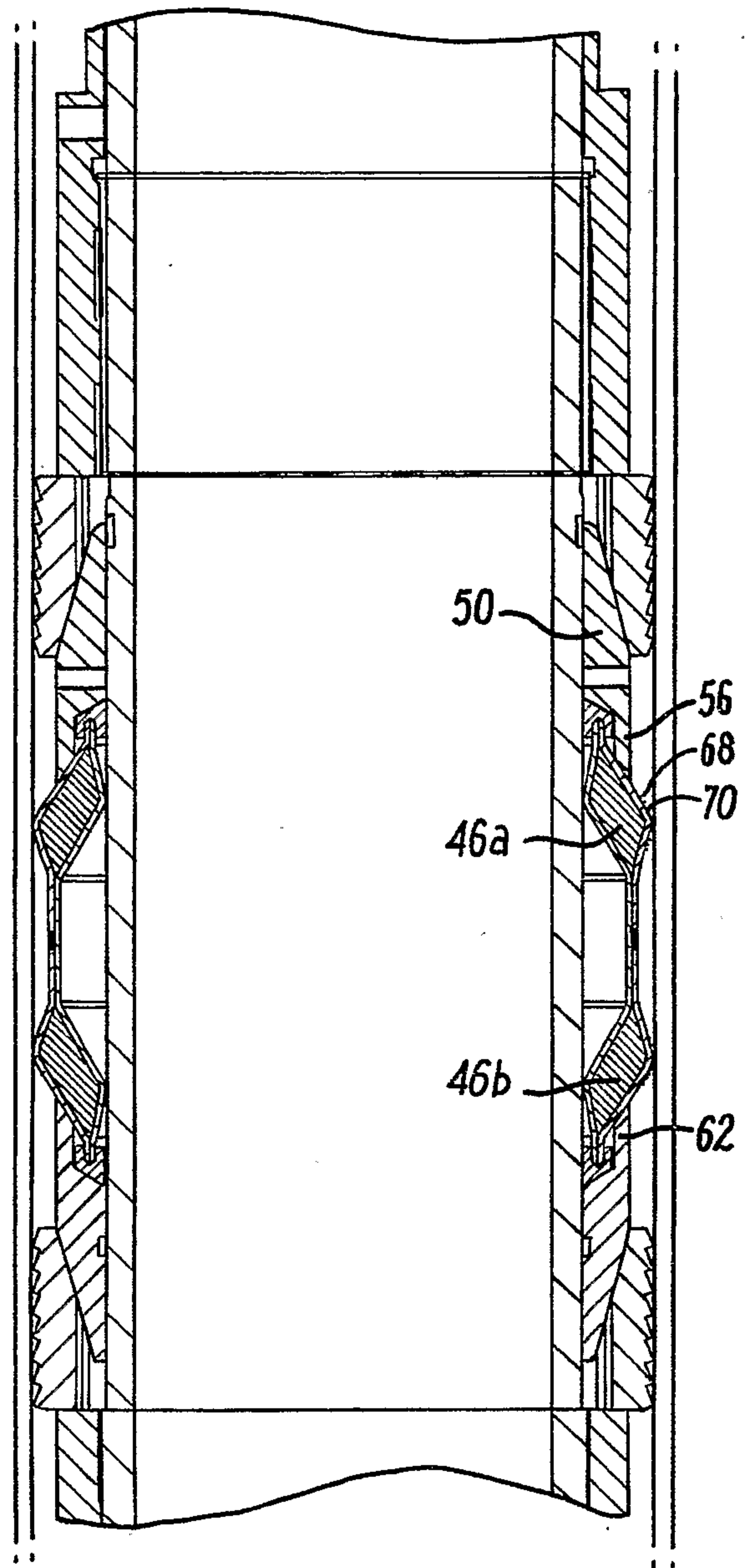


FIG. 2

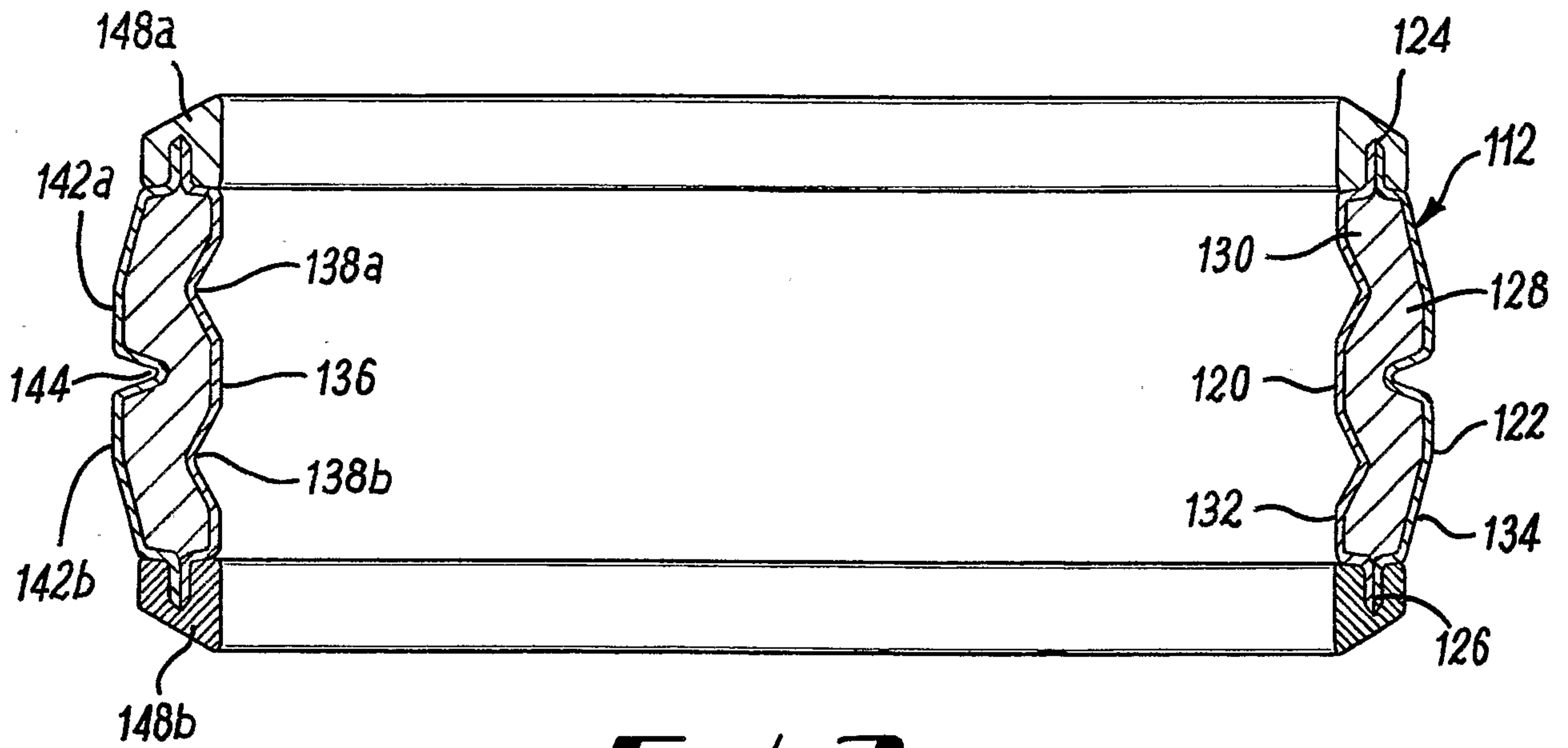


FIG. 3



FIG. 4

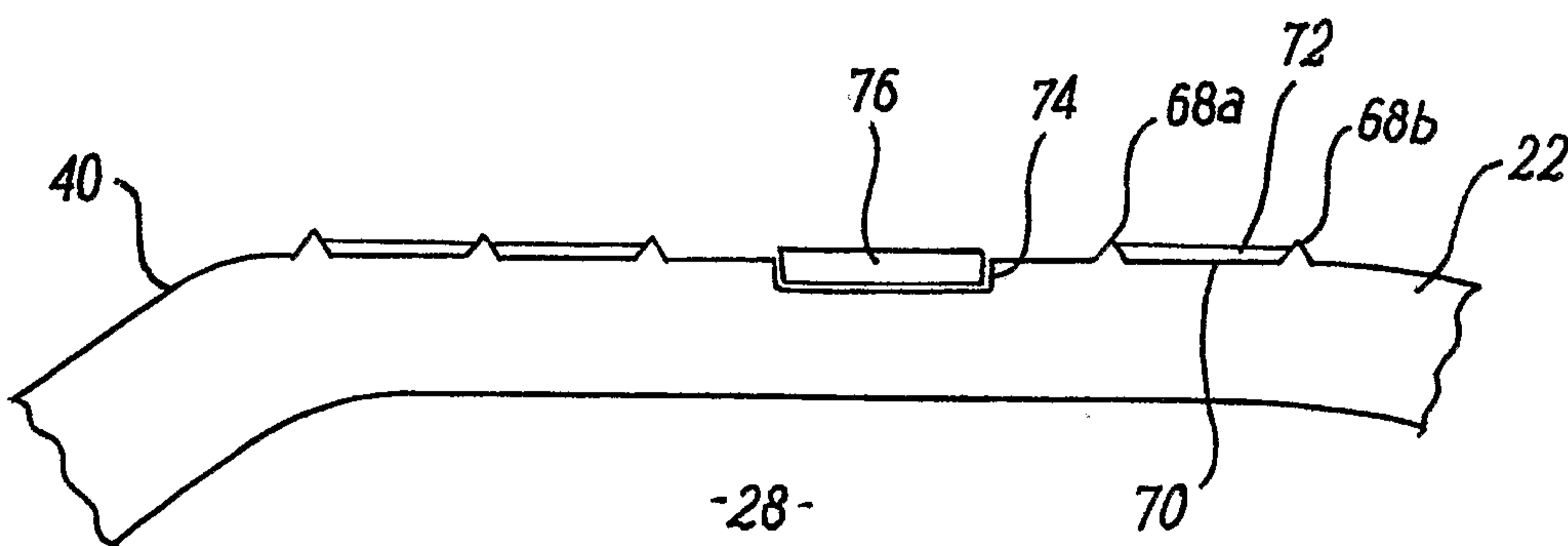


FIG. 5

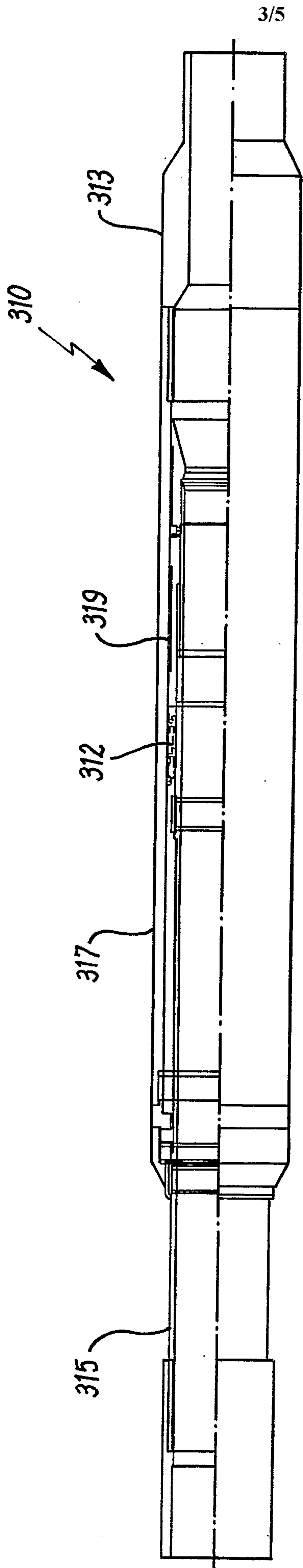


FIG 6

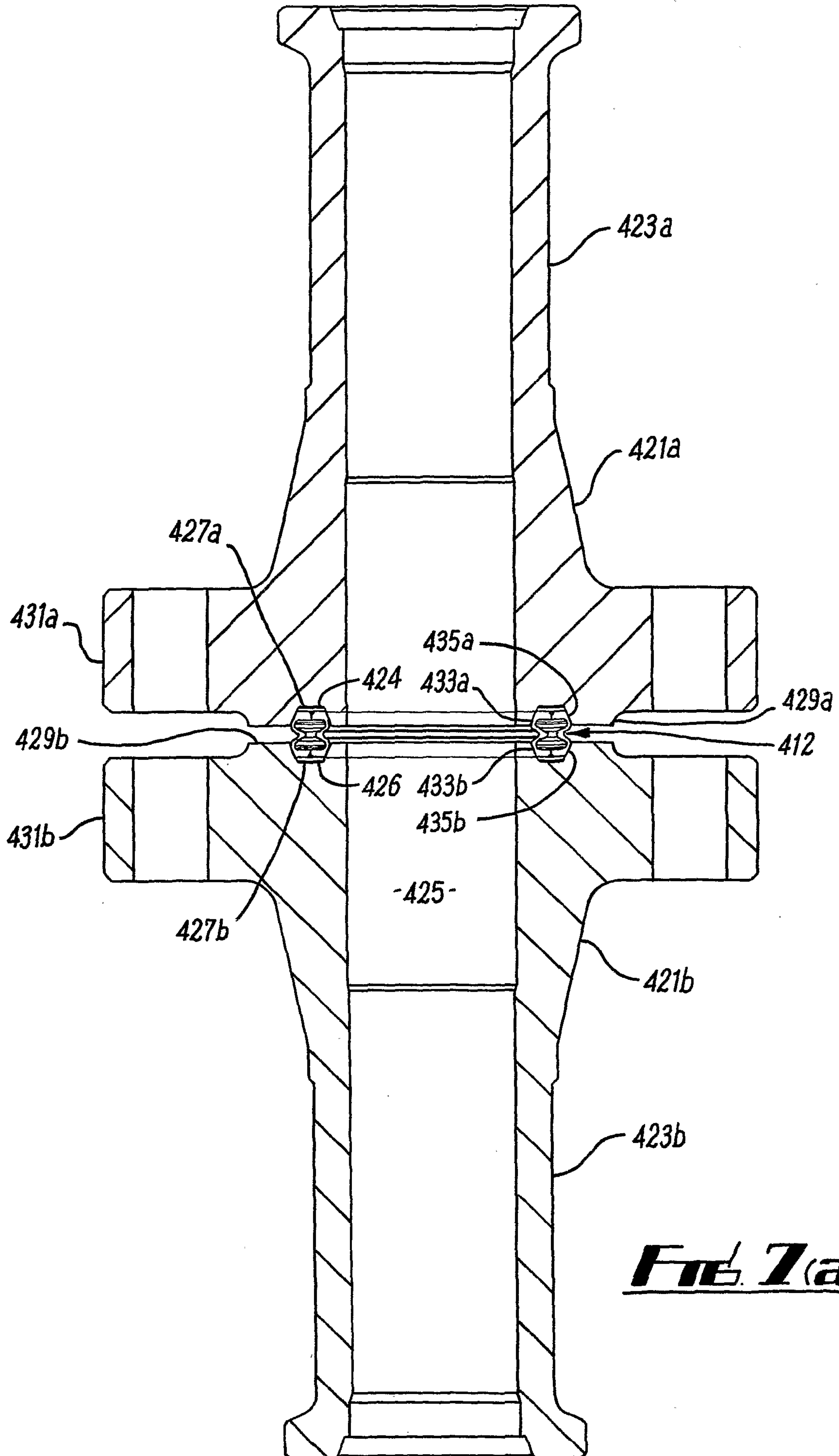


Fig. 2(a)

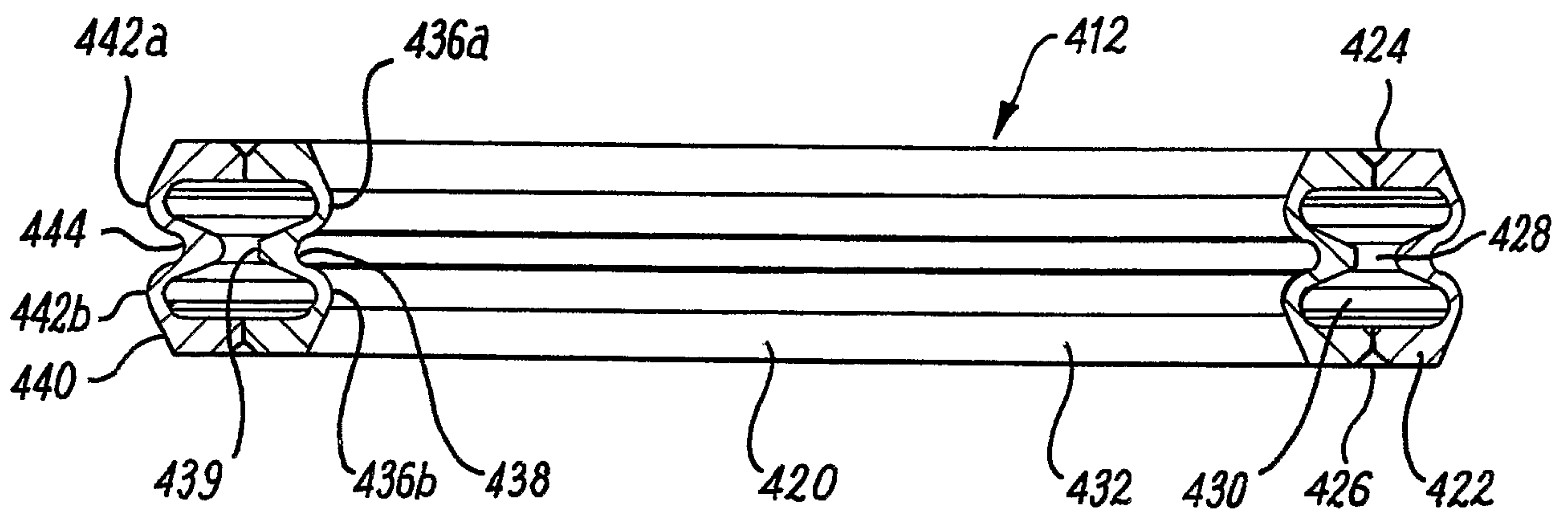


FIG. 7(b)

