



(22) Date de dépôt/Filing Date: 2009/11/09

(41) Mise à la disp. pub./Open to Public Insp.: 2010/05/11

(45) Date de délivrance/Issue Date: 2018/05/15

(30) Priorité/Priority: 2008/11/11 (GB0820619.5)

(51) Cl.Int./Int.Cl. *E21B 43/04* (2006.01),
E21B 33/10 (2006.01), *E21B 33/12* (2006.01)

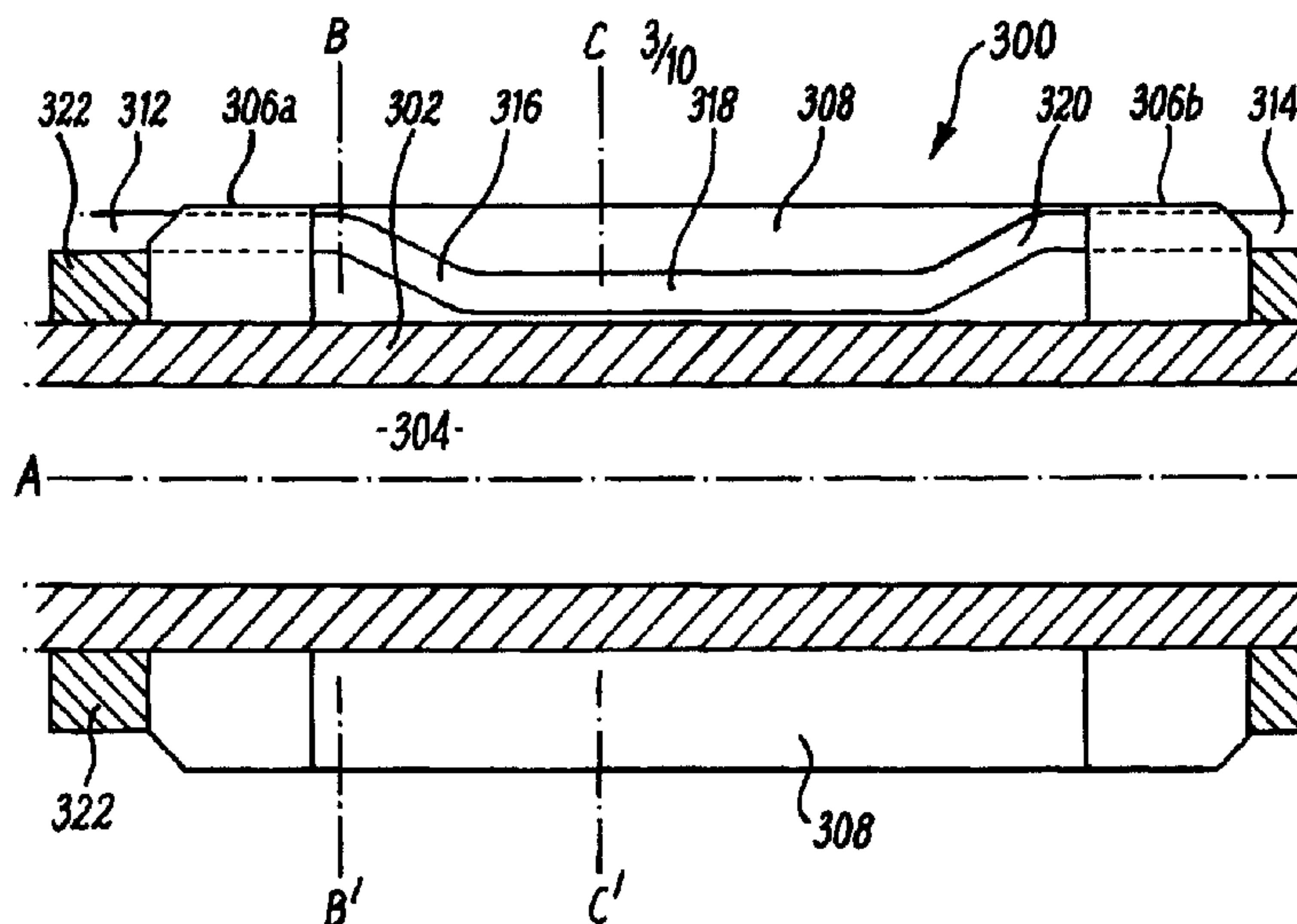
(72) Inventeurs/Inventors:
NUTLEY, KIM, GB;
NUTLEY, BRIAN, GB

(73) Propriétaire/Owner:
WEATHERFORD U.K. LIMITED, GB

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : APPAREILLAGE ET METHODE APPLICABLES A UN Puits DE FORAGE

(54) Title: WELLBORE APPARATUS AND METHOD



(57) **Abrégé/Abstract:**

An apparatus for use in a wellbore is described, the apparatus having a tubular body and a throughbore which defines a primary fluid path through the apparatus. An expanding element is disposed around the tubular body and is configured to provide an annular barrier in a space between the tubular body and a surrounding wall. A conduit defining a secondary flow path through the apparatus is provided, and is configured to be in fluid communication with at least one alternate path, such as a shunt tube, in an adjacent wellbore component (e.g. a sand control device). The conduit is arranged to vary the secondary flow path along a longitudinal direction of the apparatus, for example to redirect the flow path to a radial position closer to the tool body. The conduit is configured to have a reduced effect on the operation of the expanding element, while still allowing the conduit to be coupled to alternate flow paths of adjacent apparatus. The invention has particular application to swellable wellbore packer systems in gravel packing operations. An assembly, a method of use, and a wellbore installation are also described.

ABSTRACT

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

An apparatus for use in a wellbore is described, the apparatus having a tubular body and a throughbore which defines a primary fluid path through the apparatus. An expanding element is disposed around the tubular body and is configured to provide an annular barrier in a space between the tubular body and a surrounding wall. A conduit defining a secondary flow path through the apparatus is provided, and is configured to be in fluid communication with at least one alternate path, such as a shunt tube, in an adjacent wellbore component (e.g. a sand control device). The conduit is arranged to vary the secondary flow path along a longitudinal direction of the apparatus, for example to redirect the flow path to a radial position closer to the tool body. The conduit is configured to have a reduced effect on the operation of the expanding element, while still allowing the conduit to be coupled to alternate flow paths of adjacent apparatus. The invention has particular application to swellable wellbore packer systems in gravel packing operations. An assembly, a method of use, and a wellbore installation are also described.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

WELLBORE APPARATUS AND METHOD

FIELD OF THE INVENTION

The present invention relates to an apparatus and method for use in wellbores for the hydrocarbon exploration and production industry. The invention relates particularly, although not exclusively, to an apparatus and method for providing an alternate flow path in isolation devices.

BACKGROUND TO THE INVENTION

In the field of oil and gas exploration and production, various tools are used to provide barriers in the wellbore which prevent or restrict the fluid flow. A wellbore packer provides a seal in the annular space between two tubing strings, or between an outer casing and an open hole. A packer may be run with a completion string to a downhole location, and may be inflated or expanded into contact with the outer casing or open hole. The packer may be designed to create a complete fluid seal capable of withholding a differential pressure on either side of the packer, thereby isolating one portion of the annulus from another. Alternatively, the packer may simply provide an annular barrier, to prevent or restrict flow of fluids and/or solid particles in the annulus. Packers may for example be run on completion strings, specialised mandrels, coiled tubing, wireline and slickline tools.

1 Conventional packers are activated by mechanical or hydraulic
2 systems. More recently, packers have been developed which include a mantle of
3 swellable elastomeric material formed around a tubular body. The swellable
4 elastomer is selected to increase in volume on exposure to a triggering fluid, which
5 may be a hydrocarbon fluid or an aqueous fluid or brine. Alternatively, the
6 elastomer may be selected to increase in volume on exposure to another triggering
7 mechanism, such as heat or pressure. The packer is run to a downhole location in
8 its unexpanded state, where it is exposed to a triggering fluid and caused to
9 expand. The design, dimensions and swelling characteristics are chosen such that
10 the swellable mantle increases in volume to create an annular barrier and/or a fluid
11 seal in the annulus. Swellable packers have several advantages over conventional
12 packers including passive actuation, simplicity of construction, and robustness in
13 long term isolation applications. Examples of swellable packers and suitable
14 materials are described in GB 2411918.

15

16 One application of a wellbore packer is as an isolation device in a
17 multi-zone completion system. An example of a multi-zone completion system is
18 shown in Fig. 1. The system, generally shown at 100, includes a production facility
19 at surface, which in this case is a floating production storage and offloading (FPSO)
20 vessel 102, coupled to a well 104 via subsea tree 106. The wellbore in this case is
21 an inclined wellbore which extends through multiple production intervals 107a,
22 107b, 107c in the formation 108. The production tubing 110 provides a continuous

1 flow path which penetrates through the multiple zones. The production tubing is
2 provided with ports or inflow control devices (not shown) which allow production
3 fluid to flow into the production tubing and out to the subsea tree 106. However, in
4 order to provide control over the production process, the annulus 112 is sealed by
5 packers 114 between the different production zones 107 to prevent fluid flowing in
6 the annulus between the different zones.

7

8 Depending on the formation, the production tubing may be provided
9 with sand control devices 116, to prevent solid particles from the formation entering
10 the production tubing. The sand control devices 116 may for example be any
11 suitable sand screen system, including expandable screen systems. The sand
12 control devices may be used in conjunction with one or more gravel packs 118,
13 which comprise gravel or other particulate matter around the sand control device to
14 improve filtration and to provide additional support to the formation. Gravel packing
15 requires a good distribution of gravel in the annulus at the sand control device. To
16 improve the delivery of gravel, sand control devices have been provided with shunt
17 tubes, which create alternate flow paths for the gravel and its carrier fluid. These
18 alternate flow paths significantly improve the distribution of gravel in the production
19 interval, for example by allowing the carrier fluid and gravel to be delivered through
20 sand bridges that may be formed in the annulus before the gravel pack has been
21 completed.

22

1 Figs. 2A and 2B are schematic views of examples of sand screens
2 provided with shunt tubes in a completion system 200. A first sand control device
3 202a is coupled to a second sand control device 202b, and each comprise base
4 pipes 204 joined to define a production bore 206. Screens 208 including filter
5 media surround the base pipe 204 and are supported by ribs 210. The apparatus is
6 provided with shunt tubes 212, which in this example are steel tubes having
7 substantially rectangular cross-section. The shunt tubes 212 are supported on the
8 exterior of the screen and provide a flow path 213 alternate to the main production
9 bore 206. Jumper tubes 211 are used to provide fluid communication between
10 shunt tubes of adjacent sand control devices. The shunt tubes 212 maintain a flow
11 path 213, even if the annular space 214 is bridged, for example by a loss of integrity
12 in a part of the formation 216. Examples of shunt tube arrangements can be found
13 in US 4945991 and US 5113935. The shunt tubes may also be internal to the filter
14 media, as described in US 5515915 and US 6227303.

15

16 Use of alternate path screen systems creates difficulties in wellbore
17 isolation. In particular, alternate paths prevent the use of conventional wellbore
18 packers to isolate multiple production zones. It is proposed in WO 2007/092082
19 and WO 2007/092083 to provide packers with alternate path mechanisms which
20 may be used to provide zonal isolation between gravel packs in a well. The packers
21 described may include individual jumper tubes over a common manifold or manifold
22 region that provides fluid communication through the packer to shunt tubes of sand

1 control devices. Embodiments described in WO 2007/092082 and WO
2 2007/092083 include packers with swellable mantles which increase in volume on
3 exposure to a triggering fluid.

4

5 However, WO 2007/092082 and WO 2007/092083 do not fully
6 address the complexities of providing fluid barriers and/or fluid isolation using
7 swellable elastomer systems. For example, WO 2007/092082 and WO
8 2007/092083 are concerned with providing a continuous flow path, but do not
9 address the problems of maintaining the required annular barrier or fluid seal
10 functions of the packer with the provision of the secondary flow path through the
11 apparatus. Such problems may arise due to removal of a volume of elastomer from
12 the isolation device, improper sealing around the conduits, displacement of the
13 conduits due to expansion of the element, and/or coupling of the conduits at
14 opposing ends of the isolation device.

15

16 In particular, the arrangements proposed in these WO 2007/092082
17 and WO 2007/092083 necessitate a reduction in the overall volume of the
18 expanding element, and in particular a reduction in the volume of the expanding
19 element which is radially outward of the conduit. An arrangement with individual
20 jumper tubes requires the jumper tubes to be aligned with the shunt tubes of the
21 adjacent sand control devices. WO 2007/092082 discloses an outer diameter of
22 expanding element which is significantly below the outer diameter of adjacent sand

1 control devices. This configuration would limit the swelling performance from a
2 swellable mantle as it provides minimal mantle thickness. It is possible that at its
3 fully swollen state it would not contact the internal diameter of the drilled wellbore.
4 In addition, configuring a swellable elastomer well packer to achieve a seal at a fully
5 swollen condition may mean extremely long or impractical sealing times and
6 marginal pressure sealing performance if the swellable mantle did manage to
7 contact the wellbore.

8
9 The arrangement which comprises a manifold would also be inefficient
10 in finding a nominal balance of swellable mantle thickness. The arrangement
11 requires the outer diameter of the sleeve defining the manifold to extend beyond the
12 radial position of the shunt tubes such that the sleeve has an outer diameter
13 equivalent to the outer diameter of adjacent sand control devices. This has the
14 effect of reducing the volume of the expanding element which may be positioned on
15 the outside of the conduit. This may compromise the integrity of the seal provided
16 by the expanding element and/or increase the time to seal. Alternatively, if the
17 volume of the expanding element is to be maintained, the run-in diameter of the
18 expanding element is increased beyond the diameter of the shunt tubes, and the
19 swellable mantle is be the largest tool diametrically within a sand control string.
20 This limits swelling performance and can impact on the success of deployment
21 operations. It is desirable for the packer outer diameter to be small during run-in to
22 avoid contact with obstructions, for example ledges or washout zones. When using

1 swellable elastomer materials, they may begin to expand as they contact drilling or
2 wellbore fluids during run-in to the desired position in the wellbore.

3

4 It is therefore an object of the invention to provide an apparatus in the
5 form of an isolation device, packer and/or annular barrier and method of use which
6 overcome or mitigate at least one drawback or deficiency of previously proposed
7 apparatus and methods.

8

9 It is a further object of the invention to provide a wellbore completion
10 and/or production system or method of use which incorporates such an apparatus
11 or method.

12

13 It is a further object of the invention to provide an apparatus or method
14 which is an alternative to the method or apparatus described in the prior art.

15

1 SUMMARY OF THE INVENTION

2 According to a first aspect of the invention, there is provided an
3 apparatus for use in a wellbore comprising a tubular body having a longitudinal axis
4 and a throughbore which defines a primary fluid path through the apparatus. The
5 apparatus has; an expanding element disposed around the tubular body and
6 configured to provide an annular barrier in a space between the tubular body and a
7 surrounding wall. The apparatus further has a conduit defining a secondary flow
8 path and configured to be in fluid communication with at least one alternate path in
9 an adjacent wellbore component, wherein the conduit is arranged to vary the
10 secondary flow path along a longitudinal direction of the apparatus.

11
12 By varying the secondary flow path, the apparatus of the invention is
13 configured for improved operation of the expanding element of the apparatus. For
14 example, the required annular barrier and/or sealing function of the expanding
15 element can be maintained even with the provision of the secondary flow path
16 through the apparatus. The conduit is configured to have a reduced effect on the
17 operation of the expanding element, while still allowing the conduit to be coupled to
18 alternate flow paths of adjacent apparatus.

19
20 The apparatus may be a wellbore packer, configured to provide a seal
21 in the space between the tubular body and the surrounding wall. The apparatus

1 may alternatively be configured to provide an annular barrier which inhibits fluid flow
2 in the space and/or prevents the movement of solid particles in the annulus.

3

4 The at least one alternate path may be defined by at least one shunt
5 tube. The adjacent wellbore component is preferably a sand control apparatus,
6 such as a screen. The apparatus is preferably operable to be coupled to a first
7 sand control device and a second sand control device. The conduit is preferably
8 configured to be in fluid communication with a first shunt tube of a first of a first sand
9 control device disposed in an uphole direction of the apparatus. The conduit may
10 be in fluid communication with a second shunt tube of a second sand control device
11 disposed in a downhole direction of the apparatus.

12

13 The conduit is configured for the passage of a carrier fluid containing
14 particulate matter for a gravel pack, and thus the apparatus may be used in a gravel
15 pack operation. The gravel pack may be formed at least in part at the location of a
16 sand control device disposed in a downhole direction of the apparatus. The gravel
17 pack may be formed by passing the carrier fluid through a first shunt tube of a first
18 sand control device disposed in an uphole direction of the apparatus, and through
19 the conduit of the apparatus. The carrier fluid may be passed through a second
20 shunt tube of a second sand control device disposed in a downhole direction of the
21 apparatus.

22

1 The conduit may be arranged to vary a radial dimension of the
2 secondary flow path. The conduit may be arranged to vary the secondary flow path
3 by changing the direction of fluid flowing in the secondary flow path. In particular,
4 the conduit may be arranged to change the radial distance of the flow path from the
5 longitudinal axis of the apparatus. Thus the radial position of the flow path can be
6 selected to improve the operation of the expanding element. Embodiments of the
7 invention therefore have the advantage that the apparatus can be used with
8 standard alternate flow path and shunt tube configurations adopted by various
9 manufacturers of alternate paths and control systems.

10

11 Preferably, the conduit is configured to redirect the fluid flow radially
12 inward of the apparatus. The conduit may comprise a first portion configured to
13 redirect the flow, and may comprise a second portion arranged parallel to the
14 longitudinal axis of the apparatus. The apparatus may comprise an s-bend in the
15 secondary flow path.

16

17 The first portion may be located in a gauge ring of the apparatus, or
18 may be located in the expanding element. Alternatively, the first portion may be
19 located in conduit extension members which are disposed outside of the expanding
20 element and/or gauge ring.

21

1 The conduit may comprise an inlet at a first radial distance from the
2 longitudinal axis of the apparatus, and a second portion disposed at a second radial
3 distance from the longitudinal axis of the apparatus, the second radial distance
4 being less than the first radial distance.

5
6 Alternatively, or in addition, the conduit may be arranged to vary the
7 secondary flow path by changing the cross-sectional profile of the conduit along the
8 longitudinal direction of the apparatus. This may for example allow the conduit or a
9 portion of it to be repositioned within the apparatus in order to have a minimal
10 impact on the operation of the expanding element. It may also allow the flow area
11 to be redistributed about the circumference of the apparatus to reduce the radial
12 dimension of the flow path.

13
14 The cross-sectional profile of the secondary flow path may be varied
15 such that the total cross-sectional area of the conduit is substantially the same
16 along the longitudinal direction of the apparatus. Thus the rate of flow of fluid
17 through the conduit is substantially unaffected. Alternatively, the cross-sectional
18 shape of the secondary flow path may be varied to change the total cross-sectional
19 area of the secondary flow path longitudinally along the apparatus.

20

1 The apparatus may comprise a manifold portion arranged to receive
2 fluid from and/or direct flow into a plurality of conduit members. The manifold
3 portion may be annular or part-annular.

4

5 The apparatus may comprise a conduit bore formed in the tubular
6 body, which may be formed longitudinally in the wall of the tubular body. A plurality
7 of conduit bores may be provided. The conduit bores may be in fluid
8 communication with an alternate flow path via a manifold, and or via a flow path in a
9 gauge ring.

10

11 The apparatus may comprise one or more conduits integrally formed
12 with the tubular body. Alternatively, or in addition, the apparatus may comprise one
13 or more conduits unitarily formed with the tubular body.

14

15 The conduit may comprise a support element such as a tubular
16 conduit member, or may alternatively be defined by a recess or channel in the
17 expanding element. A flexible or collapsible conduit member may be provided.

18

19 The apparatus may comprise a gauge ring which is configured to be
20 radially disposed onto the tubular body, for example by clamping. The gauge ring
21 may comprise a recessed channel shaped to receive a conduit. The recess may be

1 configured to deform, bend, or otherwise reshape the conduit. The recess may
2 comprise a wedge-shaped longitudinal profile.

3

4 According to a second aspect of the invention, there is provided an
5 assembly for use in a wellbore comprising an apparatus having a tubular body with
6 a first throughbore and an expanding element, disposed around the tubular body,
7 configured to provide an annular barrier in a space between the tubular body and a
8 surrounding wall, and at least sand control device comprising a second throughbore
9 and at least one shunt tube. The at least one sand control device is coupled to the
10 apparatus to define a primary flow path through the assembly via the first and
11 second throughbores wherein the assembly defines a secondary flow path for a
12 gravel pack carrier fluid via the at least one shunt tube and through the apparatus
13 and wherein the secondary flow path is varied along a longitudinal direction of the
14 apparatus.

15

16 According to a third aspect of the invention, there is provided a
17 wellbore installation comprising a production tubular, at least one apparatus of the
18 first aspect of the invention, and at least one sand control device coupled to the
19 apparatus downstream of the apparatus.

20

21 Preferably, the wellbore installation comprises a second sand control
22 device coupled to the apparatus upstream of the apparatus, and the apparatus

1 provides a secondary flow path for a gravel pack between the second and first sand
2 control devices.

3

4 The wellbore installation may comprise a gravel pack disposed at one
5 or both of the sand control devices.

6

7 According to a fourth aspect of the invention, there is provided a
8 method of forming a wellbore installation. The method comprises locating a sand
9 control device at a downhole location in a producing formation, locating an annular
10 barrier apparatus at a downhole location upstream of the sand control device,
11 gravel packing the sand control device by passing a carrier fluid containing
12 particulate matter through a secondary flow path in the annular barrier apparatus to
13 the sand control device and varying the secondary flow path of the carrier fluid
14 through the annular barrier apparatus.

15

16 Varying the secondary flow path may comprise redirecting and/or
17 redistributing the flow. It may comprise changing a radial dimension and/or position
18 of the flow.

19

20 According to a fifth aspect of the invention, there is provided an
21 apparatus for use in a wellbore comprising a tubular body having a longitudinal axis
22 and a throughbore which defines a primary fluid path through the apparatus, an

1 expanding element, disposed around the tubular body, configured to provide an
2 annular barrier in a space between the tubular body and a surrounding wall, and a
3 conduit. The conduit defines a secondary flow path through the apparatus and is
4 configured to be in fluid communication with at least one alternate path in an
5 adjacent wellbore component at a first radial distance from the longitudinal axis of
6 the tubular body, wherein at least a portion of the conduit is located at a second
7 radial distance from the longitudinal axis of the tubular body, the second radial
8 distance being less than the first radial distance.

9

10 According to an sixth aspect of the invention, there is provided a
11 method of forming a wellbore installation. The method comprises locating a sand
12 control device at a downhole location in a producing formation, locating an annular
13 barrier apparatus at a downhole location upstream of the sand control device,
14 gravel packing the sand control device by passing a carrier fluid containing
15 particulate matter through a secondary flow path in the annular barrier apparatus to
16 the sand control device, and redirecting the secondary flow path from a flow path at
17 a first radial distance from the longitudinal axis of the apparatus to a flow path at a
18 second radial distance from the longitudinal axis of the tubular body, the second
19 radial distance being less than the first radial distance.

20

21 According to an seventh aspect of the invention, there is provided an
22 assembly for use in a wellbore comprising an apparatus having a tubular body with

1 a first throughbore, an expanding element, disposed around the tubular body,
2 configured to provide an annular barrier in a space between the tubular body and a
3 surrounding wall, and at least sand control device comprising a second throughbore
4 and at least one shunt tube. The at least one sand control device is coupled to the
5 apparatus to define a primary flow path through the assembly via the first and
6 second throughbores; wherein the assembly defines a secondary flow path for a
7 gravel pack carrier fluid via the at least one shunt tube and through the apparatus,
8 and wherein at least a portion of the secondary flow path is located radially closer to
9 the primary flow path than the shunt tube.

10

11 According to an eighth aspect of the invention, there is provided a
12 method of forming a wellbore installation. The method comprises locating a first
13 sand control device at a downhole location in a producing formation, locating an
14 annular barrier apparatus at a downhole location downstream of the first sand
15 control device, locating a second sand control device at a downhole location
16 downstream of the annular barrier apparatus, gravel packing the sand control
17 device by passing a carrier fluid containing particulate matter through a shunt tube
18 of the first sand control device and a secondary flow path in the annular barrier
19 apparatus to the sand control device, and redirecting the secondary flow path to be
20 radially closer to the longitudinal axis of the apparatus than the shunt tube.

21

1 Embodiments of the various aspects of the invention may comprise
2 preferred and optional features of other aspects of the invention. In particular,
3 embodiments of the fifth and seventh aspects of the invention may comprise
4 features of the first aspect. Embodiments of the invention may have particular
5 application in the methods of operation described in WO 2007/092082 and WO
6 2007/092083.

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 Figure 1 shows schematically a multi-zone production system in
3 accordance with various embodiments of the invention;

4

5 Figures 2A and 2B are respectively upper and cross-sectional views of
6 a conventional alternate path screen system;

7

8 Figures 3A to 3C are sectional views of an apparatus in accordance
9 with an embodiment of the invention;

10

11 Figures 4A to 4C are sectional views of an apparatus in accordance
12 with an alternative embodiment of the invention;

13

14 Figure 5 is a longitudinal section through an apparatus in accordance
15 with a further embodiment of the invention;

16

17 Figures 6A to 6C are sectional views through an apparatus in
18 accordance with a further alternative embodiment of the invention;

19

20 Figure 7 is a cross-sectional view through an embodiment of the
21 invention having an eccentric configuration;

22

1 Figure 8 is a cross-sectional view through an apparatus in accordance
2 with an embodiment of the invention;

3

4 Figure 9 is a cross-sectional view through an apparatus in accordance
5 with a further alternative embodiment of the invention;

6

7 Figures 10A to 10C are sectional views through an apparatus in
8 accordance with an embodiment of the invention;

9

10 Figure 11 is a longitudinal section through a part of an apparatus in
11 accordance with an alternative embodiment of the invention;

12

13 Figures 12A and 12B are cross-sectional views of a further alternative
14 embodiment during different stages of operation; and

15

16 Figures 13A and 13B are respectively transparent perspective and
17 partially exploded views of an assembly in accordance with an embodiment of the
18 invention.

19

1 DETAILED DESCRIPTION OF THE INVENTION

2 Referring firstly to Figs. 3A to 3C, there is shown an apparatus in
3 accordance with an embodiment of the invention. The apparatus is a wellbore
4 packer configured to provide an annular seal in an annulus between a production
5 tubing and the wellbore wall of an openhole system. The packer is configured in
6 particular for use in a multi-zone production system, such as that shown in Fig. 1,
7 and is configured for attachment with alternate sand control devices which comprise
8 shunt tubes for delivery of gravel packs to production intervals. Fig. 3A is a
9 longitudinal section through the apparatus 300, and Figs. 3B and 3C are
10 respectively cross-sectional views through lines B-B' and C-C'.

11

12 The packer 300 comprises a tubular body 302 which has a
13 longitudinal axis A and a throughbore 304. The tubular body 302 is provided with
14 couplings (not shown at each end), configured for connection in the production
15 string. In this embodiment, the couplings are suitable for connecting the packer to
16 adjacent screen devices. The throughbore 304 defines a primary flow path for the
17 passage of production fluids through the apparatus 300. Disposed at either end of
18 the apparatus 300 are gauge rings 306a, 306b, which provide anti-extrusion
19 resistance for the expanding element 308 and may also protect the expanding
20 element from abrasion or contact with the wellbore during deployment operations.
21 The gauge rings also function to secure the expanding element 308 in position on
22 the tubular body 302, preventing axial displacement if the element does contact the

1 wellbore. The gauge rings 306a, 306b are secured to the tubular body, for example
2 by bolts or corresponding threads which are suitably aligned for a concentric packer
3 design in this embodiment, but which may be aligned for eccentric or offset packer
4 designs in other embodiments.

5

6 The expanding element 308 is a swellable mantle, formed from a
7 swellable elastomeric material selected to increase in volume on exposure to a
8 triggering fluid. In this embodiment, the material is an ethylene propylene diene M-
9 class (EPDM) rubber, which increases in volume on exposure to a hydrocarbon
10 fluid. Other suitable materials for the swellable mantle are known in the art, and
11 include elastomers selected to increase in volume on exposure to aqueous fluids or
12 brines, and materials selected to increase in volume on exposure to both aqueous
13 and hydrocarbon fluids. Materials which increase in volume on exposure to other
14 types of stimuli, such as heat and pressure are known in the art, and may be used
15 to form the expanding element in other embodiments.

16

17 The apparatus is provided with conduits 310a, 310b which extend
18 through the apparatus to define a secondary flow path. Each conduit is of sufficient
19 diameter to allow the through-flow of a carrier fluid and a particulate matter used to
20 form a gravel pack. The conduits each comprise a metal tube which extends
21 through the expanding element, and which functions to maintain the flow path
22 through the expanding element. Each conduit includes an inlet 312 and an outlet

1 314 at opposing ends of the packer. The inlet 312 is configured to be coupled to a
2 shunt tube (not shown) of an alternate path screen located at an uphole position of
3 the packer 300. The outlet 314 is configured for coupling to a shunt tube of a
4 screen located in a downhole position of the packer.

5

6 The apparatus also includes an end ring 322 which is configured to
7 support a shunt tube or the conduit members. Conveniently, the end ring may be
8 an end ring of an adjacent sand control system.

9

10 Each conduit extends through the gauge rings 306a, 306b and
11 through the expanding element. The conduit varies the secondary flow path by
12 redirecting the flow path from a first radial position, aligned with the shunt tube, to a
13 second radial position disposed towards the tubular body. In this example, this is
14 achieved by providing a first bended or curved portion 316 of the conduit between
15 the inlet 312 and a central portion 318 of the conduit. Similarly, a second bent or
16 curved portion 320 of the conduit is located between the central portion 318 and the
17 outlet 314. This arrangement allows the central portion of the conduit to be located
18 closer to the tubular body within the expanding element, which increases the
19 volume of the expanding element radially outward of the central portion of the
20 conduit. This improves the operation of the expanding element; by providing a
21 greater volume of the swellable elastomer material outwardly of the conduit, a more
22 effective and more rapid seal can be achieved.

1

2 In this embodiment, the conduits 310a, 310b comprise an s-bend
3 portion which changes the radial position of the secondary flow path within the
4 apparatus. It will be appreciated that other shapes and dimensions of conduit may
5 be provided in alternative embodiments of the invention. It will also be appreciated
6 that any number of conduits may be provided within the scope of the invention.

7

8 The apparatus 300 may be manufactured as follows. A base layer of
9 EPDM rubber is formed on the tubular body. A conduit member 310 is located on
10 the base layer of rubber in the required circumferential position, and successive
11 layers of rubber may be formed around the conduit to build up the expanding
12 element and embed it into the packer. The gauge rings may conveniently be of a
13 clamp-on type, for example formed from part-cylindrical components secured
14 together to form an annular ring. Thus the gauge rings may be placed over the
15 conduit member in the required position. Alternatively, the end rings may be slipped
16 on to the tubular body over the conduit members.

17

18 An alternative embodiment of the apparatus is shown in Figs. 4A to
19 4C. In this embodiment, the wellbore packer, generally shown at 340, is similar to
20 the apparatus 300, and will be understood from Figs. 3A to 3C. Fig. 4A is a
21 longitudinal section through the packer 340, and Figs. 4B and 4C are respectively
22 cross-sectional views through lines B-B' and C-C'.

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

The packer 340 comprises a tubular body 342, a pair of gauge rings 346a, 346B, and an expanding element 348. Fig. 4B is a section through the gauge ring 346a. The apparatus comprises a pair of conduits 350a, 350b configured to be in fluid communication with shunt tubes of adjacent sand control devices, in the manner described with reference to Figs. 3A to 3C. The secondary flow path defined by the conduits 350 is varied by redirection of fluid flow. The packer 340 is similar in function to the packer 300, but differs in that the redirection of the flow takes place in portions of the conduit 356, 360 located in the gauge rings 346a, 346B. The central portion 358 of the conduit which extends through the expanding element 348 is parallel to the longitudinal axis A of the apparatus. Thus throughout the length of the expanding element, the apparatus has a sufficient volume of swellable elastomeric material located radially outward of the conduit.

Fig. 5 shows an alternative embodiment of the invention, which will be understood from Figs. 3 and 4. In this embodiment, the apparatus 380 is provided with conduit extension members 382a, 382b. The conduit 390 extends through the gauge rings and the expanding element in a direction substantially parallel to the longitudinal axis A. The secondary flow path defined by the conduit is varied by redirecting the flow in the portions of the conduit defined by the conduit extension members 382. Each conduit extension member redirects the flow path from a first

1 radial position, aligned with shunt tubes of adjacent sand control apparatus, to a
2 second radial position disposed towards the tubular body.

3

4 Figs. 6A to 6C show an apparatus 400 in accordance with a further
5 alternative embodiment of the invention. The apparatus 400 comprises a tubular
6 body 402, a pair of gauge rings 406a, 406b, and expanding element 408. Conduits
7 410 extend through the apparatus, and comprise a manifold portion 412 and tubular
8 conduit members 414. The manifold portions 412 are formed as annular chambers
9 in the gauge rings 406, and comprise an inlet in fluid communication with a shunt
10 tube of an adjacent screen. The manifold portions 412 are provided with support
11 members 415 which improve the strength of the gauge ring. The tubular conduit
12 members extend between the respective manifold portions 412 through the
13 expanding element 408. In this embodiment, the tubular conduit members have a
14 cross-sectional shape which is modified with respect to the previous embodiments.
15 The cross-sectional shape has a circumferential dimension which is significantly
16 greater than a radial dimension. In other words, the cross section is flattened in the
17 radial dimension. Providing such a shape of tubular varies the flow path by
18 redistributing flow about the circumference of the apparatus, correspondingly
19 reducing the radial space taken by the tubular conduit members (for the same cross
20 sectional flow area). This allows a greater volume of the expanding element to be
21 located radially outward of the tubular portion. Thus the effect on the expanding
22 element may be reduced without substantially changing the radial position of the

1 flow paths themselves, in the case of tubular conduit members 414a, 414b. Some
2 or all of the tubular conduit members may be disposed further towards the tubular
3 body, as is the case with tubular conduit members 414c and 414d. This increases
4 the volume of the expanding element located radially outward of the conduit to a
5 greater extent than is possible with the embodiments of Figs. 3 to 5.

6

7 It will be appreciated that the cross-sectional shapes of the tubular
8 conduit members of the conduit may also be used with the s-bend configurations
9 shown in Figs. 3 to 5 (or indeed other flow-redirecting configurations). In this case,
10 the conduit may comprise a transitional portion (which may include a nozzle portion
11 and/or a flared portion) which alters the shape of the conduit.

12

13 The arrangement, of Fig. 6A also redistributes the flow from two shunt
14 tubes of the screen system to four tubular conduit members 414 in the apparatus.
15 This allows the respective flow areas of the tubular conduit members 414 to be
16 reduced, allowing repositioning within the expanding element to a position which
17 reduces the effect of performance on the function of the expanding element.

18

19 In Fig. 6B, the manifold portion 412 is an annular chamber extending
20 around the tubular body. However, in other embodiments, the manifold portion may
21 only be on a circumferential part of the tubular body, and may not extend around its
22 entire circumference. For example, as shown in Fig. 6C, in an embodiment where

1 two tubular conduit members (such as 414c and 414d) are used, the manifold
2 portion may be provided around sufficient circumferential distance to be in fluid
3 communication with the openings to the tubular conduit members.

4

5 The foregoing embodiments of the invention have an expanding
6 element and corresponding gauge rings which are concentric with respect to the
7 tubular body. In other embodiments, the expanding element and gauge rings may
8 be eccentric on the tubular body, in order to provide a greater available radial depth
9 conduits can be accommodated. Indeed, many alternate path sand control systems
10 are eccentrically formed on the base pipe to accommodate shunt tubes on one side
11 of the apparatus, and the apparatus of embodiments of the invention may be
12 similarly arranged to allow it to be conveniently used with such systems. An
13 exemplary arrangement is shown in cross section in Fig. 7. Packer 440 comprises
14 a tubular body 442 and an expanding element 448 eccentrically located on the
15 body. Conduits 450a, 450b define a secondary flow path through the expanding
16 element, as will be understood from the previous embodiments. The conduits are
17 located on one side of the apparatus to correspond with the location of the shunt
18 tubes of the adjacent sand control devices. In this example, the conduits 450 are
19 shaped to increase their circumferential dimension and reduce the radial dimension,
20 relative to the dimensions of the corresponding shunt tubes. The conduits are also
21 positioned radially inwardly of the shunt tubes, towards the tubular body, to increase
22 the external volume of expanding element.

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

Fig. 8 is a cross-sectional view through an apparatus 460 in accordance with a further alternative embodiment. The apparatus comprises a tubular body 462 surrounded by an expanding element 464. The figure is a cross-section through a central portion of the packer 460. Conduits through the packer 460 are provided by tubular conduit members 466a, 466b, which are in a fluid communication with shunt tubes via a suitable manifold provided at end of the packer 460. The tubular conduit members 466a, 466b are similar to the tubular conduit members 414c, 414d of Fig. 6C. The cross-section has been radially flattened (with respect to the cross-sections of corresponding shunt tubes) to redistribute the flow in a circumferential direction of the apparatus. The apparatus of Fig. 8 differs from the apparatus of Fig. 6C in that the tubular conduit members 466a, 466b are placed on the tubular body 462, and welded on to the body to create a seal. The tubular conduit members 466a, 466b are thus integrally formed with the tubular body in order to maximise the volume of the expanding rubber which is located radially outward of the tubular conduit members on the tool. In this embodiment, the tubular body is shown concentric with the expanding element, although in other embodiments it may be eccentrically formed with the tubular conduit members located in the high radius side of the expanding element 464.

Fig. 9 shows an alternative apparatus 470, which is similar to the embodiment of Fig. 8. However, in this embodiment, the tubular conduit members

1 are formed in a unitary construction with the tubular body 472. The expanding
2 element 474 is formed eccentrically with the tubular body 472 with the tubular
3 conduit portion 476a, 476b located in the high radius side of the expanding element.
4 However, the arrangement could equally be concentrically formed.

5
6 Figs. 10A to 10C are sectional views through an apparatus in
7 accordance with further alternative embodiments. The apparatus is in the form of a
8 packer 500, which comprises a tubular body 502, a pair of gauge rings 506 (one is
9 shown in Fig. 10A) and an expanding element 508. Fig. 10A is a longitudinal
10 section through one end of the packer 500, Fig. 10B is a cross-section through line
11 B-B', and Fig. 10C is a cross-section through lines C-C'.

12
13 The packer 500 has a secondary flow path defined by a manifold 510
14 in the gauge ring 506 and conduit bores 512 formed in the tubular body itself. The
15 conduit bores 512 are formed longitudinally in the tubular body, and are formed by a
16 gun drilling process. Tubular portions 512 are in fluid communication with a
17 manifold via radially drilled apertures 514. Fluid from a shunt tube passes into the
18 manifold 510, through the apertures 514 and into the tubular conduit portion 512
19 and through the apparatus. A similar set of apertures, manifold and coupling for a
20 shunt tube are provided in the opposing gauge ring (not shown).

1 In this embodiment, four conduit bores 512 are provided, although in
2 other embodiments, for example where it is required to increase the flow area, a
3 large number of conduit portions may be provided.

4

5 In a variation to the embodiment of Figs. 10A to 10C, inserts may be
6 provided in the apparatus to resist erosion due to redirection of the carrier fluid and
7 gravel pack through the manifold and into the tubular conduits. In a further
8 variation, the apertures 514 may be shaped or angled in the direction of fluid flow to
9 reduce flow resistance and corresponding erosion issues (and similar features may
10 also be provided in other embodiments of the invention described herein).

11

12 Fig. 11 shows a further alternative embodiment of the invention. In
13 this embodiment, the packer 520 includes a tubular body 522, with longitudinally
14 drilled conduit bores through the tubular body 522, in a similar manner to the
15 embodiment of Fig. 10. The apparatus 520 differs in that the conduit bores 524 are
16 open to the ends of the tubular body. This provides fluid communication between
17 the conduits in the tubular body and the shunt tubes. The apparatus includes a
18 special coupling gauge ring 526 which is in threaded engagement with the tubular
19 body 522 via thread 530. A threaded coupling 532 is provided at the opposing end
20 of the gauge ring 526 for coupling to an adjacent sand control device 534. The
21 apparatus 520 is provided with a similar gauge ring at its opposing end (not shown).
22 The gauge ring 526 comprises a shoulder portion 536 which abuts the end of the

1 tubular body 522. The open ends of the conduit bores 524 are aligned with a flow
2 path 538 in the special gauge ring which provides fluid communication to a shunt
3 tube (not shown). The gauge ring 526, or portions of it, may be hardened to resist
4 erosion. One advantage of this embodiment is that redirection of the flow takes
5 place in the special gauge ring 526, and the tubular body 522 is unlikely to be
6 subject to erosion issues.

7
8 Figs. 12A and 12B show a further alternative embodiment. The
9 apparatus 540 comprises a tubular body 542 and an expanding element 548,
10 formed from a swellable elastomer or rubber. The apparatus is shown in cross-
11 section through a central portion of the apparatus. Opposing ends of the apparatus
12 are provided with gauge rings and manifolds (not shown) which allow fluid
13 communication between shunt tubes and conduits 544 of the apparatus. In this
14 embodiment, a secondary flow path is formed through the apparatus 540 through
15 conduits 544 formed in the expanding element 548. This embodiment differs from
16 the previous embodiments in that the conduits 544 do not have a rigid support
17 element and are expanded or inflated during use. Fig. 12A shows the apparatus in
18 a configuration where the conduits 544 are not active. The conduits are in a
19 deflated or unexpanded state with minimum cross-sectional area. Fig. 12B shows
20 the same apparatus where the conduits 544 are in an active condition. This occurs
21 when there is sufficient pressure in the flow of the gravel pack carrier fluid to initiate
22 flow through the alternative pathways or shunt tubes in sand control devices, and in

1 turn the conduits 544 within an adjacent packer. The pressure of the gravel pack
2 fluid causes the conduits 544 to partially expand or inflate, which increases their
3 cross-sectional area. This has the effect of expanding the outer diameter of the
4 expanding element 548, improving its ability to provide a seal in the bore. It should
5 be noted that in the majority of gravel pack operations, the conduits 544 will remain
6 packed off with the gravel pack slurry, which will provide continuing support for the
7 conduits 544 in the configuration shown in Fig. 12B.

8

9 In an alternative embodiment, the conduits are configured to allow
10 uniform and maximum expansion around the base pipe. This can be achieved by
11 varying the total number of conduits and or increasing or decreasing the
12 expanded/inflated inner diameter of the conduits. The pressure required to open
13 the pathways is in part a function of the rubber thickness around the conduit.
14 Certain embodiments may therefore have conduits placed close to the surface of
15 the expanding element outer diameter. In such a configuration the inflation may
16 create a blister type effect. Again the number and shape of the pathways/conduits
17 would determine the uniformity of the change in outer diameter as the conduits are
18 inflated. The conduit may or may not allow additional swell activation through
19 internal contact of the swellable element with reactive fluids that may be present in
20 the carrier fluid.

21

1 Fig. 13A is a perspective view of an apparatus in accordance with an
2 embodiment of the invention, with various components made transparent to show
3 their interaction. Fig. 13B shows the same apparatus in a partially exploded view.
4 The apparatus, generally shown at 600, comprises a sand control apparatus
5 generally shown at 610, and a packer apparatus, generally shown at 620. The sand
6 control apparatus comprises a base pipe 612, an end ring 614 located on the base
7 pipe, and a pair of shunt tubes (not shown). An auxiliary shroud 618 is provided
8 over the shunt tube to provide a continuous outer diameter to the assembly, and is
9 provided with apertures 619 to allow the throughflow of fluid. The auxiliary shroud
10 618 functions to protect the shunt tubes, jumper tubes, the exposed ends of the
11 conduit members 616 and any corresponding connectors. The auxiliary shroud
12 extends from the end ring 614 to a corresponding end ring which supports the main
13 shroud of the sand control device. The main shroud extends completely over the
14 sand control device, and provides a protective sleeve for the filter media and shunt
15 tubes. Thus the auxiliary shroud provides a continuous outer diameter in the region
16 of the string between the packer and the main shroud. The end ring 614 supports
17 the shunt tubes and components of the packer apparatus, and provides a support
18 for the end of the shroud 618. The end ring 614 and shroud are eccentrically
19 mounted on the base pipe 612, so that the shunt tubes can be accommodated on
20 the high radius side of the base pipe.
21

1 The packer apparatus 620 comprises a tubular body 622, and a
2 packer element 624 surrounded the tubular body. In this case, the packer element
3 is formed from a swellable elastomer such as EPDM. A gauge ring 626 is provided
4 at the end of the packer apparatus, and is in this embodiment configured to be
5 clamped on to the base pipe. The internal surface of the gauge ring is profiled to
6 accommodate conduit members 616, and to be coupled to the end ring 614 of the
7 sand control apparatus. The conduit members are configured to be in fluid
8 communication with the shunt tubes (not shown) or the sand control apparatus, and
9 in this embodiment have the same size, shape and material properties as the shunt
10 tubes. The conduit members 616 extend through the packer apparatus to define a
11 secondary pathway for gravel pack fluid in use.

12

13 The packer apparatus 620 is also provided with a cable feedthrough
14 arrangement, which comprises an insert 628 of a swellable material which partially
15 surrounds a cable 630. The insert 628 fits into a corresponding recess 632 in the
16 packer element 624.

17

18 The conduit member 616 extends from a longitudinal position adjacent
19 the sand control apparatus 610 and through a recess provided in the end ring 614
20 at a first radial distance from the base pipe 612. This radial height above the base
21 pipe corresponds to the radial position of the shunt tubes of the sand control
22 apparatus, such that the conduit members are in fluid communication with the shunt

1 tubes. The conduit members 616 extend through the gauge ring 626 and into the
2 packer element 624. The internal profile of the gauge ring 626 is configured such
3 that the radial position of the conduit member at the packer element side of the
4 gauge ring is closer to the base pipe. This is achieved by providing the longitudinal
5 surface of the conduit recess in the gauge ring 626 with a wedge shape profile,
6 such that the opening to the recess at the packer side of the gauge ring is at a
7 radially lower position than the opening to the recess at the sand control apparatus
8 side of the gauge ring. The gauge ring 626 is formed in two parts, and is
9 assembled over the conduit member and secured in place by bolts. The attachment
10 of the gauge ring imparts a clamping force on the conduit members 616 sufficient to
11 deform the conduit to vary the secondary flow path through the apparatus.

12

13 The apparatus of the invention is configured for improved operation of
14 the expanding element of the apparatus. For example, the required annular barrier
15 and/or sealing function of the expanding element can be maintained even with the
16 provision of the secondary flow path through the apparatus. The conduit is
17 configured to have a reduced effect on the operation of the expanding element,
18 while still allowing the conduit to be coupled to alternate flow paths of adjacent
19 apparatus. The invention has particular application with swellable wellbore packers.

20

21 The conduit may be arranged to vary a radial dimension of the
22 secondary flow path. The conduit may be arranged to vary the secondary flow path

1 by changing the direction of fluid flowing in the secondary flow path. In particular,
2 the conduit may be arranged to change the radial distance of the flow path from the
3 longitudinal axis of the apparatus. Thus the radial position of the flow path can be
4 selected to improve the operation of the expanding element. Embodiments of the
5 invention therefore have the advantage that the apparatus can be used with
6 standard alternate flow path and shunt tube configurations adopted by various
7 manufacturers of alternate paths and control systems.

8

Claims:

1

2 1. An apparatus for use in a wellbore comprising: a tubular body having a
 3 longitudinal axis and a throughbore which defines a primary fluid path
 4 through the apparatus; an expanding element comprising a swellable
 5 material disposed around the tubular body which when activated increases in
 6 volume to provide an annular barrier in a space between the tubular body
 7 and a surrounding wall; and a conduit defining a secondary flow path
 8 through the apparatus and configured to be aligned with and in fluid
 9 communication with at least one gravel pack shunt tube in an adjacent sand
 10 control device, comprising: a first portion located in the expanding element
 11 and configured to redirect the secondary fluid path; and a second portion
 12 arranged parallel to a longitudinal axis of the apparatus, wherein the conduit
 13 is arranged to vary the secondary flow path along a longitudinal direction of
 14 the apparatus.

15

16 2. The apparatus as claimed in claim 1 further configured to provide a seal in
 17 the space between the tubular body and the surrounding wall.

18

19 3. The apparatus as claimed in any one of claims 1 or 2 operable to be coupled
 20 to a first sand control device and a second sand control device.

21

22 4. The apparatus as claimed in any one of claims 1, 2 or 3 wherein the conduit
 23 is arranged to vary the secondary flow path by changing the radial distance
 24 of the flow path from the longitudinal axis of the apparatus.

25

26 5. The apparatus as claimed in claim 4 wherein the conduit is arranged to vary
 27 the secondary flow path by redirecting the fluid flow radially inward of the
 28 apparatus.

29

- 1 6. The apparatus as claimed in any one of claims 1 to 5 wherein at least a
2 portion of the secondary flow path is located radially closer to the primary
3 flow path than the shunt tube.
4
- 5 7. The apparatus as claimed in any one of claims 1 to 6 wherein the conduit is
6 arranged to vary the secondary flow path by changing the cross-sectional
7 profile of the conduit along the longitudinal direction of the apparatus.
8
- 9 8. The apparatus as claimed in claim 7 wherein the cross-sectional profile of
10 the secondary flow path is varied such that the total cross-sectional area of
11 the conduit is substantially the same along the longitudinal direction of the
12 apparatus.
13
- 14 9. The apparatus as claimed in claim 7 wherein the cross-sectional shape of the
15 secondary flow path is varied such that the total cross-sectional area of the
16 secondary flow path is changed along the longitudinal direction of the
17 apparatus.
18
- 19 10. The apparatus as claimed in any one of claims 1 to 9 further comprising a
20 manifold portion arranged to receive fluid from or direct flow into a plurality
21 of conduit members.
22
- 23 11. The apparatus as claimed in claim 10 wherein the manifold portion is
24 annular or part-annular.
25
- 26 12. The apparatus as claimed in any one of claims 1 to 11 comprising at least
27 one conduit bore formed in the tubular body, the conduit bore formed
28 longitudinally in the wall of the tubular body.
29
- 30 13. The apparatus as claimed in claim 12 comprising a plurality of conduit bores.

1

2 14. The apparatus as claimed in any one of claims 1 to 13 comprising one or
3 more conduits integrally formed with the tubular body.

4

5 15. The apparatus as claimed in any one of claims 1 to 14 comprising one or
6 more conduits unitarily formed with the tubular body.

7

8 16. The apparatus as claimed in any one of claims 1 to 15 comprising a recess
9 or channel in the expanding element.

10

11 17. The apparatus as claimed in any one of claims 1 to 16 wherein the conduit
12 comprises a support element.

13

14 18. The apparatus as claimed in claim 17 wherein the support element is a
15 tubular conduit member.

16

17 19. The apparatus as claimed in any one of claims 1 to 18 comprising a flexible
18 or collapsible conduit member.

19

20 20. The apparatus as claimed in any one of claims 1 to 19 comprising a gauge
21 ring which is configured to be radially disposed onto the tubular body.

22

23 21. The apparatus as claimed in claim 20 wherein the gauge ring comprises a
24 recess or channel shaped to receive the conduit.

25

26 22. The apparatus as claimed in claim 20 when dependent on claim 12 or claim
27 13, wherein the at least one conduit bore is in fluid communication with an
28 alternate flow path via a manifold or flow path in the gauge ring.

29

30 23. A wellbore packer comprising the apparatus of any one of claims 1 to 22.

1

2 24. An assembly for use in a wellbore comprising: an apparatus according to any
3 one of claims 1 to 23, and the at least one sand control device comprising
4 the at least one gravel pack shunt tube.

5

6 25. A wellbore installation comprising a production tubular, at least one
7 apparatus as claimed in any one of claims 1 to 23, and the at least one sand
8 control device comprising the at least one gravel pack shunt tube coupled to
9 the apparatus downstream of the apparatus.

10

11 26. The wellbore installation as claimed in claim 25 when dependent on claim 3,
12 wherein the second sand control device is coupled to the apparatus upstream
13 of the apparatus, and wherein the apparatus provides a secondary flow path
14 for a gravel pack between the second and first sand control devices.

15

16 27. The wellbore installation as claimed in claim 26 comprising a gravel pack
17 disposed at one or both of the sand control devices.

18

19 28. A method of forming a wellbore installation, the method comprising:
20 – providing a sand control device at a downhole location in a producing
21 formation;
22 – providing an annular barrier apparatus comprising a swellable
23 member at a downhole location upstream of the sand control device, the
24 apparatus comprising a tubular body and a throughbore which defines a
25 primary fluid path;
26 – gravel packing the sand control device by passing a carrier fluid
27 containing particulate matter through a gravel pack shunt tube and
28 passing the carrier fluid through a conduit forming a secondary flow
29 path in the annular barrier apparatus to the sand control device;

- 1 – varying a radial position of the secondary flow path of the carrier fluid
2 along a longitudinal direction of the annular barrier apparatus in a first
3 portion of the secondary flow path located in the swellable member;
4 – and passing the carrier fluid through a second portion of the secondary
5 fluid path and a second portion arranged parallel to a longitudinal axis of
6 the apparatus.

7

- 8 29. The method as claimed in claim 28 comprising varying the secondary flow
9 path by changing a radial dimension and/or radial position of the flow.

10

- 11 30. The method as claimed in claim 29 comprising redirecting the secondary flow
12 path from a flow path at a first radial distance from the longitudinal axis of
13 the apparatus to a flow path at a second radial distance from the longitudinal
14 axis of the tubular body, the second radial distance being less than the first
15 radial distance.

16

- 17 31. The method as claimed in any of claims 28, 29 or 30, wherein the sand
18 control device is disposed in a downhole direction of the annular barrier
19 apparatus, and the method comprises forming a gravel pack at least in part
20 at the sand control device.

21

- 22 32. The method as claimed in claim 31 comprising forming a gravel pack by
23 passing the carrier fluid through a first shunt tube of a first sand control
24 device disposed in an uphole direction of the apparatus, and through the
25 conduit of the apparatus.

26

- 27 33. The method as claimed in claim 32 comprising redirecting the secondary flow
28 path to be radially closer to the longitudinal axis of the apparatus than the
29 shunt tube.

30

- 1 34. The method as claimed in claims 32 or 33 comprising passing the carrier
2 fluid through a second shunt tube of a second sand control device disposed
3 in a downhole direction of the apparatus.
4
5
- 6 35. An assembly for use in a gravel pack operation in a wellbore, the assembly
7 comprising: an apparatus comprising a tubular body having a longitudinal
8 axis and a throughbore which defines a primary fluid path through the
9 apparatus; and at least one sand control device having a second throughbore
10 and coupled to the apparatus so that the first and second throughbores
11 define a primary fluid path through the assembly;
12 wherein the at least one sand control device comprises at least one gravel
13 pack shunt tube;
14 and wherein the apparatus comprises:
15 an expanding element comprising a swellable material disposed around the
16 tubular body which when activated expands to provide an annular barrier in
17 a space between the tubular body and a surrounding wall;
18 a gauge ring; and a conduit in fluid communication with the gravel pack
19 shunt tube of the at least one sand control device to define a secondary fluid
20 path for a gravel pack carrier fluid through the apparatus;
21 wherein the conduit is arranged to vary the radial distance of the secondary
22 fluid path along a longitudinal direction of the apparatus from a longitudinal
23 axis of the apparatus within the gauge ring.
24
- 25 36. The assembly as claimed in claim 35 wherein the conduit is arranged to
26 redirect the secondary fluid path radially inward of the apparatus.
27
- 28 37. The assembly as claimed in claim 35 or claim 36, wherein an internal profile
29 of the gauge ring is configured such that the radial distance of the secondary

1 fluid path at an expanding element side of the gauge ring is closer to the
2 tubular body than at an adjacent wellbore component side of the gauge ring.

3

4 38. The assembly as claimed in claim 37, wherein the gauge ring comprises a
5 recess having a wedge shape profile whereby an opening to the recess at the
6 expanding element side of the gauge ring is at a radial position closer to the
7 tubular body than an opening to the recess at the adjacent wellbore
8 component side.

9

10 39. The assembly as claimed in claim 38, wherein the gauge ring is configured
11 such that its attachment imparts a clamping force sufficient to deform the
12 conduit to vary the secondary fluid path through the apparatus.

13

14 40. The assembly as claimed in any one of claims 35 to 39 wherein the conduit is
15 arranged to vary the secondary fluid path by changing the cross-sectional
16 profile of the conduit along the longitudinal direction of the apparatus.

17

18 41. The assembly as claimed in claim 40 wherein the cross-sectional profile of
19 the secondary fluid path is varied to redistribute the flow area about a
20 circumference of the apparatus and reduce the radial dimension of the
21 secondary fluid path.

22

23 42. The assembly as claimed in claim 40 or claim 41 wherein the cross-sectional
24 profile of the secondary fluid path is varied such that the total cross-sectional
25 area of the conduit is substantially the same along the longitudinal direction
26 of the apparatus.

27

28 43. The assembly as claimed in claim 40 or claim 41 wherein the cross-sectional
29 shape of the secondary fluid path is varied to change the total cross-
30 sectional area of the secondary fluid path longitudinally along the apparatus.

1

2 44. The assembly as claimed in any one of claims 35 to 43 further configured to
3 provide a seal in the space between the tubular body and the surrounding
4 wall.

5

6 45. The assembly as claimed in any one of claims 35 to 44 wherein the at least
7 one sand control device comprises a first sand control device and a second
8 sand control device, and the assembly is operable to be coupled to the first
9 sand control device and the second sand control device.

10

11 46. The assembly as claimed in any one of claims 35 to 45 wherein at least a
12 portion of the secondary fluid path is located radially closer to the primary
13 fluid path than the alternate fluid path in the adjacent wellbore component.

14

15 47. The assembly as claimed in any one of claims 35 to 46 wherein the conduit
16 comprises a first portion within the gauge ring and configured to redirect the
17 secondary fluid path and a second portion arranged parallel to the
18 longitudinal axis of the apparatus.

19

20 48. The assembly as claimed in any one of claims 35 to 47 further comprising a
21 manifold portion arranged to receive fluid from or direct flow into a plurality
22 of conduit members.

23

24 49. The assembly as claimed in claim 48 wherein the manifold portion is annular
25 or part-annular.

26

27 50. The assembly as claimed in any one of claims 35 to 49 comprising at least
28 one conduit bore formed in the tubular body, the conduit bore formed
29 longitudinally in the wall of the tubular body.

30

- 1 51. The assembly as claimed in claim 50 comprising plurality of conduit bores.
2
- 3 52. The assembly as claimed in claim 50 or claim 51 wherein the at least one
4 conduit bore is in fluid communication with an alternate fluid path via a
5 manifold or fluid path in the gauge ring.
6
- 7 53. The assembly as claimed in any one of claims 35 to 52 comprising one or
8 more conduits integrally formed with the tubular body.
9
- 10 54. The assembly as claimed in any one of claims 35 to 53 comprising one or
11 more conduits unitarily formed with the tubular body.
12
- 13 55. The assembly as claimed in any one of claims 35 to 54 comprising a recess
14 or channel in the expanding element.
15
- 16 56. The assembly as claimed in any one of claims 35 to 55 wherein the conduit
17 comprises a support element.
18
- 19 57. The apparatus as claimed in claim 56 wherein the support element is a
20 tubular conduit member.
21
- 22 58. The assembly as claimed in any one of claims 35 to 57 comprising a flexible
23 or collapsible conduit member.
24
- 25 59. The assembly as claimed in any one of claims 35 to 58 wherein the gauge
26 ring is configured to be radially disposed onto the tubular body.
27
- 28 60. The assembly as claimed in any one of claims 35 to 59 wherein the gauge
29 ring comprises a recess or channel shaped to receive the conduit.
30

- 1 61. The assembly as claimed in 60 wherein the recess or channel is configured to
2 deform, bend, or otherwise reshape the conduit.
3
- 4 62. The assembly as claimed in claim 60 or claim 61 wherein the recess or
5 channel comprises a wedge-shaped longitudinal profile.
6
- 7 63. The assembly as claimed in any one of claims 35 to 62 wherein the
8 apparatus is a wellbore packer.
9
- 10 64. A wellbore installation comprising a production tubular and at least one
11 assembly as claimed in any one of claims 35 to 63.
12
- 13 65. The wellbore installation as claimed in claim 64 when dependent on claim 45,
14 wherein the second sand control device is coupled to the apparatus upstream
15 of the apparatus, and wherein the apparatus provides a secondary fluid path
16 for a gravel pack between the second and first sand control devices.
17
- 18 66. The wellbore installation as claimed in claim 65 comprising a gravel pack
19 disposed at one or both of the sand control devices.
20
- 21 67. A method of forming a wellbore installation, the method comprising:
22 – providing a sand control device at a downhole location in a producing
23 formation;
24 – providing an annular barrier apparatus comprising a swellable member
25 at a downhole location upstream of the sand control device;
26 – gravel packing the sand control device by passing a carrier fluid
27 containing particulate matter through a shunt tube, and passing the
28 carrier fluid containing particular matter through a secondary fluid path
29 in the annular barrier apparatus to the sand control device;

1 – varying the radial position of the secondary fluid path of the carrier fluid
2 along a longitudinal direction of the apparatus from a longitudinal axis
3 within a gauge ring of the annular barrier apparatus.
4

5 68. The method as claimed in claim 67 comprising varying the secondary fluid
6 path by changing a radial dimension of the flow.
7

8 69. The method as claimed in claim 68 comprising redistributing the flow area
9 about a circumference of the apparatus to reduce the radial dimension of the
10 secondary fluid path.
11

12 70. The method as claimed in claim 68 comprising redirecting the secondary fluid
13 path from a fluid path at a first radial distance from the longitudinal axis of
14 the apparatus to a fluid path at a second radial distance from the longitudinal
15 axis of the tubular body, the second radial distance being less than the first
16 radial distance.
17

18 71. The method as claimed in any one of claims 67 to 70, wherein the sand
19 control device is disposed in a downhole direction of the annular barrier
20 apparatus, and the method comprises forming a gravel pack at least in part
21 at the location of the sand control device.
22

23 72. The method as claimed in claim 71 comprising forming a gravel pack by
24 passing the carrier fluid through a first shunt tube of a first sand control
25 device disposed in an uphole direction of the apparatus, and through the
26 conduit of the apparatus.
27

28 73. The method as claimed in claim 72 comprising redirecting the secondary fluid
29 path to be radially closer to the longitudinal axis of the apparatus than the
30 shunt tube.

1

2 74. The method as claimed in claim 72 or claim 73 comprising passing the
3 carrier fluid through a second shunt tube of a second sand control device
4 disposed in a downhole direction of the apparatus.

5

6 75. The method as claimed in any one of claims 67 to 74 wherein the apparatus
7 comprises a conduit member defining the secondary fluid path through the
8 apparatus, and the method comprises attaching the gauge ring to the
9 apparatus thereby imparting a clamping force on the conduit member
10 sufficient to deform the conduit and vary the secondary fluid path through
11 the apparatus.

12

13

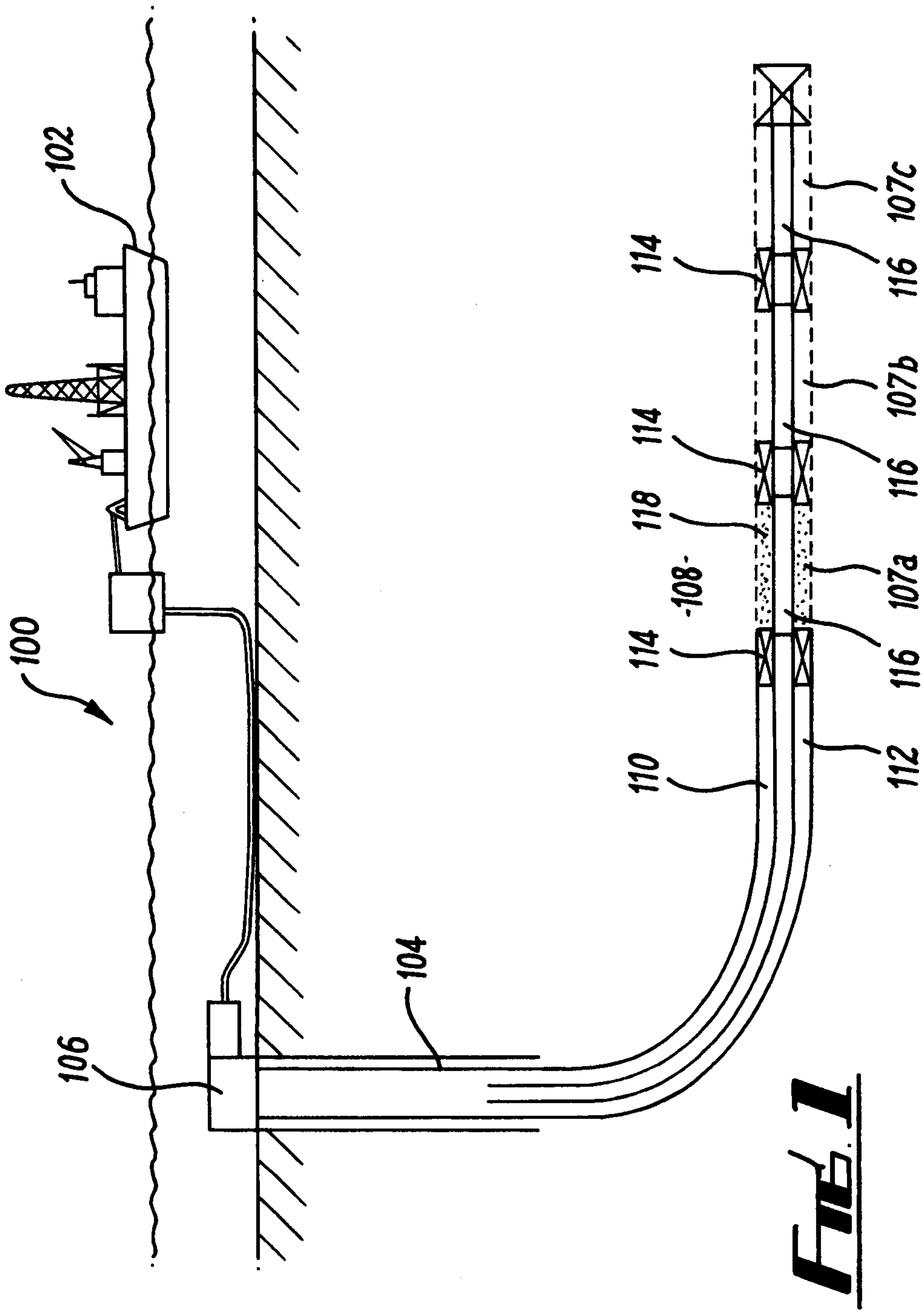
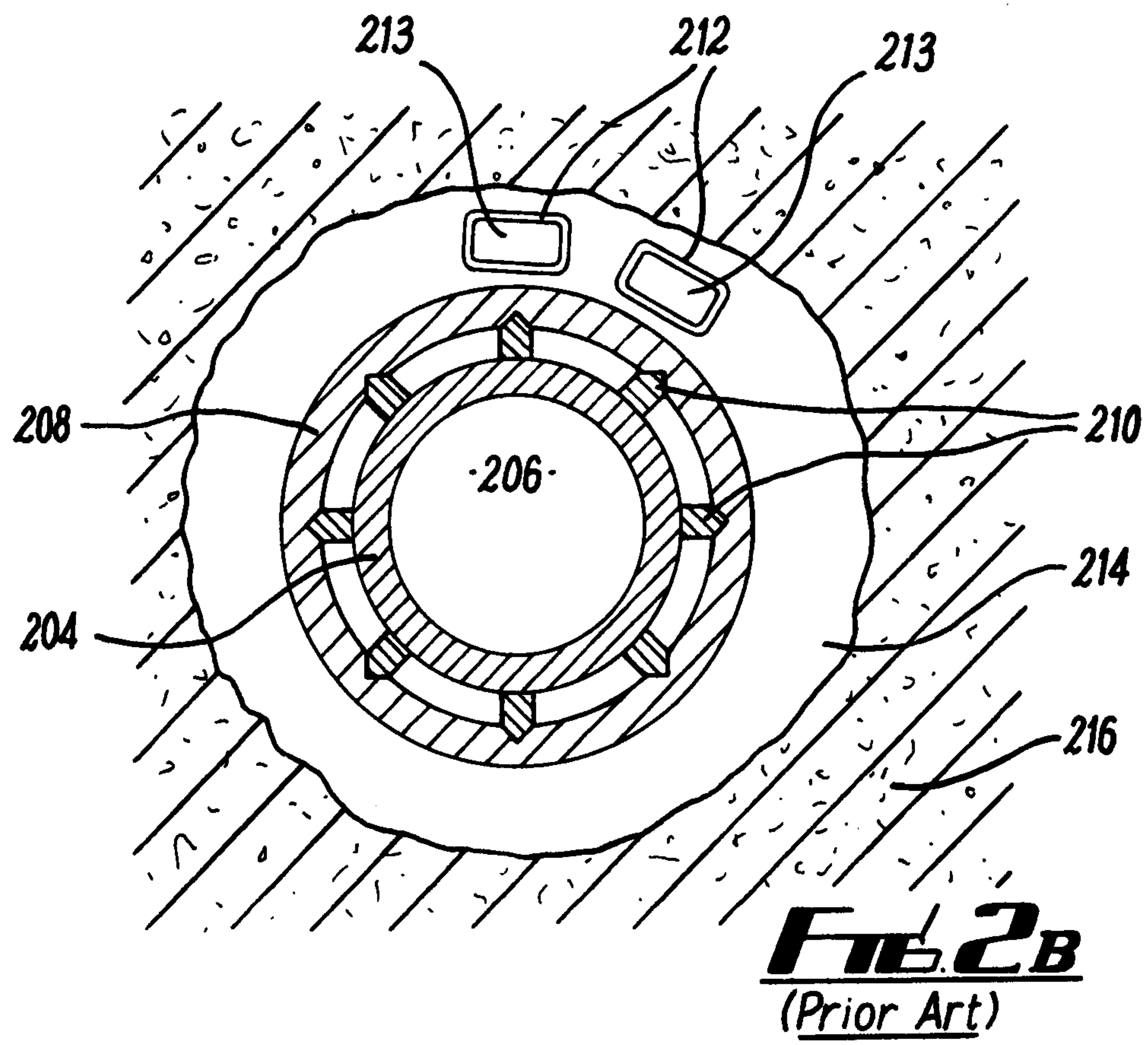
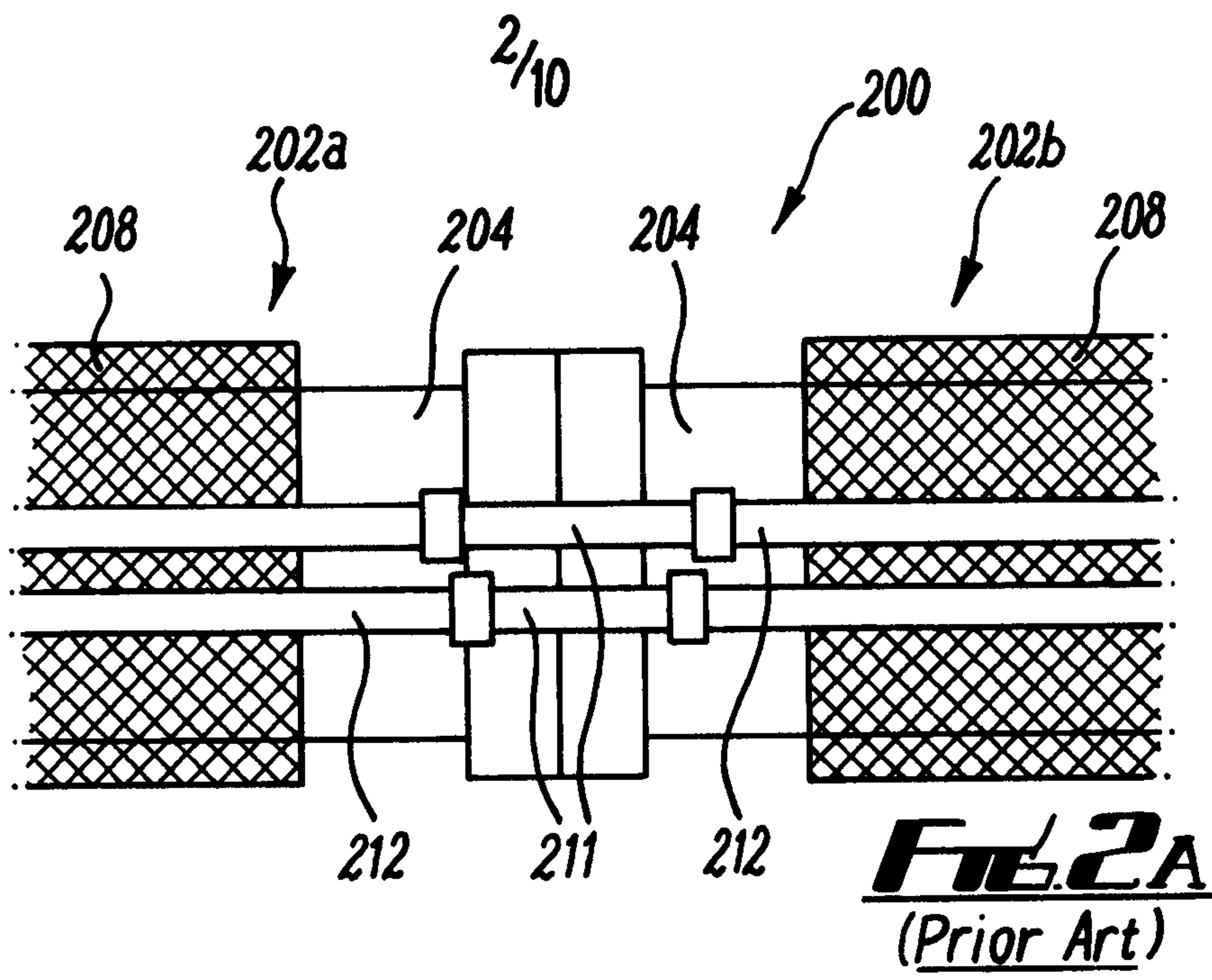
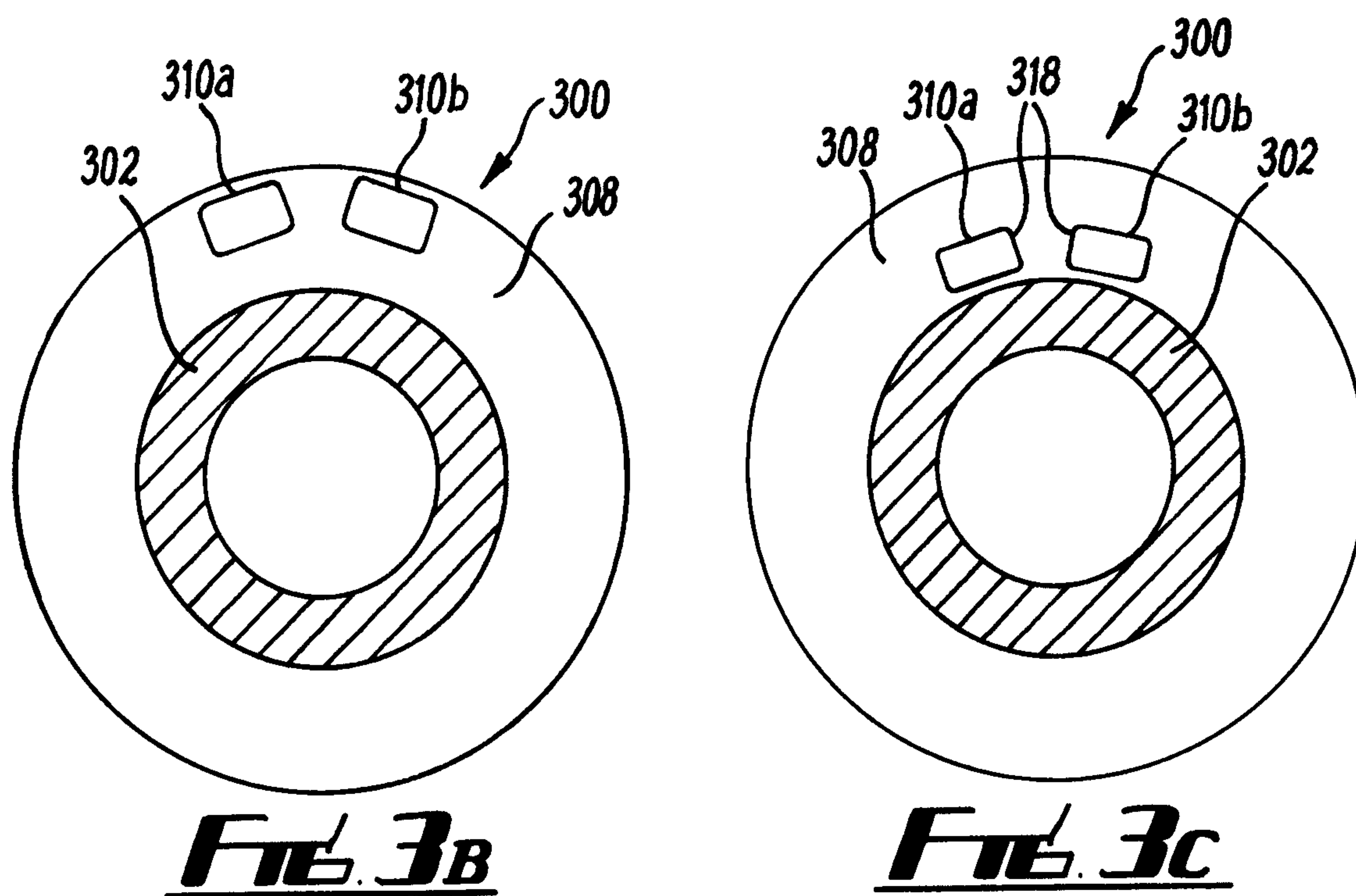
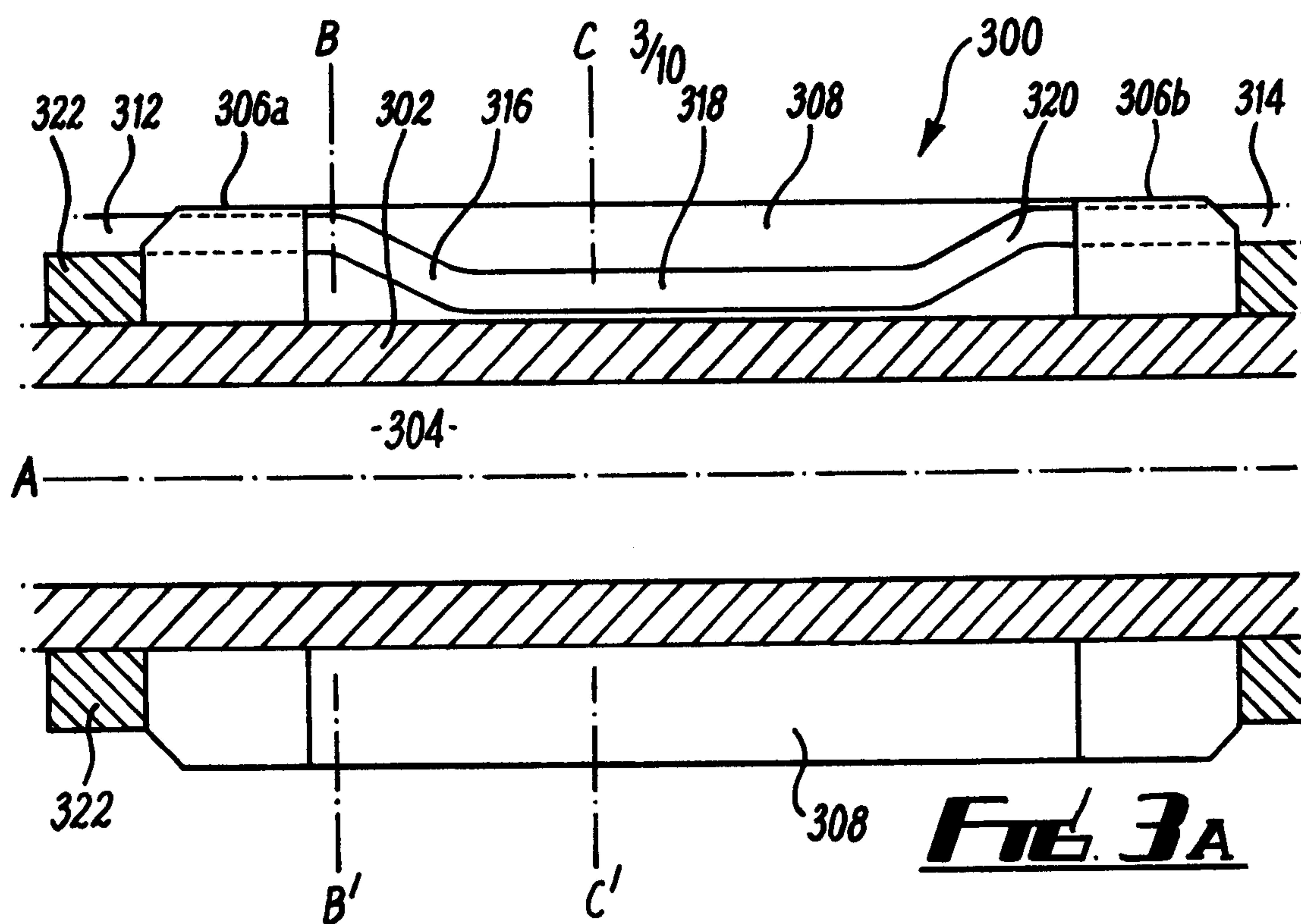
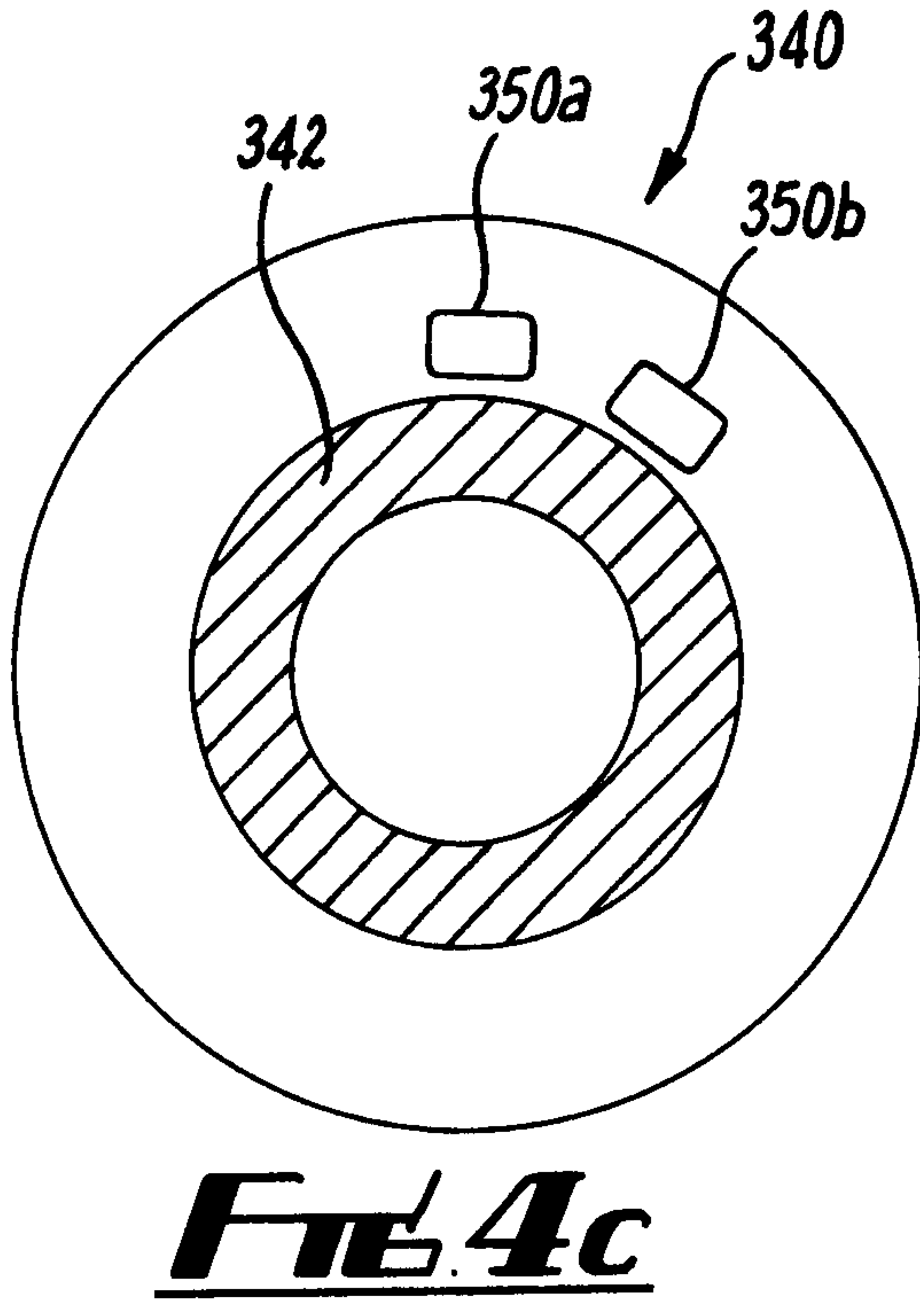
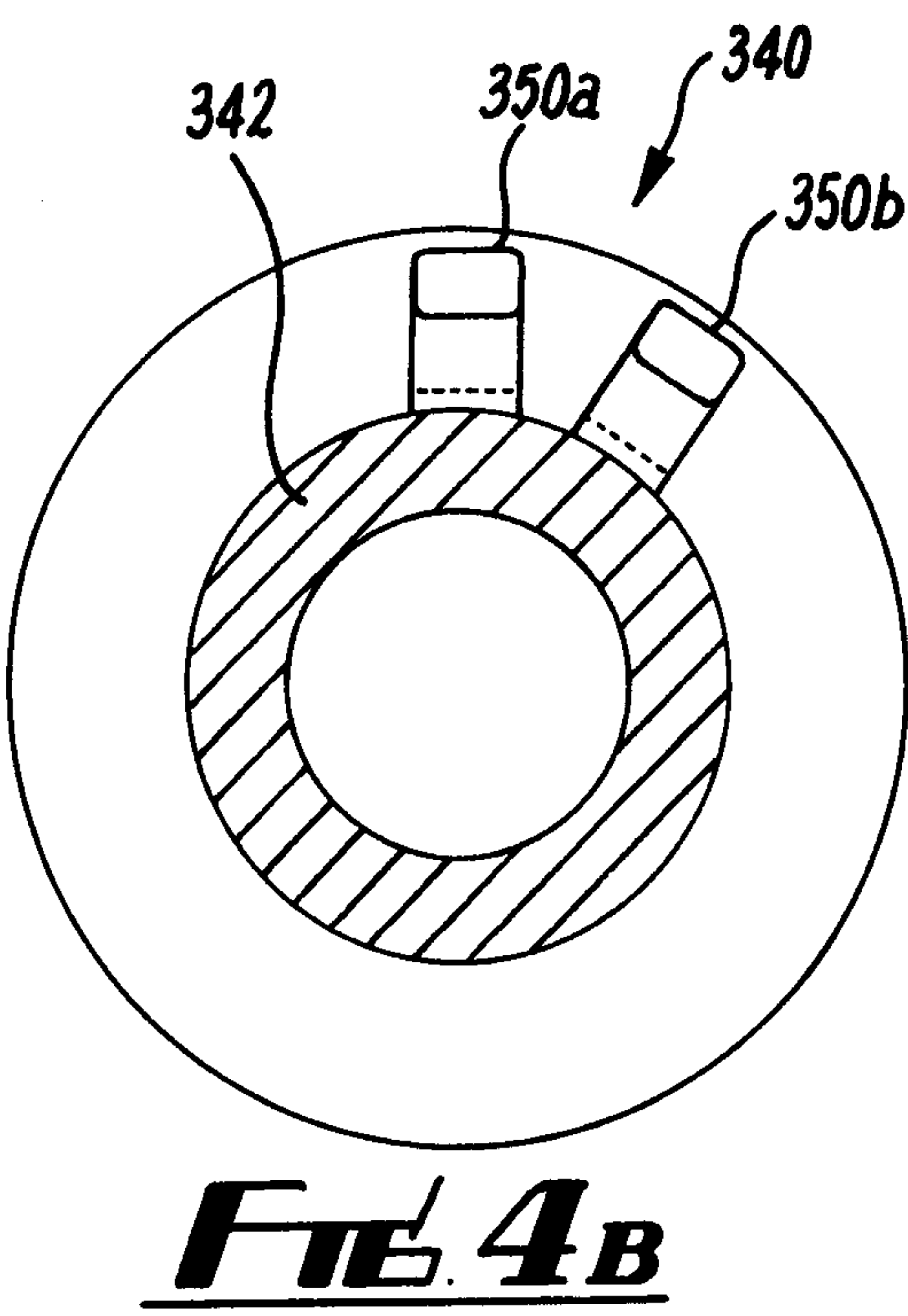
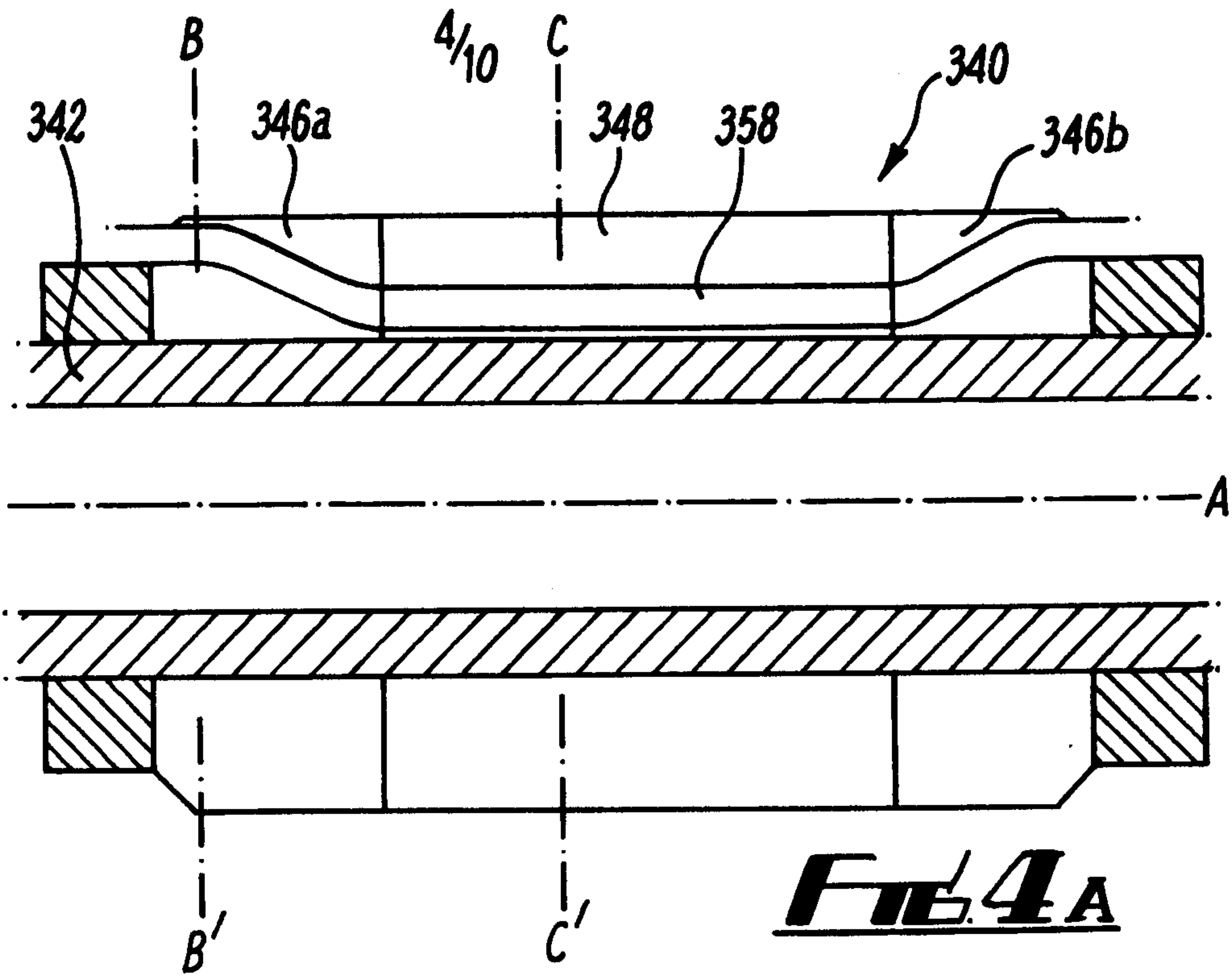


Fig. 1







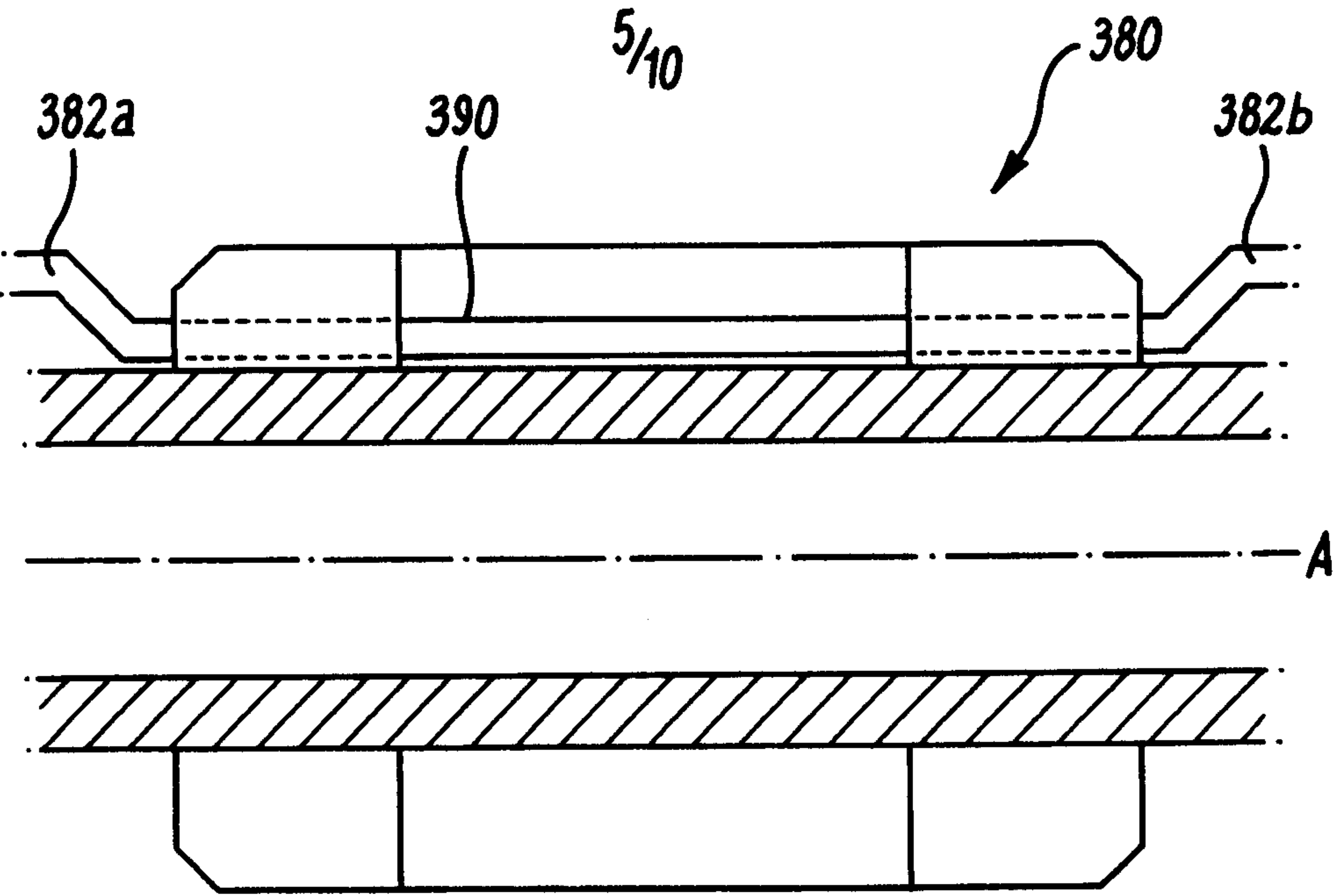


FIG. 5

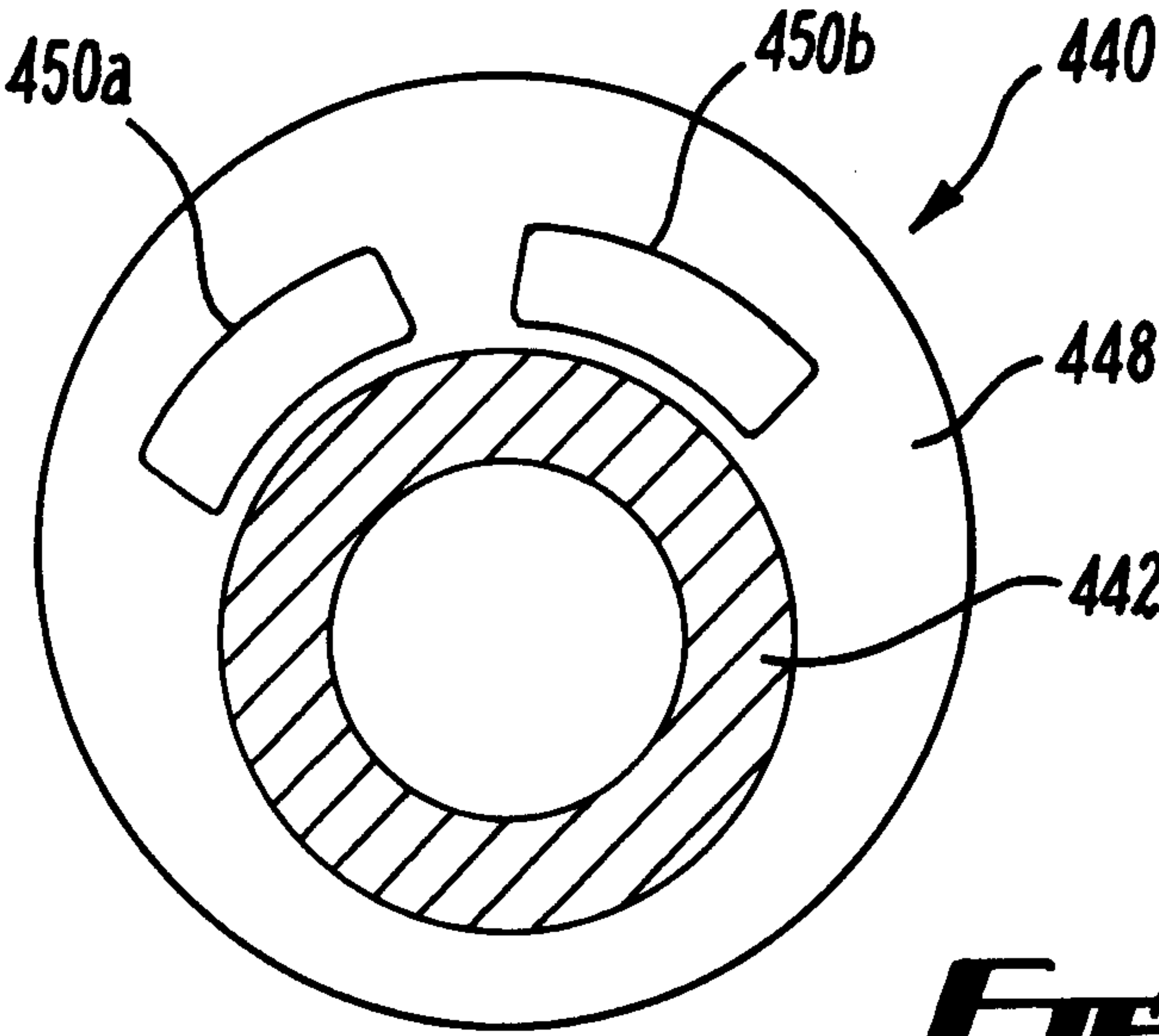
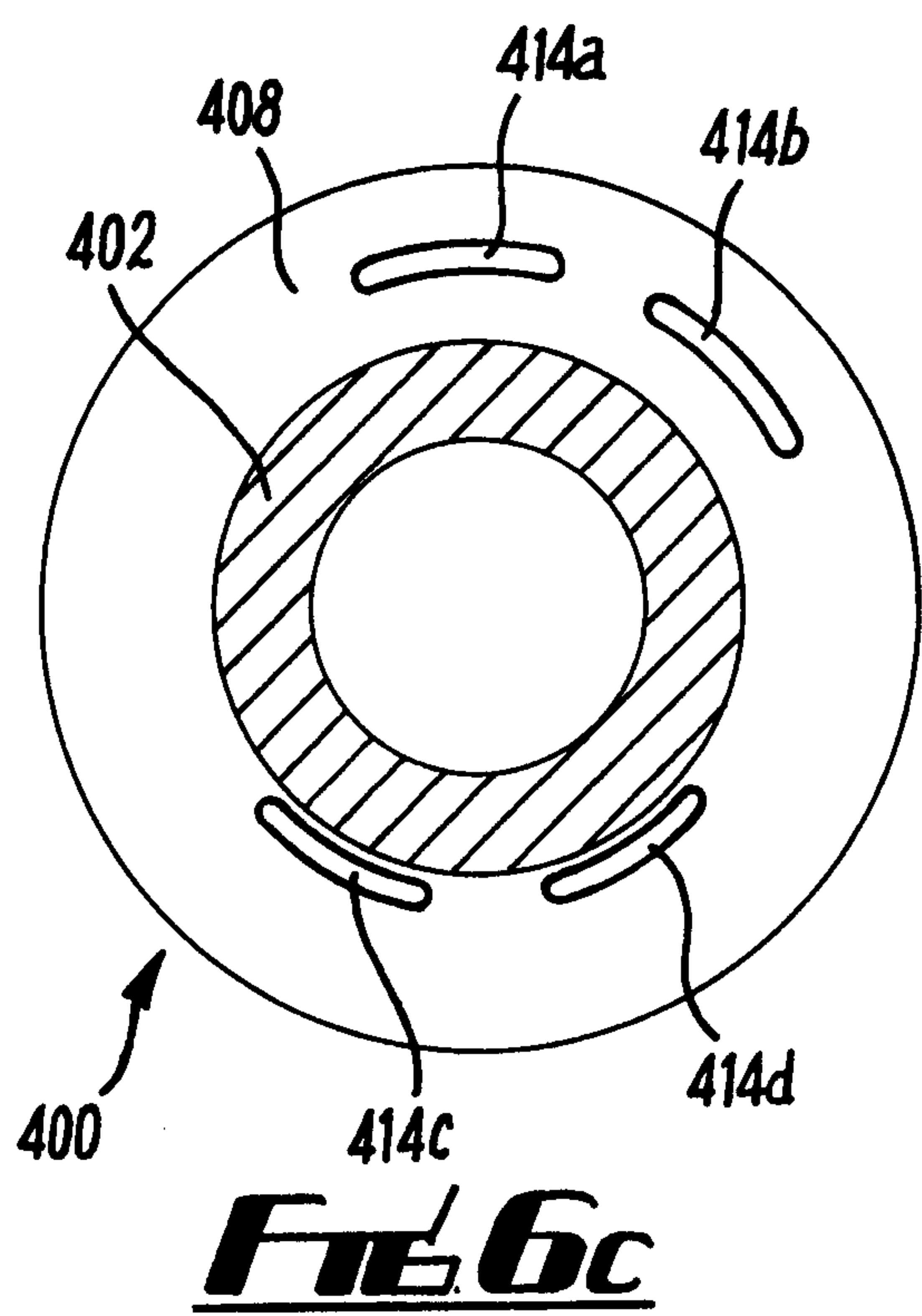
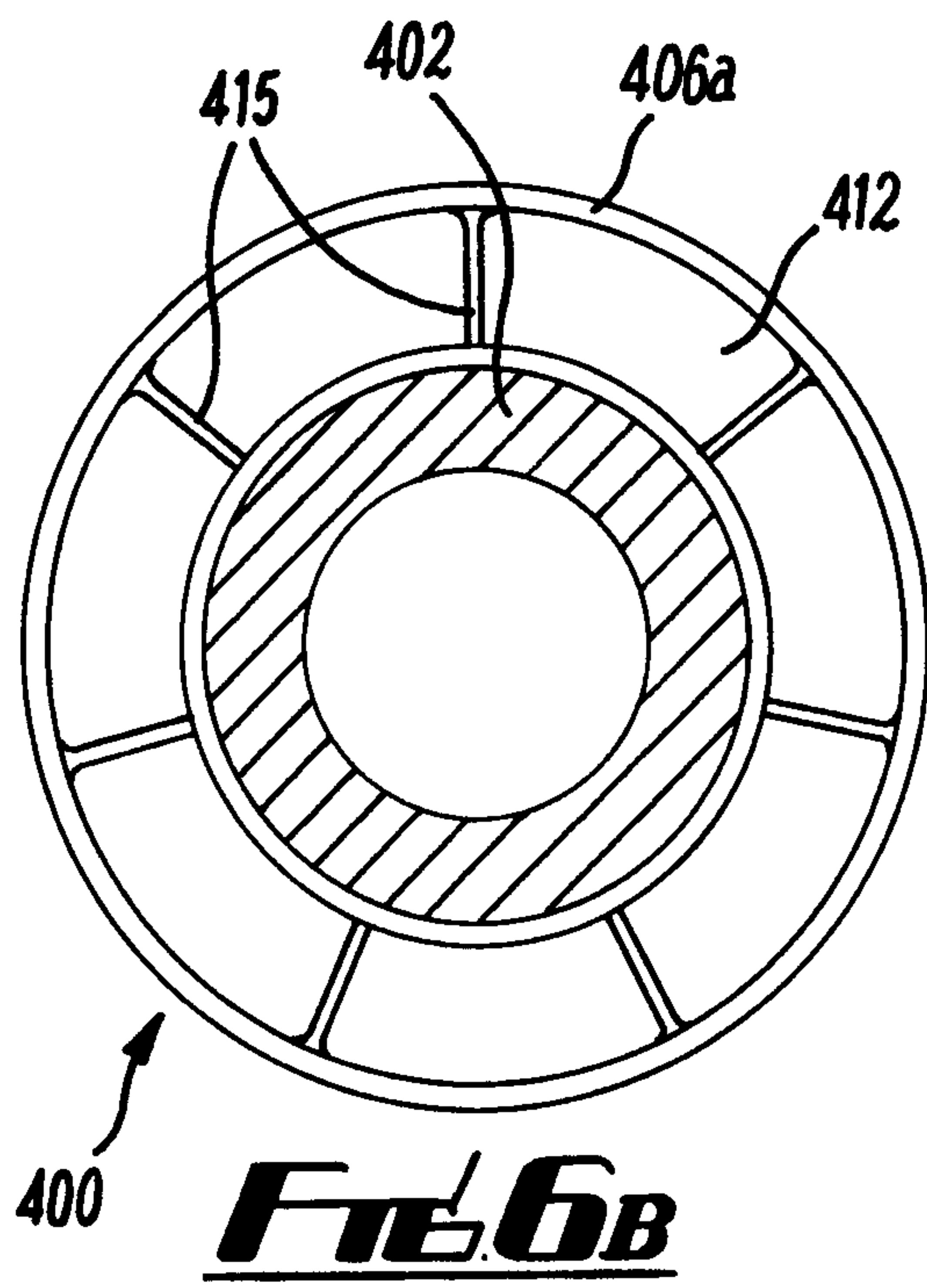
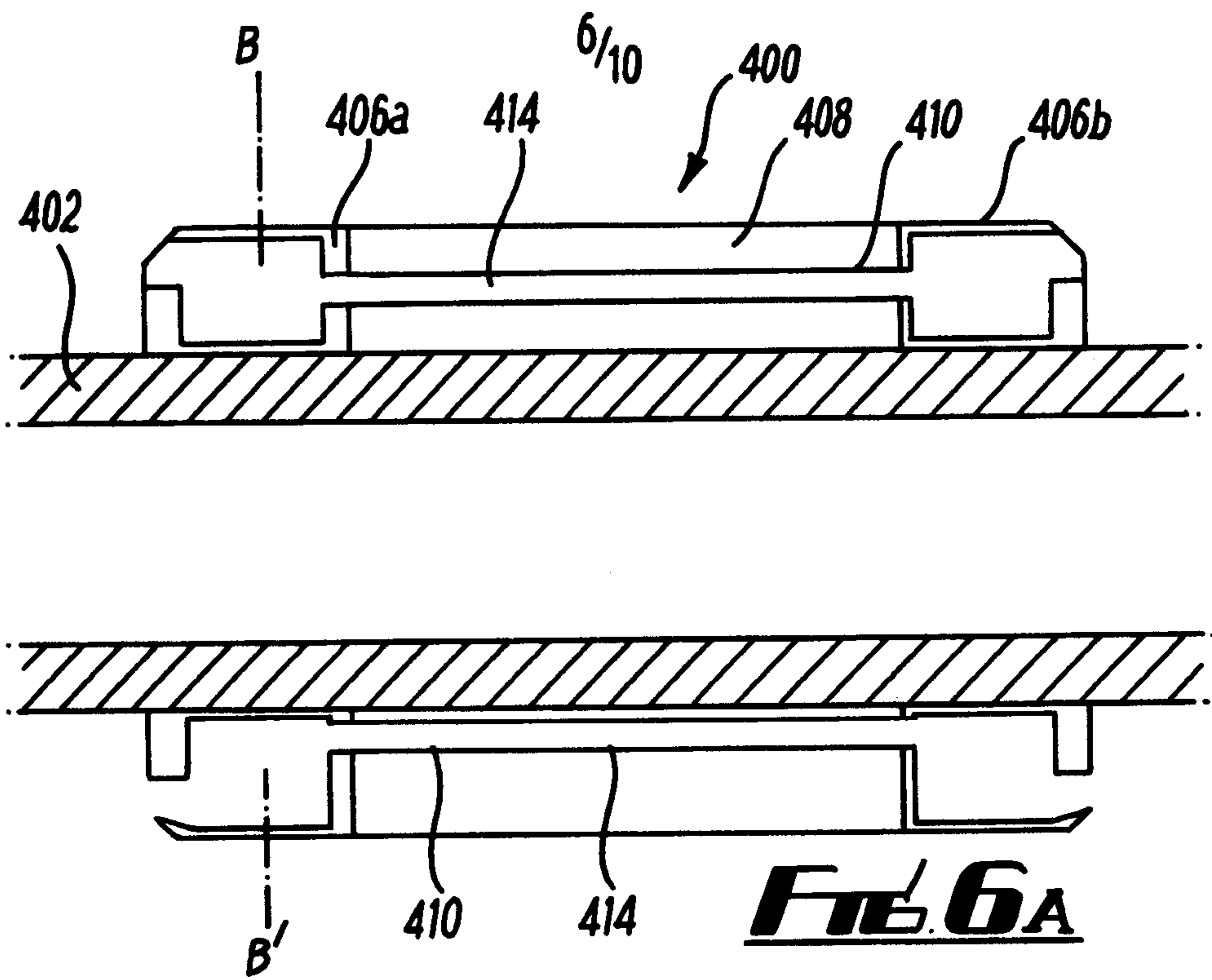


FIG. 7



7/10

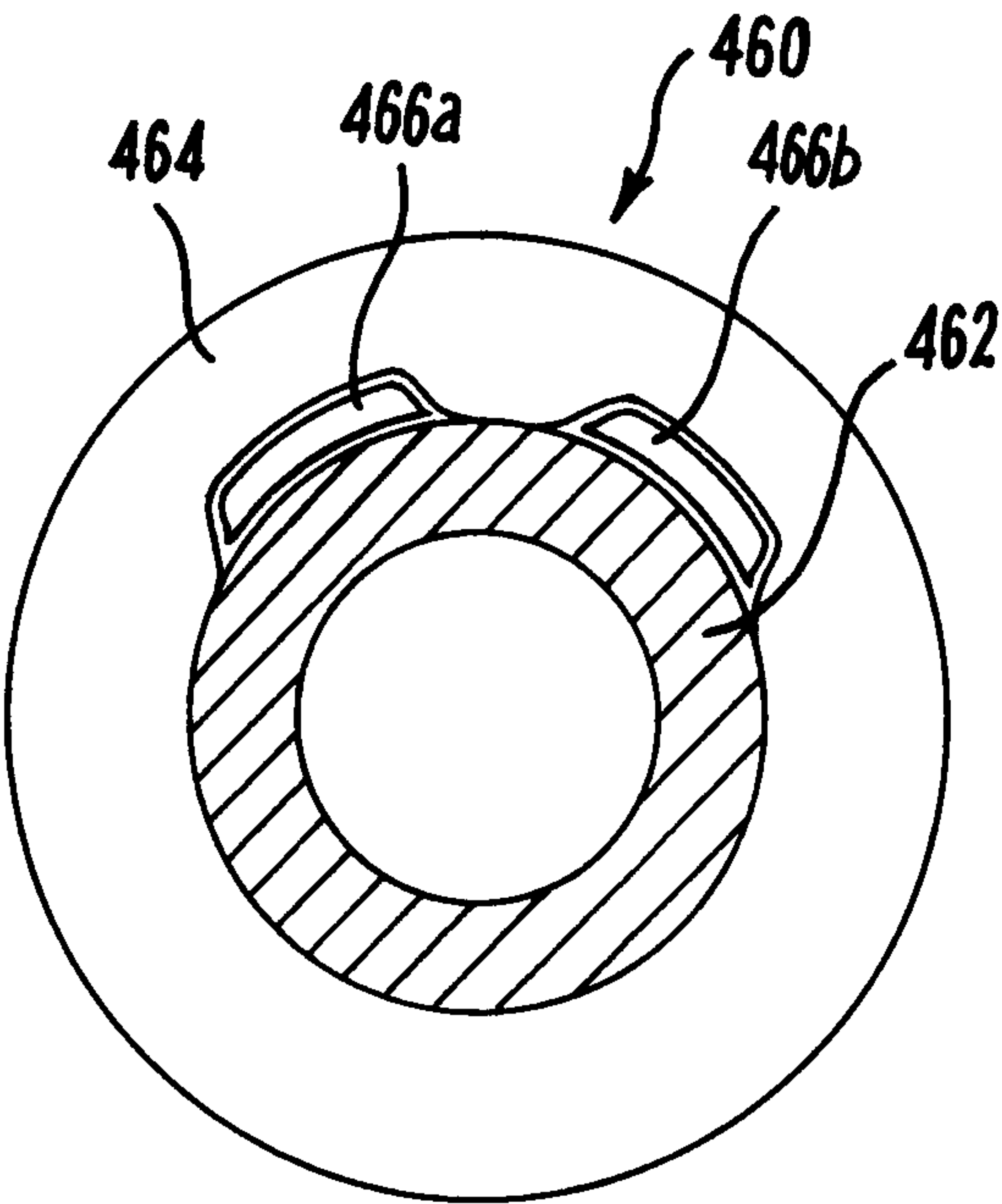


FIG. 8

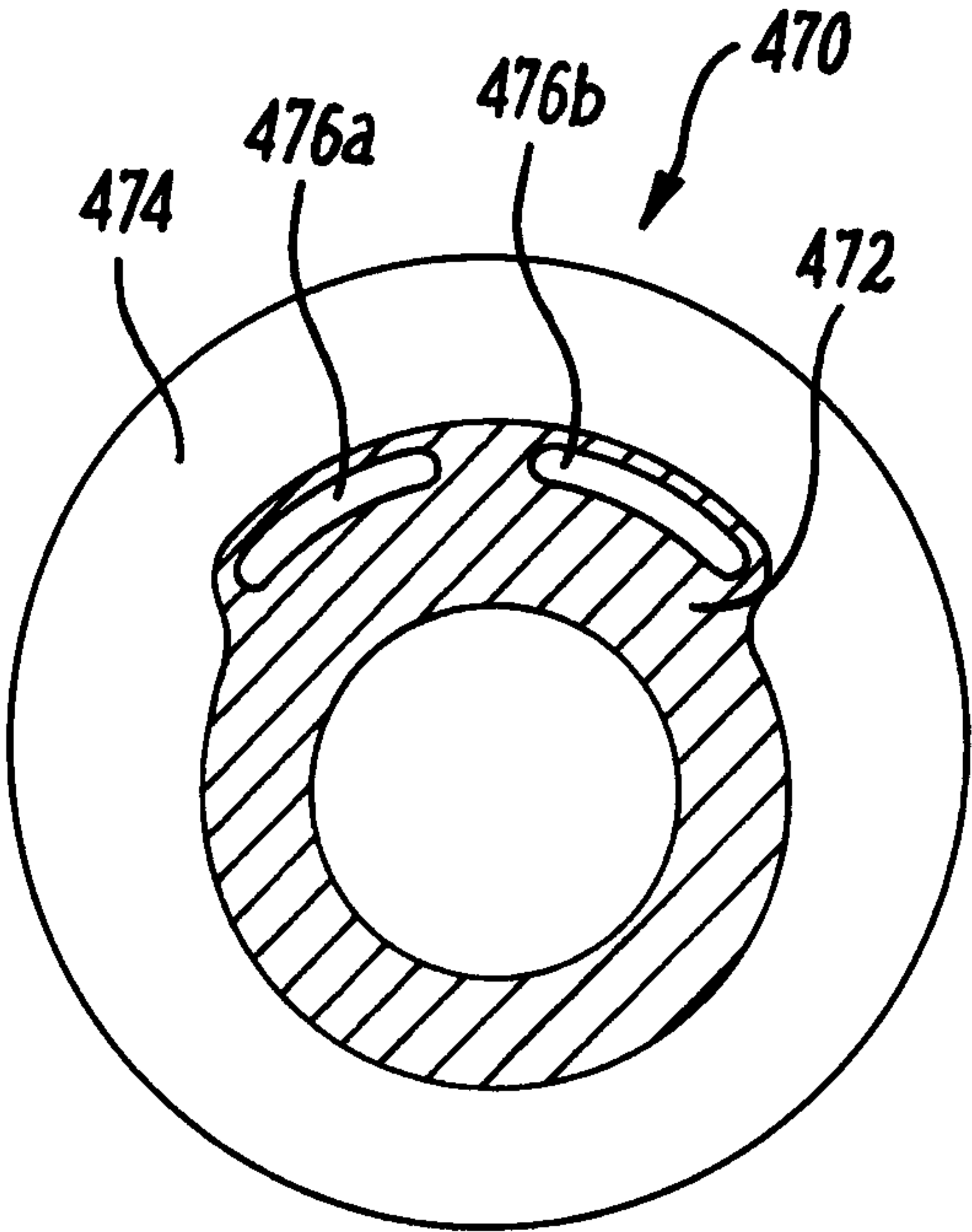


FIG. 9

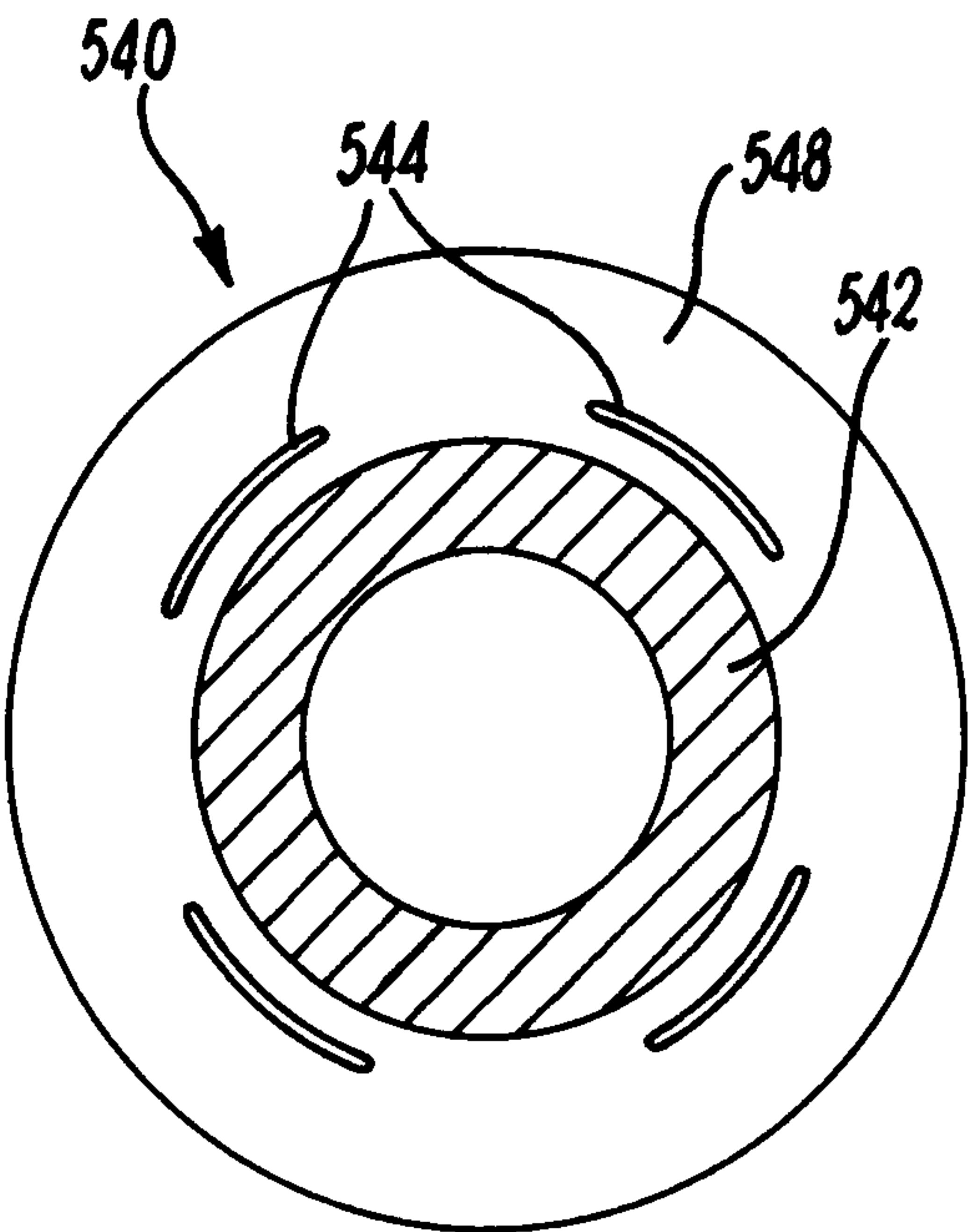


FIG. 12A

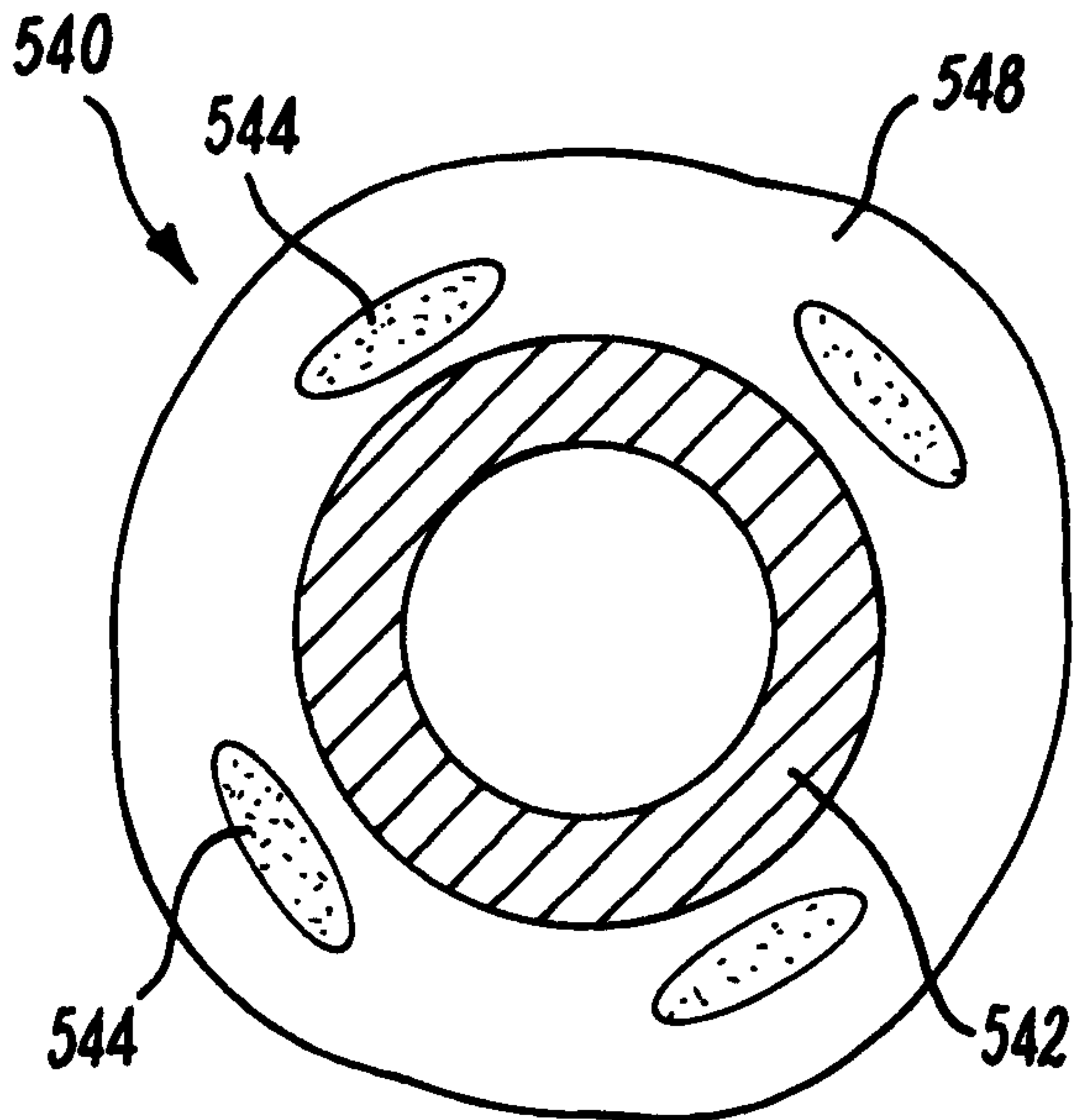


FIG. 12B

