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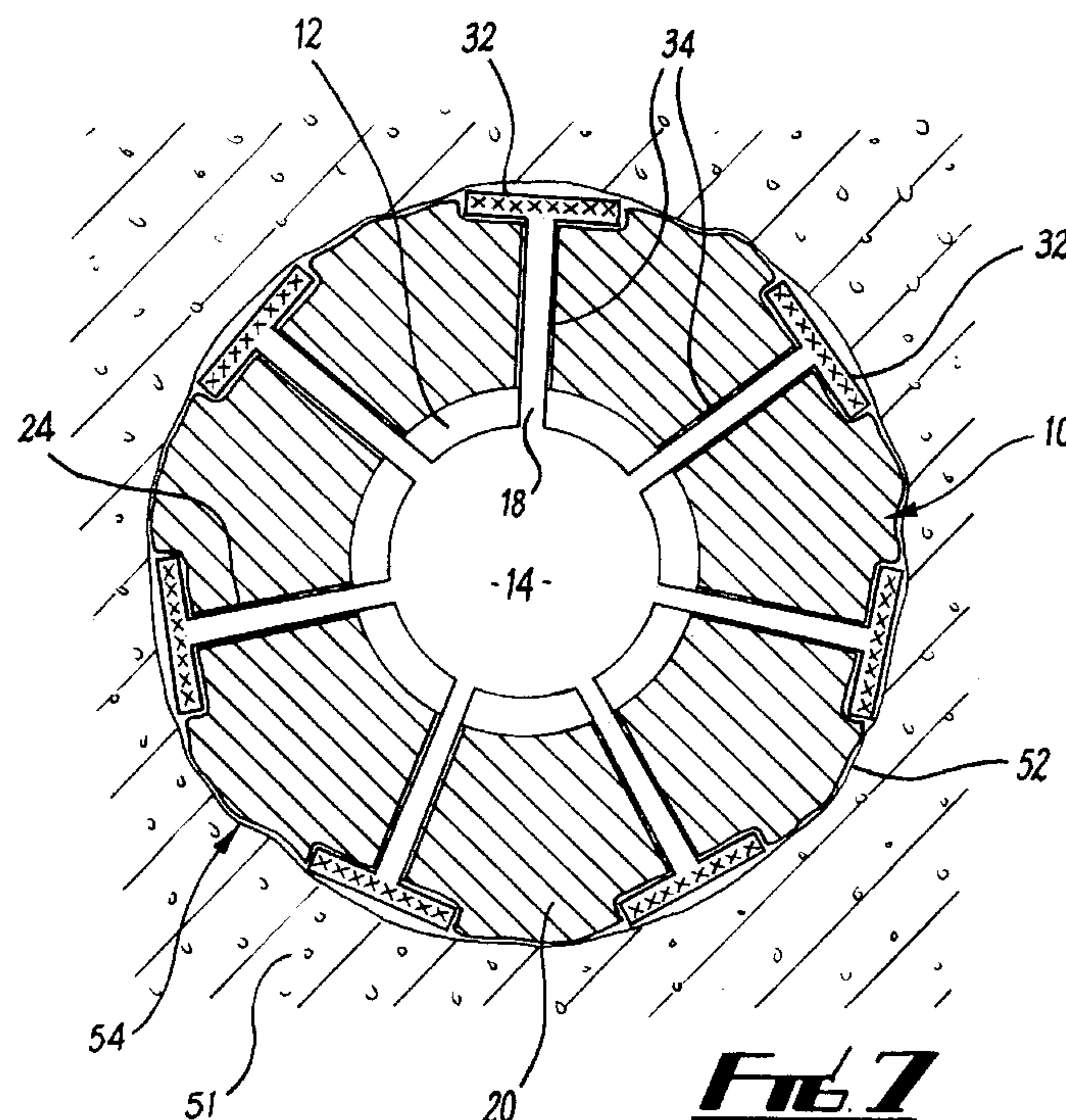


Fig. 7

(57) **Abrégé/Abstract:**

A downhole apparatus is described comprising a main body coupled with a well tubing and a swellable mantle disposed on the main body. The swellable mantle expands upon contact with at least one predetermined fluid, and the main body comprises at least one opening for fluid flow between an exterior of the main body and the bore. An insert permits the passage of fluid, through the swellable mantle, between the exterior of the apparatus and the opening. In one aspect of the invention a screen filters solids between the exterior of the apparatus and the bore, and a swellable mantle comprises a first region which allows the passage of fluid between the exterior of the apparatus and the main body and a second region, circumferentially adjacent the first region, which substantially prevents passage of fluid. Corresponding well completion and production methods are also described.



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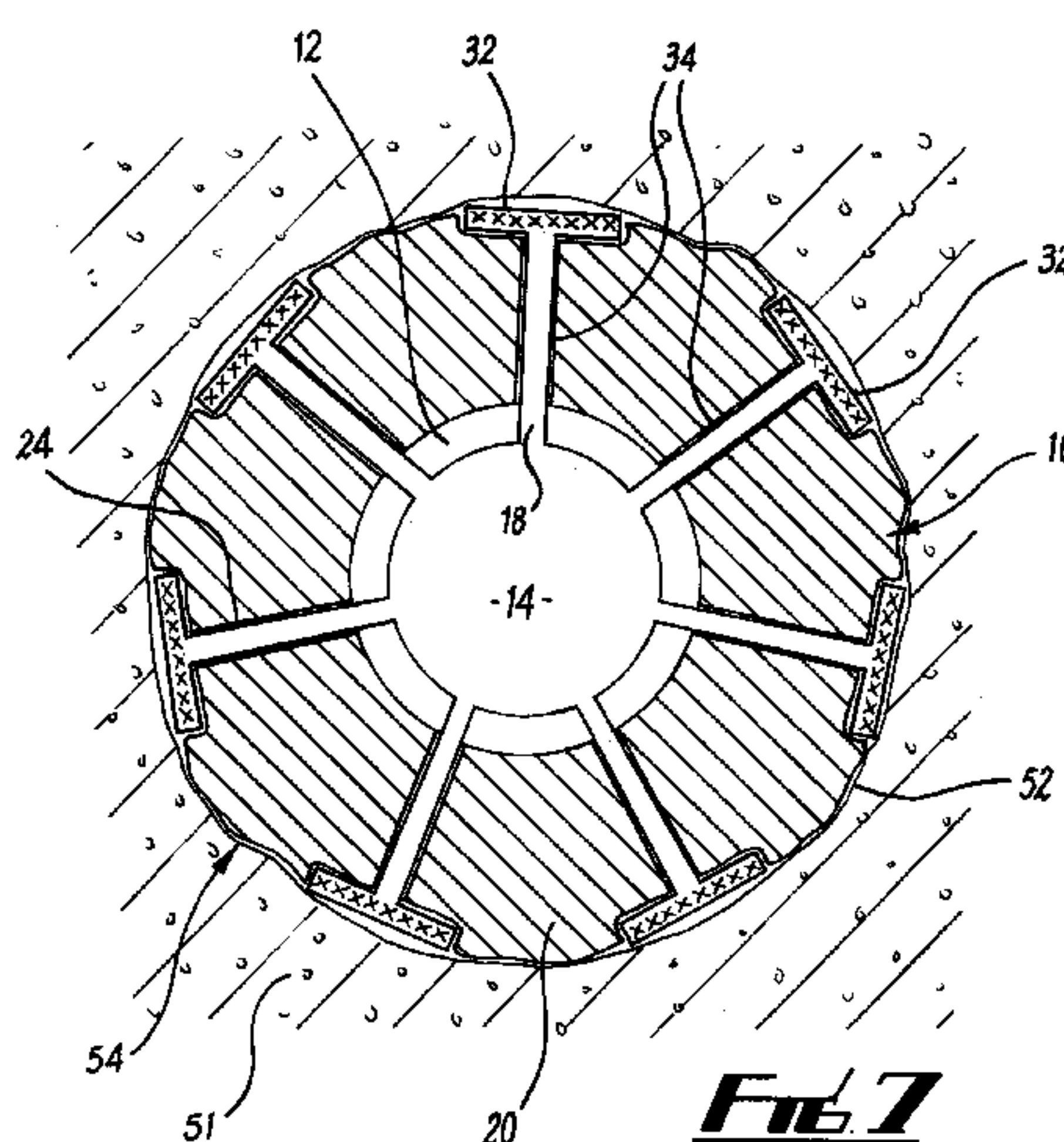
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(54) Title: DOWNHOLE APPARATUS AND METHOD



(57) Abstract: A downhole apparatus is described comprising a main body coupled with a well tubing and a swellable mantle disposed on the main body. The swellable mantle expands upon contact with at least one predetermined fluid, and the main body comprises at least one opening for fluid flow between an exterior of the main body and the bore. An insert permits the passage of fluid, through the swellable mantle, between the exterior of the apparatus and the opening. In one aspect of the invention a screen filters solids between the exterior of the apparatus and the bore, and a swellable mantle comprises a first region which allows the passage of fluid between the exterior of the apparatus and the main body and a second region, circumferentially adjacent the first region, which substantially prevents passage of fluid. Corresponding well completion and production methods are also described.

WO 2008/122809 A1

1 **Downhole apparatus and method**

2
3 The present invention relates to a downhole apparatus and method for use in the
4 completion of hydrocarbon wells, and in one aspect to a downhole screen including a
5 swellable material and a method of use.

6
7 In the completion of hydrocarbon wells, it is known to use screens to prevent the
8 production of solids from the formation. Expandable tubular technology has been used to
9 expand metal screens to reduce the annular space around the screen and thereby reduce
10 or eliminate the requirement for gravel packing and provide structural support for the
11 formation.

12
13 There are a number of drawbacks to using expanding tubulars. It can be difficult to control
14 the force used to expand the tubular, and there may be resulting problems with the
15 application of an undue, damaging force onto the formation. Expandable tubulars also
16 have a limited expansion range, which means that maximum expansion can still result in
17 an unsupported formation in a wash out zone.

18
19 US 2005/0173130 describes an arrangement in which a swellable layer is located over an
20 expanding screen to allow the apparatus to conform to the borehole shape. Holes in the

1 swellable layer allow the passage of formation fluids. However, it is desirable in many
2 applications to avoid the use of expanding tubulars. Additionally, by providing the screen
3 around the expandable pipe at a location displaced from the borehole wall, there is an
4 annular space into which solids may be produced, and along which solids may flow. This
5 increases the risk of blocking the screen and creating so-called hotspots which are prone
6 to erosion.

7
8 The proposal of WO 2006/003112 attempts to overcome these deficiencies by providing a
9 screen which is expanded into contact with the borehole wall by swellable rings. This
10 approach relies on overlaid screen sheets which are forced outward by the swelling of the
11 rings. This has the undesirable effect of restraining expansion of the swellable material,
12 which may only be capable of exerting a pressure of 50 to 100 PSI (345 to 690 KPa). In
13 addition, the gaps between overlaid screen sheets provide route for solid particles to enter
14 the production tubing.

15
16 It is one aim of at least one aspect the invention to provide a downhole apparatus and
17 method which overcomes or mitigates the deficiencies of previously proposed apparatus
18 and methods.

19
20 It is another aim of at least one aspect of the invention to provide an alternative apparatus
21 and method to those previously proposed.

22
23 It is an aim of at least one aspect of the invention to provide a downhole apparatus offering
24 improved performance and or wider operating parameters than the apparatus of the prior
25 art.

26
27 According to a first aspect of the invention there is provided a downhole apparatus
28 comprising a main body having a bore arranged to be coupled with a well tubing; and a
29 swellable mantle disposed on the main body, which swellable mantle expands upon
30 contact with at least one predetermined fluid; wherein the main body comprises at least
31 one opening for fluid flow between an exterior of the main body and the bore, and the
32 swellable mantle is provided with an insert to permit the passage of fluid between the
33 exterior of the apparatus and the at least one opening through the swellable mantle.

1 Thus the apparatus may permit fluid flow from its exterior into the bore, through the
2 openings in the main body, and onward to the well tubing. The apparatus may therefore
3 communicate with production tubing, and may be adapted to permit flow of production fluid
4 from a producing zone into the production tubing.

5
6 The swellable mantle may be disposed around an elongate portion of the main body, and
7 may form a substantially cylindrical member around the main body. The elongate portion
8 may comprise at least one opening therein, and the swellable mantle may be adapted to
9 allow the passage of fluid between the exterior of the apparatus and the at least one
10 opening in the elongate portion. The apparatus may therefore be arranged to permit fluid
11 flow across an area or surface over which the swellable mantle is disposed.

12
13 The main body may be a tubular, and may form a base pipe of the apparatus. The main
14 body may comprise a liner tubular. Preferably, the main body comprises a plurality of
15 openings. The openings may be slots or perforations. The main body may therefore be a
16 slotted or pre-perforated tubular.

17
18 In a preferred embodiment, the main body is formed to a fixed diameter, and is not
19 adapted for expansion in use.

20
21 The swellable mantle may be provided with at least one formation to promote fluid flow
22 between the exterior of the apparatus and the at least one opening.

23
24 Preferably, the swellable mantle is provided with at least one aperture therein. The
25 aperture may be a hole, groove or slot in the swellable mantle. The aperture may be a
26 radial opening in the swellable mantle. The aperture may comprise a groove extending
27 circumferentially of the swellable mantle, and may comprise an annular groove in the
28 swellable mantle. Alternatively, or in addition, the aperture may comprise a groove
29 extending longitudinally of the swellable mantle. The aperture may comprise a groove
30 defining a groove axis, which may be oriented longitudinally, circumferentially, or helically
31 of the swellable mantle.

32
33 The aperture may comprise a hole extending radially of the swellable mantle.

34

1 The aperture may provide a fluid flow path from the exterior of the apparatus to main body.
2 The apparatus may comprise a flow path from the exterior of the apparatus to the bore, via
3 the aperture and the at least one opening in the main body. The flow path may be from a
4 producing formation to the bore, via the aperture and the at least one opening in the main
5 body.

6
7 The insert may be provided in the aperture. The insert preferably permits fluid flow
8 through the aperture. The insert may be adapted to maintain a flow path in the aperture.
9 The insert may comprise a fluid permeable material. The insert may function as a filter for
10 filtering solid particles from the fluid flowing through the aperture.

11
12 The insert may be disposed over one or more openings of the main body. The insert may
13 extend longitudinally and/ or radially of the main body. The insert may substantially fill a
14 volume defined by the aperture. The insert may function to support or abut a portion of the
15 swellable mantle, and may define a bearing surface for a portion of the swellable mantle.
16 The insert may therefore limit or prevent the expansion of the swellable mantle in at least
17 one direction, and may be arranged to prevent the expansion of the swellable mantle into
18 the flow path defined by the aperture.

19
20 The insert may be formed from a permeable rope, a braided line or a fibrous material,
21 which may be wound into the aperture. Alternatively, the insert may comprise a sintered
22 metal component.

23
24 In a further alternative, the insert may comprise an impermeable metal component having
25 fluid apertures formed therein. The insert may comprise an abrasion-or erosion-resistant
26 material such as tungsten carbide or similar.

27
28 The insert may define a conduit in the swellable mantle. The insert may define a radially
29 extending conduit through an aperture in the swellable mantle. The conduit may be a
30 bounded conduit, which may be adapted to maintain a flow path in the aperture. The
31 conduit may be defined by a tube. The conduit may extend from the exterior of the
32 swellable mantle to main body. The conduit may have a first end arranged for fluid flow to
33 and/ or from an exterior of the apparatus and a second end arranged for fluid flow to and/
34 or from the main body. The second end may be located at or adjacent to the main body.
35 The second end may be coupled to the apparatus at an opening on the main body.

1 Alternatively, the second end may fully or partially extend into main body. The second end
2 may be bonded to the main body.

3
4 The conduit may be of variable length. The conduit may be telescopic, and may comprise
5 a first member at the first end, movably coupled to a second member at the second end.

6 The first and second members may therefore move relative to one another to create a
7 channel of variable length. Such relative movement result from expansion of the swellable
8 mantle. The second member may be bonded to the swellable mantle. The first member
9 may be adapted to move relative to the second member on expansion of the swellable
10 mantle. A seal may be provided between the first and second members.

11
12 In an embodiment of the invention, there is provided one or more flow-directing members
13 or channels disposed on an outer surface of the apparatus. The flow-directing member
14 may be adapted to couple multiple apertures, and or direct flow to multiple apertures. The
15 flow-directing member may be provided with holes corresponding to apertures in the
16 swellable mantle. The flow-directing member may provide a fluid path from the exterior of
17 the apparatus to one or more apertures. The flow-directing member may be coupled to
18 an insert to an aperture.

19
20 Preferably, the flow-directing member is coupled to multiple inserts, and may be integral
21 therewith. More preferably, the flow-directing member is coupled to multiple conduits, or
22 first members thereof. The flow directing member may partially or fully define the inserts
23 to the apertures.

24
25 The flow-directing member and the inserts can be considered in one embodiment to
26 function as a gutter and a series of drainpipes respectively.

27
28 Preferably, the apparatus comprises a screen for filtering solids between the exterior of the
29 apparatus and the bore. Preferably the screen is arranged to filter solids from fluid flowing
30 from the exterior of the apparatus to the bore. The screen functions to filter solids
31 produced from the formation, such as sands or shale or the like, from the fluid. The screen
32 may comprise a plurality of layers. The screen may comprise at least one mesh layer, but
33 preferably comprises a plurality of mesh layers.

34

1 The screen may comprise a filter mesh layer having a filter grade of 50 microns to 350
2 microns. The screen may further comprise one or both of an outer protective shroud or a
3 drainage support mesh layer. Preferably, the screen comprises a first drainage support
4 mesh layer on one side of a filter mesh layer, and a second drainage support mesh layer
5 on an opposing side of a filter mesh layer.

6
7 The screen is preferably disposed over the openings. More preferably, the screen is
8 disposed over the apertures. The screen may be disposed in the flow directing member.

9
10 The apparatus may comprise multiple screens at discrete locations. The apparatus may
11 comprise at least two screens having different filter grades.

12
13 The swellable mantle is preferably disposed around the main body and may be arranged
14 to expand upon contact with at least one predetermined fluid and thereby move the screen
15 outwardly of the main body. The screen is preferably arranged such that any restraining
16 force imparted by the screen onto the swellable mantle which acts against its expansion
17 can be overcome by the swellable mantle. More preferably, substantially no restraining
18 force is imparted on the swellable mantle by the screen.

19
20 The apparatus may be arranged such that the surface area of the screen is maintained in
21 use, between an unexpanded condition and an expanded condition. The screen may have
22 a screen surface area; and the swellable mantle may be disposed around the main body
23 between the main body and the screen. Preferably, the swellable mantle is arranged to
24 expand upon contact with at least one predetermined fluid and thereby move the outwardly
25 of the main body while maintaining the screen surface area.

26
27 The swellable mantle may comprise a first region located between the main body and the
28 screen which allows the passage of fluid between the exterior of the apparatus and the
29 main body. The swellable mantle may include a second region, which may be
30 circumferentially adjacent the first region, which substantially prevents passage of fluid
31 between the exterior of the apparatus and the main body.

32
33 Preferably, the second region is adapted to be expanded into contact with the borehole
34 wall.

35

1 The screen may be discontinuous around the circumference of the main body. The screen
2 may consist of multiple portions of screening material, which may be discrete in an
3 expanded condition of the apparatus. The multiple portions may additionally be discrete in
4 an unexpanded condition of the apparatus. Preferably, the swellable member is disposed
5 around the main body between the main body and the screen such that on expansion the
6 screen is moved outwardly of the main body. The screen may comprise at least two
7 discrete screens or screen sections circumferentially spaced on the apparatus.

8
9 Preferably, the swellable mantle is disposed between the main body and a borehole wall in
10 use. The apparatus may be adapted to provide stand off of the main body from the bore in
11 the apparatus is located. More preferably the swellable mantle is further adapted to
12 provide support to a wall of the bore in which it is located.

13
14 The apparatus may be used to support a loose or unstable borehole formation, such as a
15 sandstone or shale formation. The apparatus may be adapted for compliant expansion of
16 the swellable mantle to the formation, such that the swellable mantle contacts the
17 formation without unduly stressing the formation. This has the advantage of reducing rock
18 fatigue and reducing the tendency of solids to flow out of the formation with the fluid.

19
20 Although the term "swellable mantle" is used herein it should not be taken to imply a single
21 piece of swellable material unless otherwise specified. Certain embodiments of the
22 invention comprise multiple, separate pieces of swellable material which combine to
23 provide the so-called swellable mantle. Other embodiments comprise a unitary swellable
24 mantle.

25
26 The swellable material may comprise an ethylene-propylene co-polymer cross-linked with
27 at least one of a peroxide and sulphur. More specifically the swellable member may
28 comprise ethylene propylene diene monomer rubber (EPDM).

29
30 Alternatively or in addition the swellable member may contain at least one or multiple
31 water absorbing resins or more precisely any lightly cross-linked hydrophilic polymer
32 embedded within the main swellable member elastomer which may comprise at least one
33 of chloroprene, styrene butadiene or ethylene-propylene rubbers. Such water-absorbing
34 resins are termed "superabsorbent polymers" or "SAPs" and when embedded within the
35 swellable member it may expand when in contact with an aqueous solution.

1
2 Examples of water absorbent resin include cross-linked polyacrylic acid salts, cross-linked
3 copolymers of vinyl alcohol and acrylic acid salt, cross-linked products of polyvinyl alcohol
4 grafted with maleic anhydride, crosslinked copolymers of acrylic acid salt and meth-acrylic
5 acid salt, cross-linked saponification products of methyl acrylate-vinyl acetate copolymer,
6 cross-linked products of starch-acrylic acid salt graft copolymer, crosslinked saponification
7 products of starch-acrylonitrile graft copolymer, crosslinked saponification products of
8 starch-ethyl acrylate graft copolymer, crosslinked carboxymethyl cellulose and the like.

9
10 Alternatively or in addition, the swellable member may comprise an ethylene-propylene-
11 diene polymer with embedded water absorbent resin such that expansion of the swellable
12 member may result from contacting either an aqueous solution or polar liquid such as oil or
13 a mixture of both.

14
15 According to a second aspect of the invention there is provided a well completion or
16 hydrocarbon production method comprising the steps of:

- 17 a. Providing a swellable mantle over an opening on a main body of an apparatus;
18 b. Locating the apparatus at a downhole location;
19 c. Expanding the swellable mantle by exposing it to a predetermined fluid;
20 d. Maintaining a fluid flow path in the swellable mantle using an insert in the
21 swellable mantle;
22 e. Allowing fluid flow between an exterior of the apparatus and the at least one
23 opening through the swellable mantle.

24
25 The method may comprise the step of allowing fluid to flow through the insert. The
26 method may comprise the step of receiving fluid from the formation and into a well tubing
27 to which the apparatus is coupled.

28
29 The method may include the additional step of screening solids from the fluid received
30 from the formation.

31
32 The method may include the additional step of moving a screen outwardly of the main
33 body during expansion of the swellable mantle.

34

1 The method may include the step of expanding the swellable mantle without changing the
2 surface area of the screen.

3
4 The method may include the step of expanding the swellable mantle such that the screen
5 consists of a plurality of discrete screen sections after expansion.

6
7 Other preferred and optional features of the second aspect of the invention are defined
8 with respect to the first aspect of the invention.

9
10 According to a third aspect of the invention there is provided downhole apparatus
11 comprising a main body having a bore communicating with a well tubing, and at least one
12 opening for fluid flow between an exterior of the main body and the bore; a screen for
13 filtering solids between the exterior of the apparatus and the bore; and a swellable mantle
14 disposed around the main body and arranged to expand upon contact with at least one
15 predetermined fluid and thereby move the screen outwardly of the main body, wherein the
16 swellable mantle comprises a first region located between the main body and the screen
17 which allows the passage of fluid between the exterior of the apparatus and the main
18 body; and a second region, circumferentially adjacent the first region, which substantially
19 prevents passage of fluid between the exterior of the apparatus and the main body.

20
21 Thus the invention in this aspect provides a swellable mantle with a surface which is
22 designed to permit or prevent fluid flow through circumferentially separated areas. This
23 facilitates the use of a screen which is not continuous around the circumference of
24 swellable mantle. The discontinuous nature of the screen permits the screen to be moved
25 outwardly of the main body more readily than if a continuous screen were used.

26
27 Preferably, the second region is adapted to be expanded into contact with the borehole
28 wall.

29
30 The screen is preferably arranged such that any restraining force imparted by the screen
31 onto the swellable mantle which acts against its expansion can be overcome by the
32 swellable mantle. More preferably, substantially no restraining force is imparted on the
33 swellable mantle by the screen.

34

1 The apparatus may be arranged such that the surface area of the screen is maintained in
2 use, between an unexpanded condition and an expanded condition. The screen may have
3 a screen surface area; and the swellable mantle may be disposed around the main body
4 between the main body and the screen. Preferably, the swellable mantle is arranged to
5 expand upon contact with at least one predetermined fluid and thereby move the outwardly
6 of the main body while maintaining the screen surface area.

7
8 The screen may be discontinuous around the circumference of the main body. The screen
9 may consist of multiple portions of screening material, which may be discrete in an
10 expanded condition of the apparatus. The multiple portions may additionally be discrete in
11 an unexpanded condition of the apparatus. Preferably, the swellable member is disposed
12 around the main body between the main body and the screen such that on expansion the
13 screen is moved outwardly of the main body. The screen may comprise at least two
14 discrete screen sections circumferentially spaced on the apparatus.

15
16 Other preferred and optional features of the third aspect of the invention are defined with
17 respect to the first and second aspects of the invention.

18
19 According to a fourth aspect of the invention there is provided a well completion or
20 hydrocarbon production method comprising the steps of:

- 21 a. Providing a swellable mantle over an opening on a main body of an apparatus;
- 22 b. Locating the apparatus at a downhole location;
- 23 c. Expanding the swellable mantle by exposing it to a predetermined fluid to
24 thereby move a screen outwardly of the main body;
- 25 d. Allowing fluid to flow between an exterior of the apparatus and the at least one
26 opening through a first region of the swellable mantle located between the main
27 body and the screen, while substantially preventing passage of fluid between the
28 exterior of the apparatus and the main body in a second region of the swellable
29 mantle, circumferentially adjacent the first region.

30
31 The method may comprise the step of receiving fluid from the formation and into a well
32 tubing to which the apparatus is coupled.

33
34 The method may include the additional step of screening solids from the fluid received
35 from the formation.

1
2 The method may include the step of expanding the swellable mantle without changing the
3 surface area of the screen.

4
5 The method may include the step of expanding the swellable mantle such that the screen
6 consists of a plurality of discrete screen sections after expansion.

7
8 Other preferred and optional features of the fourth aspect of the invention are defined with
9 respect to the first to third aspects of the invention.

10
11 According to a fifth aspect of the invention there is provided a downhole apparatus
12 comprising a main body having a bore communicating with a well tubing, and at least one
13 opening for fluid flow between an exterior of the main body and the bore; a screen for
14 filtering solids between the exterior of the apparatus and the bore having a screen surface
15 area; and a swellable member disposed around the main body between the main body
16 and the screen, wherein the swellable member is arranged to expand upon contact with at
17 least one predetermined fluid and thereby move the screen outwardly of the main body
18 while maintaining the screen surface area.

19
20 Other preferred and optional features of the fifth aspect of the invention are defined with
21 respect to the first to fourth aspects of the invention.

22
23 According to a sixth aspect of the invention there is provided a downhole apparatus
24 comprising a main body having a bore communicating with a well tubing, and at least one
25 opening for fluid flow between an exterior of the main body and the bore; a screen for
26 filtering solids between the exterior of the apparatus and the bore; and a swellable
27 member disposed around the main body between the main body and the screen, wherein
28 the swellable member is arranged to expand upon contact with at least one predetermined
29 fluid and thereby move the screen outwardly of the main body, wherein the screen
30 comprises at least two discrete screen sections circumferentially spaced on the apparatus.

31
32 Other preferred and optional features of the sixth aspect of the invention are defined with
33 respect to the first to fifth aspects of the invention.

34

1
2 Use of the first, third, fifth and sixth aspects of the invention in well completion or
3 production methods is within the scope of the invention. A volume of hydrocarbon
4 obtained by using the apparatus or methods described also forms part of the invention.
5

6 There will now be described, by way of example only, various embodiments of the
7 invention with reference to the following drawings, of which:
8

9 Figure 1 is a perspective view of an apparatus in accordance with a preferred
10 embodiment of the invention;
11

12 Figure 2 is a perspective view of the apparatus of Figure 1 with the swellable
13 mantle removed to show other components;
14

15 Figure 3 is an exploded view of the swellable mantle of the apparatus of Figures 1
16 and 2;
17

18 Figure 4 is a perspective view of an insert used with the apparatus of Figures 1, 2
19 and 3;
20

21 Figures 5A and 5B are schematic views of the insert of Figure 4 in retracted and
22 extended conditions respectively;
23

24 Figure 6 is a schematic exploded view of a filter used in accordance with
25 embodiments of the invention;
26

27 Figure 7 is a schematic sectional view of the apparatus of Figure 1 in use in a
28 wellbore;
29

30 Figure 8 is a schematic representation of apparatus in accordance with an
31 alternative embodiment of the invention in partial longitudinal section;
32

33 Figure 9 is a schematic representation of apparatus in accordance with a second
34 embodiment of the invention in partial longitudinal section;
35

Figure 10 is a cross-sectional view of apparatus in accordance with a further embodiment of the invention;

Figure 11A is a cross-sectional view of apparatus in accordance with a further embodiment of the invention; and

Figure 11B is a cross-sectional view of the apparatus of Figure 11A in an expanded configuration.

Referring firstly to Figures 1 to 3, there is shown a downhole apparatus, generally depicted at 10, in accordance with an embodiment of the invention. The apparatus 10 comprises a main body 12 formed from tubular base pipe. The body 12 is adapted to be coupled to well tubing (not shown) such that the bore 14 of the apparatus communicates with the bore of the well tubing.

A section 16 of the main body 12 extending over a length of the apparatus is provided with openings 18 or perforations distributed longitudinally and circumferentially on the section 16. The openings are through-openings from an exterior of the main body 12 to the bore 14. In this embodiment, the openings 18 are regularly distributed, although in alternative embodiments other arrangements of openings may be provided.

Disposed over the main body 12 is a swellable mantle 20. Figure 2 shows the mantle removed from the apparatus 10. The swellable mantle 20 is a substantially tubular member shaped to fit over the section 16 of the apparatus. The swellable mantle is sized to be bonded or slipped onto the main body, and is located on the section 16 by end rings 22. The end rings 22 are secured to the main body to prevent axial and radial movement and to abut the respective ends of the swellable mantle 20.

The swellable mantle 20 is provided with apertures 24 and inserts 26 to the apertures. The inserts 26 are located in longitudinal recessed grooves 28 on the outer surface of the swellable mantle 20. The inserts 26 will be described in more detail below.

The swellable mantle 20 is formed from a material which is selected to expand on contact with a predetermined fluid. Such swellable materials are known in the art. In this example, the swellable mantle is required to swell in oil, and the material comprises

1 ethylene propylene diene monomer rubber (EPDM). In an alternative embodiment, where
2 the swellable mantle is required to swell in water, the material comprises any lightly
3 crosslinked hydrophilic polymer embedded within the main swellable member elastomer,
4 such as at least one of chloroprene, styrene butadiene or ethylene-propylene rubbers.
5 Such water-absorbing resins are termed "superabsorbent polymers" or "SAPs" and when
6 embedded within the swellable member may expand when in contact with an aqueous
7 solution. In a further alternative embodiment, the swellable member comprises an
8 ethylene-propylene diene polymer with embedded water absorbent resin such that
9 expansion of the swellable member results from contacting either an aqueous solution or
10 polar liquid such as oil or a mixture of both.

11
12 The apertures 24 function to allow fluid to flow from the exterior of the swellable mantle 20
13 to its interior. When the swellable mantle is positioned on the main body 12, the apertures
14 24 allow fluid flow from the exterior of the apparatus to the main body 12 and through the
15 openings 18 in the main body to the bore 14. In this embodiment, the spacing of the
16 apertures 24 corresponds to the spacing of the openings 18, such that the apertures 24
17 and openings 18 may be aligned to provide minimal resistance to fluid flow from the
18 exterior of the apparatus to the bore 14.

19
20 The swellable mantle 20 functions to expand on contact with a well bore fluid such that the
21 outer surface of the apparatus comes into contact with the borehole wall. The dimensions
22 and properties of the swellable mantle are selected for compliant expansion of the
23 swellable mantle into contact with the borehole wall, such that an appropriately low force is
24 imparted to the borehole to create a seal, but to prevent damage to the rock formation or
25 sandface. The dimensions and material of the swellable mantle are also selected to
26 expand into a washout zone in the borehole to similarly create a seal with a suitably low
27 force on the formation. In this way, the formation is supported from collapse towards the
28 main body 12, but without damaging the formation in a way that would increase the inflow
29 of solids.

30
31 The insert includes a screen support 30 and screen material 32. The insert 26 therefore
32 defines screen sections 33 of the apparatus along circumferentially spaced longitudinal
33 regions of the swellable mantle 20. Disposed between the screen sections are longitudinal
34 regions of the swellable mantle 20 which substantially prevent fluid flow to the interior of
35 the mantle 20. In this regard, it is noted that the swellable material may permit fluid

1 penetration by diffusion through the swellable material, but does not permit fluid flow such
2 as that required for the inflow of production fluids into the bore 14 or the injection of fluids
3 from the bore 14 into the formation.
4

5 Figures 4, 5A and 5B show the insert 26 in more detail, with the screen material 32
6 removed. The insert 26 includes a plurality of conduits 34 which extend through the
7 swellable mantle to the main body. Multiple conduits are connected by a channel 35
8 defined by the screen support 30. The conduits 34 each comprise a first member 36
9 received in a second member 38. The first and second members 36, 38 are movable
10 relative to one another to accommodate expansion of the swellable mantle 20. The
11 conduits function to maintain the flow path of the aperture after expansion. In alternative
12 embodiments of the invention, the conduits, or a subset of conduits, are provided with flow
13 control members such as valves or check valves to restrict fluid flow therethrough.
14

15 When assembled, the second member 38 is an interference fit with the aperture 24 of the
16 swellable mantle into which it locates. The undersurface 42 of the screen support 30 is
17 bonded to the surface of the swellable mantle 20 along the longitudinal groove 28. When
18 the swellable mantle expands, the first member 36 moves relative to the second member
19 38 such that the conduit telescopically extends.
20

21 In alternative embodiments, the second member 38 may be fixed to the main body 12
22 and/or may be received in the opening 18 in the main body.
23

24 Referring now to Figure 6, the screen material 32 is shown as comprising a plurality of
25 overlaid layers. Adjacent the screen support 30 is provided a drainage support mesh 44,
26 onto which is overlaid a filter mesh 46. The filter mesh is selected to have an appropriate
27 mesh grade for filtering solids which may be produced from the formation. Typically, the
28 filter mesh will have a mesh grade of around 100 to 300 microns. Over the filter mesh 46
29 is a further drainage support mesh 48, and finally an outer protective shroud 50, having
30 relatively large apertures, is provided on the exterior of the screen material.
31

32 The present invention encapsulates embodiments in which different screen sections are
33 provided with different filter grades. The invention also facilitates customisation of the
34 apparatus by selecting appropriate filter grades during assembly of the apparatus.
35

1 Figure 7 shows the apparatus 10 in use in a borehole, in a swelled condition. The
2 apparatus 10 has been run to a location in a sand-producing formation 51, and exposure
3 to wellbore fluids has caused the swellable mantle 20 to expand into contact with the
4 borehole wall 52. As expansion takes place, the conduits 34 defined by the inserts 26
5 telescopically extend such that a bounded conduit is formed between the exterior of the
6 apparatus and the openings 18 in the main body 12. The inserts prevent the swellable
7 mantle 20 from expanding to close the apertures 24.

8
9 The screen sections 33 are placed adjacent to the sandface by expansion of the swellable
10 mantle under the insert, and adjacent regions 54 of the swellable mantle form a compliant
11 seal on the borehole wall 52. Fluid flow from the formation is permitted in the areas at
12 which the screen sections 32 are provided, and is directed through the apertures 24, via
13 the conduits 34, and into the bore 14. Flow is not permitted through the regions 54.

14
15 This embodiment of the invention provides compliant expansion of a swellable member to
16 a borehole wall, providing structural support to the borehole without damaging the
17 sandface. The screen sections 33 are carried or moved in a radial direction to be placed
18 adjacent to the sandface. This minimises the annular space in which solids produced from
19 the formation can flow. The flow of fluid is only permitted in the regions at which the
20 screen material is provided, with adjacent sections supported and sealed by the swellable
21 mantle. By providing the plurality of discrete screen sections, movement of the screen
22 outwardly from the main body of the apparatus is accomplished effectively without
23 restraining swelling of the mantle. The embodiment of the invention is also conducive to
24 customisation and configuration of the filter grades used, which may differ between screen
25 sections.

26
27 There will now be described alternative embodiments of the invention with reference to
28 Figures 8 to 11.

29
30 Referring to Figure 8, there is shown a downhole apparatus, generally depicted at 100
31 consisting of the main body 112 formed from a tubular base pipe and adapted to be
32 coupled to well tubing in the same manner as apparatus 10. In a similar fashion to
33 apparatus 10, the main body 112 is provided with a plurality of through-openings 118
34 distributed on the body.

1 Disposed on the body 112, and shown in the Figure in longitudinal section, are end rings
2 122 and a swellable mantle 120 consisting of three longitudinally spaced sections 121a,
3 121b, and 121c. Apertures 124 are provided in the form of circumferential grooves to the
4 swellable mantle 120 extending from its outer surface to the main body 112. Provided in
5 the apertures 124 are inserts 126, which in this embodiment are constructed from a
6 permeable rope which is wound around the main body into the aperture. The insert 126 is
7 wound tightly on the main body and provides an abutting surface for the adjacent portions
8 of the swellable mantle 120. In use, the swellable mantle expands outwardly and partially
9 over the insert 126, but without covering the aperture to prevent fluid flow.

10
11 The inserts 126 function to permit fluid flow through the aperture and into the main body,
12 while maintaining the flow path and limiting or preventing the expansion of the swellable
13 mantle in the longitudinal direction. The insert additionally functions as a filter for solid
14 particles in the fluid flowing through the aperture.

15
16 In an alternative embodiment, the insert 126 is wound from a braided line or wire, or a
17 fibrous material.

18
19 Figure 9 shows an alternative embodiment, generally depicted at 130, similar to the
20 embodiment of Figure 8 and with like components identified by like reference numerals.
21 This embodiment differs in the form of the inserts 136, 138 provided to the apertures 124.

22
23 Insert 136 is in the form of a cylinder sized to slip onto the main body 112, and provided
24 with first and second flange members 137a, 137b extending outwardly from the main body.
25 Holes are provided in the insert 136 to allow fluid flow to the main body. The flange
26 members 137a and 137b function to provide an abutting surface to adjacent portions of the
27 swellable mantle to limit or prevent expansion of the swellable mantle across the aperture
28 124. Insert 138 consists of a pair of flange portions extending outwardly from the main
29 body, and exposing the main body to the aperture 124.

30
31 In this embodiment, one or both of the inserts of 136, 138 may comprise a hardened,
32 erosion-resistant material such as tungsten carbide. This functions to resist erosion
33 caused by solid particles contained in the fluid, which would have a tendency to erode the
34 swellable mantle and/or the openings in the main body 112. It will be appreciated that the
35 apparatus may comprise only one type of the inserts 136, 138.

Figure 10 shows a further alternative embodiment of the invention, generally depicted at 140. In this embodiment, the apertures 144 and the swellable mantle 146 are longitudinal grooves, at the inserts 146 are formed from blocks of sintered metal material. The blocks of sintered metal material are overlaid with screen sections 148 before filtering solids from fluid flowing through the apertures 144 and into the main body. In use, the swellable mantle expands outwardly and partially over the screen section, but without covering the aperture to prevent fluid flow. In alternative embodiments, the apertures 144 are helical or circumferential slots or holes in the swellable mantle.

A further alternative embodiment is shown in Figures 11A and 11B. In this embodiment, shown generally at 150, a substantially tubular screen 152 is embedded into a swellable mantle 153. Apertures 158 are provided in the mantle 153 to allow fluid flow to the main body 159. The screen 152 comprises longitudinal support members 154 which function to provide support to the relatively flexible screen material 156. In Figure 13A, the screen material is folded, bent or creased to such that its radial dimension is less than the maximum radial dimension which can be defined by the screen 152. The screen has a fixed surface area, but is embedded into the swellable mantle such that it may expand radially on expansion of the swellable material to a position shown in Figure 13B, without stretching the screen material or affecting the filter grade.

Variations to the above-described embodiments are within the scope of the invention. For example, any of the described insert configurations could be used in combination on the same apparatus in the scope of the invention. Combinations of features other than those expressly claimed are within the scope of the invention.

In further alternative embodiments of the invention, the apertures, or selected apertures in the swellable mantle, are provided with flow control members such as valves or check valves to restrict fluid flow therethrough.

The present invention in its various aspects provides an improved and alternative downhole apparatus and method offering improved performance and/ or wider operating parameters than the apparatus of the prior art.

1 **Claims**

2

3

1. A downhole apparatus comprising:

4

 a main body having a bore communicating with a well tubing, and at least
one opening for fluid flow between an exterior of the main body and the bore;

6

 a screen for filtering solids between the exterior of the apparatus and the
bore; and

8

 a swellable mantle disposed around the main body and arranged to expand
upon contact with at least one predetermined fluid and thereby move the screen outwardly
of the main body,

11

 wherein the swellable mantle comprises:

12

 a first region located between the main body and the screen which
allows the passage of fluid between the exterior of the apparatus and the main
body; and

15

 a second region, circumferentially adjacent the first region, which
substantially prevents passage of fluid between the exterior of the apparatus and
the main body.

18

19

2. The apparatus as claimed in claim 1 wherein the second region is
adapted to be expanded into contact with the borehole wall.

21

22

3. The apparatus as claimed in claims 1 or 2, wherein the screen has a
screen surface area, and the swellable mantle is arranged to move the screen outwardly of
the main body while maintaining the screen surface area.

25

26

4. The apparatus as claimed in claims 1, 2, or 3, wherein the screen is
discontinuous around the circumference of the main body.

28

29

5. The apparatus as claimed in any one of claims 1 to 4, wherein the
screen consists of multiple portions of screen material which are discrete in an expanded
condition of the apparatus.

32

33

6. The apparatus as claimed in claim 5, wherein the multiple portions
are discrete in an unexpanded condition of the apparatus.

35

1 7. The apparatus as claimed in any one of claims 1 to 6, wherein the
2 screen comprises at least two discrete screen sections circumferentially spaced on the
3 apparatus.

4
5 8. The apparatus as claimed in any in any one of claims 1 to 7, wherein
6 the apparatus comprises at least two screens or screen sections having different filter
7 grades.

8
9 9. The apparatus as claimed in any one of claims 1 to 8, wherein an
10 insert is provided in an aperture in the swellable mantle.

11
12 10. The apparatus as claimed in claim 9 wherein the insert functions to
13 limit the expansion of the swellable mantle in at least one direction.

14
15 11. A well completion method comprising the steps of:
16 providing a swellable mantle over an opening on a main body of an
17 apparatus at a downhole location;
18 expanding the swellable mantle by exposing it to a predetermined fluid to
19 thereby move a screen outwardly of the main body; and
20 allowing fluid to flow between an exterior of the apparatus and the at least
21 one opening through a first region of the swellable mantle located between the main body
22 and the screen, while substantially preventing passage of fluid between the exterior of the
23 apparatus and the main body in a second region of the swellable mantle, circumferentially
24 adjacent the first region.

25
26 12. The method as claimed in claim 11, comprising the additional step of
27 receiving fluid from the formation and into a well tubing to which the apparatus is coupled.

28
29 13. The method as claimed in claims 11 or 12 comprising the additional
30 step of screening solids from the fluid received from the formation.

31
32 14. The method as claimed in claims 11, 12, or 13, comprising the
33 additional step of expanding the swellable mantle without changing the surface area of the
34 screen.

35

- 1 15. The method as claimed in any one of claims 11 to 14 comprising the
2 additional step of expanding the swellable mantle such that the screen consists of a
3 plurality of discrete screen sections after expansion.
4
- 5 16. A hydrocarbon production method comprising the steps of:
6 providing a well completion by the method of any one of claims 11 to 15;
7 and;
8 allowing fluid to flow through the swellable mantle between an exterior of
9 the apparatus and the at least one opening in the main body.
10
- 11 17. The method as claimed in claim 16 comprising the additional step of
12 receiving fluid from the formation and into a well tubing to which the apparatus is coupled.
13
- 14 18. The method as claimed in claim 17 comprising the additional step of
15 screening solids from the fluid received from the formation.
16
- 17 19. A downhole apparatus comprising:
18 a main body having a bore arranged to be coupled with a well tubing and a
19 swellable mantle disposed on the main body, which swellable mantle expands upon
20 contact with at least one predetermined fluid;
21 wherein the main body comprises at least one opening for fluid flow
22 between an exterior of the main body and the bore, and the swellable mantle is provided
23 with an insert to permit the passage of fluid, through the swellable mantle, between the
24 exterior of the apparatus and the at least one opening in the main body.
25
- 26 20. The apparatus as claimed in claim 19 ,wherein the main body
27 comprises a plurality of openings and the insert is disposed over one or more openings of
28 the main body.
29
- 30 21. The apparatus as claimed in claims 19 or 20, wherein the insert
31 comprises an impermeable metal component having fluid apertures formed therein.
32
- 33 22. The apparatus as claimed in any one of claims 19, 20, or 21,
34 wherein the insert comprises an abrasion- or erosion-resistant material.
35

1

2 23. The apparatus as claimed in any one of claims 19 to 22 wherein the
3 insert functions as a filter for filtering solid particles from the fluid flowing through an
4 aperture in the swellable mantle.

5

6 24. The apparatus as claimed in any one of claims 19 to 23, wherein the
7 insert comprises a sintered metal component.

8

9 25. The apparatus as claimed in any of claims 19 to 23, wherein the
10 insert comprises an elongate material wound into the aperture.

11

12 26. The apparatus as claimed in claim 25, wherein the insert is selected
13 from one of a permeable rope, a braided line or a fibrous material.

14

15 27. The apparatus as claimed in any one of claims 19 to 26, wherein the
16 insert defines a radially extending conduit through an aperture in the swellable mantle.

17

18 28. The apparatus as claimed in claim 27, wherein the conduit
19 comprises a first end adjacent the exterior of the apparatus and a second end adjacent the
20 main body.

21

22 29. The apparatus as claimed in claims 27 or 28, wherein the conduit is
23 of variable length.

24

25 30. The apparatus as claimed in claim 29, wherein the conduit is
26 telescopic, and comprises a first member at the first end, movably coupled to a second
27 member at the second end.

28

29 31. The apparatus as claimed in claim 30, wherein the first member is
30 adapted to move relative to the second member on expansion of the swellable mantle.

31

32 32. The apparatus as claimed in claims 30 or 31, wherein a seal is
33 provided between the first and second members.

34

1 33. The apparatus as claimed in any one of claims 19 to 32, further
2 comprising one or more flow-directing members disposed on an outer surface of the
3 apparatus.

4
5 34. The apparatus as claimed in claim 33, wherein the flow-directing
6 member provides a fluid path from the exterior of the apparatus to one or more apertures
7 in the swellable mantle.

8
9 35. The apparatus as claimed in claims 33 or 34, wherein the flow-
10 directing member is coupled to the insert.

11
12 36. The apparatus as claimed in claim 35, wherein the apparatus
13 comprises multiple inserts, and the flow-directing member is coupled to multiple inserts.

14
15 37. The apparatus as claimed in any one of claims 33 to 36, wherein the
16 insert comprises a part of the flow directing member.

17
18 38. The apparatus as claimed in any one of claims 19 to 37, further
19 comprising a screen for filtering solids between the exterior of the apparatus and the bore.

20
21 39. The apparatus as claimed in claim 38 wherein the screen comprises
22 a filter mesh layer having a filter grade of 50 microns to 350 microns.

23
24 40. The apparatus as claimed in claims 38 or 39, when dependent on
25 any of claims 33 to 37, wherein the screen is disposed in the flow-directing member.

26
27 41. The apparatus as claimed in claims 38, 39, or 40, wherein the
28 screen is discontinuous around a circumference of the main body.

29
30 42. The apparatus as claimed in any one of claims 38 to 41, comprising
31 multiple screens at discrete locations.

32
33 43. The apparatus as claimed in claim 42, wherein the screen comprises
34 at least two discrete screen sections circumferentially spaced on the apparatus.

35

1 44. The apparatus as claimed in claims 42 or 43, further comprising at
2 least two screens or screen sections having different filter grades.

3

4 45. The apparatus as claimed in any one of claims 38 to 44, wherein the
5 swellable mantle is disposed around the main body and is arranged to expand upon
6 contact with at least one predetermined fluid and thereby move the screen outwardly of the
7 main body.

8

9 46. The apparatus as claimed in claim 45 wherein the screen has a
10 screen surface area; and the swellable mantle is arranged to move the screen outwardly of
11 the main body while maintaining the screen surface area.

12

13 47. The apparatus as claimed in any one of claims 38 to 46, wherein the
14 swellable mantle comprises a first region located between the main body and the screen
15 which allows the passage of fluid between the exterior of the apparatus and the main
16 body; and a second region, circumferentially adjacent the first region, which substantially
17 prevents passage of fluid between the exterior of the apparatus and the main body.

18

19 48. The apparatus as claimed in claim 47, wherein the second region is
20 adapted to be expanded into contact with a borehole wall.

21

22 49. A well completion method comprising the steps of:
23 providing an apparatus at a downhole location, the apparatus comprising a
24 main body and a swellable mantle over an opening on the main body;
25 expanding the swellable mantle by exposing it to a predetermined fluid; and
26 maintaining a fluid flow path in the swellable mantle using an insert in the
27 swellable mantle.

28

29 50. The method as claimed in claim 49 comprising the additional step of
30 moving a screen outwardly of the main body during expansion of the swellable mantle.

31

32 51. The method as claimed in claim 50 comprising the additional step of
33 expanding the swellable mantle without changing the surface area of the screen.

34

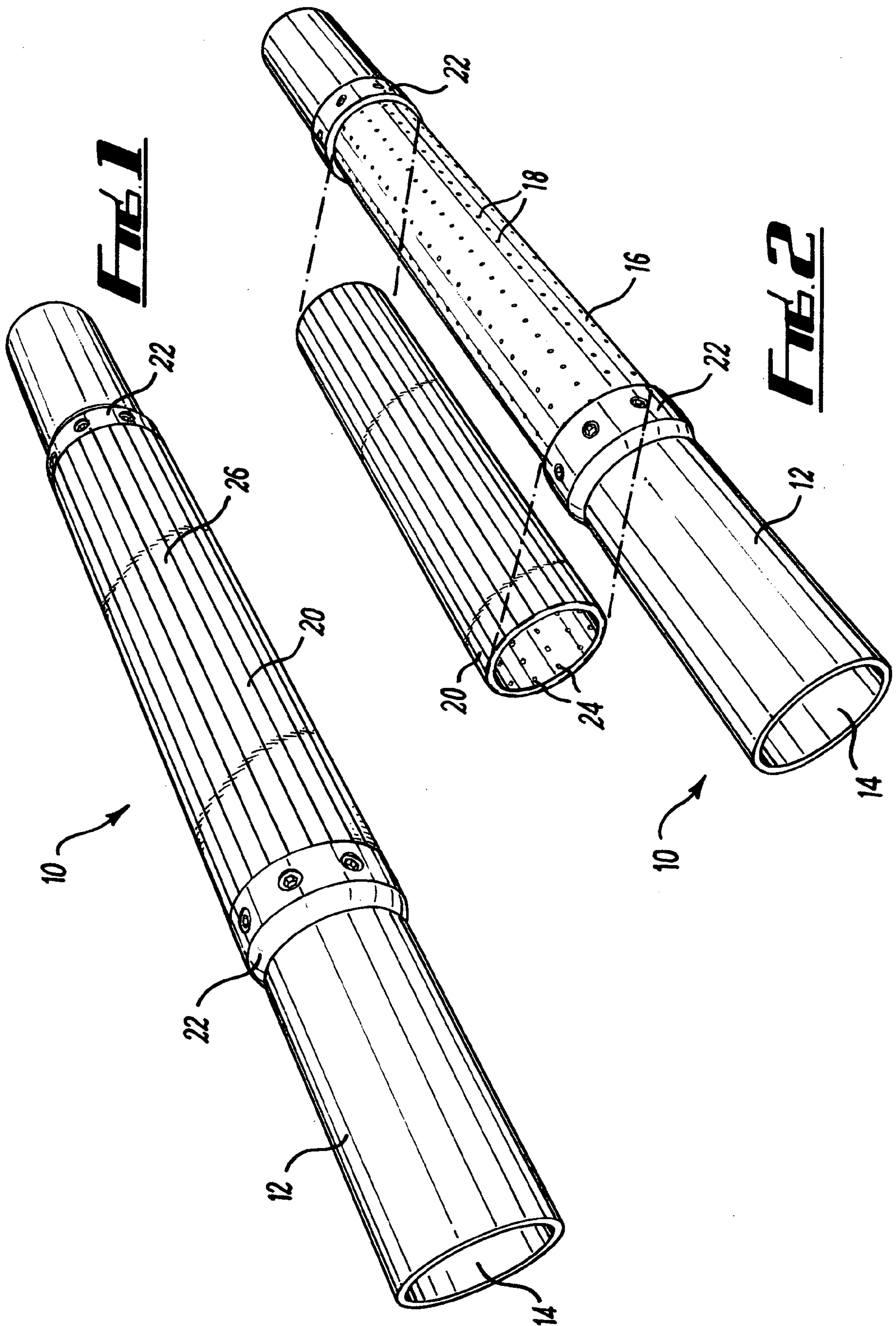
1 52. The method as claimed in claims 50 or 51, comprising the additional
2 step of expanding the swellable mantle such that the screen consists of a plurality of
3 discrete screen sections after expansion.

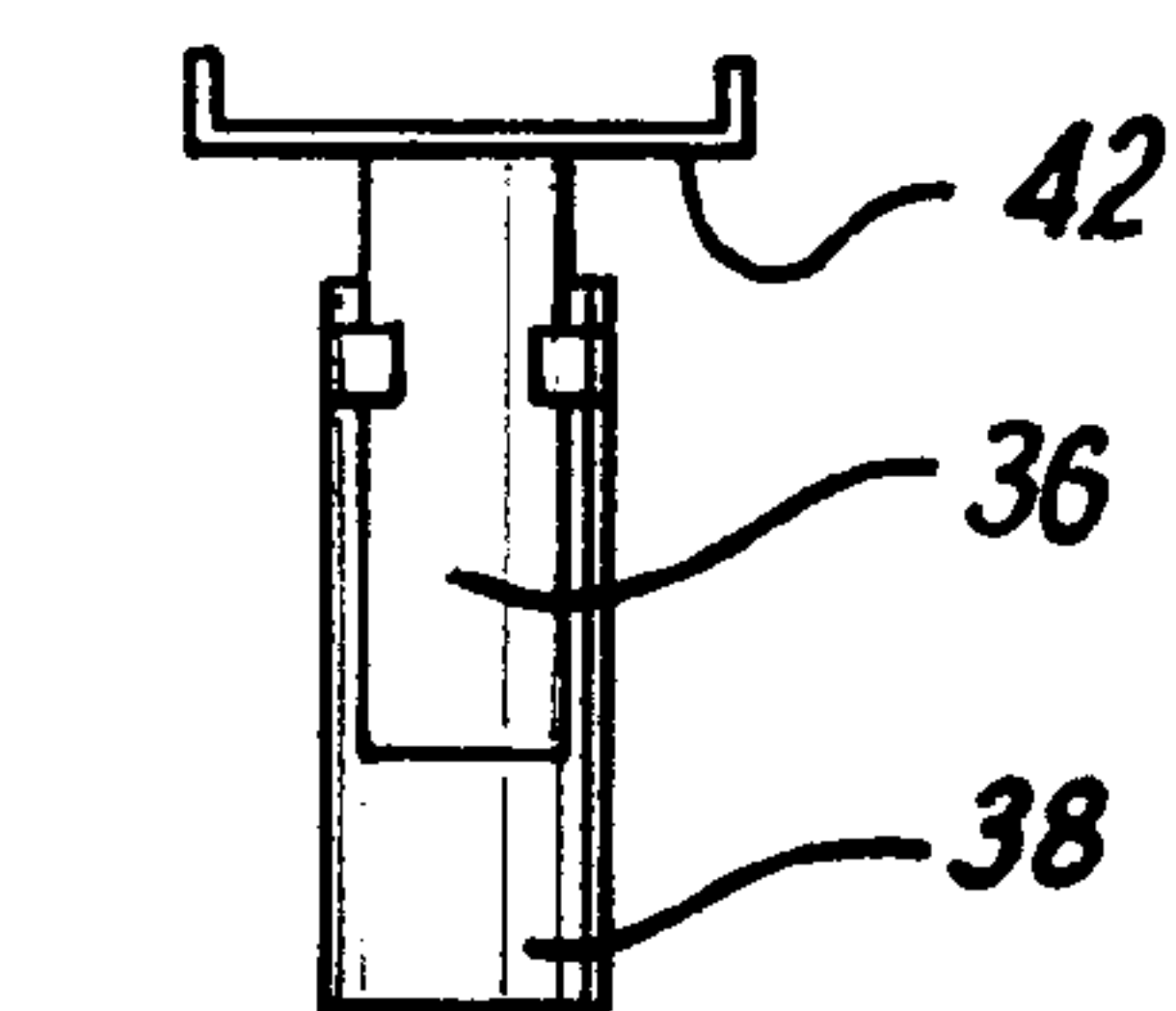
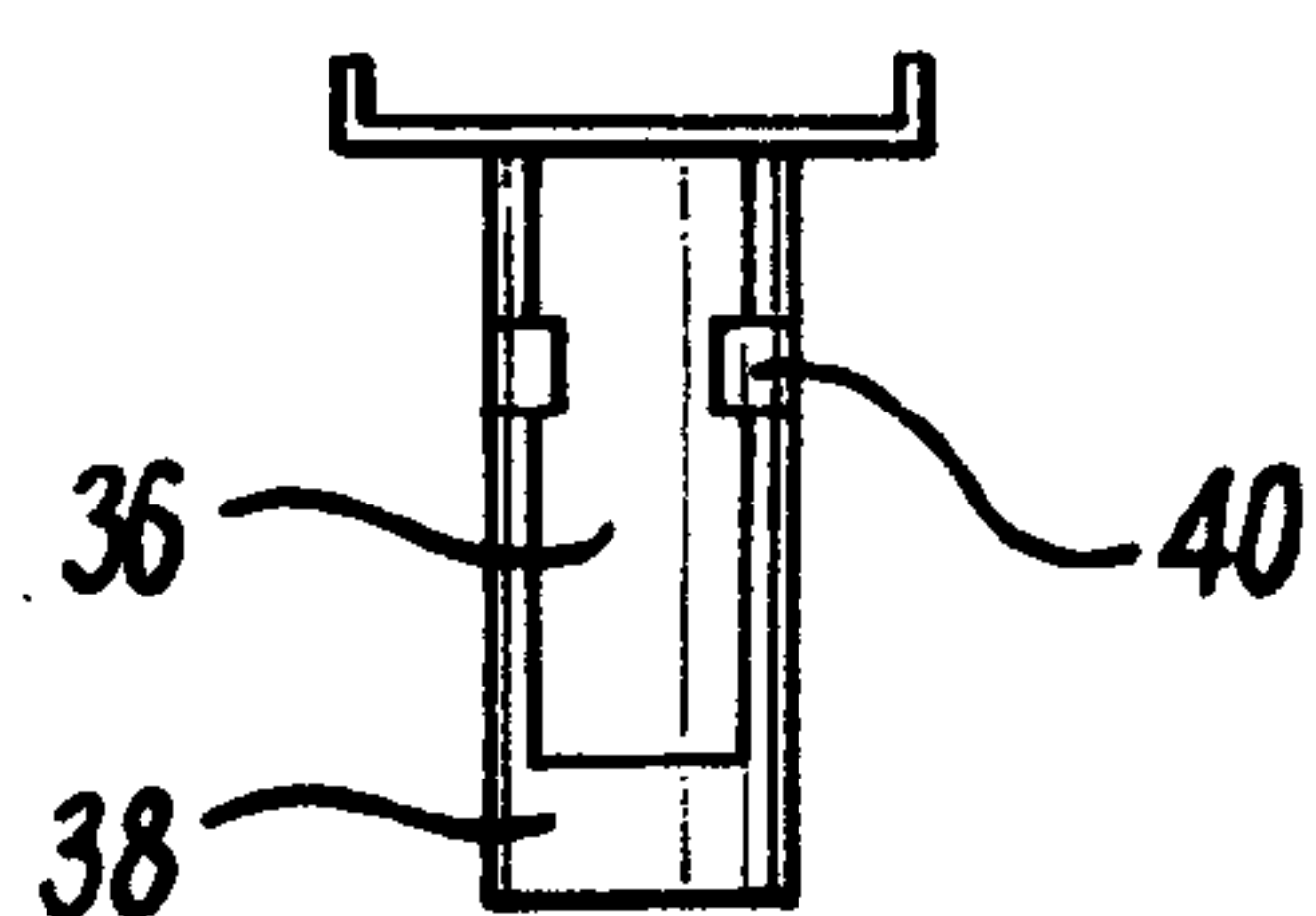
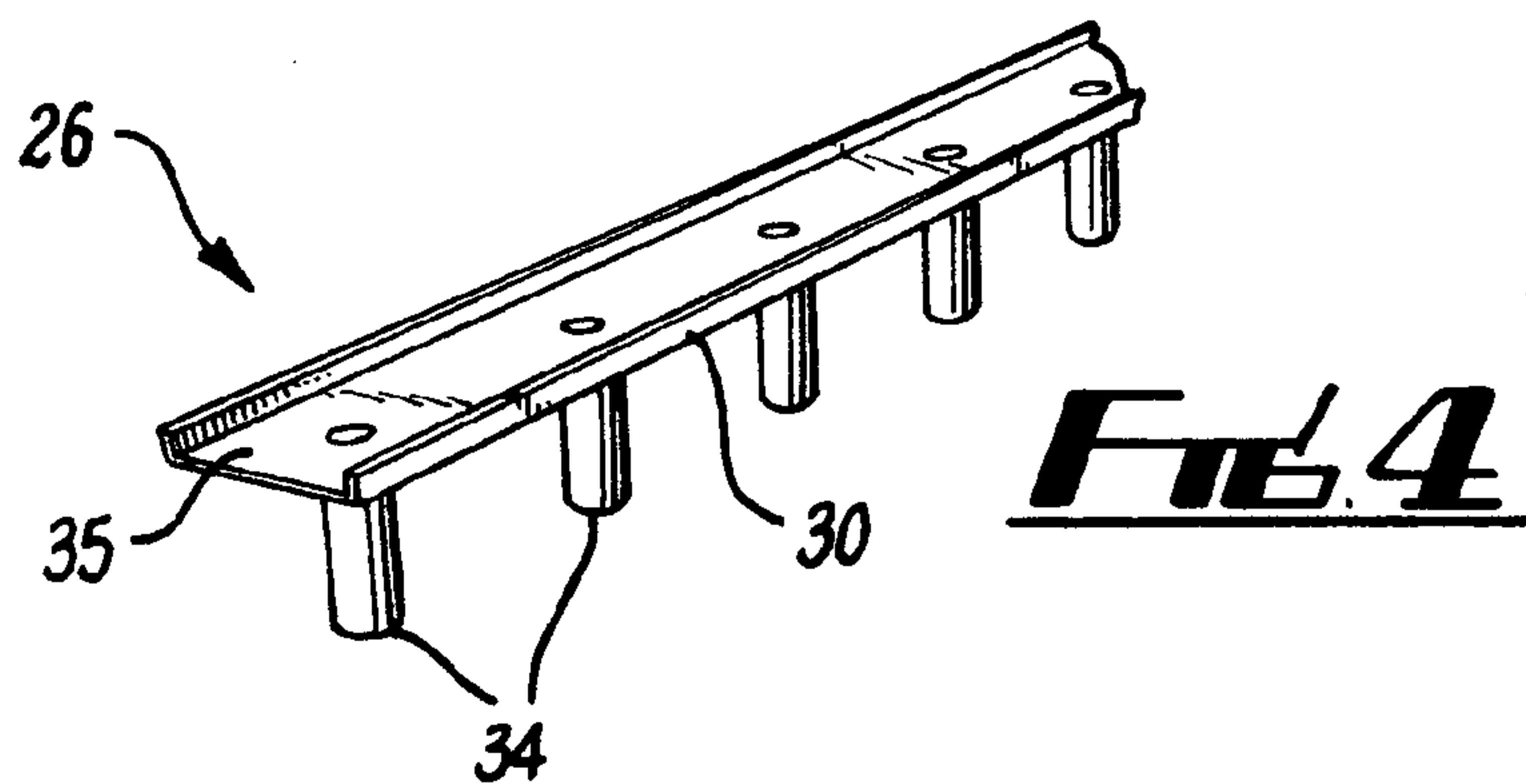
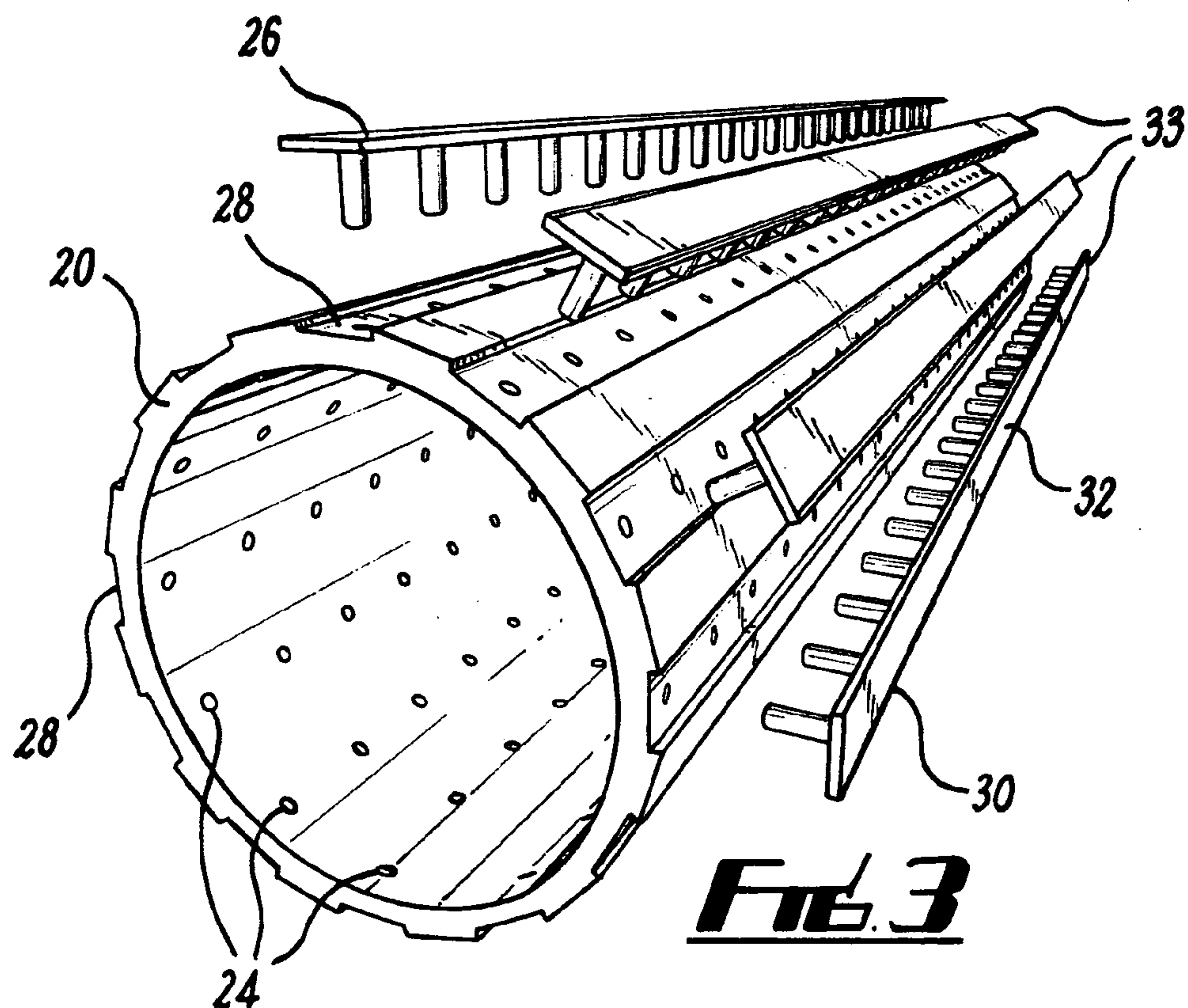
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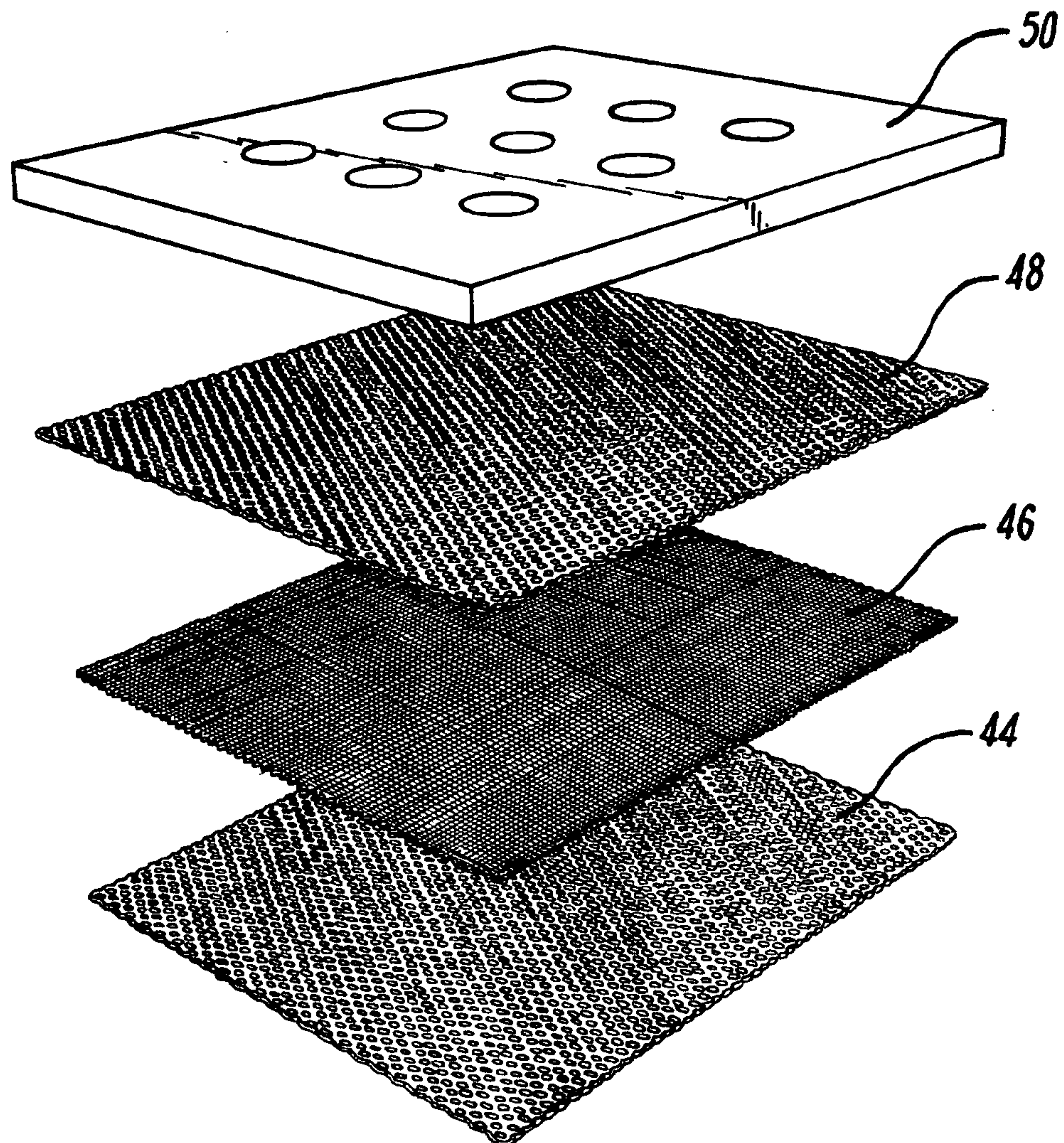
5 53. A hydrocarbon production method comprising the steps of:
6 providing a well completion by the method of any of claims 49 to 52, and;
7 allowing fluid to flow through the swellable mantle between an exterior of
8 the apparatus and the at least one opening in the main body.

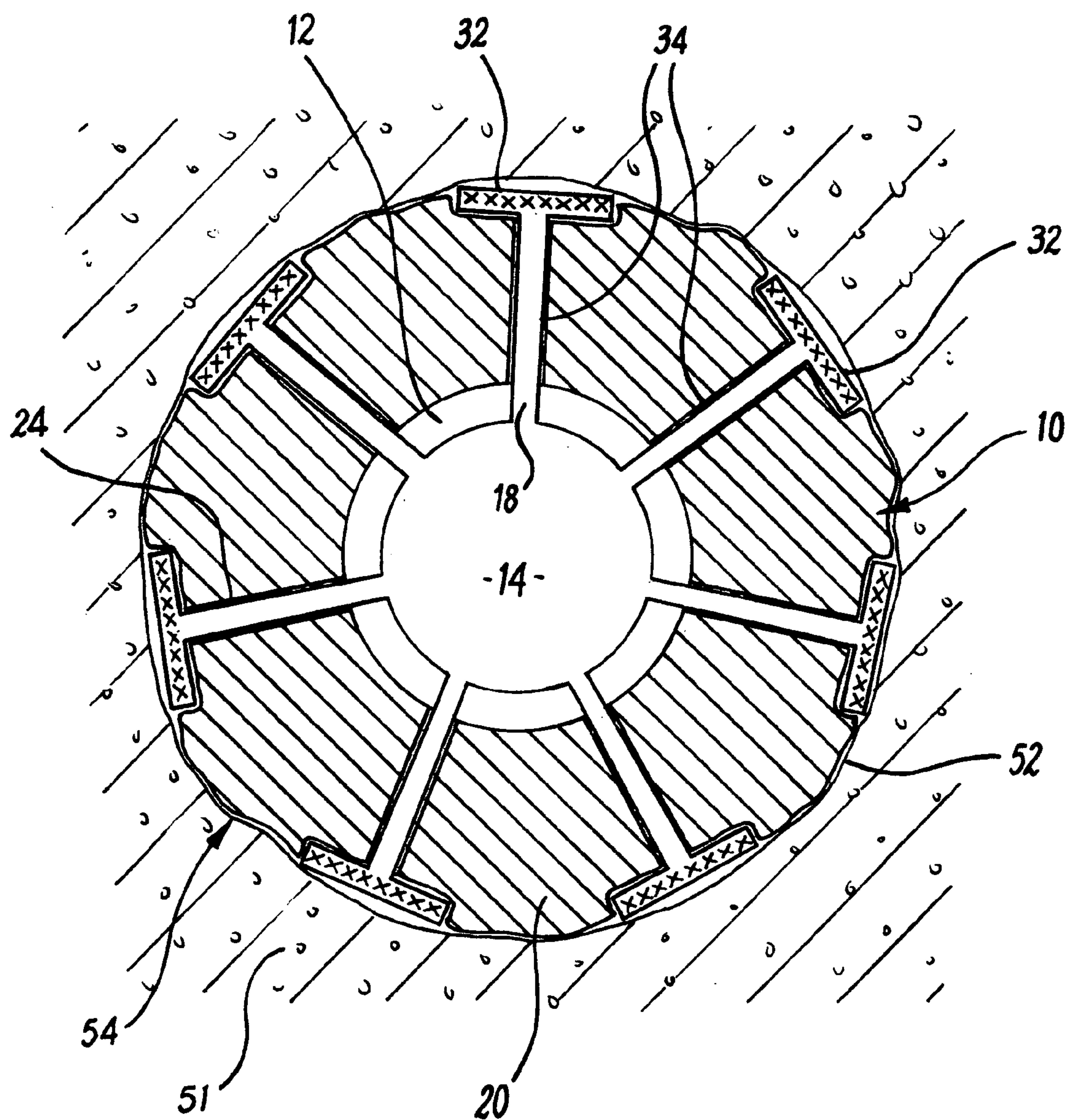
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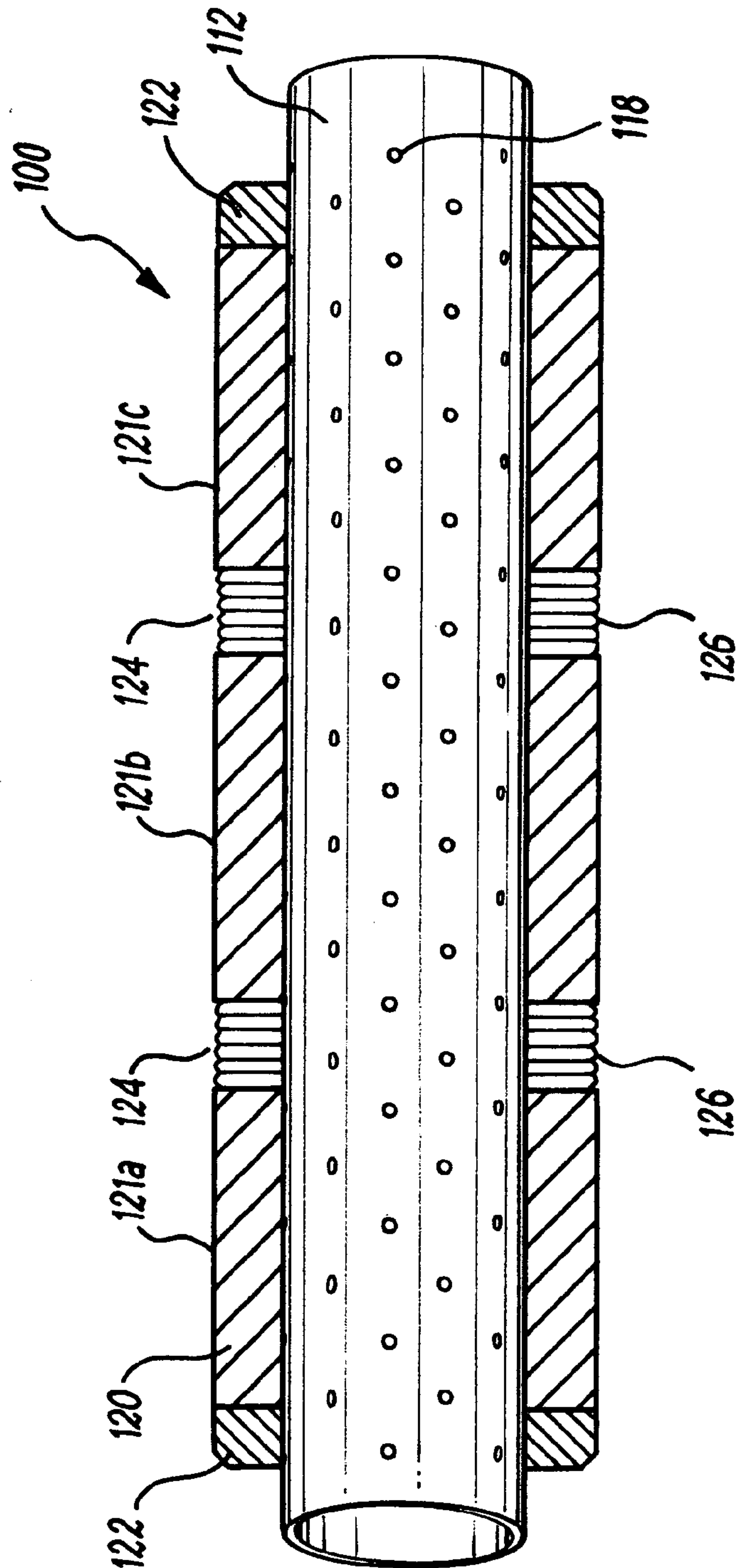
10 54. The method as claimed in claim 53 comprising the additional step of
11 receiving fluid from the formation into a production tubing to which the apparatus is
12 coupled.





**FIG. 6**

**FIG. 7**

**Fig. 8**

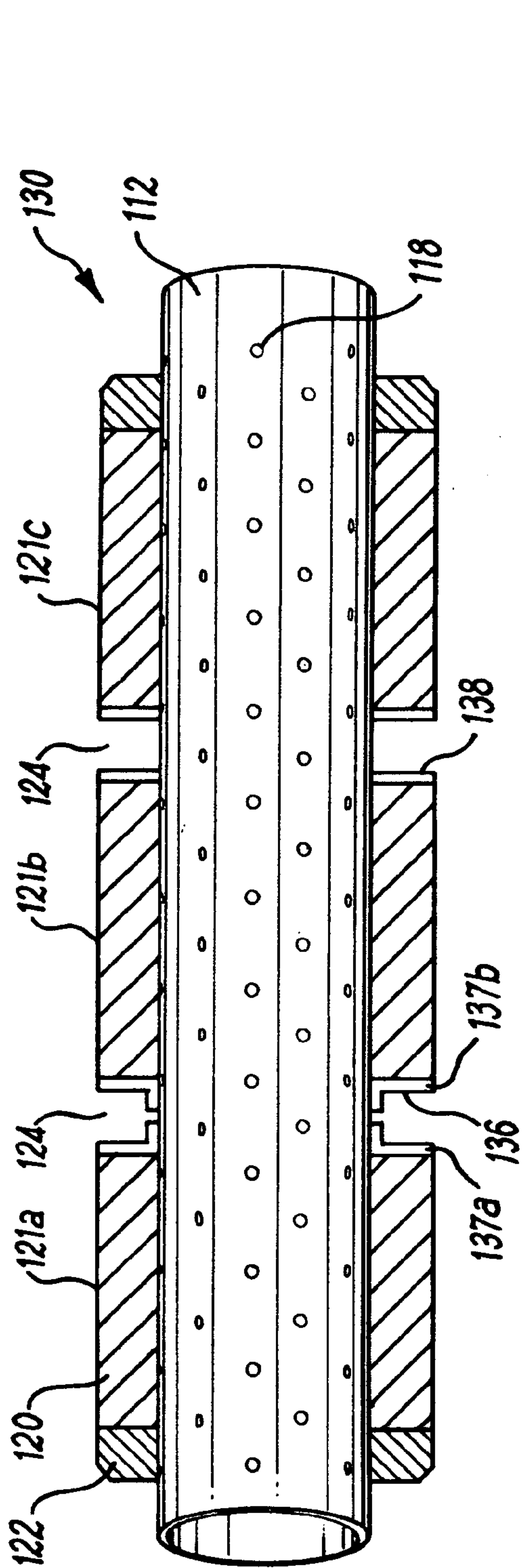


Fig. 9

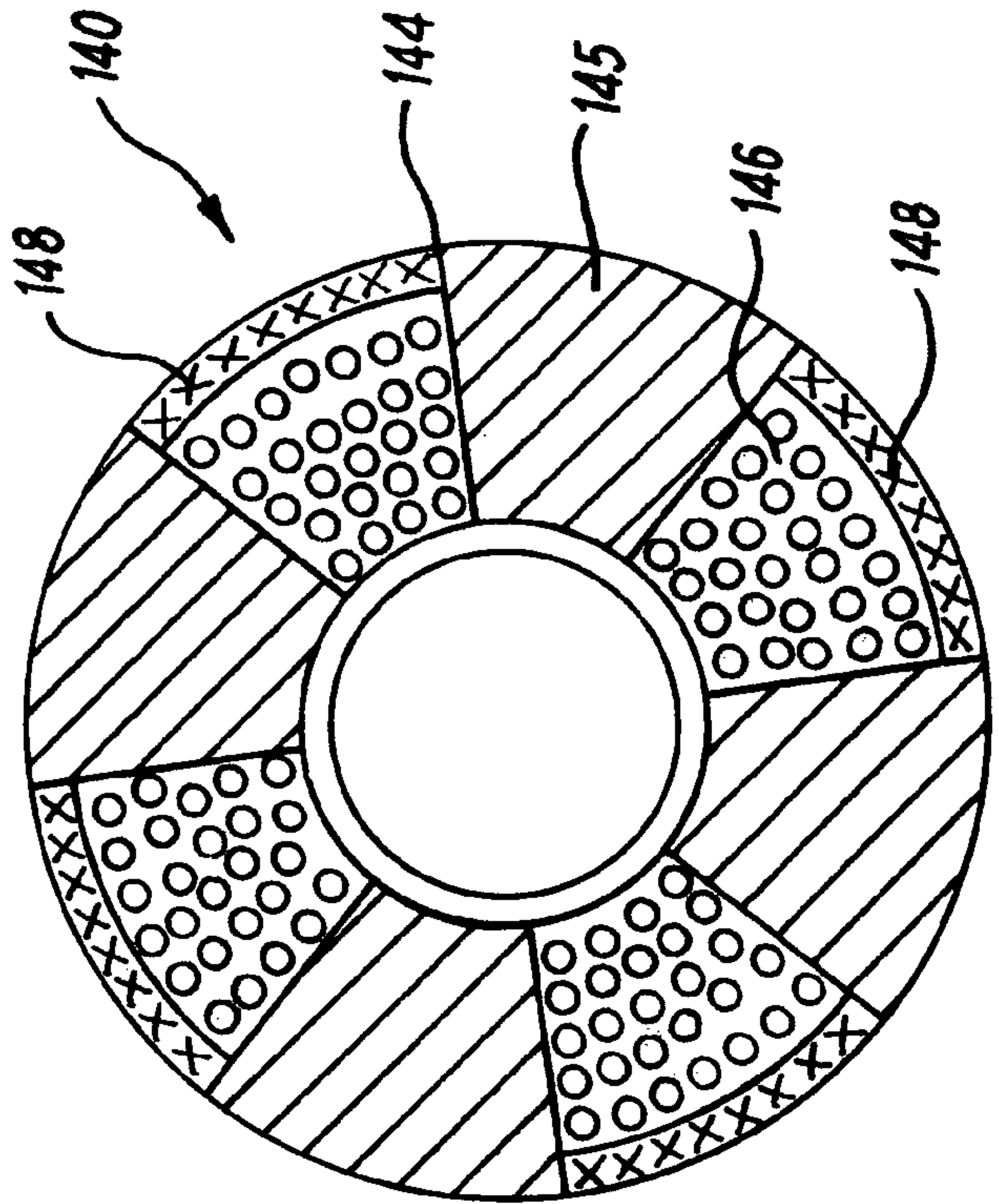
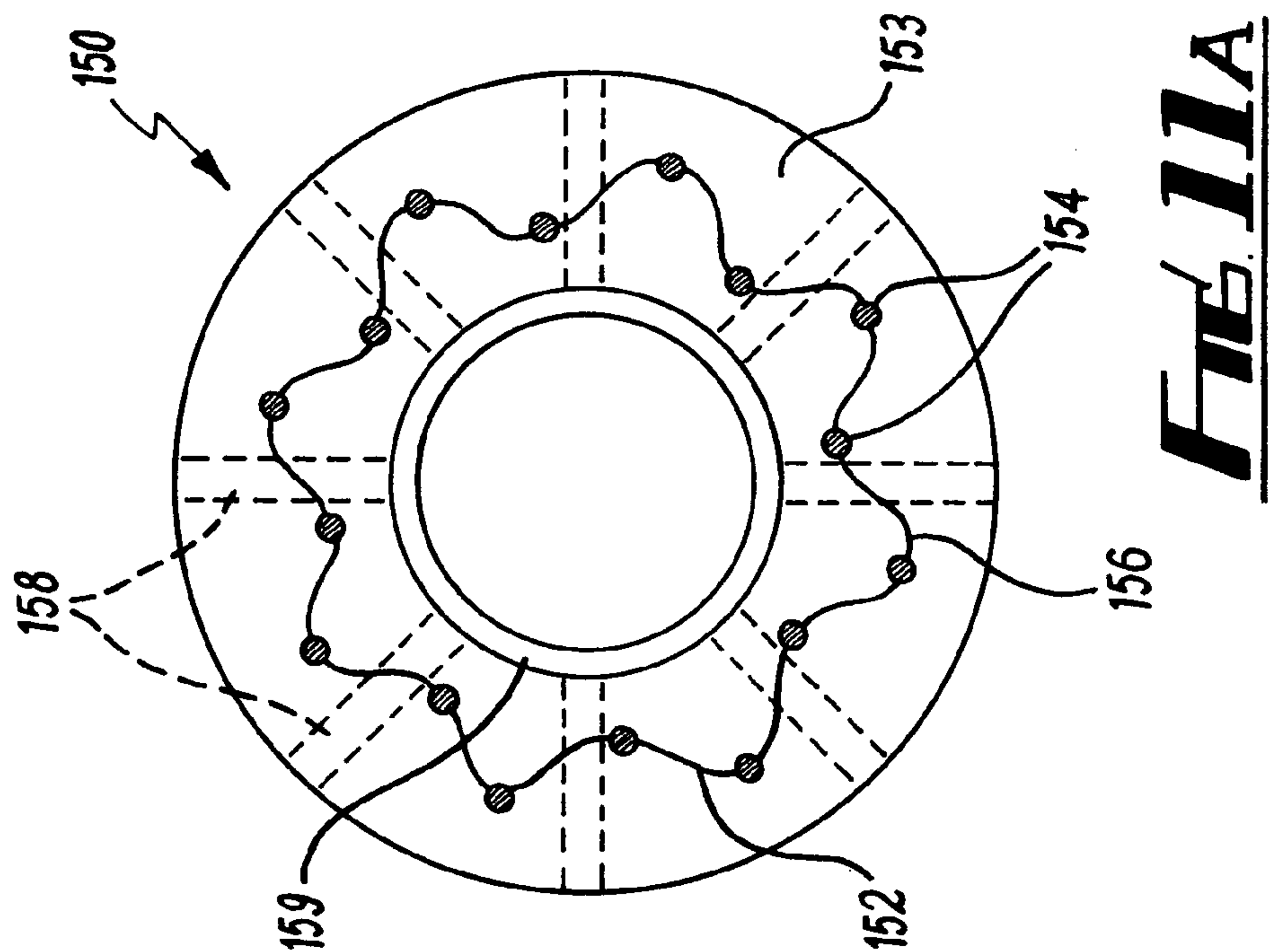
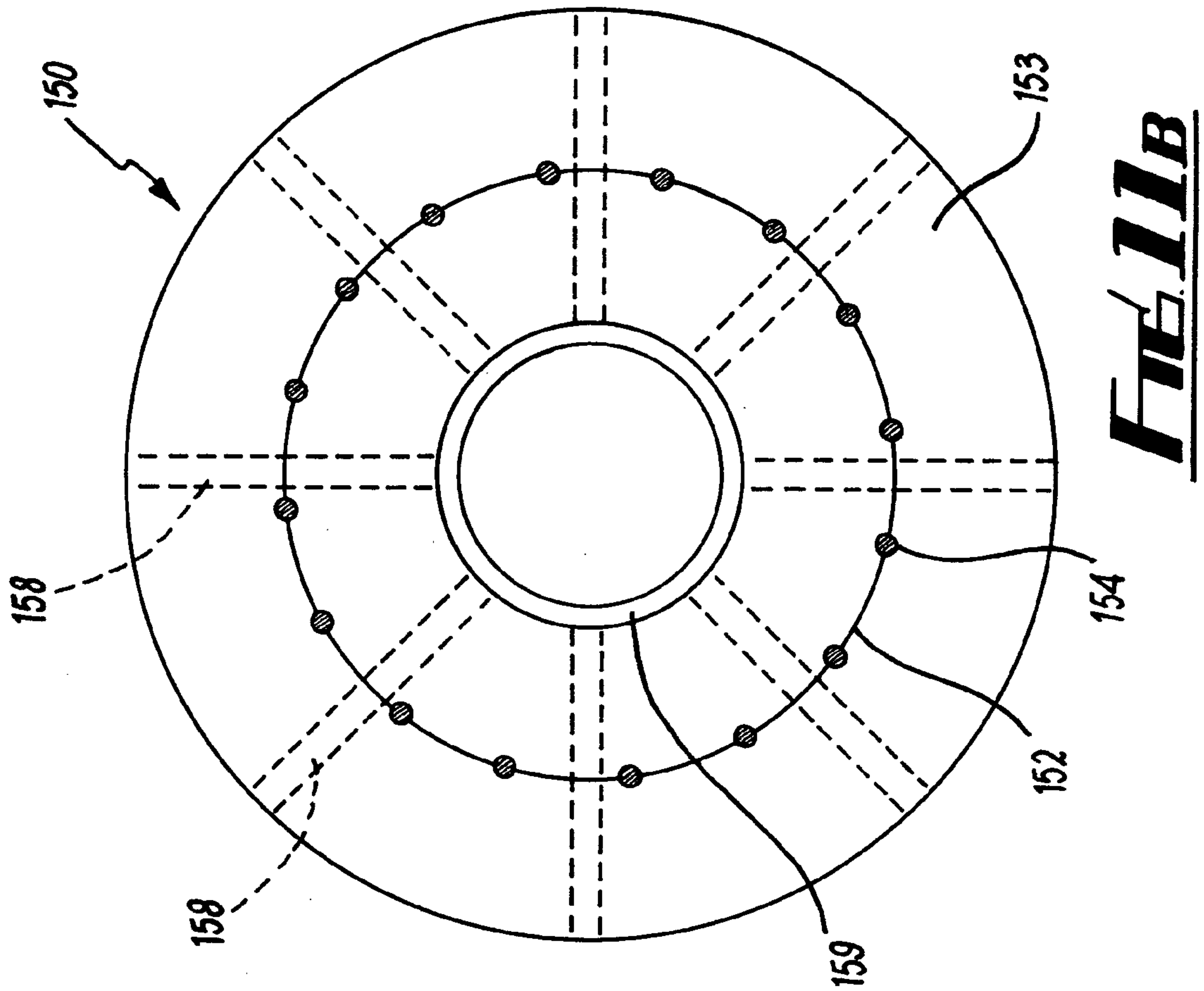


Fig. 10



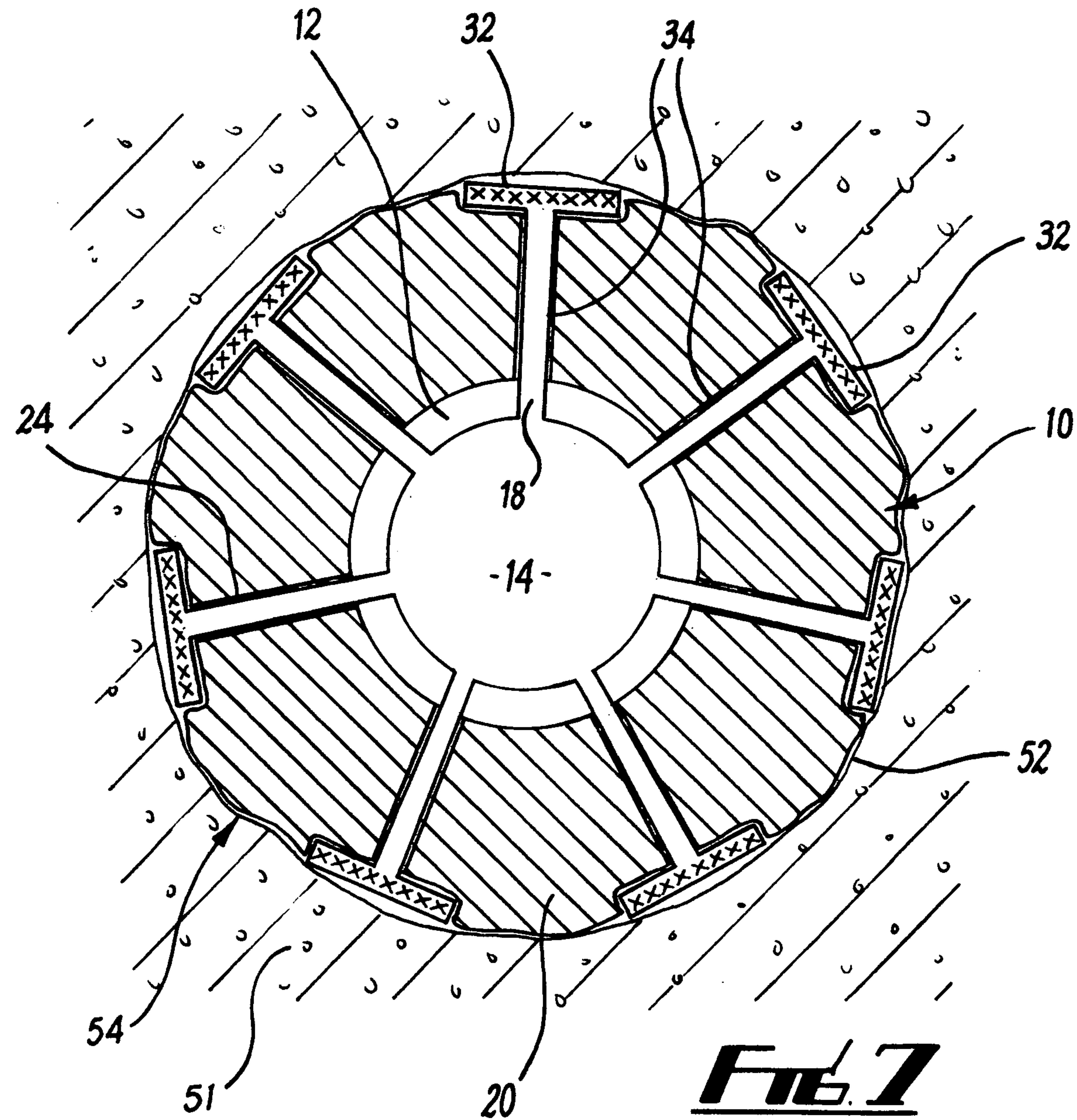


FIG. 7