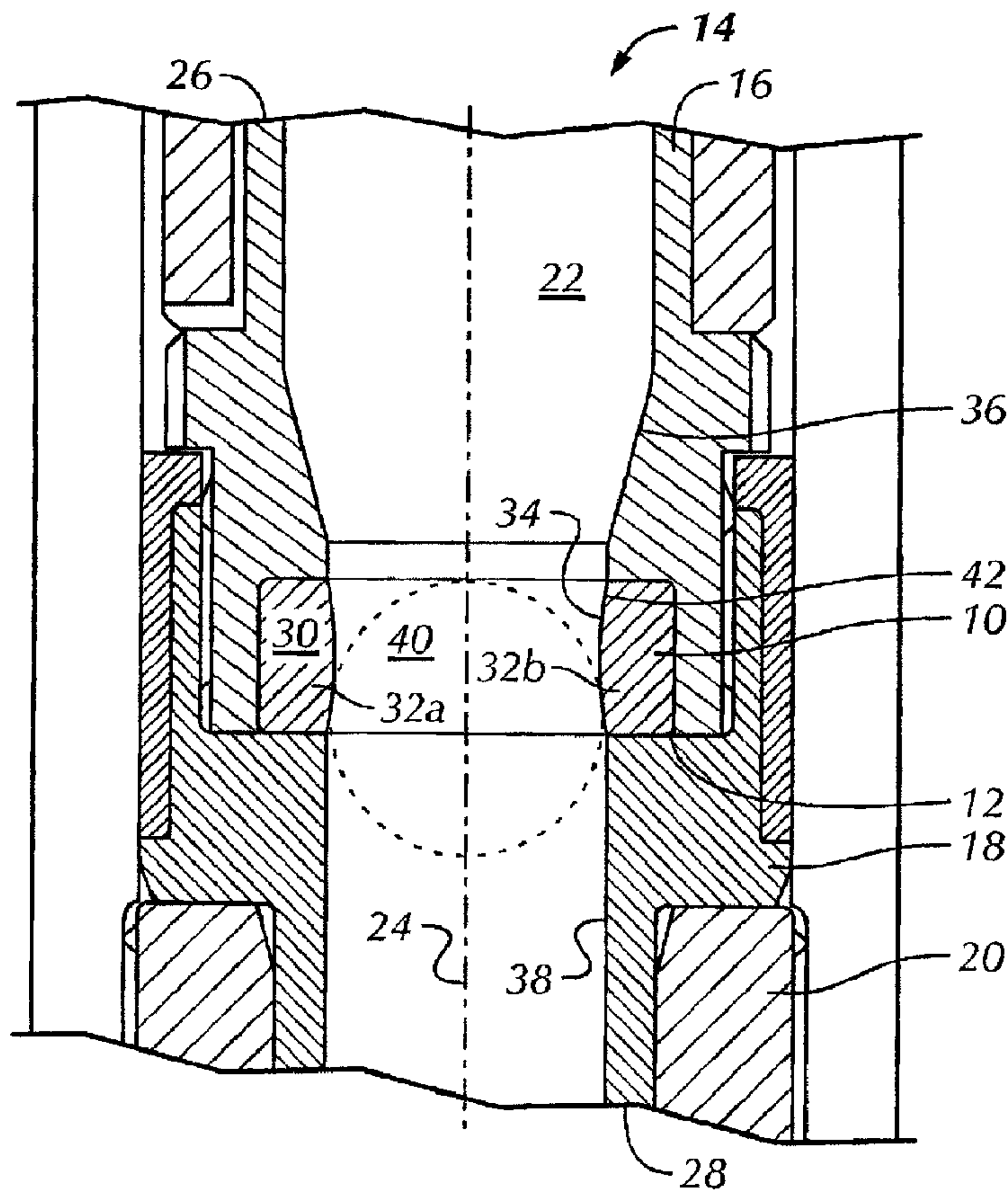




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(54) Titre : SIEGE DE SOUPAPE  
 (54) Title: VALVE SEAT



(57) Abrégé/Abstract:

A ball valve seat (10) is disclosed which provides a temporary seal for a plug (40). The valve seat comprises a substantially cylindrical body (30) of a first volume, which defines a seating surface (34). A pressure differential is developed across the valve



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

seat when the plug sealingly engages the seating surface. The body is formed of an elastic material which compresses from a first volume to a smaller second volume by application of a force on the plug, to provide a clearance which is greater than a plugging dimension of the plug, thus allowing passage of the plug downstream. After passage of the plug, the body returns to the first volume.

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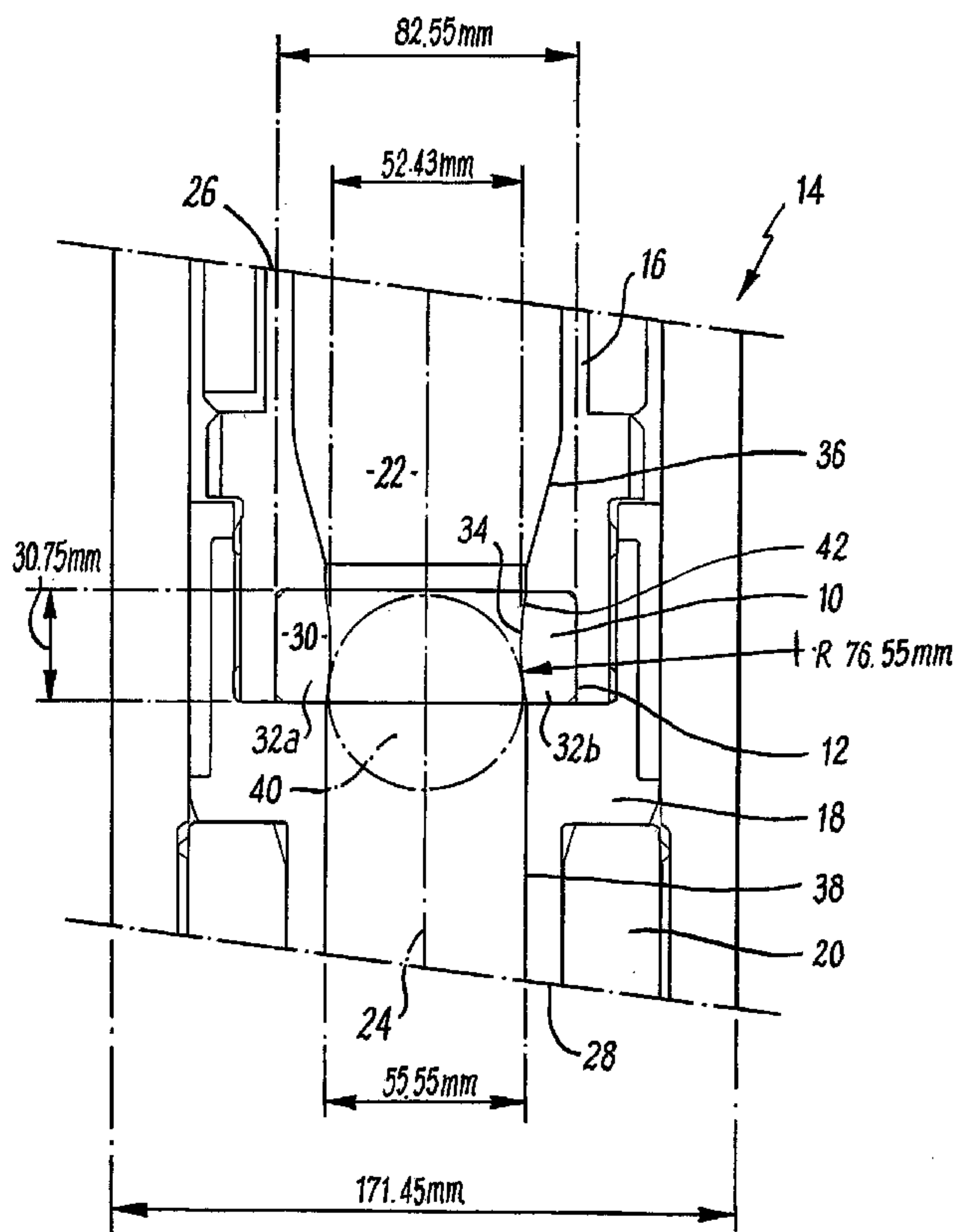
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(54) Title: VALVE SEAT



(57) Abstract: A ball valve seat (10) is disclosed which provides a temporary seal for a plug (40). The valve seat comprises a substantially cylindrical body (30) of a first volume, which defines a seating surface (34). A pressure differential is developed across the valve seat when the plug sealingly engages the seating surface. The body is formed of an elastic material which compresses from a first volume to a smaller second volume by application of a force on the plug, to provide a clearance which is greater than a plugging dimension of the plug, thus allowing passage of the plug downstream. After passage of the plug, the body returns to the first volume.

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1 Valve Seat

2

3 The present invention relates to valves used in downhole  
4 tools within the oil and gas industry and, in particular,  
5 a ball valve seat which provides a temporary seal for a  
6 travelling plug through the valve seat.

7

8 In the drilling, completion and production of oil and gas  
9 wells, downhole tools are mounted on a work string and  
10 run into a well bore to perform tasks or operations at  
11 locations within the well bore. A known method of  
12 getting the tool to perform the task at the required time  
13 and location, is to drop a plug, typically in the form of  
14 a ball, through the work string, to engage with and  
15 actuate the tool. Such plugs are carried with the fluid  
16 flow to the tool whereupon they encounter a valve seat  
17 and provide a sealed obstruction to the fluid flow path.

18

19 Commonly, shearable connectors, such as shear pins, are  
20 used in combination with the plug and valve seat to  
21 render the obstruction of a fluid flow path reversible.  
22 In practice, the plug sealingly engages the valve seat  
23 over a range of operating pressures. When a

1 predetermined fluid pressure threshold is exceeded, the  
2 pins shear, opening fluid paths around the combination of  
3 the plug and valve seat. A disadvantage of this approach  
4 is that the tool must be designed with bypass channels  
5 which open around the plug and valve seat when the pins  
6 shear. These designs are expensive to manufacture and the  
7 channels can become blocked with debris carried in the  
8 well bore fluid.

9  
10 A further disadvantage of these designs is that once the  
11 plug is seated, the central bore of the work string is  
12 permanently obstructed. This prevents the passage of  
13 other strings such as wireline through the work string.

14  
15 To overcome this problem various valves have been  
16 designed with the aim of temporarily holding the plug  
17 while the tool is actuated and then releasing the plug to  
18 travel further through the work string. Deformable balls  
19 have been used which deform over a pressure threshold to  
20 squeeze through the valve seat. A disadvantage of these  
21 deformable balls is that they are typically made of  
22 materials which can be susceptible to damage as the ball  
23 passes down the work string. If damaged they may not  
24 form a seal at the valve seat.

25  
26 Releasable valve seats have been proposed which rely on a  
27 collet to hold the ball temporarily. These seats can  
28 lack the effective seal between the ball and seat.

29  
30 Metal valve seats have also been proposed, for example in  
31 US5,146,992. This presents an aluminium valve seat which  
32 is adapted for receiving and temporarily sealingly  
33 engaging, a valve plug which is positionable within the

1 wellbore. The seat includes a sealing lip which is  
2 adapted for sealingly engaging the valve plug and for  
3 substantially occluding the passage of fluid from an  
4 upstream location to a downstream location, wherein a  
5 pressure differential developed across the valve seat and  
6 plug operates to deform the sealing lip and allow passage  
7 of the valve plug downstream within the fluid conduit,  
8 when a predetermined amount of force is applied thereto.

9

10 While this arrangement has the advantage of temporarily  
11 sealing at the valve and allowing the plug to be later  
12 released, the valve seat has a number of disadvantages.  
13 The main disadvantage is that once a plug has passed  
14 through the seat, the valve seat has been deformed,  
15 providing a wider clearance, so that a plug of similar or  
16 identical dimensions would not seat within the valve, but  
17 pass therethrough. This means that the valve seat can  
18 only be used once with a valve plug of a first dimension,  
19 and if a further occlusion of the fluid passage is  
20 required, each consecutive plug must have a greater  
21 plugging dimension. This requires the operator to be  
22 fully aware of the properties of the material used and  
23 how it will behave under pressure and temperature to  
24 provide a plug which will have sufficient dimensions to  
25 make an effective seal on the seat, whilst still being  
26 able to deform the valve seat at a required pressure  
27 differential.

28

29 A further disadvantage of this invention is that the  
30 deformation takes place primarily at a sealing lip, the  
31 sealing lip extending in the direction of fluid flow.  
32 There is therefore a cavity behind the sealing lip into  
33 which the sealing lip moves or deforms. Debris and other

1 deleterious material within the flow path can collect or  
2 gather behind the sealing lip. This will then restrict  
3 the amount of deformation that can take place, and thus a  
4 plug can become stuck within the valve seat, and the  
5 assembly will have to be removed from the well bore at  
6 substantial cost.

7

8 It is therefore an object of the present invention to  
9 provide a valve seat for use with a plug in a downhole  
10 tool which can be repeatably used for the temporary  
11 occlusion of fluid flow through the tool by the use of  
12 plugs having similar or identical plugging dimensions.

13

14 It is a further object of at least one embodiment of the  
15 present invention to provide a valve seat which is truly  
16 elastic, in that it deforms within its own volume when  
17 pressure is applied, and returns to its original shape on  
18 release of the pressure.

19

20 According to a first aspect of the present invention,  
21 there is provided a valve seat, adapted for receiving a  
22 plug having a plugging dimension, for use in a fluid  
23 conduit of a downhole tool having an inner wall disposed  
24 about a central longitudinal axis, said inner wall  
25 defining a central bore for passage of fluid from an  
26 upstream location to a downstream location, comprising:  
27 a substantially cylindrical body having a first bore  
28 therethrough defined by an inner surface of the body and  
29 the body being of a first volume;  
30 a first clearance through said body, defined by a portion  
31 of said inner surface, which is smaller than the plugging  
32 dimension;

1 a seating surface located upon the inner surface facing  
2 upstream for sealingly engaging with said plug and  
3 substantially occluding passage of said fluid from said  
4 upstream location to said downstream location;  
5 wherein a pressure differential is developed across said  
6 valve seat when said plug sealingly engages said seating  
7 surface, applying force to said seating surface;  
8 said body being formed of an elastic material which  
9 compresses to a second volume, smaller than said first  
10 volume, by application of said force to provide a second  
11 clearance to said body which is greater than the plugging  
12 dimension, and thus allows passage to said plug  
13 downstream within said fluid conduit; and  
14 wherein after passage of said plug, said body returns to  
15 said first volume with substantially said first  
16 clearance.

17

18 As the valve seat is elastic, it compresses under the  
19 force of the plug so that the outer dimensions of the  
20 body remain the same while the bore increases radially to  
21 provide sufficient clearance for the plug to pass through  
22 the seat. Further, as the valve seat returns to its same  
23 shape and volume after passage of the plug, an identical  
24 plug can be dropped and the process repeated an  
25 indeterminate number of times.

26

27 Preferably the elastic material is a polymer.

28

29 More preferably the elastic material is a thermoplastic  
30 polymer. Such thermoplastics include polyethylene and  
31 polypropylene.

32

1 The elastic material may be a thermoplastic  
2 polycondensate such as a polyamide or nylon.

3

4 The elastic material is preferably the thermoplastic  
5 polycondensate, polyetheretherketone (PEEK). Indeed,  
6 those skilled in the art will appreciate that materials  
7 which exhibit visco-elastic properties similar to  
8 polyetheretherketone would be acceptable.

9 Polyetheretherketone is also known under the trade names  
10 Arotone, Doctalex, Kadel, Mindel, PEEK, Santolite,  
11 Staver, Ultrapek and Zyex.

12

13 Preferably also the elastic material is a virgin  
14 material. Alternatively the elastic material may include  
15 an additive. The additive may be glass granules.  
16 Alternatively the additive may be a fibre filler, such as  
17 carbon. The additive may be in a quantity of  
18 approximately 10 to 30%.

19

20 Preferably said inner surface is arcuate with said  
21 central longitudinal axis. More preferably, said inner  
22 surface is convex to said central longitudinal axis.  
23 Preferably an apex of the convex defines the first  
24 clearance. Such an arcuate profile provides a venturi  
25 feature as the gentle angle, both in and out through the  
26 valve seat will cause the plug to be sucked into the seat  
27 via the Bernoulli effect. Thus, the inner surface  
28 provides a gradual decrease to the first clearance which  
29 is symmetrical to the central longitudinal axis.

30

31 Preferably the inner surface is continuous with the inner  
32 wall. This provides a non-turbulent fluid flow stream  
33 through the fluid conduit.

1

2 According to a second aspect of the present invention,  
3 there is provided a method of sealing a central bore of a  
4 downhole tool to temporarily prevent passage of fluid  
5 from an upstream location to a downstream location  
6 comprising:

7

- 8 (a) providing an elastic valve seat having a first  
9 volume and defining a seat clearance within said  
10 central bore;
- 11 (b) providing a first plug having a first plugging  
12 dimension, which exceeds said seat clearance of  
13 said elastic valve seat;
- 14 (c) seating said first plug against said elastic valve  
15 seat;
- 16 (d) developing, with said fluid, a differential  
17 pressure across said elastic valve seat; and
- 18 (e) compressing said elastic valve seat at a pre-  
19 selected pressure differential level to a second  
20 volume, smaller than said first volume, to provide  
21 a clearance greater than the seat clearance and  
22 allow passage of said first plug through said  
23 elastic valve seat, wherein said elastic valve seat  
24 returns to its first volume upon clearance of the  
25 first plug.

26

27 Preferably the method of sealing further comprises the  
28 steps of:

- 29 (f) providing at least one additional plug, which  
30 together with said first plug constitutes a  
31 plurality of plugs having substantially similar  
32 plugging dimensions;

- 1 (g) successively seating said plurality of plugs  
2 against said elastic valve seat;
- 3 (h) successively developing, with said fluid, the same  
4 pressure differential across said elastic valve  
5 seat; and
- 6 (i) successively compressing said elastic valve seat at  
7 the pre-selected pressure differential level to  
8 provide clearance for said plurality of valve plugs  
9 to pass through said elastic seat and return the  
10 valve seat to its first volume between successive  
11 seatings.

12

13 Advantageously, the method includes the step of sucking  
14 said plug towards said valve seat, as said plug  
15 approaches said valve seat.

16

17 An embodiment of the present invention will now be  
18 described, by way of example only, with reference to the  
19 accompanying Figure.

20

21 Figure 1 is a longitudinal section view through a portion  
22 of a downhole tool, as would be used in the oil and gas  
23 industry. The valve seat 10 is located within a recess  
24 12 made from parts, generally indicated 14, of the  
25 downhole tool. Parts 14 comprise an upper section 16,  
26 mid section 18 and a lower section 20. Sections 16, 18,  
27 20 are provided for assembly purposes of the tool, and  
28 will all move together as the seat 10 moves through the  
29 central bore 22.

30

31 The central bore 22 is located on a longitudinal axis 24  
32 running symmetrically through the tool parts 14. The  
33 central bore 22 provides a fluid conduit from upstream to

1 downstream, upstream being located towards the upper end  
2 26 of the tool parts 14, and downstream being located  
3 towards and extending from the lower end 28 of the tool  
4 parts 14.

5  
6 Recess 12 provides a substantially annular recess having  
7 a rectangular cross-section in the central bore 22. The  
8 recess 12 is made from the upper part 16 and mid part 18  
9 of the tool parts 14. Located as a tight fit within the  
10 recess 12 is the valve seat 10.

11  
12 The valve seat 10 comprises a unitary annular body 30  
13 being donut or ring shaped. In cross-section, as shown in  
14 the figure, it provides two opposite identical faces  
15 being mirror images. Each face 32 a,b comprises  
16 substantially planar upper and lower surfaces. A  
17 substantially cylindrical outer surface abuts the recess  
18 base. An inner surface 34 faces the central bore 22.  
19 Inner surface 34 is substantially cylindrical with an  
20 arcuate profile on the longitudinal axis 24. The profile  
21 is made from a radius or arc with an apex or rise at a  
22 midpoint over the surface 34. As illustrated, the body  
23 30 defines a first volume.

24  
25 The seat 10 is formed of polyetheretherketone, commonly  
26 referred to as PEEK. PEEK is a semi-crystalline polymer  
27 and falls within the class of thermoplastic  
28 polycondensates. This material goes under the trade names  
29 of PEEK, Arotone, Doctalex, Kadel, Mindel, Santolite,  
30 Staver, Ultrapek and Zyex. PEEK has a high tensile and  
31 flexural strength, high impact strength and a high  
32 fatigue limit. Additionally it has a high heat  
33 distortion temperature, high chemical resistance and high

1 radiation resistance. It further has good electrical  
2 properties, good slip and wear characteristics and low  
3 flammability. The material can be injection moulded and  
4 may be formed with approximately a 10 to 30% addition of  
5 glass granules. The addition of glass to PEEK increases  
6 its flexural modulus.

7

8 It is the visco-elastic properties of this material that  
9 make it suitable, in that it can be compressed repeatedly  
10 and will always return to its original volume and  
11 dimensions.

12

13 The typical mechanical properties of PEEK are:

14

15 Tensile stress at yield, at break	92 N/mm <sup>2</sup>
16 Tensile modulus of elasticity	3,600 N/mm <sup>2</sup>
17 Flexural modulus	5 to 25 Gpa over -100 to 150°C

18

19 Those skilled in the art will appreciate that other  
20 materials may be used for the formation of the valve  
21 seat, providing they have visco-elastic properties which  
22 are around those found in PEEK. It is likely that these  
23 will come from polymers, e.g., polyamide (nylon),  
24 polyethylene, polypropylene and elastomers.

25

26 In use, the single piece valve seat 10 is located in a  
27 downhole tool between mating parts 16, 18. Preferably  
28 the seat 10 is located within a recess 12, such that the  
29 inner surface 34 aligns with the inner surfaces 36,38 of  
30 the central bore 22 both above and below the seat 10.  
31 The surfaces 36,38, together with the inner surface 34,  
32 are provided with gentle angles and slopes, such that

1 they provide a non-turbulent flow of fluid through the  
2 central bore 22.

3

4 As it is located in the tool, the valve seat 10 is  
5 positioned within a wellbore in a work string in which  
6 the tool is situated. The material of the seat 10 is  
7 non-erodable, thus chemicals and other flushing  
8 materials, such as muds, can be pumped through the bore  
9 22 without damage to the seat 10. Further, as the seat  
10 is formed of a relative soft material, it will not catch  
11 on any wireline or other tool inserted through the bore  
12 22.

13

14 When a plug in the form of a ball 40 is released through  
15 the work string, it will travel in the fluid through the  
16 central bore 22. The ball 40 is sized to have a  
17 dimension or diameter greater than the clearance through  
18 the seat 10 at the inner wall 34. In this way, as the  
19 ball 40 travels through the bore 22 it will come to rest  
20 upon the seat 10. This mating occurs at the upper edge  
21 of the seat 10 against a surface 42. The surface 42 may  
22 be referred to as a seating or sealing surface, as a seal  
23 is formed due to the circumferential match of the ball  
24 and the valve seat 10, as they come together. The ball  
25 40 is then seated in the valve seat 10.

26

27 Due the arcuate profile of the surface 42 on the inner  
28 surface 34, the ball 40 will be sucked towards the seat  
29 10, as it moves towards the seat due to the Bernoulli  
30 effect. This prevents the ball from chattering or  
31 otherwise travelling back up the bore 22. Such phenomena  
32 exists if the ball 40 may be made of a light weight  
33 material and the fluid pressure through the bore 22 is

1 insufficient to carry the ball with sufficient force to  
2 the seat. Additionally, the action of sucking the ball  
3 40 towards the seat 10 assists in tools which are located  
4 in horizontal or deviated wells where gravity is not  
5 available to assist passage of the ball 40.

6

7 With the ball 40 on the sealing surface 42 of the seat  
8 10, fluid flow from upstream to downstream through the  
9 bore 22 is prevented. As fluid is pumped towards the  
10 ball 40 from upstream, a pressure differential will occur  
11 across the valve seat 10. The force upon the ball 40  
12 will be translated to a force on to the sealing surface  
13 42 and to the body 30. This force will begin to compress  
14 the material of the seat 10. Compression will move the  
15 inner surface 34 radially into its own body 30. The body  
16 30 does not yield, expand, extrude or deform. This is  
17 not required as the material of the seat itself will  
18 compress into a smaller volume as the ball 40 pushes its  
19 way through the seat 10. This is evidenced by the fact  
20 that the recess 12 is of substantially the same  
21 dimensions as the body 30, so that there is no room for  
22 the body to yield, extrude or deform by expanding out of  
23 the central bore 22. As the seat 10 is compressed, the  
24 clearance through the seat 10 will increase until it has  
25 the same dimensions of the ball 40, whereupon the ball 40  
26 will pass through the seat. Pressure upon the ball will  
27 now force the ball 40 through the remainder of the bore  
28 22 and a drop in the pressure differential will be noted  
29 at the well surface as fluid flow is restored through the  
30 bore 22.

31

32 For the period of time that the ball is located on the  
33 sealing surface 42 and fluid is occluded through the bore

1 22, the additional pressure differential not only forces  
2 the ball 40 through the seat 10, it will also have the  
3 effect of forcing everything in line with this surface 42  
4 downstream. In the embodiment shown, it will mean that  
5 the parts 16, 18 and 20 will be forced relatively  
6 downstream with respect to the work string to which the  
7 tool is attached. This movement of the parts causes  
8 actuation of the tool. On release of the ball through  
9 the valve seat 10, if springs are located in the tool,  
10 these may reposition the parts 16, 18, 20 on release of  
11 the ball. Thus the tool is both actuated and returned to  
12 its initial configuration by the passage of a single ball  
13 through the valve seat.

14

15 As an example embodiment, a valve seat being provided  
16 with an outer diameter of 82.55mm, a depth of 30.75mm, an  
17 arcuate profile radius of 76.55mm and a clearance at the  
18 input and output faces of 55.55mm will operate with a  
19 steel drop ball having a diameter of 52.43mm.

20

21 The principle advantage of the present invention is that  
22 it provides a ball valve seat which can be used a  
23 multiple number of times to temporarily halt the passage  
24 of a ball through the valve seat, the valve seat being  
25 self-healing and returning to its original dimensions  
26 after the passage of each ball. This allows the  
27 repetitive deployment of identical drop balls through a  
28 downhole tool to actuate the tool any chosen number of  
29 times.

30

31 A further advantage of the present invention is that the  
32 valve seat is shaped to provide a venturi effect as a  
33 plug or drop ball reaches the valve seat. This

1 effectively sucks the ball into the seat, providing a  
2 firm seating to the ball.

3

4 Various modifications may be made to the invention herein  
5 described without departing from the scope thereof. For  
6 example, as discussed, any suitable material having  
7 visco-elastic properties which exhibit the compressible  
8 feature required of the invention could be used.

9 Further, the relative dimensions of the valve seat may be  
10 altered to suit the size of drop ball required, and the  
11 degree of space available to provide a recess. Further,  
12 the radius of the arcuate surface of the seat within the  
13 bore can be selected to provide a required pressure  
14 differential level at which the tool will activate.

**Claims:**

1. A downhole tool for attachment to a work string, the downhole tool having an inner wall disposed above a central longitudinal axis, the inner wall defining a central bore for passage of fluid from an upstream location to a downstream location; the  
5 downhole tool also having a valve seat, adapted for receiving a plug having a plugging dimension, for use in the central bore of the downhole tool, wherein the valve seat comprises:
  - a substantially cylindrical body having a first bore therethrough defined by an  
10 inner surface of the body and the body being of a first volume;
    - a first clearance through said body, defined by a portion of said inner surface, which is smaller than the plugging dimension;
    - a seating surface located upon the inner surface facing upstream for sealingly engaging with said plug and substantially occluding passage of said fluid from said  
15 upstream location to said downstream location;
      - wherein a pressure differential is developed across said valve seat when said plug sealingly engages said seating surface, applying force to said seating surface;
      - said body being formed of an elastic material which compresses to a second volume, smaller than said first volume, by application of said force to provide a second  
20 clearance to said body which is greater than the plugging dimension, and thus allows passage of said plug downstream within said fluid conduit;
        - wherein after passage of said plug, said body returns to said first volume with substantially said first clearance; and
        - wherein the central bore of the downhole tool has an open upper end for receiving  
25 the plug.
2. A downhole tool as claimed in claim 1, wherein the elastic material is a polymer.
3. A downhole tool as claimed in claim 2, wherein the elastic material is a  
30 thermoplastic polymer.

4. A downhole tool as claimed in claim 3, wherein the elastic material is selected from the group consisting of polyethylene and polypropylene.
- 5 5. A downhole tool as claimed in claim 1, wherein the elastic material is a thermoplastic polycondensate.
6. A downhole tool as claimed in claim 5, wherein the elastic material is selected from the group consisting of polyamide and nylon.
- 10 7. A downhole tool as claimed in claim 5, wherein the thermoplastic polycondensate is polyetheretherketone (PEEK).
8. A downhole tool as claimed in any one of claims 1 to 7, wherein the elastic  
15 material is a virgin material.
9. A downhole tool as claimed in any one of claims 1 to 7, wherein the elastic material includes an additive.
- 20 10. A downhole tool as claimed in claim 9, wherein the additive is glass granules.
11. A downhole tool as claimed in claim 9, wherein the additive is a fibre filler.
12. A downhole tool as claimed in claim 9, 10 or 11, wherein the additive is in a  
25 quantity of approximately 10 to 30 wt%.
13. A downhole tool as claimed in any one of claims 1 to 12, wherein said inner surface is arcuate with respect to said central longitudinal axis.
- 30 14. A downhole tool as claimed in claim 13, wherein said inner surface is convex to said central longitudinal axis.

15. A downhole tool as claimed in claim 14, wherein an apex of the convex inner surface defines the first clearance.

5 16. A downhole tool as claimed in claim 13, wherein the arcuate profile provides a venturi feature adapted to cause the plug to be sucked into the seat via the Bernoulli effect.

10 17. A downhole tool as claimed in claim 16, wherein the inner surface provides a gradual decrease to the first clearance, which is symmetrical to the central longitudinal axis.

18. A downhole tool as claimed in any one of claims 1 to 17, wherein the inner surface is continuous with the inner wall.

15

19. A method of sealing a central bore of a downhole tool to temporarily prevent passage of fluid from an upstream location to a downstream location comprising:  
providing an elastic valve seat within said central bore, the elastic valve seat having a first volume and defining a seat clearance and the central bore having an open upper end  
20 for receiving a first plug;  
providing the first plug having a first plugging dimension, which exceeds said seat clearance of said elastic valve seat;  
seating said first plug against said elastic valve seat;  
developing, with said fluid, a differential pressure across said elastic valve seat; and  
25 compressing said elastic valve seat at a pre-selected pressure differential level to a second volume, smaller than said first volume, to provide a clearance greater than the seat clearance and allow passage of said first plug through said elastic valve seat, wherein said elastic valve seat returns to its first volume upon clearance of the first plug.

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20. A method as claimed in claim 19, further comprising the steps of:  
providing at least one additional plug, which together with said first plug constitutes a  
plurality of plugs having substantially similar plugging dimensions;
- 5 successively seating said plurality of plugs against said elastic valve seat;  
successively developing, with said fluid, the same pressure differential across said elastic  
valve seat; and  
successively compressing said elastic valve seat at the pre-selected pressure differential  
level to provide clearance for said plurality of valve plugs to pass through said elastic seat
- 10 and return the valve seat to its first volume between successive seatings.
21. A method as claimed in claim 19, including the step of sucking said plug towards  
said valve seat, as said plug approaches said valve seat.

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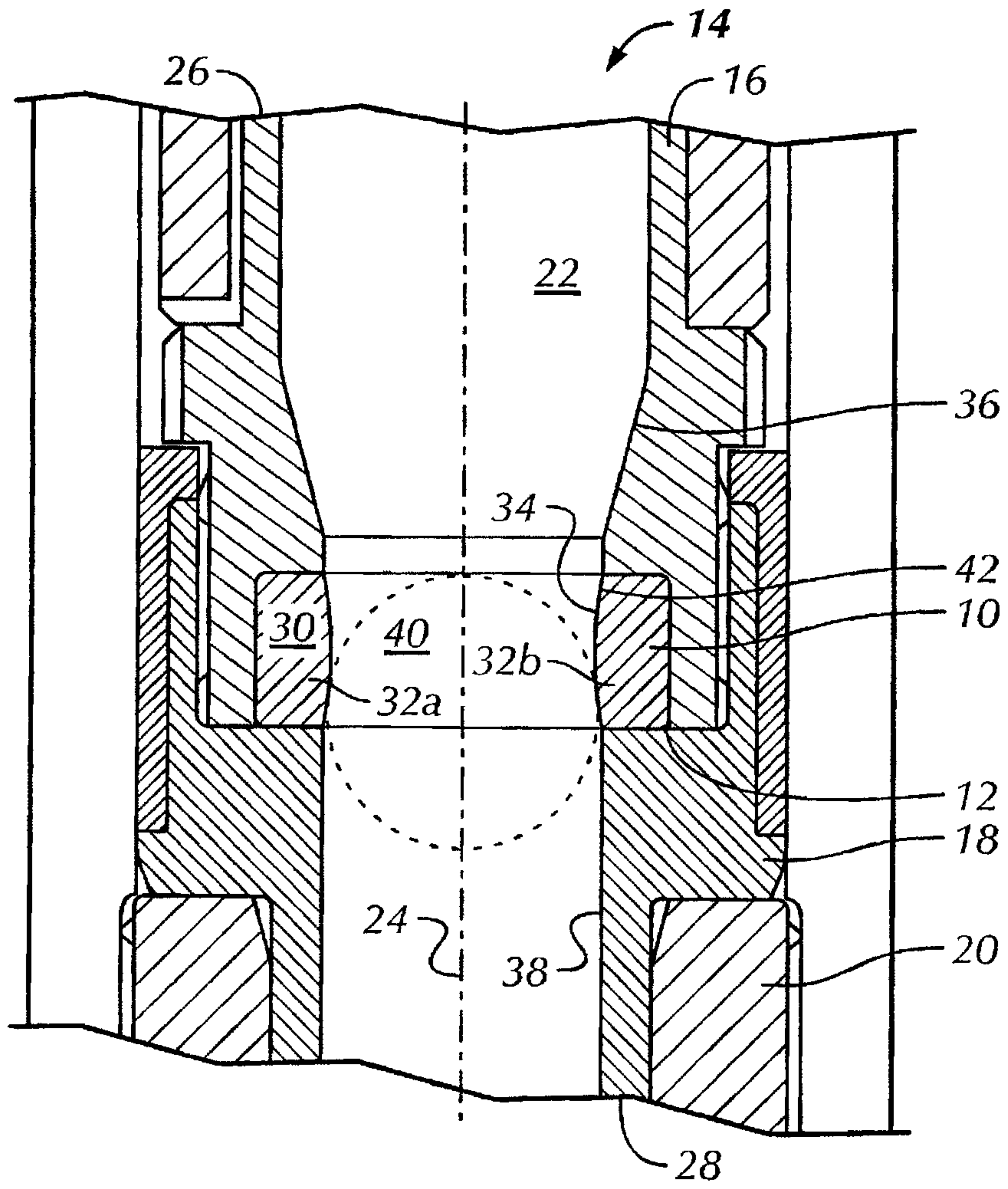


FIG. 1

