

(21) **2 854 716**

(12) **DEMANDE DE BREVET CANADIEN**
CANADIAN PATENT APPLICATION

(13) **A1**

(22) Date de dépôt/Filing Date: 2014/06/13

(41) Mise à la disp. pub./Open to Public Insp.: 2015/04/29

(30) **Priorités/Priorities:** 2013/10/29 (US61/897,003);
2013/11/11 (US61/902,607); 2013/11/29 (US61/910,233)

(51) Cl.Int./Int.Cl. *E21B 34/14* (2006.01)

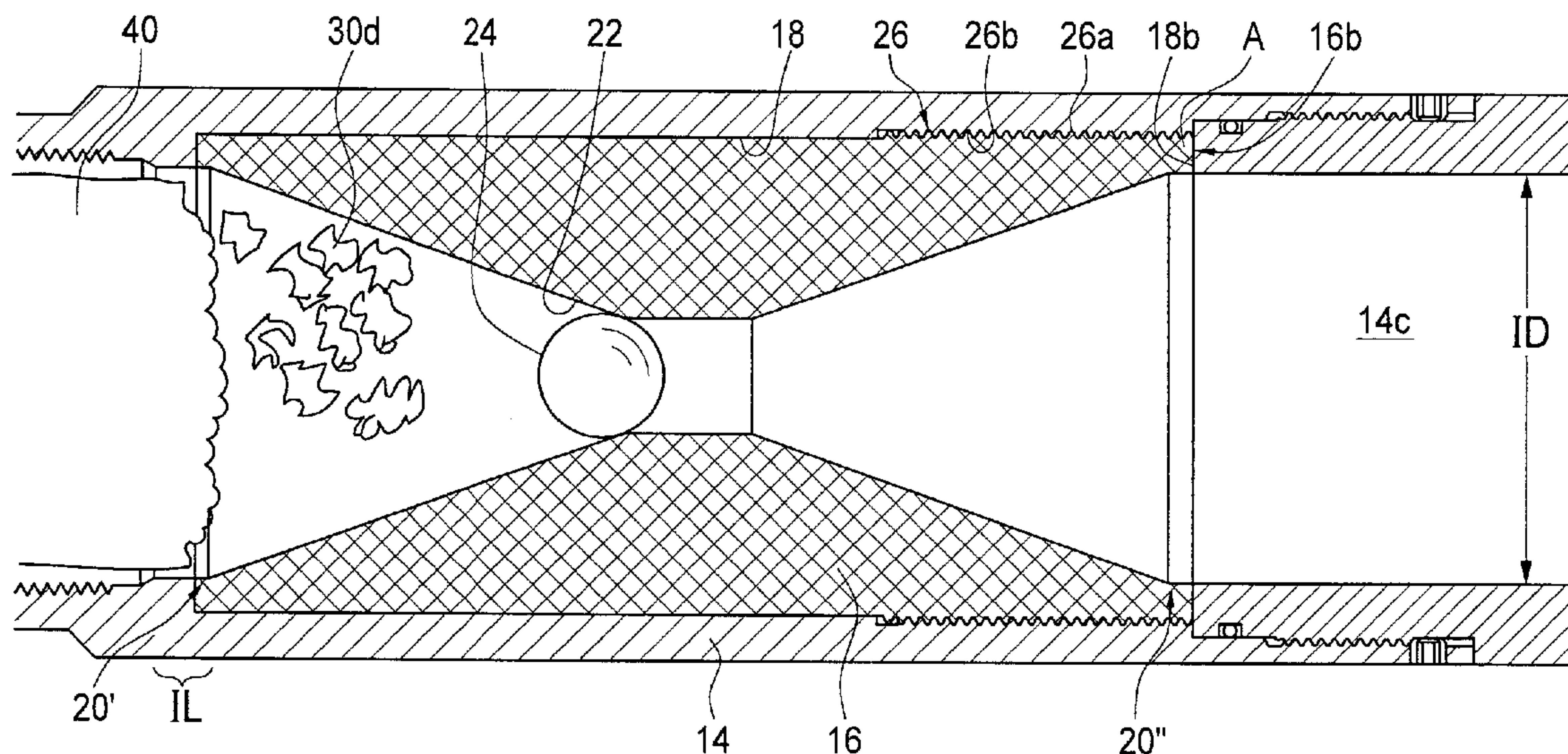
(71) Demandeur/Applicant:
RESOURCE COMPLETION SYSTEMS INC., CA

(72) Inventeurs/Inventors:
HUGHES, JOHN, CA;
SCHMIDT, JAMES WILBURN, CA

(74) **Agent:** BENNETT JONES LLP

(54) Titre : OUTIL DE BARRIERE CONTRE LES DEPOTS FORABLE

(54) Title: DRILLABLE DEBRIS BARRIER TOOL



(57) **Abrégé/Abstract:**

A drillable debris barrier tool is positioned under a stage tool to protect tools therebelow from contamination with debris from the stage tool, as it is drilled out. The debris barrier tool includes features that facilitate drill up of stage tool debris and reduce the size of debris generated from removal of the barrier tool.

Abstract

A drillable debris barrier tool is positioned under a stage tool to protect tools therebelow from contamination with debris from the stage tool, as it is drilled out. The debris barrier tool includes features that facilitate drill up of stage tool debris and reduce the size of debris generated from removal of the barrier tool.

DRILLABLE DEBRIS BARRIER TOOL

Field

The invention relates to a wellbore tool and method and, in particular, a barrier tool for wellbore string applications, wellbore strings and methods.

Background

A wellbore string, such as of casing or liner, but herein collectively called casing, may be cemented into a well. When the string includes tools, such as open hole completion tools, a stage tool may be employed to allow cement placement in the annulus above the tools.

In such a string installation, the casing is run into the well. Cement is then pumped down the casing, out the ports of the stage tool into the annulus surrounding the casing. In some embodiments, a wiper plug is pumped down the casing and is used to close the communication ports on the stage tool. The wiper plug, if any, and internal components of the stage tool are then drilled out to provide an inside diameter through which intervention tools and balls may pass. In order to prevent debris from the drilled out stage tool falling down the hole, where it may interfere with the functioning of the string's tools, a barrier tool is used to catch debris. After drilling out the stage tool, the barrier tool also has to be drilled out. Overall, the passage of fragments should be avoided to avoid interference with the performance of the string's tools down hole of the barrier tool. In addition, it is desirable that the drill out process generate an inner diameter through the

drilled out tool without jagged edges and with a diameter suitable for tubing conveyed tools to pass.

Summary of the Invention

In accordance with a broad aspect of the present invention, there is provided a debris barrier tool comprising: a liner forming a seat in a bore through the tool, the seat formed to retain a ball to be landed in the seat, wherein the liner is formed of a cast iron.

In accordance with another broad aspect of the present invention, there is provided a method for drilling out a wellbore string comprising: landing a ball in a seat of a debris barrier tool; operating a drilling assembly to drill through the wellbore string uphole of the debris barrier tool; and drilling through the seat of the debris barrier tool while debris from uphole drilling is crushed between the drilling assembly and the debris barrier tool.

It is to be understood that other aspects of the present invention will become readily apparent to those skilled in the art from the following detailed description, wherein various embodiments of the invention are shown and described by way of illustration. As will be realized, the invention is capable for other and different embodiments and its several details are capable of modification in various other respects, all without departing from the spirit and scope of the present invention. Accordingly the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

Drawings

A further, detailed, description of the invention, briefly described above, will follow by reference to the following drawings of specific embodiments of the invention. These drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. In the drawings:

Figures 1A, 1B, 1C, 1D, 1E and 1F are schematic sectional views through a wellbore with a production casing installed therein. The Figures 1A, 1B, 1C, 1D, 1E and 1F show the wellbore, respectively, after casing run in, just prior to cementing, during cementing, just after cementing, during drill out and after drill out.

Figures 2A, 2B, 2C and 2D are axial sectional views of a debris barrier tool during installation, during cementing, during drill out and after drill out, respectively.

Detailed Description of Various Embodiments

The description that follows and the embodiments described therein are provided by way of illustration of an example, or examples, of particular embodiments of the principles of various aspects of the present invention. These examples are provided for the purposes of explanation, and not of limitation, of those principles and of the invention in its various aspects. In the description, similar parts are marked throughout the specification and the drawings with the same respective reference numerals. The drawings are not necessarily to scale and in some instances proportions may have been exaggerated in order more clearly to depict certain features.

With reference to the Figures, a drillable debris barrier tool 10 includes a tubular body suited to installation in a wellbore string 12. Tool 10 includes an outer tubular housing 14 and an inner liner 16. Outer tubular housing 14 has an open upper end 14a and an open lower end 14b and a bore 14c extending between the ends. In this embodiment, these ends 14a, 14b are formed, for example as by threading, for connection into a string. Bore 14c has an inner diameter ID that is substantially a full bore diameter, which is within the nominal diameter across bore 12b of string 12 and greater than the drift diameter.

Inner liner 16 is positioned substantially concentrically within outer housing 14. The inner liner is positioned in an annular recess 18 in the wall of the outer housing. The annular recess is spaced from the ends of the housing.

Inner liner 16 has a tubular form, wherein a bore 20 extends through the liner from its upper end 16a to its lower end 16b such that a fluid passage is provided through the liner and the tool. The bore has defined therein a seat 22 which is a constriction where the bore's diameter is reduced relative to other portions of the bore. The inner walls defining the bore may be formed frustoconically, as at 22a, leading to the constriction forming seat 22. The seat accepts and retains a ball 24 or other plug form. The ball used with barrier tool 10 is sized to pass through string uphole of tool 10 and to enter bore 20. However, the

ball is selected to have a diameter too large to pass through the seat 22. Thus, ball 24 can be dropped to land in seat 22 of the barrier tool when it is desired to plug bore 20.

The debris barrier tool may be used in a string 12 and in a wellbore installation, for example as shown in Figures 1A to 1F. Barrier tool 10 may, for example, be used in conjunction with a stage tool 30 in a cemented-in wellbore string application. String 12, which may be production casing or another form of liner, includes a stage tool 30 for stage cementing and tools down hole of the stage tool. The tools may be completion tools such as packers 32, wellbore treatment tools 34, etc. In the illustrated embodiment, the wellbore treatment tools 34 are ball-activated frac sleeves. However, barrier tool 10 may be employed with other string configurations and tools such as, for example, screens, full bore frac sleeves or burst type tools.

Stage tool 30 allows stage cementing wherein cement C may be introduced to the annulus 11 between string 12 and the wellbore wall 13, herein partially defined by surface casing 13a. A stage tool allows cement to be introduced along a length of the string without the need to flow the cement out the distal end 12a of the string, which is useful if the string includes tools 32, 34 not conducive to placement of cement thereabout.

After stage tool 30 is used to stage cement, the stage tool is drilled out to open the string's bore 12b to a drilled out diameter which is large enough for wellbore structures moved through the bore to pass. Wellbore structures may include actuators, such as balls to actuate wellbore treatment tools 34, strings such as intervention strings, tools such as shifting tools, etc. The drilled out diameter is that diameter large enough for wellbore structures moved through the bore to pass and, as such, may sometimes be less than the drift diameter. However, the drilled out diameter often is about the same as or greater than the drift diameter. In some embodiments, the drilled out diameter may be at least as large as (i.e. greater than or equal to) the drift diameter, but is generally less than or equal to the full bore diameter.

Barrier tool 10 is positioned in the string's bore 12b between stage tool 30 and the string's tools 32, 34. That is, the barrier tool is positioned in the string bore down hole of the stage

tool and uphole of the string's tools. Thus, barrier tool 10 is positioned to protect tools 32, 34 from debris generated by the drill out of stage tool 30.

In use, production casing 12 is run into the well 13 (Figure 1A). This may include running the string into a horizontal and/or open hole section 13' of the well. At the desired depth, packers 32 are set (Figure 1B). In one embodiment, packers may be hydraulically set to expand out and engage the wellbore wall. In the illustrated embodiment, packers 32 are of the type known as open hole and hydraulically set and pressure is applied through string 12 to set the packers.

During this process, as shown in Figure 2A, the barrier tool bore 20 remains open so that fluid can be circulated therethrough and, thus, pressure can be communicated therebelow to packers 32.

The stage tool is also manipulated to open ports 30a establishing communication between the inside bore 12b of the casing string and the annulus 11. The stage tool can be manipulated to open by various processes. In one embodiment, for example, the stage tool can also be actuated hydraulically to open ports 30a. Depending on the operation of stage tool, this may be conducted with the setting of packers, while the barrier tool remains open or after the barrier tool is closed, described below.

At least before cementing, ball 24 is circulated down the casing and lands on the drillable debris barrier tool 10 (Figures 1B and 2B). This closes access through bore 12b to the string and its components below (i.e. down hole of) tool 10. Cement C is then pumped down the casing (Figure 1C), out the ports of the stage tool into the annulus surrounding the casing. The cementing operation is then concluded and the stage tool is then closed. For example as shown in Figures 1C and 1D, a wiper plug 30b may be pumped down the casing to land on a stop 30c in the stage tool. Wiper plug 30b may be used to force the residual cement down to the stage tool and to close communication ports 30a on the stage tool.

The wiper plug 30b and internal components such as stop 30c of the stage tool are then drilled out by a drilling assembly 40 including a mill to provide the drilled out diameter D_s

through bore 12b. Even if some remnants of stage tool 30s remain, the drilled out diameter, as noted, is large enough so that intervention string and tools and/or balls for tools 34 may pass (Figures 1E and 2C).

Barrier tool 10 acts during drill out to at least substantially prevent stage tool debris 30d from moving therepast and falling down the hole where the debris may interfere with the functioning of tools 34. For example, the barrier tool with ball 24 therein provides a platform (Figure 2C) to catch the debris generated by drill out. Further, the barrier tool provides a platform against which the debris can be drilled into small enough pieces that they can be circulated out of the well. Circulation may be through the drilling assembly 40 in the forward direction with fluid passing out of the drilling assembly and up the annular area between casing 12 and the drilling assembly 40.

At some point during or after the stage tool debris is drilled into small pieces, the components of the debris barrier tool that constrict the inner diameter also have to be drilled out. As shown in Figure 2D, the surface of barrier tool 16s remaining after an opening is drilled through the seat of the debris barrier tool should have a relatively smooth surface, substantially without abrupt shoulders or jagged edges and should have a drilled out diameter D large enough for wellbore structures moved through the bore to pass. As noted above, wellbore structures may include actuators, such as balls to actuate wellbore treatment tools 34, strings such as intervention strings, tools such as shifting tools, etc. While the drilled out diameter D may be less than the drift diameter, in some embodiments, the drilled out diameter may be at least as large as (i.e. greater than or equal to) the drift diameter, but is generally less than or equal to the full bore diameter. The drill out diameter is about the same or slightly larger than the diameter of the mill. Thus, if the same mill is used to drill out stage tool 30 and barrier tool 10, the drilled out diameters Ds and D are substantially the same.

To protect the tools, the barrier tool seat in liner 16 and ball 24 drill up substantially without generating large fragments and with circulation such that fragments are deterred from falling down hole, thus avoiding interference of fragments with the performance of the tools 34.

After drill out, the string including at the location of stage tool 30 and barrier tool 10 is opened up to the drilled out diameter. The string can then be used for wellbore treatments (Figure 1F) such as fluid treatments, arrows F, through tools 34.

The drillable debris barrier tool 10 includes a combination of geometry and material selection to provide a stable platform to catch debris and against which stage tool debris can be drilled. Also, the debris tool allows fragments to be drilled up into small enough pieces that can be circulated to surface without falling down hole or getting caught between the drill string and the casing.

The debris barrier tool liner is formed of a material that provides adequate support, wherein the stage tool debris can be drilled and broken up against seat 22 substantially before the seat itself is fully broken down and drilled out. The material selection may be made to ensure that the stage tool debris substantially cannot dig into or destroy the liner 16, but the liner can be broken down by the drilling assembly. The stage tool stop and wiper plug may be formed of one or more materials including, for example, cast iron, aluminum, rubber, polymers, etc. Barrier tool liner 16 may be formed of a material about the same or harder than these materials, but still capable of being drilled out by standard tubing clean out drilling set ups, which means it is softer than steel, the material from which casing 12 is made. For example, in one embodiment, the debris barrier tool liner 14 is manufactured from cast iron, such as for example, ductile iron or gray iron, such as for example, class 30 to 50 gray iron, for example, class 40 gray iron. Class 30 to 50 gray iron (i) is generally harder and stronger than the materials used in stage tool drillable components and (ii) is drillable and has a nodular grain structure, tending to crumble into small pieces when it is drilled out.

Ball 24 may be formed of various materials. In one embodiment, the ball is formed of a material the same as or softer than the liner, but is retained by seat 22 at the pressures employed. Ball 24 can wedge into seat.

Housing 14 of tool 10 may be formed of steel or another material similar to the material from which casing 12 is made, which is harder than the material of liner 16.

Figure 2C best shows the geometric features that enable liner 16 to provide a stable platform for drilling out stage tool debris. These features may also enable the seat to be drilled out without producing unnecessarily large fragments.

Tool 10 may include a contact shoulder between liner 16 and housing 14 at a lower end of the liner that holds the liner in place against the compressive load generated when the drill pushes down on the debris and the seat. The contact shoulder is formed between an end wall 18b of recess 18 and lower end 16b of the liner. The end wall 18b is abruptly angled, such as at an acute or substantially right angle, at A between the inner diameter of recess 18 and the end wall 18b. This causes the end wall to form an annular platform that is planar or frustoconically formed. Liner 16 has a corresponding angled surface at its lower end 16b, which is for example, either planar or frustoconically formed with its thickness tapering toward the rear facing side. The corresponding shape of end 16b and wall 18b provides for good contact between the parts such that compressive force may be effectively transferred from liner 16 to housing 14 and the liner tends to be driven into engagement with housing rather than being driven inwardly into bore 14c. Thus, the contact shoulder provides a stable platform preventing the seat from prematurely crumbling, even when sufficient weight is applied to the barrier tool to drill out both the stage tool debris and the seat.

In addition, liner 16 has an outer diameter greater than the drilled out diameter, which ensures that a cylindrical portion of the liner can remain after drill out. For example, liner 16 may have an outer diameter 5 to 40% larger than the intended drilled out diameter (which depends on the diameter of the mill). By placement in annular recess 18, this enlarged outer diameter of liner 16 may be accommodated in the wall of the outer housing. For example, stated another way, liner 16 may have a wall thickness at lower end 16b that is substantially similar to the depth of the annular recess at end wall 18b. For example, the depth of annular recess at end wall may be approximately 25 to 75% of the thickness of the wall of housing 14 and liner 16 thus has a thickness of 25 to 75% of the thickness of the wall of housing 14, which causes the liner to have an outer diameter larger than the diameter of any mill to be used to drill out the string. The thickness of the liner and its

positioning in recess beyond the reach of the mill ensures that a portion thereof resides in the annular recess and can remain therein even after drill out. After drill out a cylindrical portion 16s remains in housing 14. Thus, the generation of large free fragments of the liner is avoided.

Liner 16 can have a similar enlarged outer diameter/minimum thickness along its length such that, for example, at upper end 16a as well the liner can have a thickness approximately 25 to 75% of the thickness of the wall of housing 14. Upper end 16a can, as well, be recessed in annular recess 18.

The tool's exposed bore 14c, 20 has an initial length IL adjacent uphole end 14a with a substantially constant inner diameter at substantially a full bore diameter, which is greater than the drift diameter and generally greater than the drilled out diameter. The liner defines at least portion of this initial length. In particular, bore 20 at upper end 16a of liner has an initial portion 20' that extends a length at substantially the full bore diameter. At the lower end of that initial portion 20', the inner walls at area 22a of the liner defining bore 20 begin to taper towards the seat 22. The mill generally has a diameter less than full bore diameter. Thus, when the mill enters the tool, it will pass through the initial length IL, including initial portion 20', at the upper end substantially without drilling into the barrier tool. Instead, the mill will only start to actively contact, apply force against and drill out the liner where the walls taper to a diameter less than the diameter of the mill, which is large enough to form a suitable drilled out diameter that is often greater than or equal to drift diameter but less than the full bore diameter. Thus, contact with the mill at the more fragile, upper end is avoided and the liner is drilled out only further along its length where it is more fully supported by liner material uphole and downhole of the contact region. This geometry acts against uncontrolled breakdown of the liner. The initial length IL having full bore diameter at the entrance to the liner also guides the drilling assembly into the seat before drilling commences.

The frustoconical surface 22a also guides the drilling assembly into the seat. In addition, the frustoconical surface 22a ensures stage tool debris 30d that is pushed ahead of the drilling assembly can be packed tightly above ball 24 and is held in position to be acted

upon by drilling assembly 40, such that it can be drilled into small pieces while also drilling through the seat. Compression of debris 30d above ball 24 may also cause the debris to break down and be crushed between drilling assembly 40 and liner 16. By forming the liner of a material with a hardness and strength greater than that of the debris, it is ensured that debris is supported by the liner, rather than digging into the material of the liner.

In the illustrated embodiment, another interval in the bore of the tool at its lower end has a full bore diameter. Again, liner 16 defines at least a portion, at 20", of that interval, wherein bore 20 at lower end 16b of liner extends a length at substantially a full bore diameter. As such, again the lower end of the liner may have a large enough diameter such that it is out of drilling contact with the mill during drill out. Thus, liner 16, which is more fragile at its ends, tends not to be acted upon (i.e. not drilled into) by the mill at portion 20' and interval 20".

The liner has external threads 26a on its rear facing side opposite portion 20" so that the tool can be threaded to the outer housing 14 of the debris barrier tool eliminating the opportunity for remnants of the seat to break off and fall down hole or become jammed. Threads 26a may extend from end 16b up past portion 20". Corresponding threads 26b may be formed in annular recess 18 and may extend fully to end wall 18b.

The threads permit threaded engagement of the liner to the housing and prevent the seat from rotating during drill out. The threads may, for example, be right handed to counteract the tendency to rotate imparted by operation of drilling assembly 40. During installation, liner 16 may be threaded onto threads 26b and torqued up to cause firm engagement of liner 16 into housing 14. End wall 18b may be formed by threading together a lower portion and an upper portion of housing 14.

The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to those embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the

embodiments shown herein, but is to be accorded the full scope consistent with the claims, wherein reference to an element in the singular, such as by use of the article "a" or "an" is not intended to mean "one and only one" unless specifically so stated, but rather "one or more". All structural and functional equivalents to the elements of the various embodiments described throughout the disclosure that are known or later come to be known to those of ordinary skill in the art are intended to be encompassed by the elements of the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 USC 112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or "step for".

CLAIMS

1. A debris barrier tool comprising:

a liner forming a seat in a bore through the tool; and

a ball formed to land in the seat,

wherein the liner is formed of a cast iron.
2. The debris barrier tool of claim 1 wherein the liner is formed of class 30 to class 50 gray iron.
3. The debris barrier tool of claim 1 further comprising an outer housing including an inner wall defining a bore and an annular recess in the inner wall and the liner being mounted in the annular recess and a contact shoulder formed between the outer housing and the liner at a lower end of the liner.
4. The debris barrier tool of claim 3 wherein a lower end wall of the annular recess and a lower end of the liner are corresponding shaped.
5. The debris barrier tool of claim 3 wherein the tool has a drift diameter and the liner has an outer diameter greater than the drift diameter.
6. The debris barrier tool of claim 2 wherein the outer housing is formed of a material harder than cast iron.
7. The debris barrier tool of claim 1 further comprising a full bore diameter portion between an upper end of the liner and the seat.
8. The debris barrier tool of claim 7 further comprising a frustoconical surface between the upper end and the seat.
9. The debris barrier tool of claim 1 further comprising a full bore diameter interval at a lower end of the liner.

10. The debris barrier tool of claim 9 further comprising an outer housing and the liner is mounted within the outer housing and threadedly engaged to the outer housing opposite the full bore diameter interval.
11. The debris barrier tool of claim 1 further comprising a right hand thread between the seat and the outer housing preventing rotation of the seat during drill out.
12. A method for drilling out a wellbore string comprising:
 - landing a ball in a seat of a debris barrier tool;
 - operating a drilling assembly to drill through the wellbore string uphole of the debris barrier tool; and
 - drilling through the seat of the debris barrier tool while debris from uphole drilling is crushed between the drilling assembly and the debris barrier tool.
13. The method of claim 12 wherein drilling through the seat includes passing the drilling assembly through a full bore portion at an upper end of a drillable liner on which the seat is formed without drilling into the full bore portion.
14. The method of claim 12 wherein drilling the debris barrier tool includes passing the drilling assembly through a full bore interval at a lower end of the drillable liner without drilling into the full bore interval.
15. The method of claim 12 wherein drilling through the seat leaves a cylindrical portion of the seat remaining in debris barrier tool.
16. The method of claim 12 wherein during drilling, stopping rotation of the seat by providing a thread engaging the seat to an outer housing of the debris barrier tool.
17. The method of claim 12 further comprising circulating fluid through the drilling assembly.

18. The method of claim 12 further comprising stage cementing through a stage tool uphole of the debris barrier tool and operating a drilling assembly drills out portions of the stage tool.

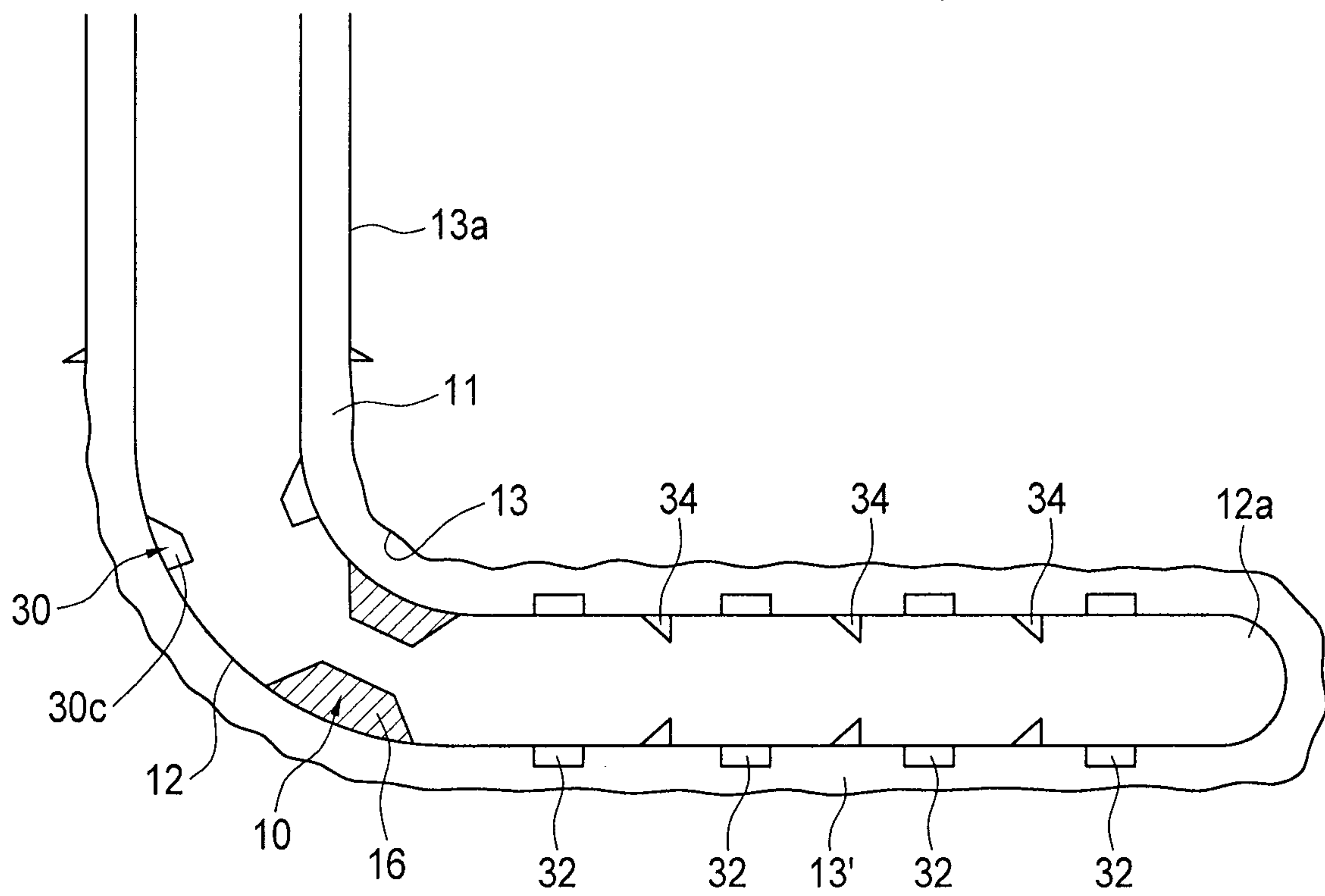


FIG. 1A

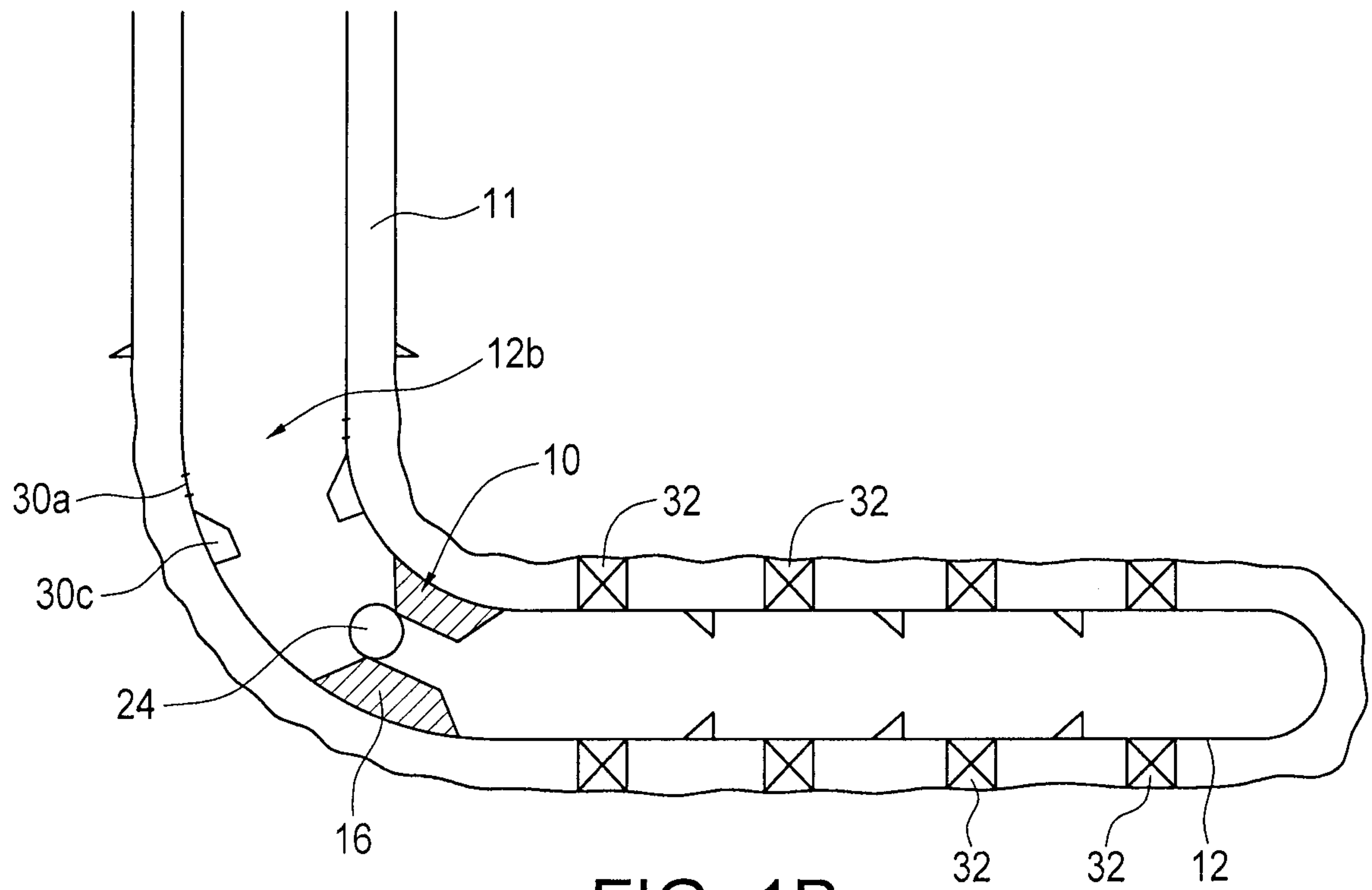


FIG. 1B

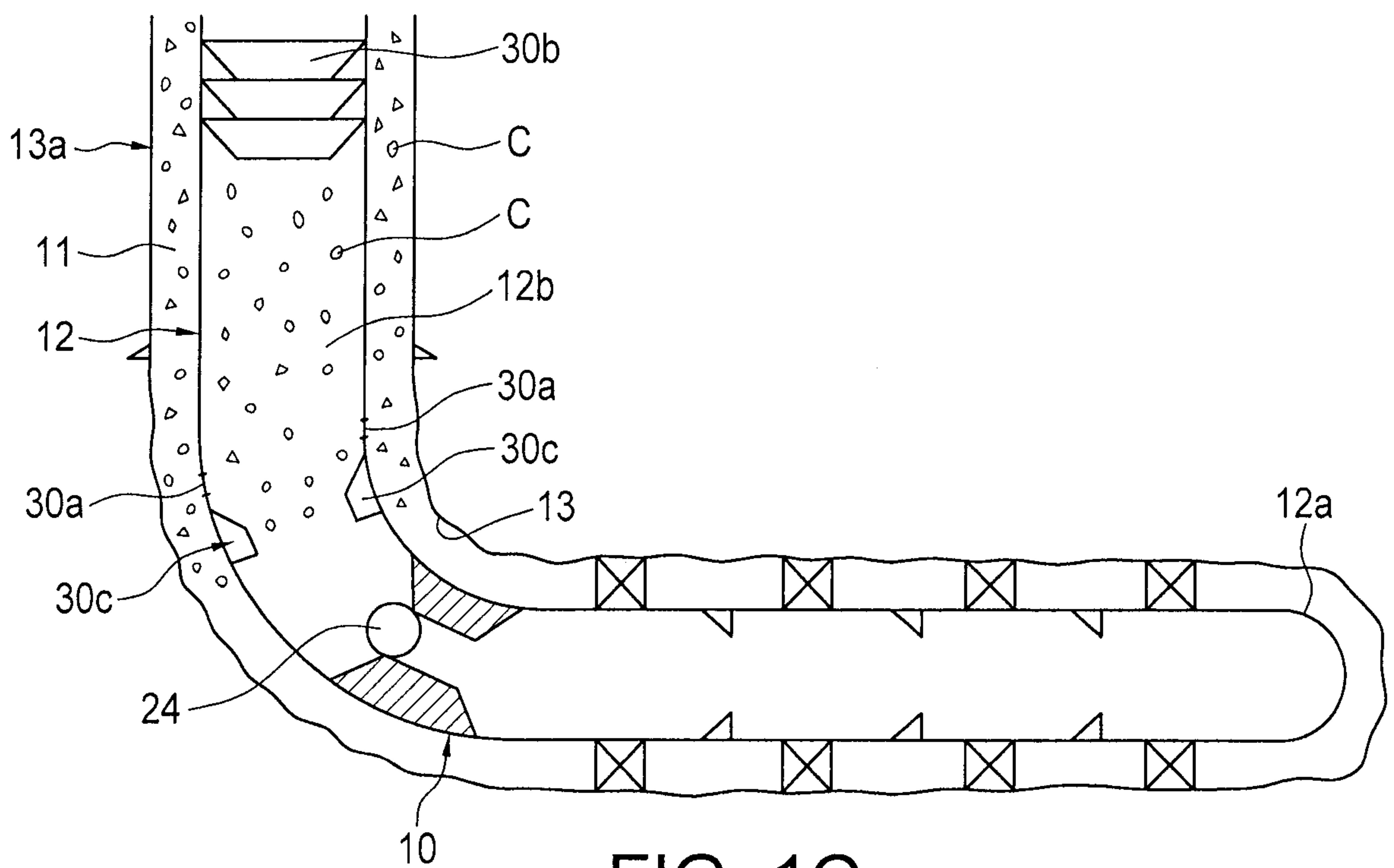


FIG. 1C

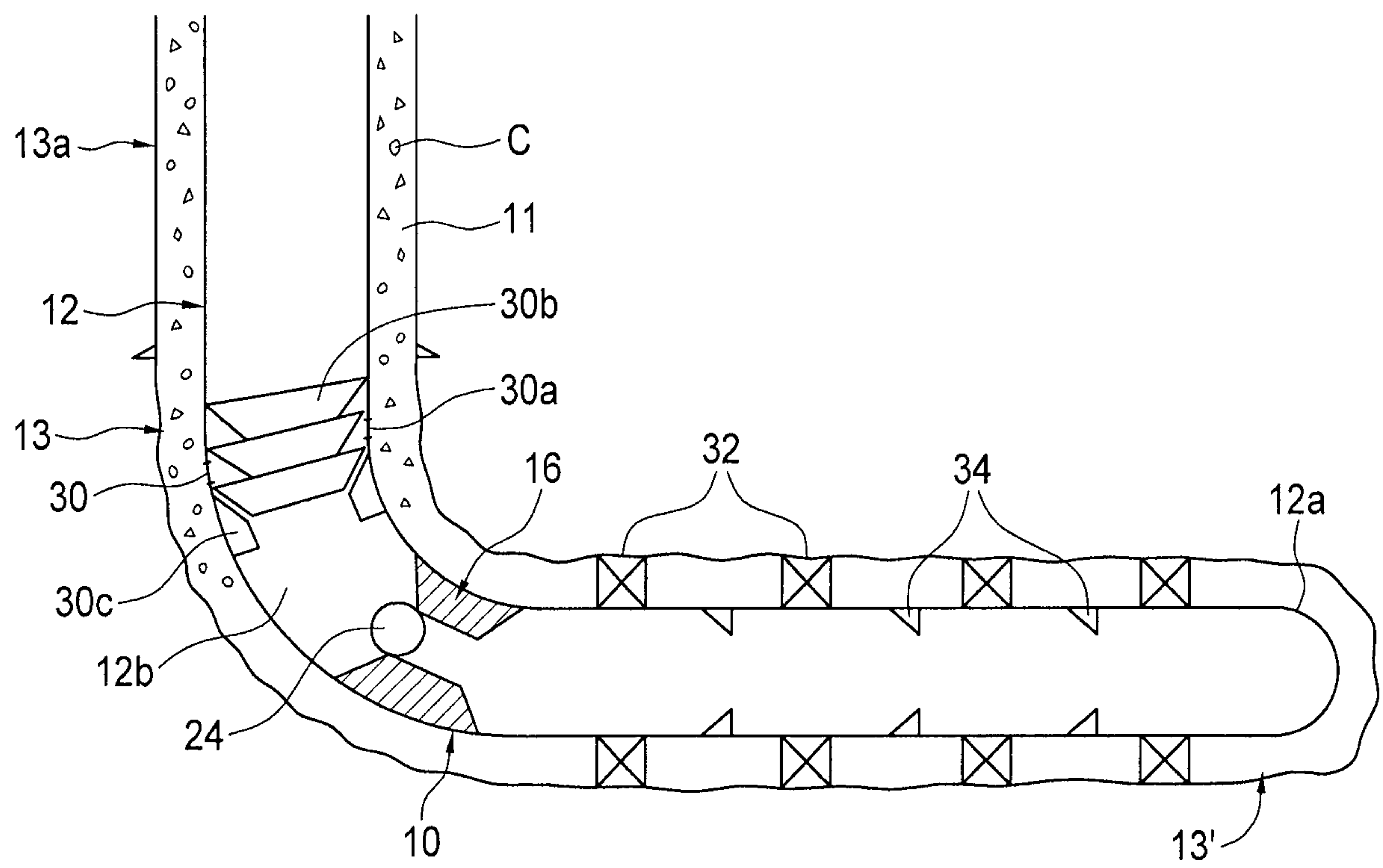


FIG. 1D

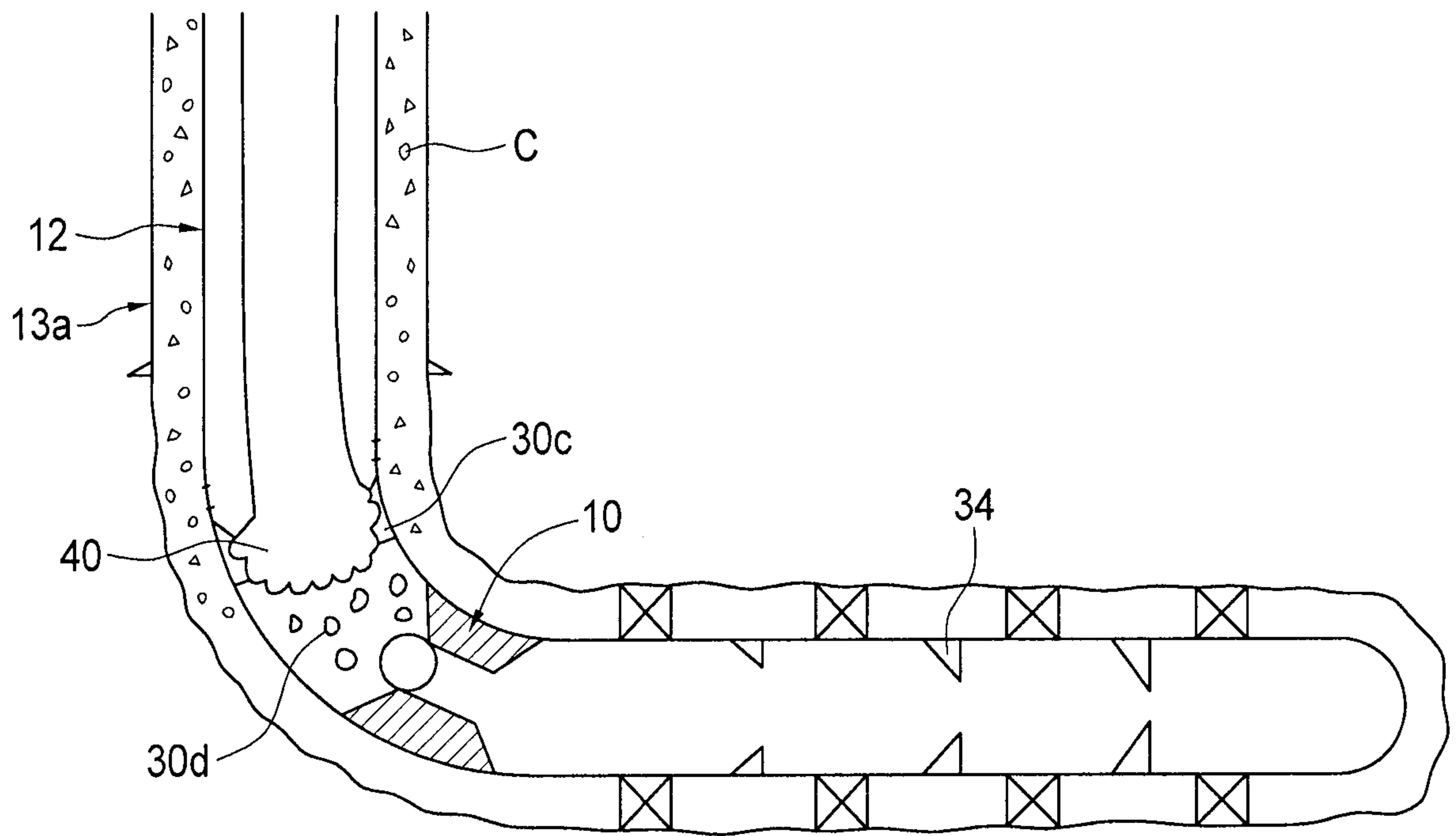


FIG. 1E

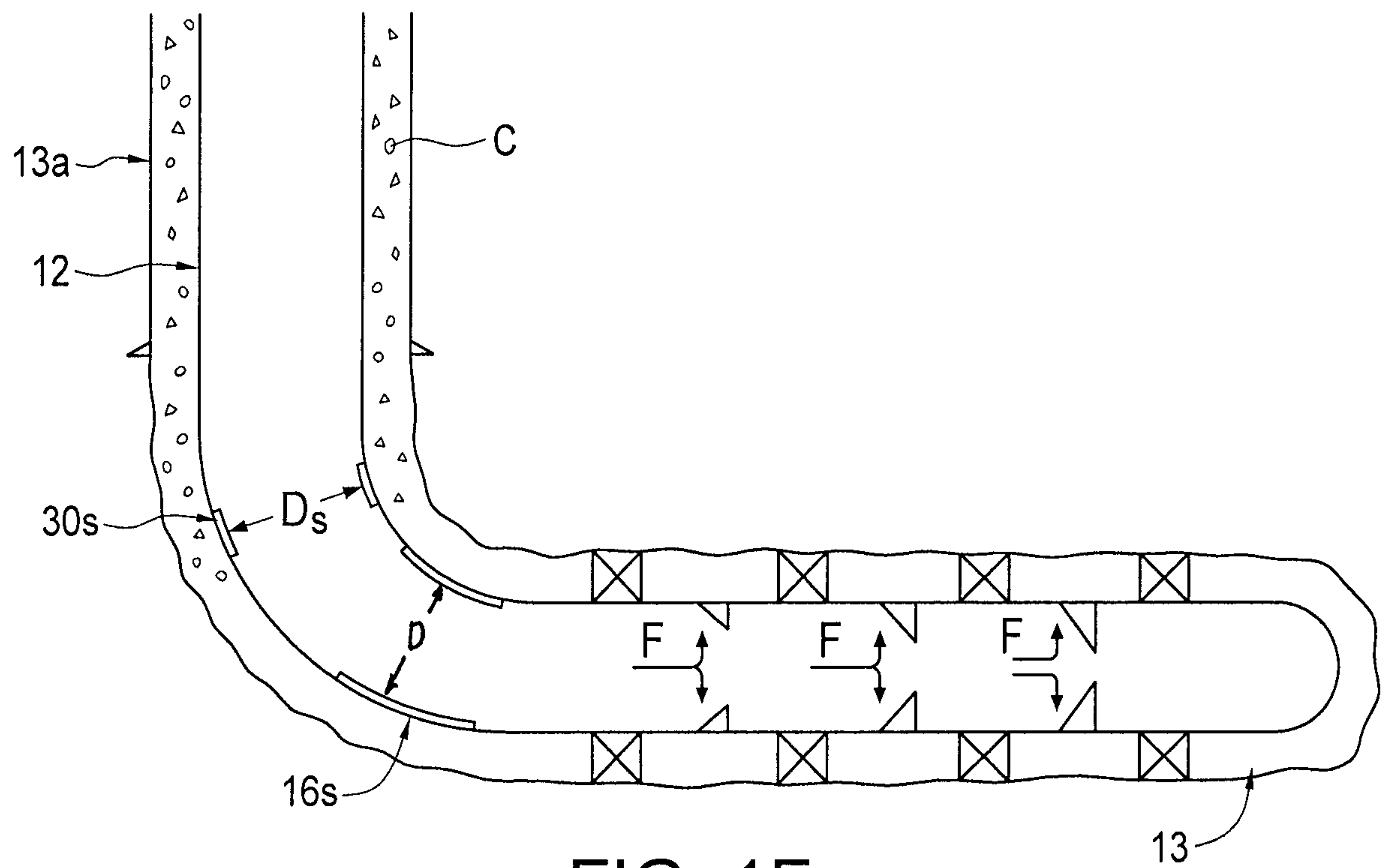


FIG. 1F

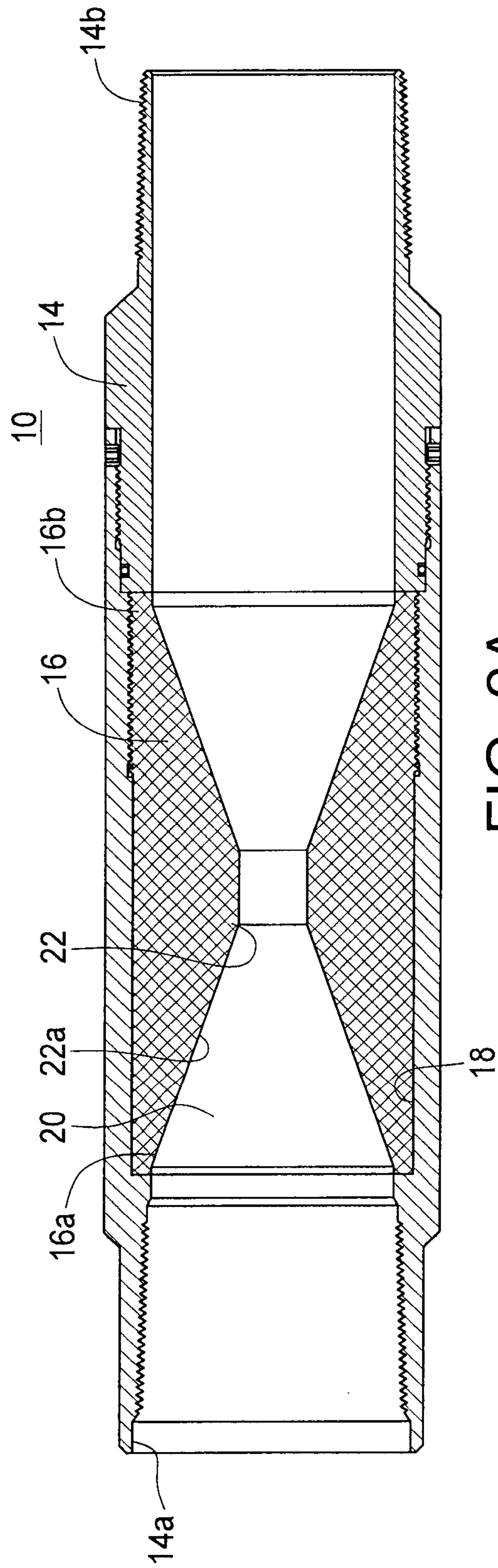


FIG. 2A

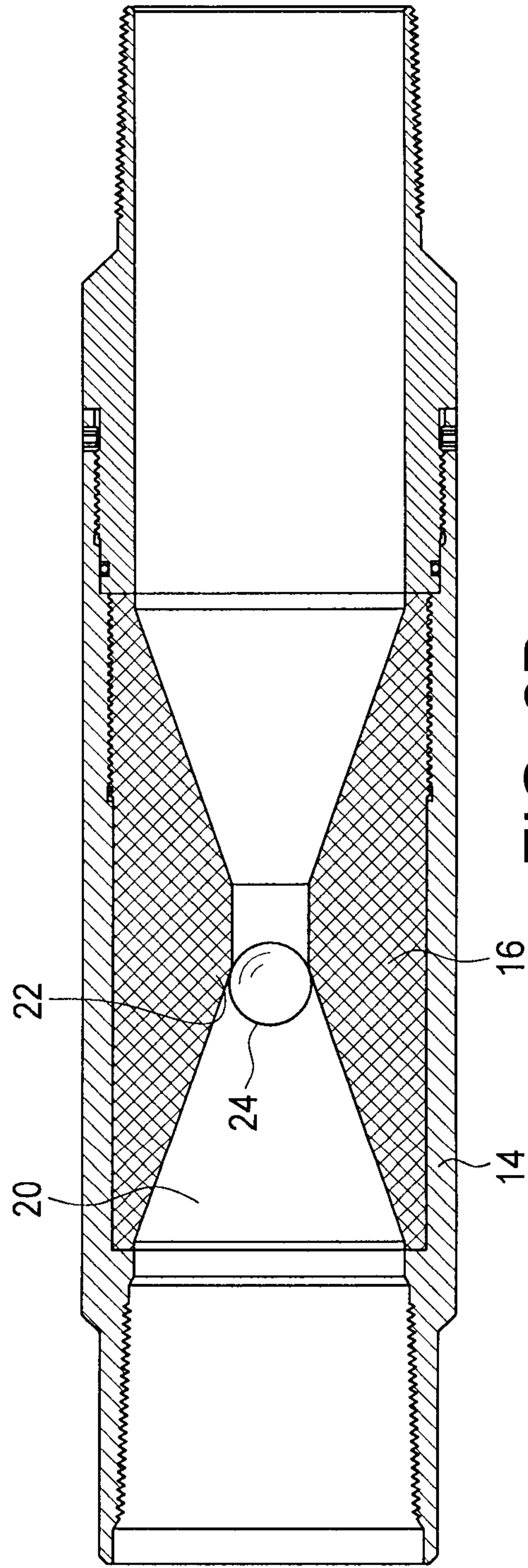


FIG. 2B

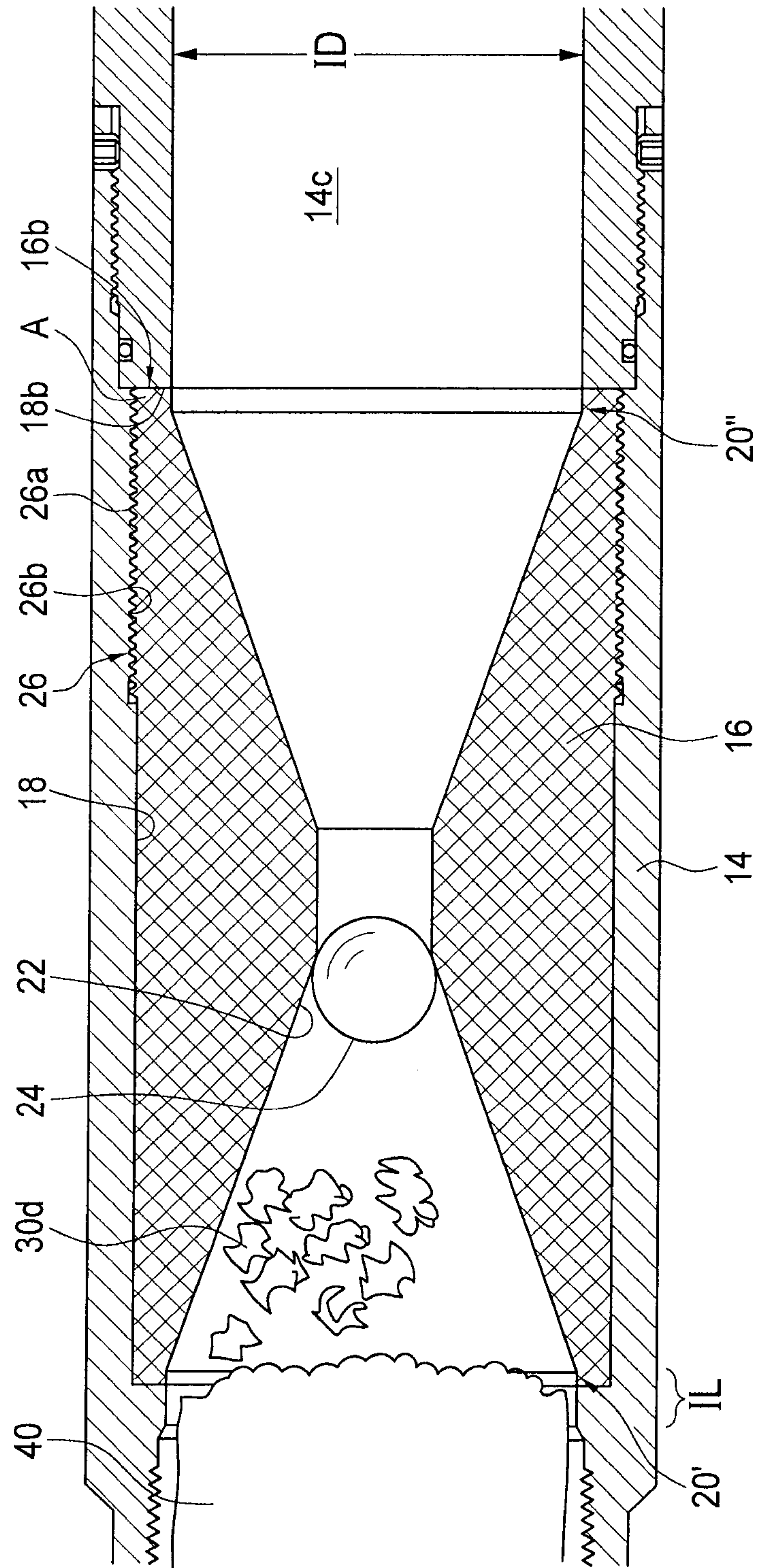


FIG. 2C

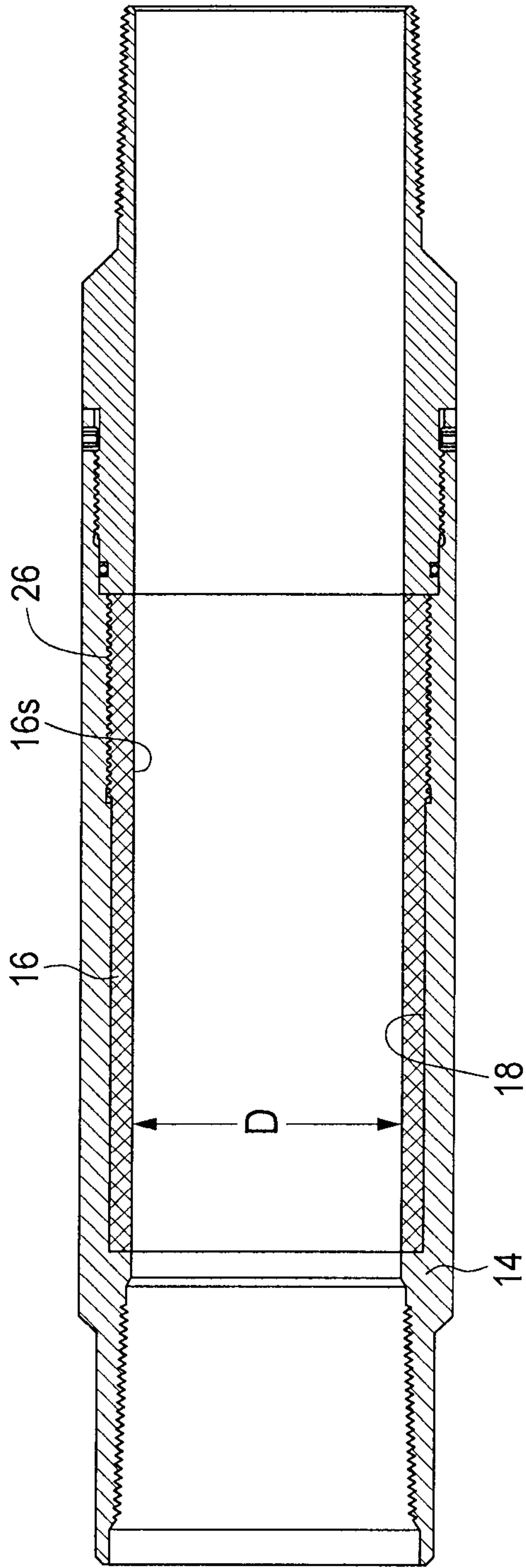


FIG. 2D

