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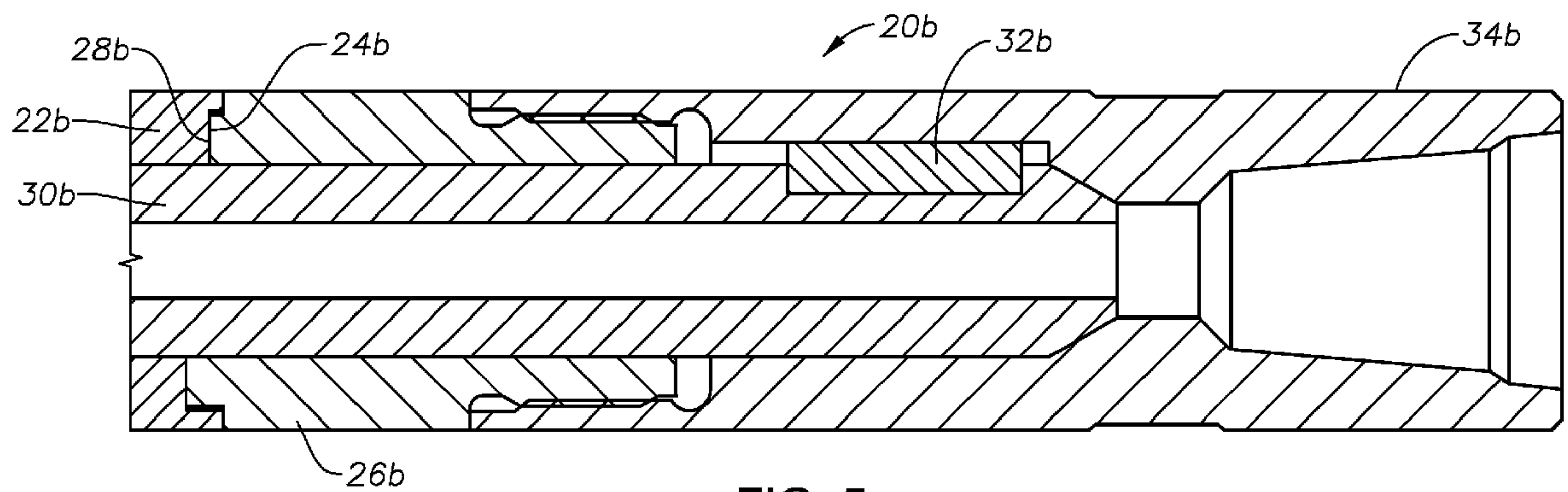

FIG. 5

(57) **Abrégé/Abstract:**
A downhole apparatus connected to a workstring within a wellbore. The workstring is connected to a bit member. The apparatus includes a mandrel operatively connected to a downhole motor mechanism, an anvil member operatively formed on the bit member, the anvil member being operatively connected to the mandrel, a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about the mandrel, and a hammer member slidably attached to the radial bearing housing unit.

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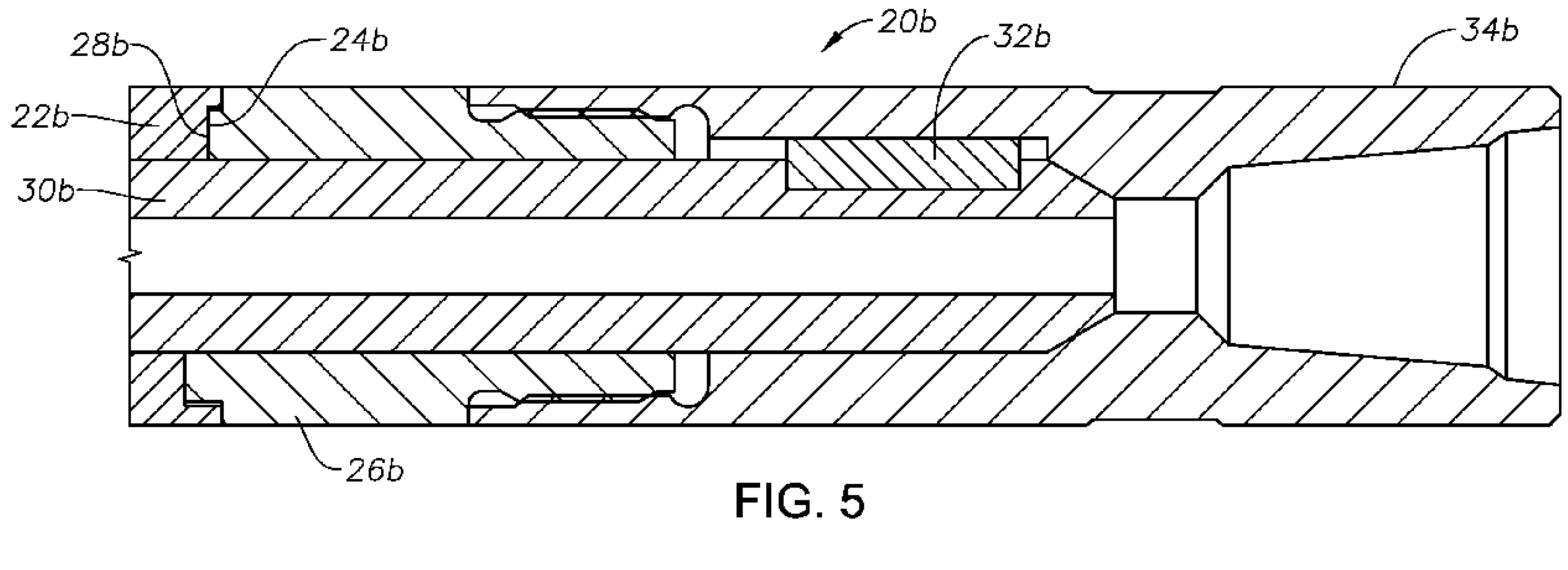

FIG. 5

(57) **Abstract**: A downhole apparatus connected to a workstring within a wellbore. The workstring is connected to a bit member. The apparatus includes a mandrel operatively connected to a downhole motor mechanism, an anvil member operatively formed on the bit member, the anvil member being operatively connected to the mandrel, a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about the mandrel, and a hammer member slidably attached to the radial bearing housing unit.

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HAMMER DRILL

This application claims priority from U.S. nonprovisional patent application serial number 13/848,839, entitled “Hammer Drill” and filed on 22 March 2013, which claims priority from U. S. provisional patent application serial number 61/615,518, entitled “Hammer Drill” and filed on 26 March 2012, both of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention relates to downhole tools. More particularly, but not by way of limitation, this invention relates to a downhole percussion tool.

In the drilling of oil and gas wells, a bit means is utilized to drill a wellbore. Downhole percussion tools, sometimes referred to as hammers, thrusters, or impactors are employed in order to enhance the rate of penetration in the drilling of various types of subterranean formations. In some types of wellbores, such as deviated and horizontal wells, drillers may utilize downhole mud motors. The complexity and sensitivity of bottom hole assemblies affects the ability of drillers to use certain tools, such as downhole hammers.

SUMMARY OF THE INVENTION

In one embodiment, a downhole apparatus connected to a workstring within a wellbore is disclosed. The workstring is connected to a bit member. The apparatus comprises a power mandrel operatively connected to a motor means; an anvil member operatively formed on the bit member, the anvil member being operatively connected to the power mandrel; a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about the power mandrel; a spring saddle operatively attached to the radial bearing housing unit; a spring spacer disposed about the spring saddle; a spring having a first end and a second end, with the first end abutting the spring saddle; a hammer member slidably attached to the spring saddle, and wherein the hammer member abuts the second end of the spring. In one preferred embodiment, the hammer and the anvil is below the radial bearing housing unit. The workstring may be a tubular drill string, or coiled tubing or snubbing pipe. The anvil member contains a radial cam face having an inclined portion and a upstanding portion. The hammer member contains a radial cam face having an inclined portion and a upstanding portion.

In another embodiment, a downhole apparatus is connected to a workstring within a wellbore, with the downhole apparatus connected to a bit member. The apparatus comprises a mandrel operatively connected to a motor means; an anvil operatively formed on the bit member, with the anvil being operatively connected to the mandrel; a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about the mandrel; and a hammer slidably attached to the radial bearing housing unit. In one embodiment, the hammer and the anvil is below the radial bearing housing unit. The anvil contains a cam face having an inclined portion and an upstanding portion, and the hammer contains a cam face having an inclined portion and a upstanding portion. The apparatus may optionally further include a spring saddle operatively attached to the radial bearing housing unit; and, a spring spacer disposed about the spring saddle, with a spring having a first end and a second end, with the first end abutting the spring spacer. In one embodiment, the hammer is slidably attached to the radial bearing housing unit with spline means operatively positioned on the spring saddle.

Also disclosed in one embodiment, is a method for drilling a wellbore with a workstring. The method includes providing a downhole apparatus connected to the workstring within a wellbore, the apparatus being connected to a bit member, the downhole apparatus comprising: a power mandrel operatively connected to a motor means, thereby providing torque and rotation from the motor to the bit via the power mandrel, an anvil member operatively formed on the bit member, the anvil member being operatively connected to the power mandrel; a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about the power mandrel; a spring saddle operatively attached to the radial bearing housing unit; a spring spacer disposed about the spring saddle, a spring having a first end and a second end, with the first end abutting the spring - spacer; a hammer member slidably attached to the spring saddle, and wherein the hammer member abuts the second end of the spring. The method further includes lowering the workstring into the wellbore; contacting the bit member with a subterranean interface (such as reservoir rock); engaging a distal end of the power mandrel with an inner surface of the bit member; slidably moving the anvil member; and, engaging a radial cam surface of the anvil member with a reciprocal radial cam surface of the hammer member so that the hammering member imparts a hammering (sometimes referred to as oscillating) force on the anvil member.

In one disclosed embodiment, when activating the motor (pumping fluid), the power mandrel, the drive shaft and the bit box sub are spinning the bit. If the hammermass cam surface and the anvil cam surface are engaged, the hammering (i.e. percussion) is activated and adds an oscillating force to the bitbox sub. Thus, the bit will be loaded with the static weight on bit from the drill string and the added oscillating force of the impacting hammermass. If the hammermass cam surface and the anvil cam surface are disengaged, the bitbox sub is only rotating.

A feature of the disclosure is that the spring means is optional. With regard to the spring embodiment, the type of spring used may be a coiled spring or Belleville spring. An aspect of the spring embodiment includes if the hammermass cam surface and the anvil cam surface are engaged and the hammermass is sliding axially relative to the anvil member, the spring means will be periodically compressed and released thus periodically accelerating the hammermass towards the anvil member that in turn generates an additional impact force. A feature of the spring embodiment is the spring adjusted resistance without moving the mandrel relative to the housing. Another feature of one embodiment is the mandrel is defined by supporting the axial and radial bearings. Another feature of one embodiment is that the hammer mechanism can be located between the bit and the motor or below the bearing section and the motor.

As per the teachings of the present disclosure, yet another feature includes that the motor means turns and hammers (i.e. oscillating force) when drilling fluid is pumped through the motor and both cam faces are engaged. Another feature is the motor only turns when drilling fluid is pumped through the motor and both cam faces are disengaged. The motor does not turn nor hammers when no drilling fluid is pumped.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a partial sectional view of a first embodiment of the downhole apparatus.

FIGURE 2 is a partial sectional view of lower housing of the downhole apparatus of the first embodiment in the engaged mode.

FIGURE 3 is a partial sectional view of the lower housing of the downhole apparatus of the first embodiment in the disengaged mode.

FIGURE 4 is a partial sectional view of the downhole apparatus of the first embodiment as part of a bottom hole assembly.

FIGURE 5 is a partial sectional view of lower housing of the downhole apparatus of a second embodiment in the engaged mode.

FIGURE 6 is a partial sectional view of the lower housing of the downhole apparatus of the second embodiment in the disengaged mode.

FIGURE 7A is perspective view of one embodiment of the anvil radial cam member.

FIGURE 7B is a top view of the anvil radial cam member seen in FIGURE 7A.

FIGURE 8 is a perspective view of one embodiment of the hammer radial cam member.

FIGURE 9 is a schematic depicting the downhole apparatus of the present invention in a wellbore.

FIGURE 10A is a graph of static weight on bit (WOB) versus time during drilling operations.

FIGURE 10B is a graph of dynamic WOB utilizing a percussion unit.

FIGURE 10C is a graph of dynamic WOB utilizing percussion unit, wherein the impact force is overlaid relative to the static load.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the Fig. 1, a partial sectional view of the downhole apparatus 2 of a first embodiment will now be discussed. The first embodiment apparatus 2 includes a power mandrel, seen generally at 4, that is operatively attached to the output of a downhole mud motor (not shown). The apparatus 2 also includes a radial bearing housing unit, seen generally at 6. The radial bearing housing unit 6 will be operatively attached to the workstring, such as drill pipe or coiled tubing, as will be described later in this disclosure. More particularly, Fig. 1 shows the power mandrel 4 (which is connected to the output of the motor section, as is well understood by those of ordinary skill in the art). The mandrel 4 may be referred to as the power mandrel or flex shaft. Also shown in Fig. 1 is the upper bearing housing 10a which includes the upper radial bearings 12a, lower radial bearing 14a , balls 16a and thrust races 18a. The lower housing is seen generally at 20a in Fig. 1 and will be described in further detail.

As seen in Fig. 1, a partial sectional view of lower housing 20a of the downhole apparatus 2 of the first embodiment is shown. Fig. 1 depicts the hammermass 22a (sometimes referred to as the hammer member or hammer), which is attached (for instance, by spline means via a spring saddle 40a) to the radial bearing housing unit 6. The hammermass 22a will have a radial cam surface 24a. The hammermass 22a will engage with the anvil 26a, wherein the anvil 26a has a first end that contains a radial cam surface 28a, wherein the radial cam surface 28a and radial cam surface 24a are reciprocal and cooperating in the preferred embodiment, as more fully set out below. Fig. 1 also depicts the power mandrel 4, which is fixed connected to the driveshaft 30a via thread connection or similar means. A key 32a (also referred to as a spline) allows for rotational engagement of the power mandrel 4 and the driveshaft 30a with the bitbox sub 34a, while also allowing for lateral movement of the bitbox sub 34 relative to the drive shaft 30a. The anvil 26a is fixedly connected to the bitbox sub 34a.

Fig. 1 also depicts the spring means 36 for biasing the hammermass 22a. The spring means 36 is for instantaneous action. More specifically, Fig. 1 depicts the spring saddle 40a that is an extension of the bearing housing 6 i.e. the spring saddle 40a is attached (via threads for instance) to the bearing housing 6. The spring saddle 40a is disposed about the driveshaft 30a. Disposed about the spring saddle 40a is the spacer sub 42a, wherein the spacer sub 42a can be made at a variable length depending on the amount of force desired to load the spring means 36. As shown, the spring means 36 is a coiled spring member. The spring means 36 may also be a Belleville washer spring. One end of the spring means 36 abuts and acts against the hammermass 22a which in turn urges to engagement with the anvil 26a.

In Fig. 2, a partial sectional view of the lower housing 20a of the downhole apparatus 2 of the first embodiment in the engaged mode is shown. It should be noted that like numbers appearing in the various figures refer to like components. The cam surface 24a and cam surface 28a are abutting and are face-to-face. Note the engaged position of the end 37a of the driveshaft 30a with the angled inner surface 38a of the bitbox sub 34a securing the axial transmission of the WOB from the drillstring to the bitbox sub 34a and the bit (not showing here). In Fig. 3, a partial sectional view of the lower housing 20a of the downhole apparatus 2 of the first embodiment in the disengaged mode will now be described. In this mode, the apparatus 2 can be, for instance, running into the hole or pulling out of the hole, as is well understood by those of ordinary skill in the art. Therefore, the radial cam surface 24a of hammer 22a is no longer engaging the radial cam surface 28a of the anvil 26a. Note the position of the end 37a of the driveshaft 30a in relation to the angled inner surface 38a of the bitbox sub 34a. As stated previously, the bit member (not shown in this view) is connected by ordinary means (such as by thread means) to the bitbox sub 34a.

Referring now to the Fig. 4, a schematic view of the downhole apparatus 2 of the first embodiment will now be discussed as part of a bottom hole assembly. The first embodiment the apparatus 2 includes the power mandrel, seen generally at 4, that is operatively attached to the output of a downhole mud motor “MM”. The apparatus 2 also includes a radial bearing housing unit, seen generally at 6. The radial bearing housing unit 6 will be operatively attached to the workstring 100, such as drill pipe or coiled tubing. Also shown in Fig. 4 is the upper bearing housing 10a which includes the upper radial bearings 12a, lower radial bearing 14a, balls 16a and thrust races 18a. The lower housing is seen generally at 20a. As shown in Fig. 4, the bit 102 is attached to the apparatus 2, wherein the bit 102 will drill the wellbore as readily understood by those of ordinary skill in the art.

Fig. 5 and Fig. 6 depict the embodiment of the apparatus 2 without the spring means. Referring now to Fig. 5, a partial sectional view of lower housing 20b of the downhole apparatus 2 of a second embodiment in the engaged mode is shown. Fig. 5 depicts the hammermass 22b (sometimes referred to as the hammer member or hammer), which is attached (for instance, by spline means) to the spring saddle and the radial bearing housing unit (not shown here). The hammermass 22b will have a radial cam surface 24b. The hammermass 22b will engage with the anvil 26b, wherein the anvil 26b has a first end that contains a radial cam surface 28b, wherein the radial cam surface 28b and radial cam surface 24b of the hammermass 22b are reciprocal and cooperating in the preferred embodiment, as more fully set out below. Fig. 5 also depicts the driveshaft 30b (with the driveshaft 30b being connected to the power mandrel, not shown here). A key 32b (also referred to as a spline) allows for rotational engagement of the drive shaft 30b with the bitbox sub 34b, while also allowing for lateral movement of the bitbox sub 34b relatively to the driveshaft 30b -. The anvil 26b is fixed connected to the bitbox sub 34b.

In Fig. 6, a partial sectional view of the lower housing 20b of the downhole apparatus 2 of the second embodiment in the disengaged mode will now be described. In this mode, the apparatus 2 can be, for instance, running into the hole or pulling out of the hole, as well understood by those of ordinary skill in the art. Hence, the radial cam surface 24b of hammermass 22b is no longer engaging the radial cam surface 28b of the anvil 26b. Note the position of the end 37b of the driveshaft 30b in relation to the angled inner surface 38b of the bitbox sub 34b. As previously mentioned, a bit member is connected (such as by thread means) to the bitbox sub 34b.

Referring now to Fig. 7A, a perspective view of one embodiment of the anvil radial cam member. More specifically, Fig. 7A depicts the anvil 26a having the radial cam surface 28a, wherein the radial cam surface 28a includes an inclined portion 50, horizontal (flat) portion 51, and an upstanding portion 52. The inclined portion 50 may be referred to as a ramp that leads to the vertical upstanding portion 52 as seen in Fig. 7A. Fig. 7B is a top view of the anvil radial cam member seen in Fig. 7A. In one embodiment, multiple ramps (such as inclined portion 50, horizontal portion 51, extending to an upstanding portion 52) can be provided on the radial cam surface 26a.

In Fig. 8, a perspective view of one embodiment of the hammer radial cam member is depicted. More specifically, Fig. 8 shows the hammermass 22a that has a radial cam surface 24a. The radial cam surface 24a also has an inclined portion 54, horizontal (flat) portion 55 and an upstanding portion 56, which are reciprocal and cooperating with the inclined portion and upstanding portion of the anvil radial cam surface 28a, as noted earlier. Note that the cam means depicted in Figs. 7A, 7B and 8 will be the same cam means for the second embodiment of the apparatus 2 illustrated in Figs. 5 and 6.

A schematic of a drilling rig 104 with a wellbore extending therefrom is shown in Fig. 9. The downhole apparatus 2 is generally shown attached to a workstring 100, which may be a drill string, coiled tubing, snubbing pipe or other tubular. The bit member 102 has drilled the wellbore 106 as is well understood by those of ordinary skill in the art. The downhole apparatus 2 can be used, as per the teachings of this disclosure, to enhance the drilling rate of penetration by use of a percussion effect with the hammer 22a/22b impacting force on the anvil 26a/26b, previously described. In one embodiment, the downhole hammer is activated by the bit member 102 coming into contact with a reservoir interface, such as reservoir rock 108 found in subterranean wellbores or other interfaces, such as bridge plugs. In one embodiment, a driller can drill and hammer at the same time. As per the teachings of this invention, in the spring (first) embodiment, the hammermass will be accelerated by a spring force of the compressed spring thus generating an impact force when the hammermass hits the anvil member.

Referring now to Figs. 10A, 10B and 10C, graphs of the weight on bit (WOB) versus time during drilling operations will now be discussed. More specifically, Fig. 10A is the static WOB versus time; Fig. 10B is a dynamic WOB utilizing the hammer and anvil members (i.e. percussion unit); and, Fig. 10C represents -the summarized WOB wherein the impact force is graphically overlaid (i.e. summation) relative to the static load, in accordance with the teachings of this disclosure. As noted earlier, the percussion unit is made-up of the anvil, hammer, cam shaft arrangement and spring. The wave form W depicted in Figs. 10B and 10C represent the oscillating impact force of the percussion unit during use. Note that in Fig. 10C, W1 represents the force when the hammermass impacts the anvil and W2 represents the force when the hammermass does not impact the anvil. It must be noted that the size and shape of the wave form can be diverse depended on the material and the design of the spring, the anvil, the hammermass and the spacer sub.

An aspect of the disclosure is that the static weight of the drill string is transmitted different to the bit than the impact force (dynamic weight on bit) created by the hammer and anvil member. The static WOB is not transmitted through the hammer and anvil members including cam surface (i.e. cam shaft arrangement). The impact force is transmitted through the hammer and anvil to the bit and not through the camshaft arrangement. The percussion unit will generate the impact force if the cam shafts arrangements are engaged independently of the amount of WOB. Yet another aspect of one embodiment of the disclosure is the power section of the motor is simultaneously rotationally driving the bit and axially driving the hammer member. No relative axial movement is taking place between the housing of the apparatus and the inner drive train (including the power mandrel and the driveshaft) that is driving the bit and the percussion unit.

Another aspect of the one embodiment is the anvil is positioned as close as possible to the bit; the bit box and/or bit can function as an anvil. Still yet another aspect of one embodiment is that when the bit does not encounter a resistance, no interaction between the two cams is experienced and thus no percussion motion.

It will be apparent to one skilled in the art that modifications may be made to the illustrated embodiments without departing from the spirit and scope of the invention. Insofar as the description above and the accompanying drawing disclose any additional subject matter that is not within the scope of the claims below, the inventions are not dedicated to the public and right to file one or more applications to claim such additional inventions is reserved.

We claim:

1. A downhole apparatus connected to a workstring within a wellbore, said workstring being connected to a bit member having a motor means comprising:

-a power mandrel operatively connected to the motor means;

-an anvil member operatively formed on the bit member, said anvil member being operatively connected to said power mandrel;

-a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about said power mandrel;

-a spring saddle operatively attached to the radial bearing housing unit;

-a spring spacer disposed about said spring saddle;

-a spring having a first end and a second end, with the first end abutting the spring saddle;

-a hammer member slidably attached to said spring saddle, and wherein the hammer member abuts the second end of the spring.

2. The apparatus of claim 1 wherein said hammer member and said anvil member is below the radial bearing housing unit.

3. The apparatus of claim 2 wherein the workstring is a tubular drill string.

4. The apparatus of claim 2 wherein the workstring is a coiled tubing string.

5. The apparatus of claim 2 wherein said anvil member contains a radial face having an inclined portion and a upstanding portion.

6. The apparatus of claim 2 wherein the hammer member contains a radial face having an inclined portion and a upstanding portion.

7. A downhole apparatus connected to a workstring within a wellbore, said workstring being connected to a bit member with a motor means comprising:

-a power mandrel operatively connected to the motor means;

-an anvil member operatively formed on the bit member, said anvil member being operatively connected to said power mandrel;

-a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about said power mandrel;

-a hammer member slidably attached to said radial bearing housing unit.

8. The apparatus of claim 7 wherein said hammer member and said anvil member are below the radial bearing housing unit.

9. The apparatus of claim 7 wherein the workstring is a tubular drill string.

10. The apparatus of claim 7 wherein the workstring is a coiled tubing string.

11. The apparatus of claim 7 wherein the anvil member contains a cam face having an inclined portion and an upstanding portion.

12. The apparatus of claim 7 wherein the hammer member contains a cam face having an inclined portion and a upstanding portion.

13. The apparatus of claim 7 wherein the apparatus further comprises:

-a spring saddle operatively attached to the radial bearing housing unit;

-a spring spacer disposed about said spring saddle;

-a spring having a first end and a second end, with the first end abutting the spring saddle.

14. The apparatus of claim 13 wherein said hammer member is slidably attached to said radial bearing housing unit with spline means operatively positioned on said spring saddle.

15. The apparatus of claim 13 wherein the hammer member is located between the bit and the motor means.

16. The apparatus of claim 13 wherein the hammer member is located below the bearing sectionof the apparatus.

17. A method for drilling a wellbore with a workstring, comprising:

-providing a downhole apparatus connected to the workstring within the wellbore, said apparatus being connected to a bit member, the downhole apparatus comprising: a power mandrel operatively connected to a motor means; an anvil member with a radial cam surface operatively formed on the bit member, said anvil member being operatively connected to said power mandrel; a radial bearing housing unit operatively connected to the workstring, with the radial bearing housing unit being disposed about said power mandrel; a spring saddle operatively attached to the radial bearing housing unit; a spring spacer disposed about said spring saddle, a spring having a first end and a second end, with the first end abutting the spring saddle; a hammer member with a radial cam surface slidably attached to said spring saddle, and wherein the hammer member abuts the second end of the spring;

-lowering the workstring into the wellbore;

-contacting the bit member with a reservoir interface;

-engaging a distal end of said power mandrel with a surface of said bit member;

-slidably moving the anvil member;

-engaging a radial cam surface of the anvil member with a reciprocal radial cam surface of the hammer member so that the hammer member imparts an impact force on the anvil member thereby imparting the impact force on the bit member.

18. The method of claim 17 wherein the method further provides that static weight on the bit member is transmitted to the bit member different than the impact force created by the hammer and anvil member whereby the maximum force on the bit member is the sum of the static weight on bit member and the impact force created by the hammer and the anvil member

19. The method of claim 17 wherein the method further provides that the static weight on the bit is not transmitted through the cam shaft arrangement, which includes the cam surfaces.

20. The method of claim 17 wherein the method further provides that independent of the amount of weight on bit an oscillating impact force will be generated if the radial cam surfaces of the hammer member and the anvil member are engaging each other

21. The method of claim 17 wherein the method further provides that the impact force is transmitted through other surfaces of the hammer and anvil then through the radial cam surfaces of the hammer member and the anvil member.

22. The method of claim 17 wherein the method further provides that when the bit does not encounter resistance, so that there is no interaction between the two cam surfaces of the hammer and anvil member, no oscillating motion is created between the hammer member and the anvil member.

23. The method of claim 17 wherein the method further provides the power section of the motor

is simultaneously rotationally driving the bit member and axially driving the hammer member.

24. The method of claim 17 wherein no relative axial movement is taking place between the housing of the apparatus and the inner drive train that is rotationally driving the bit member and axially driving the hammer member.

25. The method of claim 17 wherein the bit box of the apparatus can function as an anvil member.

26. The method of claim 17 wherein the bit member can function as an anvil member.

27. The method of claim 17 wherein when the radial cam surface of the hammer member and the anvil cam surface of the anvil member are engaged, and the hammer member is sliding axially relative to the anvil member, the spring will be periodically compressed and released thereby periodically accelerating the hammer member towards the anvil member which in turn generates an additional impact force.

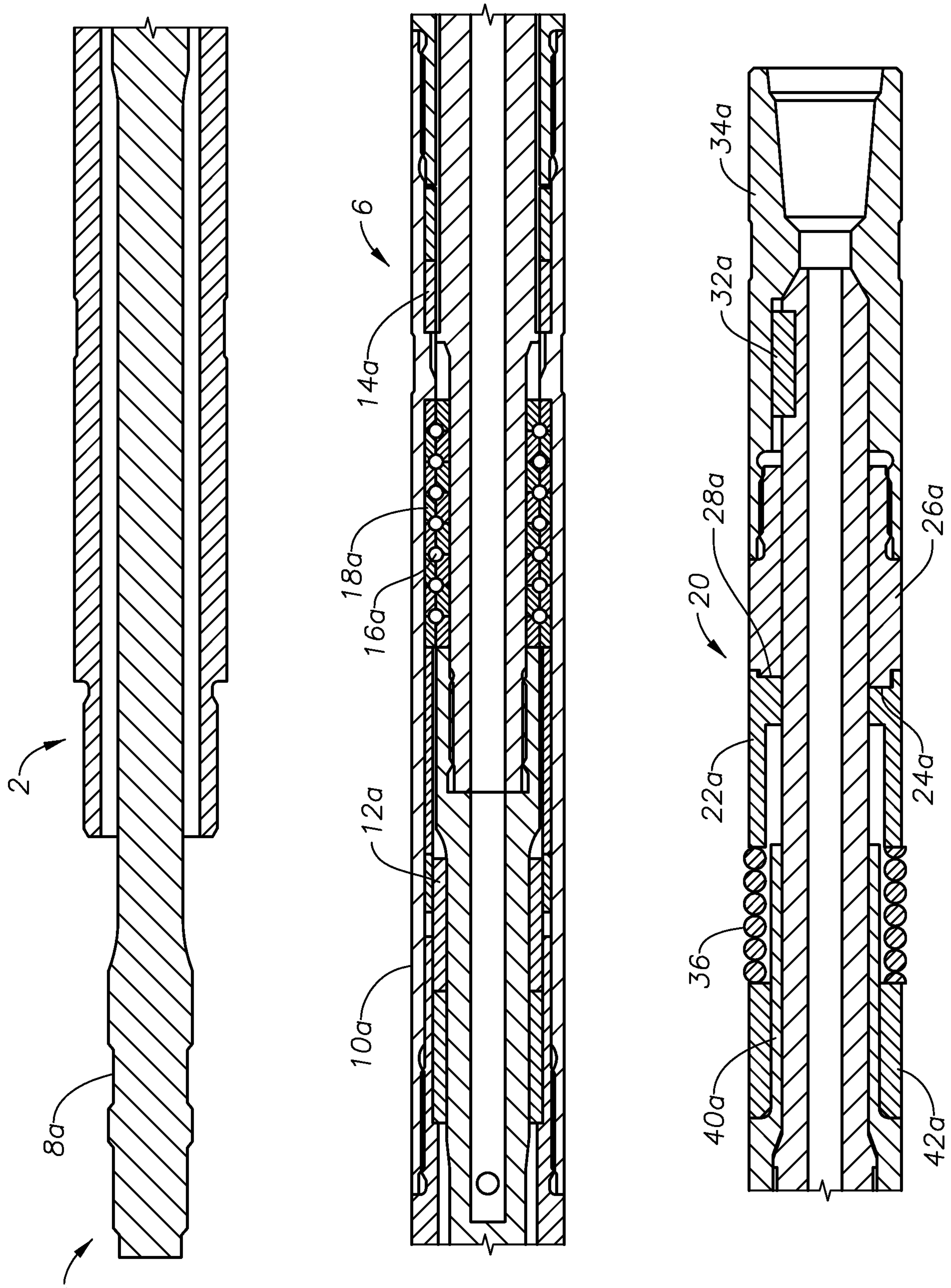
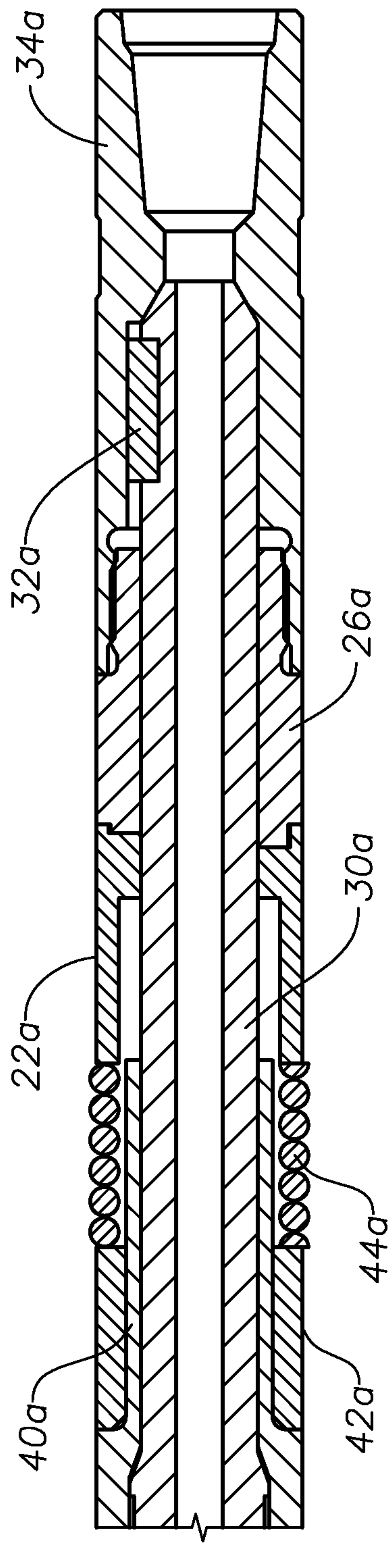


FIG. 1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32a
26a
30a
22a
44a
40a
42a

FIG. 2

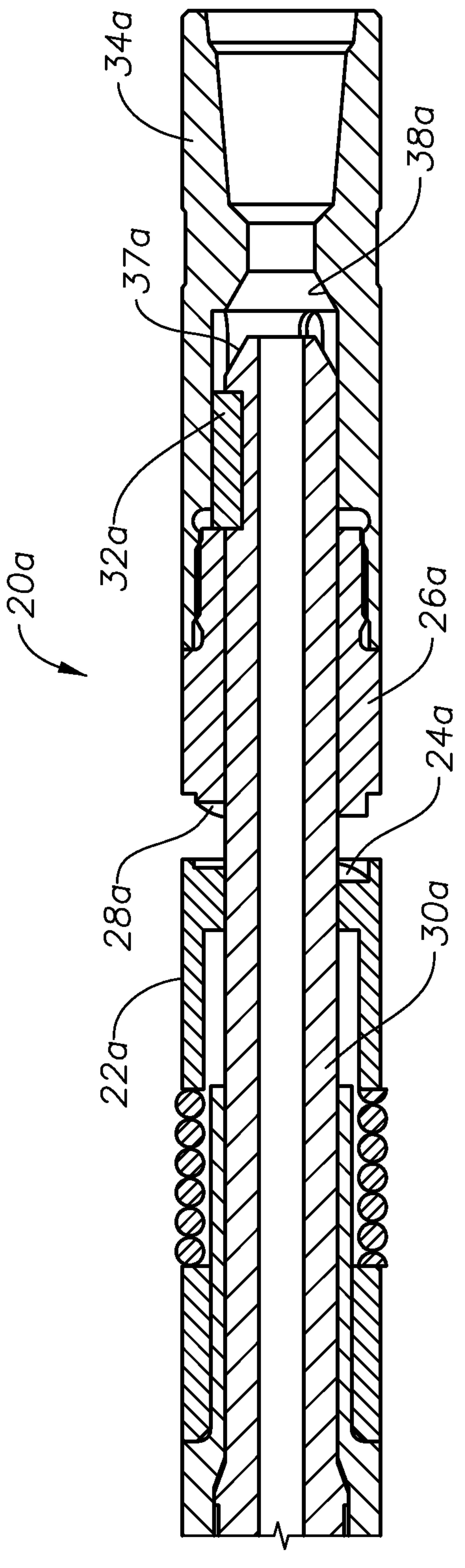
34a
38a
37a
32a
20a
26a
24a
28a
30a
22a

FIG. 3

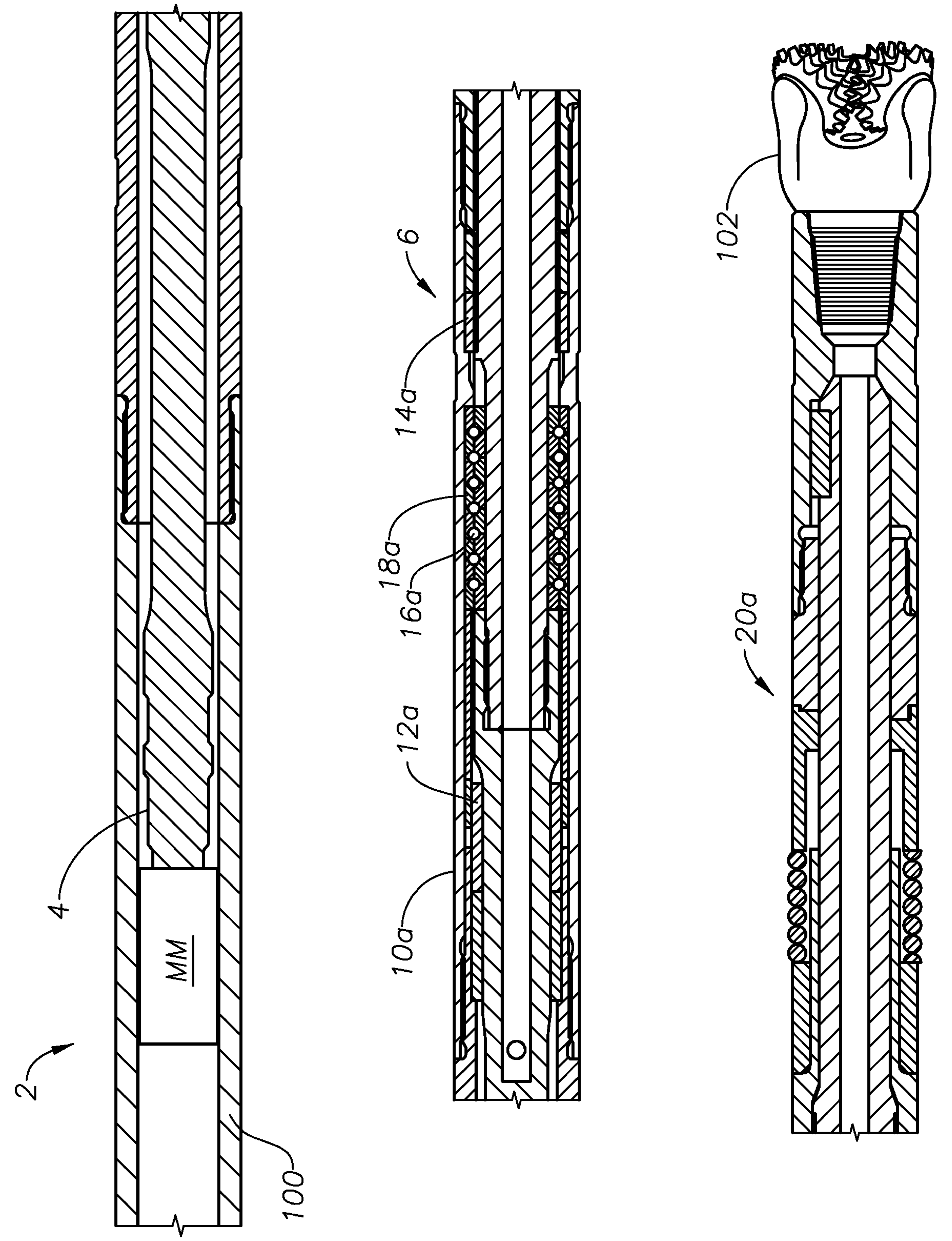

FIG. 4

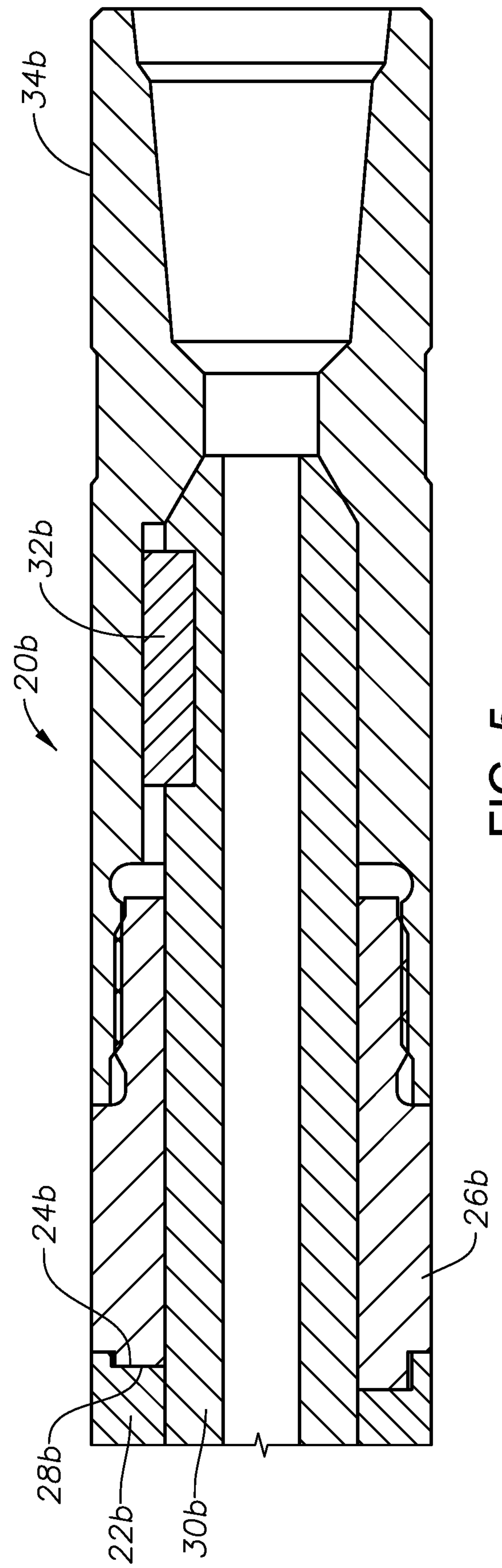
34b
32b
20b
24b
26b
28b
22b
30b

FIG. 5

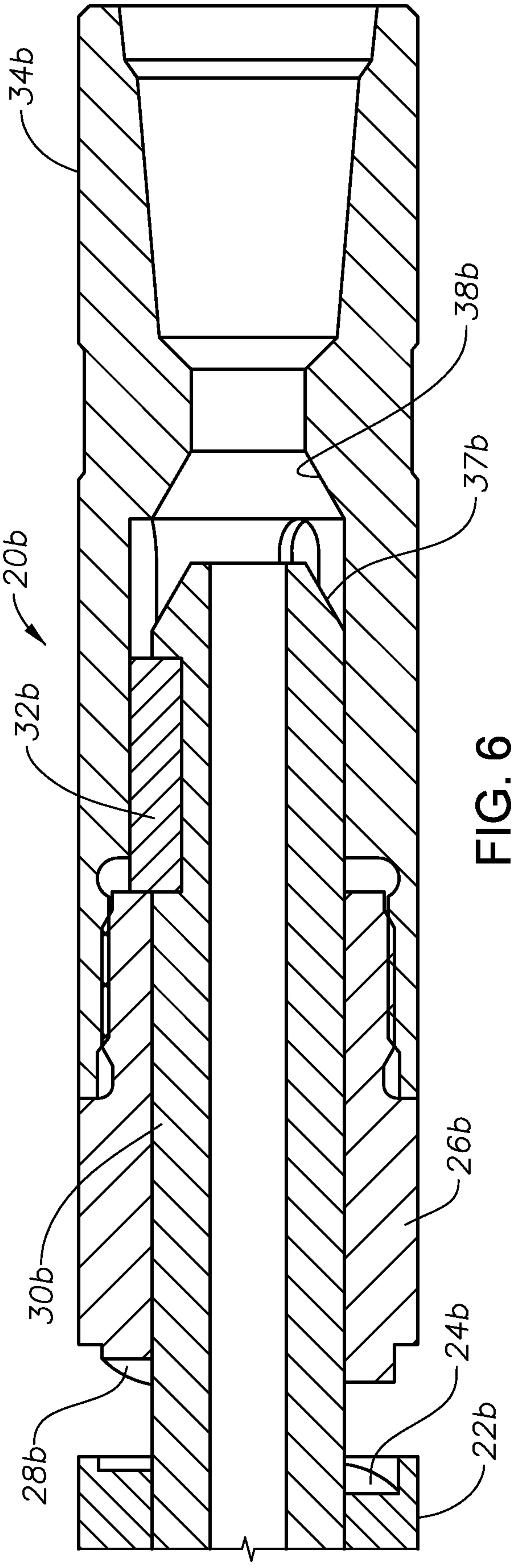
34b
38b
37b
20b
32b
26b
30b
24b
28b
22b

FIG. 6

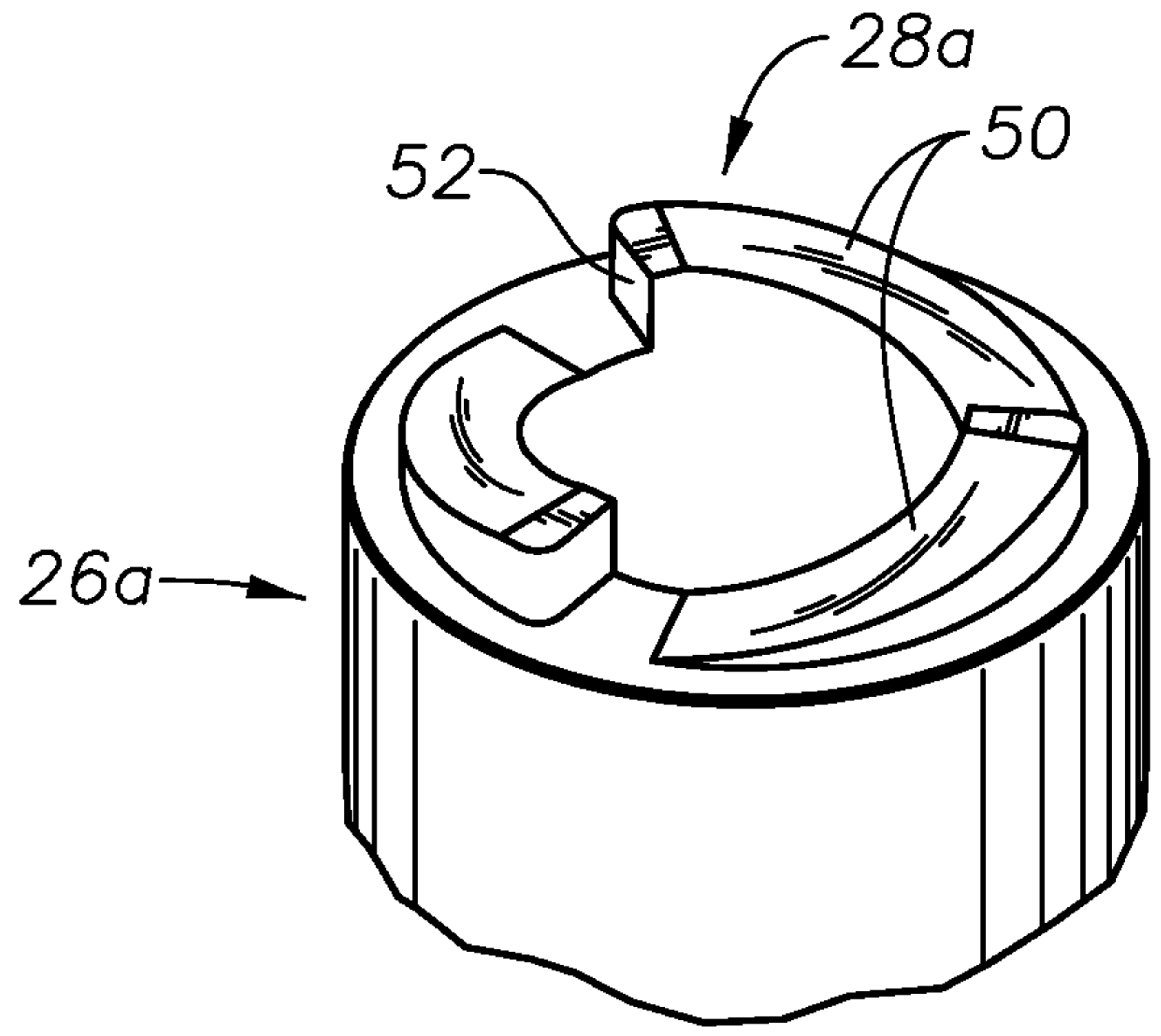

FIG. 7A

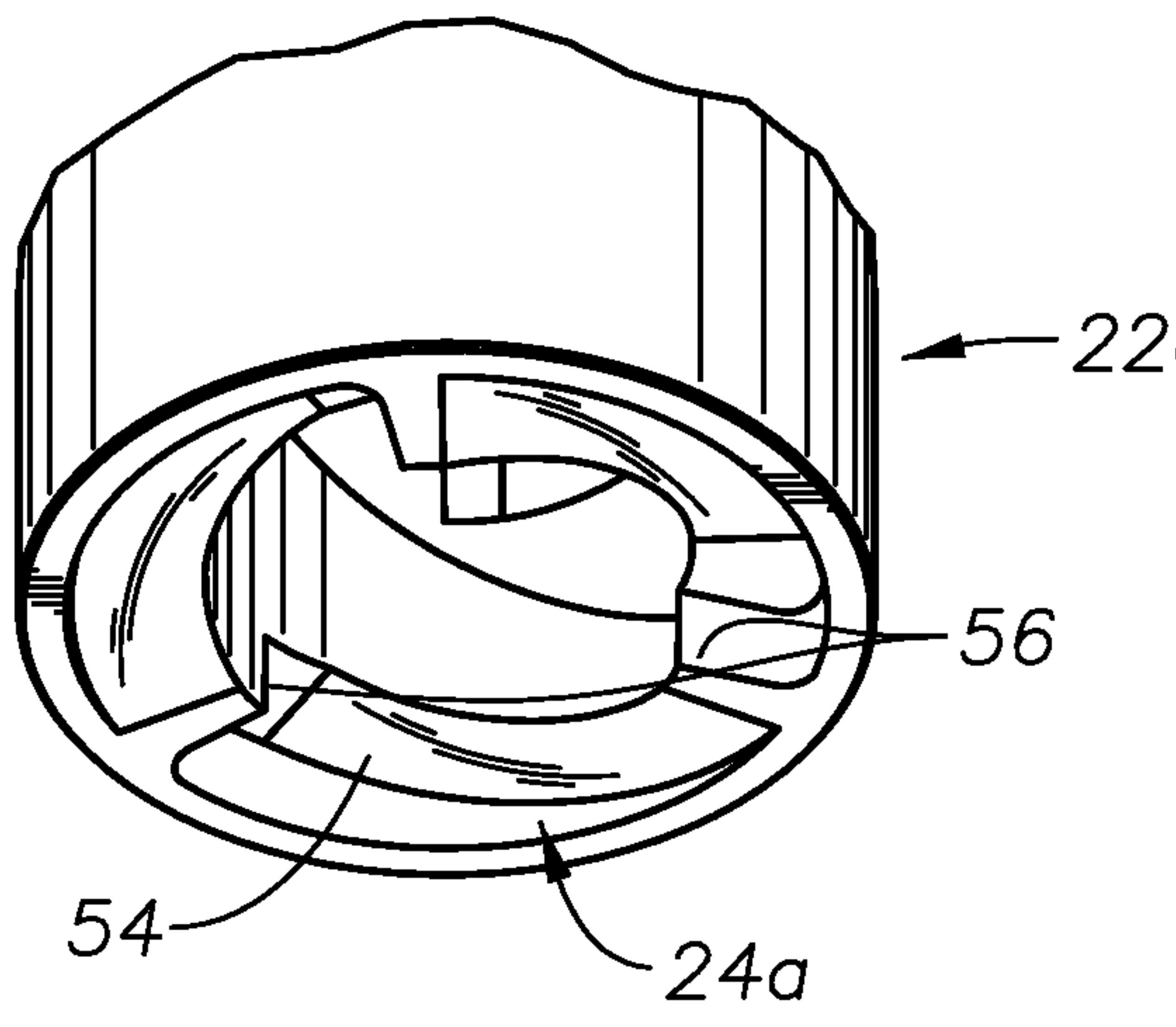

FIG. 8

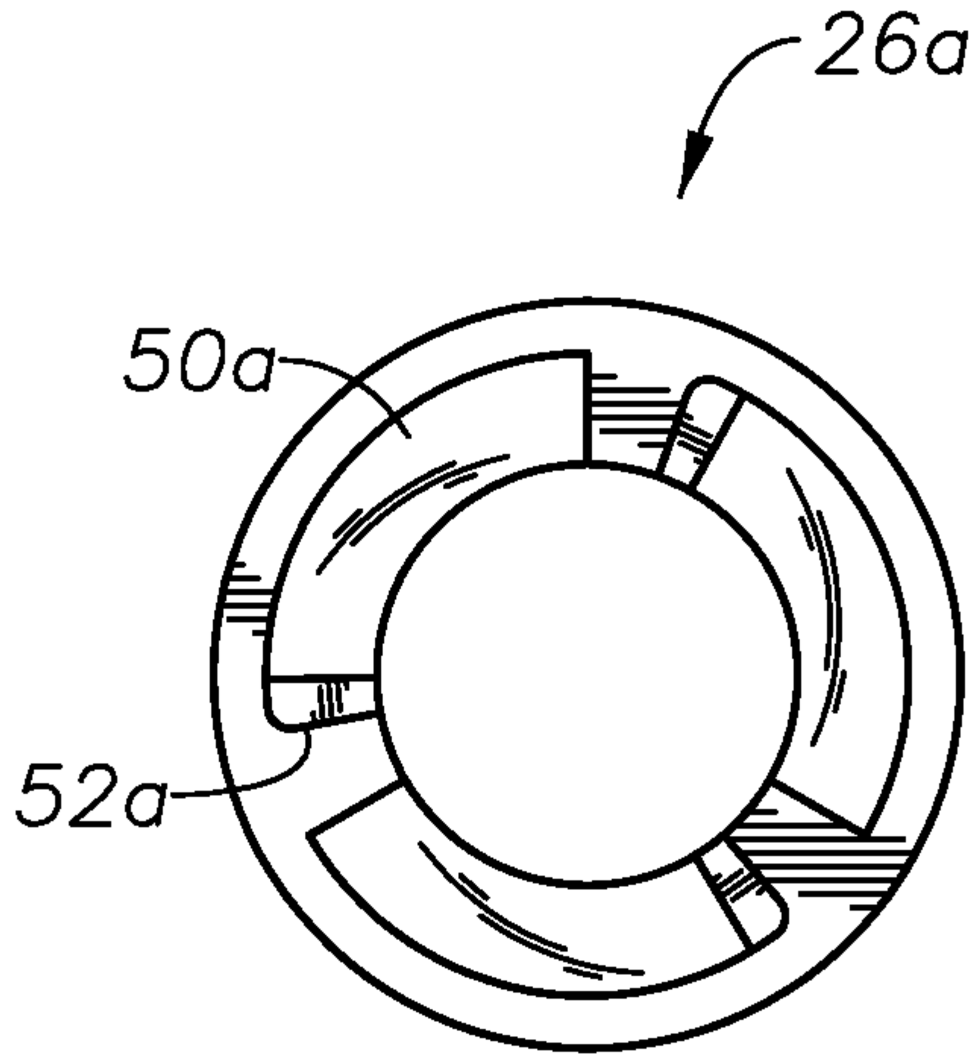

FIG. 7B

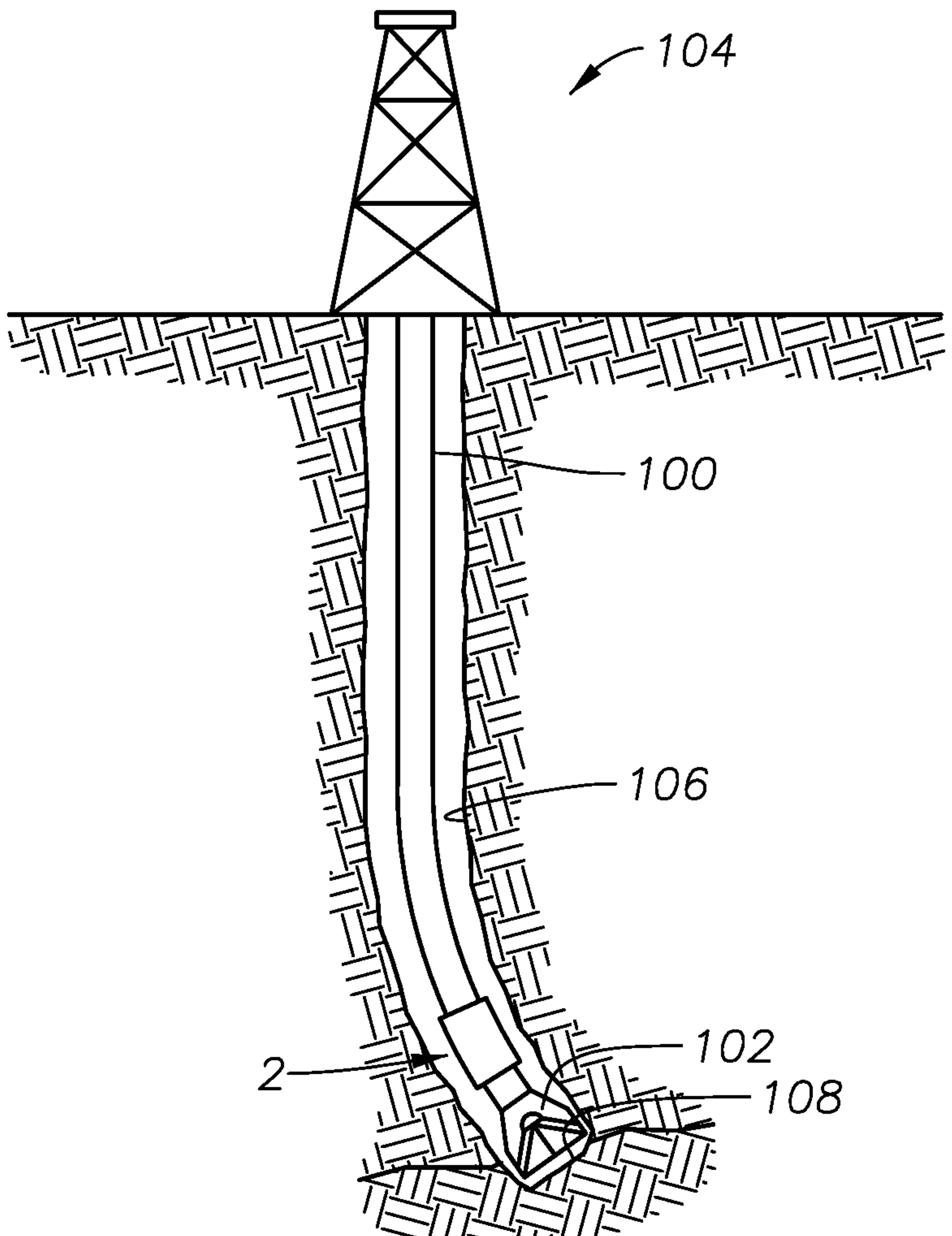

FIG. 9

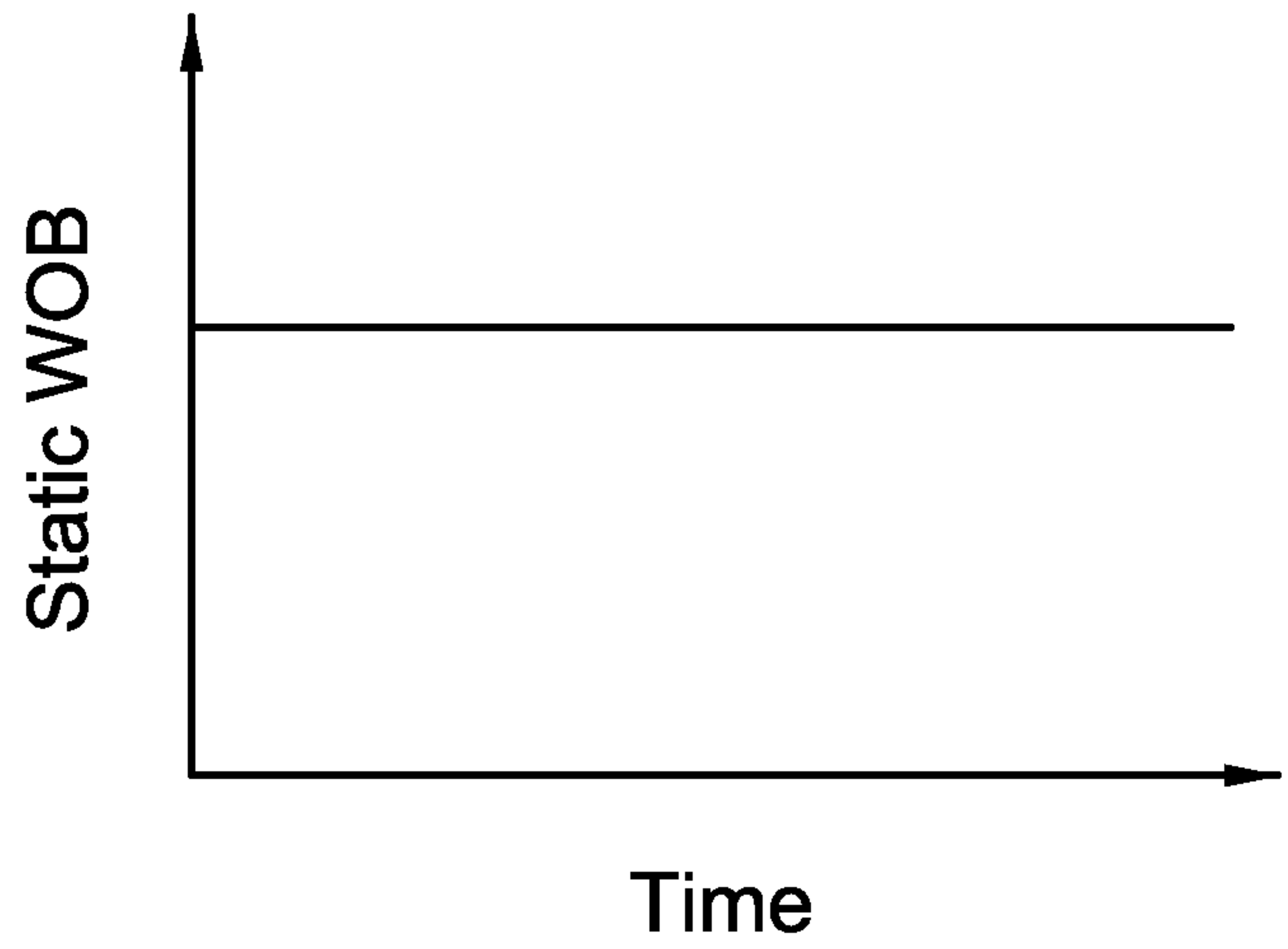

FIG. 10A

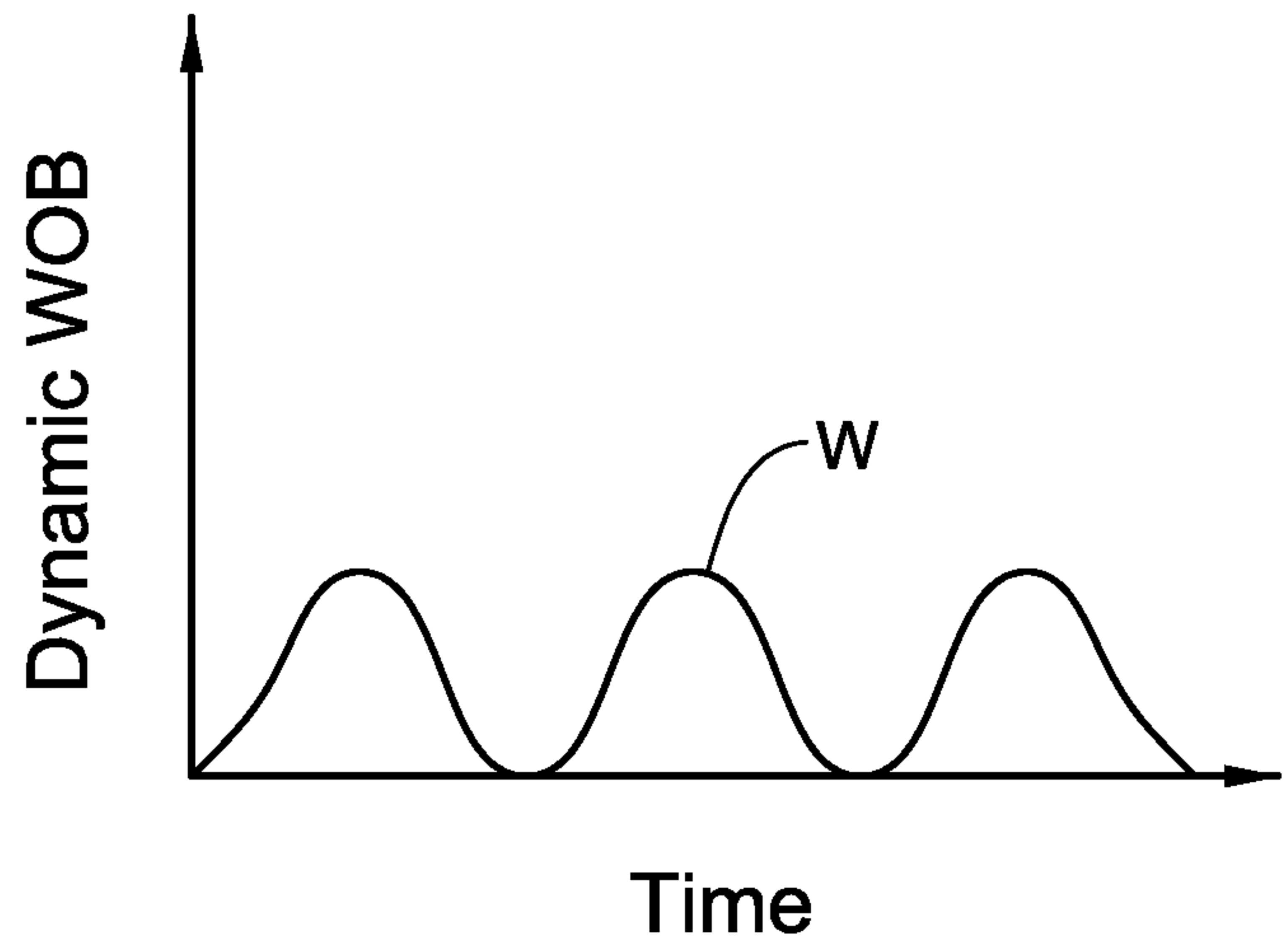

FIG. 10B

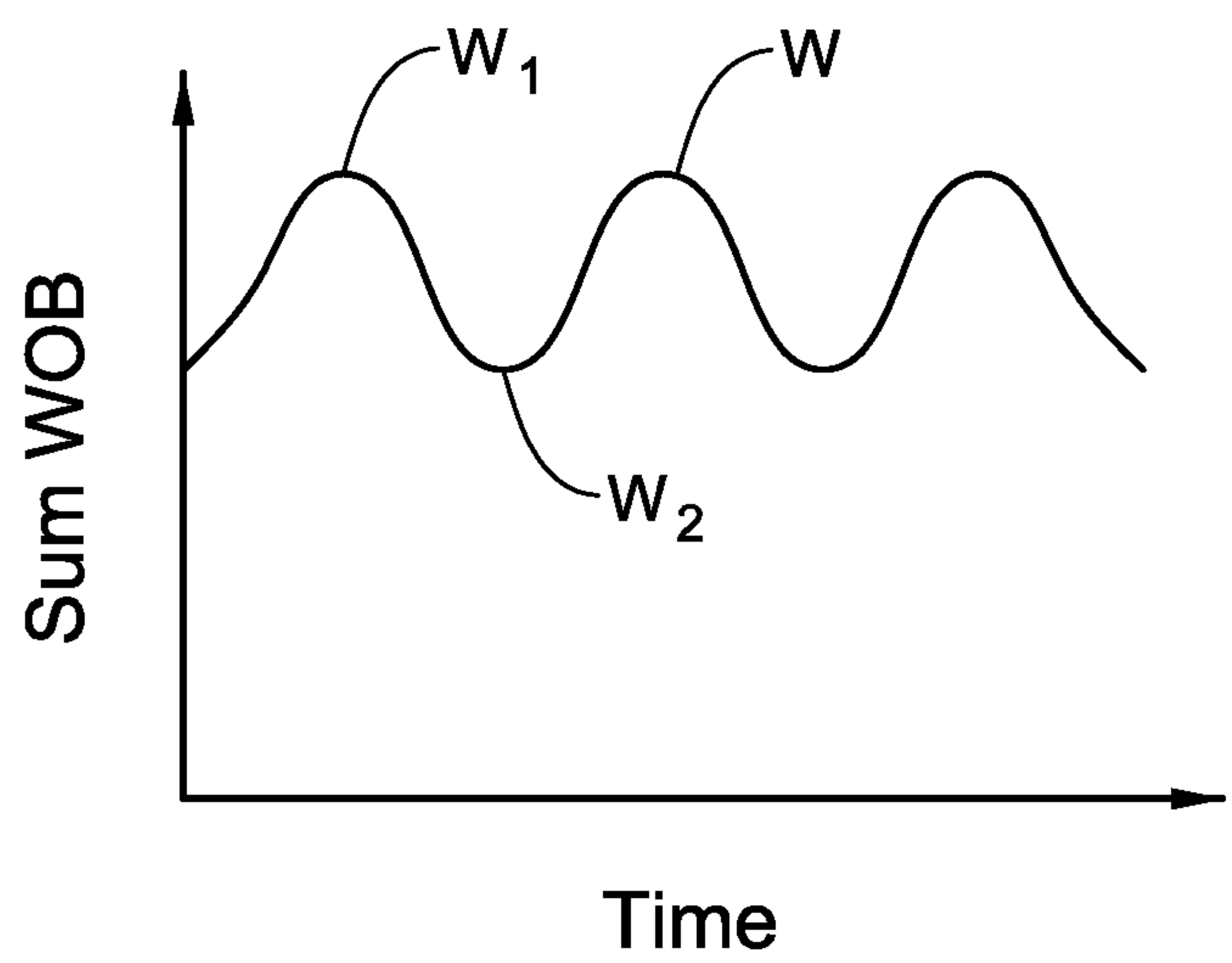

FIG. 10C

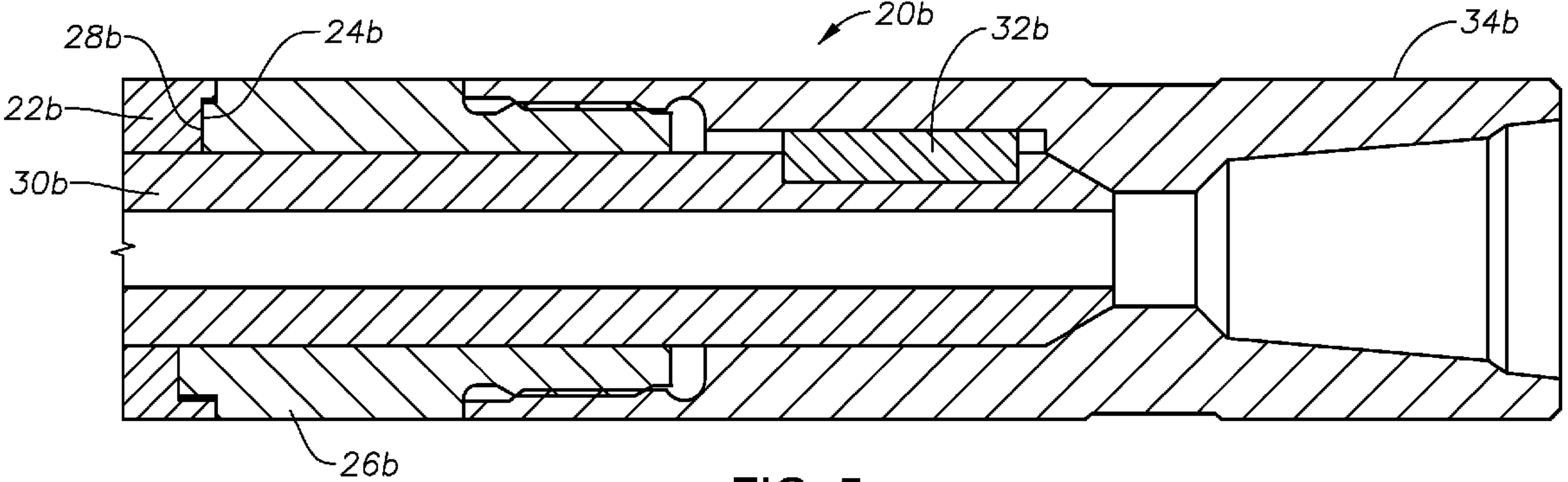

FIG. 5