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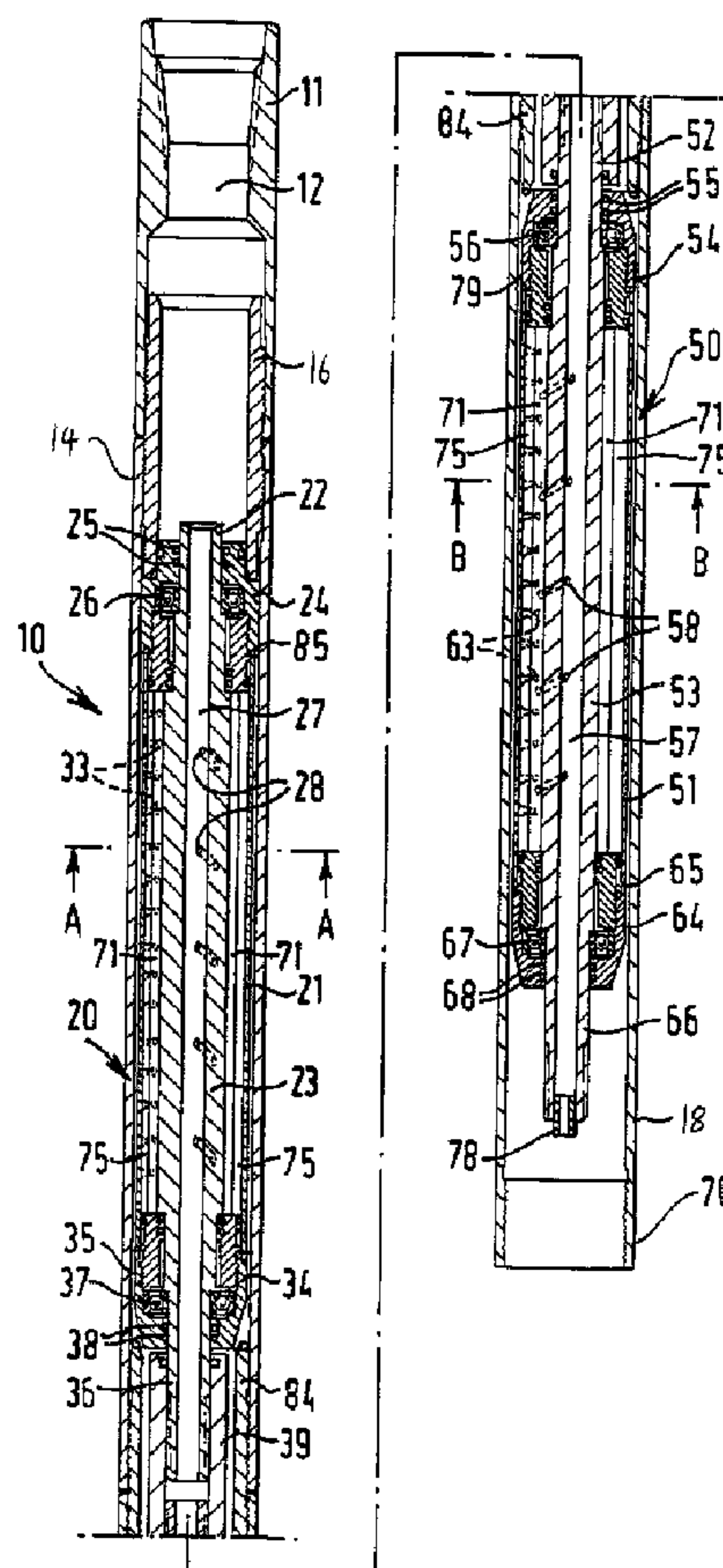
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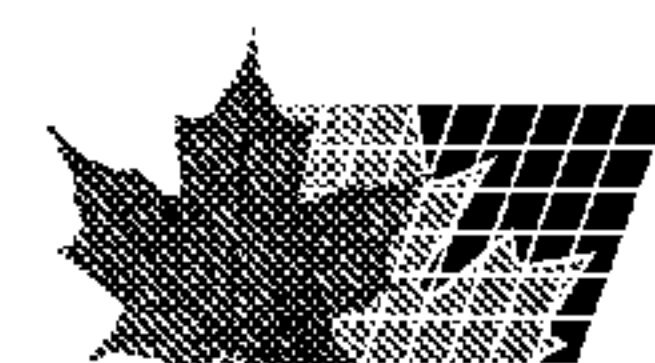
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(54) Title: DOWNHOLE MOTOR FOR A DRILLING APPARATUS



(57) Abrégé/Abstract:

A drilling motor (20) comprises a stator (21) and a rotor (23) rotatably mounted in a stator (21). The stator (21) is provided with two opposed rod recesses (75) and two opposed exhaust ports (33). In use motive fluid is pumped through a central channel (27) in



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

the rotor (23) and through a plurality of radially extending channels (58) into action chambers (31) between the rotor (23) and the stator (21). The rotor (23) has two opposed seals (76) which engage the stator (21) and the rod recesses (75) are each provided with rods (71) which, in use, also form a seal between the stator (21) and the rotor (23). The seals (76) and rods (71) can be made of a variety of materials including stainless steel. Two drilling motors (20, 50) can be arranged in parallel with their rotors out of phase to provide a relatively smooth power output and inhibit stalling.



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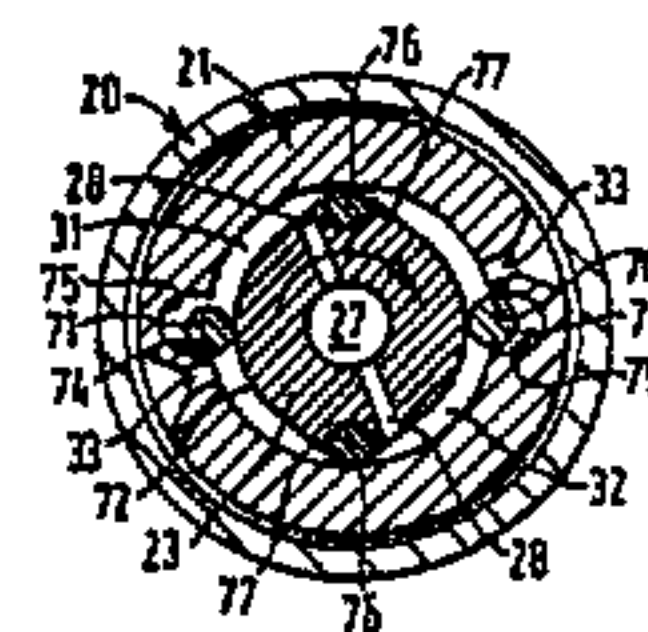
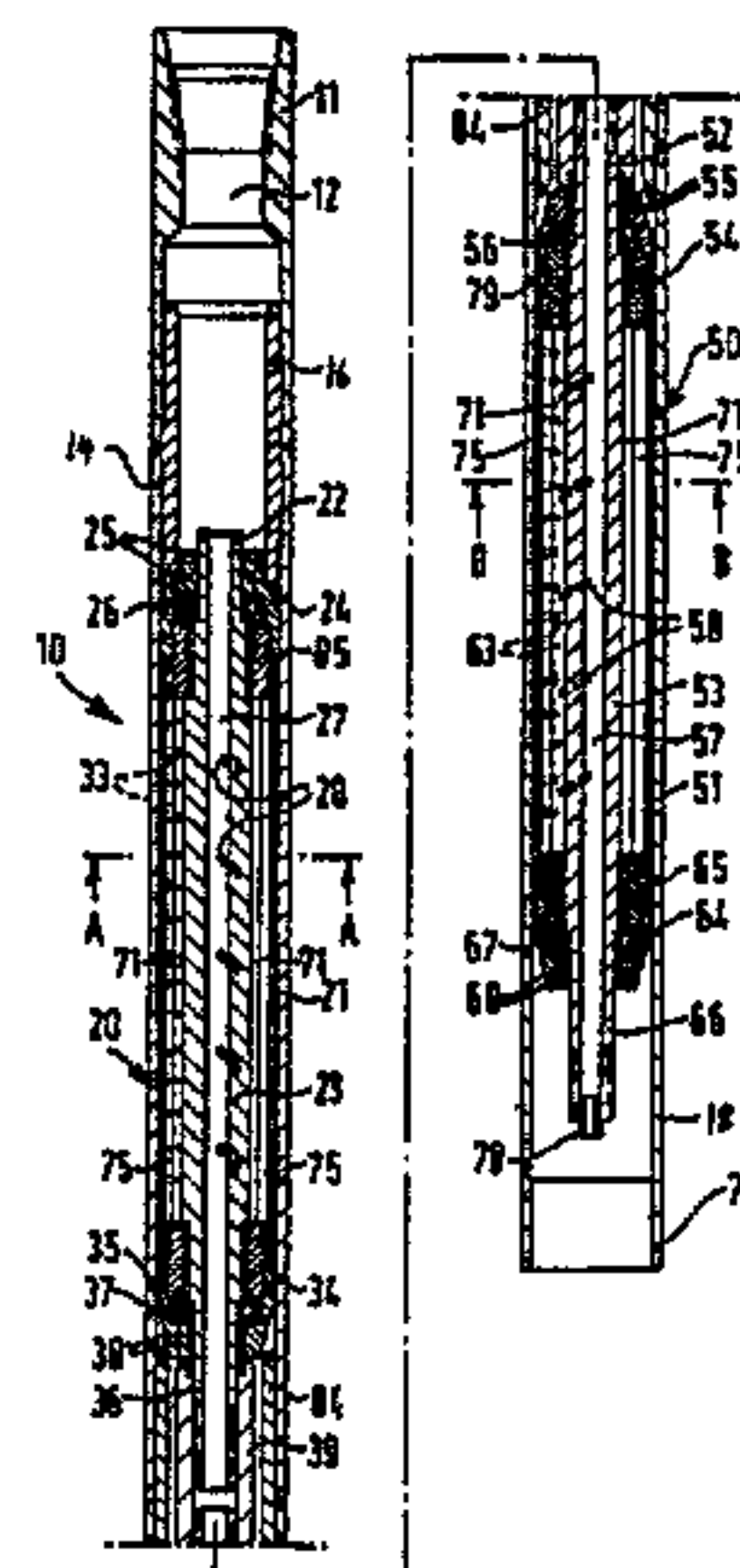
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(54) Title: DOWNHOLE MOTOR FOR A DRILLING APPARATUS

(57) Abstract

A drilling motor (20) comprises a stator (21) and a rotor (23) rotatably mounted in a stator (21). The stator (21) is provided with two opposed rod recesses (75) and two opposed exhaust ports (33). In use motive fluid is pumped through a central channel (27) in the rotor (23) and through a plurality of radially extending channels (58) into action chambers (31) between the rotor (23) and the stator (21). The rotor (23) has two opposed seals (76) which engage the stator (21) and the rod recesses (75) are each provided with rods (71) which, in use, also form a seal between the stator (21) and the rotor (23). The seals (76) and rods (71) can be made of a variety of materials including stainless steel. Two drilling motors (20, 50) can be arranged in parallel with their rotors out of phase to provide a relatively smooth power output and inhibit stalling.



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Downhole motor for a drilling apparatus

This invention relates to a drilling motor, to a drilling apparatus including said drilling motor and to
5 a drilling rig including said drilling apparatus.

Traditionally, well bores are drilled by rotating a drill string with a motor situated at the surface. Whilst this technique is quite satisfactory for drilling vertical bores it is not suitable for deviated drilling
10 where it may be desired to drill a near horizontal branch bore from a vertical bore. For this purpose it is usual to employ a drilling motor which is disposed near the drill bit and is powered by pumping hydraulic or pneumatic fluid from the surface to the drilling
15 motor.

At the present time "Moineau" motors are used for this purpose.

One of the difficulties with using such drilling motors is that they do not operate reliably at temperatures above about 120°C (250°F) and are thus not suitable for use in drilling most geothermal wells and other wells where the ambient temperature exceeds 120°C. Attempts have been made to replace parts of Moineau
20 motors with materials which will withstand higher temperatures. However, these attempts have not been entirely successful.

The aim of at least preferred embodiments of the present invention is to provide a drilling motor which is relatively reliable particularly, but not exclusively,
30 ly, when operating at temperatures in excess of 120°C.

According to one aspect of the present invention there is provided a drilling motor which comprises a stator and a rotor rotatably mounted in said stator, wherein said stator is provided with a rod recess and an
35 exhaust port, wherein said rotor is provided with a

rotor channel and at least one channel for conducting motive fluid from said rotor channel to a chamber between said rotor and said stator, and wherein said rod recess is provided with a rod which, in use, forms a seal between said stator and said rotor.

Although not essential it is highly desirable that the rotor be provided with a seal for engagement with the stator.

Preferably, said seal is made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Advantageously, said rod is made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably, said stator is provided with two rod recesses which are disposed opposite one another, two exhaust ports which are disposed opposite one another, each of said rod recesses is provided with a respective rod, and said rotor has two seals which are disposed opposite one another.

According to another aspect, the present invention provided a drilling apparatus comprising two drilling motors in accordance with the invention arranged with their respective rotors connected together.

Preferably, said drilling motors are connected in parallel although they could be connected in series if desired.

Advantageously, said drilling motors are arranged so that, in use, one drilling motor operates out of phase with the other. Thus, in the preferred embodiment each drilling motor has two chambers and the chambers in the first drilling motor are 90° out of phase with the chambers in the second drilling motor. Similarly, in an

embodiment in which each drilling motor has four chambers, the chambers in the first drilling motor would preferably be 45° out of phase with the chambers on the second drilling motor. This arrangement helps ensure a smooth power output and inhibits stalling.

The present invention also provides a drilling rig including a drill string provided with drilling apparatus in accordance with the invention and a well tool rotatable by said drilling apparatus.

The well tool will normally be a drill bit although it could comprise, for example, a rotatable cleaning head. The well tool could also be a drill used to dig a pit (sometimes referred to as a "glory hole") in the sea bed to house sub-sea well head equipment.

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For a better understanding of the present invention reference will now be made, by way of example, to the accompanying drawings in which:-

5 Fig. 1 is a longitudinal cross sectional view of one embodiment of drilling apparatus according to the present invention;

Fig. 2A-2D are cross sectional views along line A-A of Fig. 1 showing the rotor in four different positions;

10 Fig. 3A-3D are cross sectional views along line B-B of Fig. 1 showing the rotor in four different positions; and

Fig. 4 is a cross sectional view of a typical bearing housing and drill bit.

15 Referring now to Fig. 1, there is shown a drilling apparatus which is generally identified by reference numeral 10. The drilling apparatus 10 comprises a first motor 20 and a second motor 50.

20 The first motor 20 comprises a stator 21 and a rotar 23. A top portion 22 of the rotor 23 extends through an upper bearing assembly 24 which comprises a thrust bearing 26 and seals 25.

25 Motive fluid, e.g. water, drilling mud or gas under pressure, flows down through a central sub channel 12 into a central rotor channel 27, and then out through rotor flow channels 28 into action chambers 31 and 32.

30 Following a motor power stroke, the motive fluid flows through exhaust ports 33, and then downwardly through an annular channel circumjacent the stator 21 and flow channels 35 in a lower bearing assembly 34. A portion 36 of the rotor 23 extends through the lower bearing assembly 34 which comprises a thrust bearing 37 and seals 38.

35 The ends of the stator 21 are castellated and the castellations engage in recesses in the respective upper bearing assembly 24 and lower bearing assembly 34

respectively to inhibit rotation of the stator 21. The upper bearing assembly 24 and lower bearing assembly 34 are a tight fit in an outer tubular member 14 and are held against rotation by compression between threaded sleeves 16 and 84.

A splined union 39 joins a splined end of the rotor 23 to a splined end of the rotor 53 of the second motor 50. The second motor 50 has a stator 51.

A top portion 52 of the rotor 53 extends through an upper bearing assembly 54. Seals 55 are disposed between the upper bearing assembly 54 and the exterior of the top portion 52 of the rotor 53. The rotor 53 moves on thrust bearings 56 with respect to the upper bearing assembly 54.

Motive fluid flows into a central rotor channel 57 from the central rotor channel 27 and then out through rotor flow channels 58 into action chambers 61 and 62. Following a motor power stroke, the motive fluid flows through exhaust ports 63 and then downwardly through an annular channel circumjacent the stator 51 and flow channels 65 in a lower bearing assembly 64. A portion 66 of the rotor 53 extends through the lower bearing assembly 64. The rotor 53 moves on thrust bearings 67 with respect to the lower bearing assembly 64 and seals 68 seal the rotor-bearing assembly interface. Also motive fluid which flowed through the flow channels 35 in the lower bearing assembly 34, flows downwardly through channels 79 in the upper bearing assembly 54, past stator 51 and through flow channels 65 in the lower bearing assembly 64.

The upper bearing assembly 54 and lower bearing assembly 64 are a tight fit in an outer tubular member 18 and are held against rotation by compression between threaded sleeve 84 and a lower threaded sleeve (not shown).

A lower sub is threadedly connected to the stator 51 via threads 70 and provides interconnection with a drill bit connection/bearing housing S (Fig. 4) and a typical drill bit D (Fig. 4). A solid plug or a flow restrictor 78 at the bottom of the rotor 53 may be used to restrict motive fluid flow to the drill bit D and to ensure that a desired amount of motive fluid passes through the motors.

Figs. 2A-2D and 3A-3D depict a typical cycle for the first and second motors 20 and 50 and show the status of the two motors with respect to each other at various times in the cycle. For example, Fig. 2c shows an exhaust period for the first motor 20 while Fig. 3c, at that same moment, shows a power period for the second motor 50.

As shown in Fig. 2A, motive fluid flowing through the rotor flow channels 28 enters the action chambers 31 and 32. Due to the geometry of the chambers (as discussed below) and the resultant forces, the motive fluid moves the rotor in a clockwise direction as seen in Fig. 2B. The action chamber 31 is sealed at one end by a rolling vane rod 71 which abuts an exterior surface 72 of the rotor 23 and a portion 74 of a rod recess 75.

At the other end of the action chamber 31, a seal 76 on a lobe 77 of the rotor 23 sealingly abuts an interior surface of the stator 21.

As shown in Fig. 2B, the rotor 23 has moved to a point near the end of a power period.

As shown in Fig. 2C, motive fluid starts exhausting at this point in the motor cycle through the exhaust ports 33.

As shown in Fig. 2D, the rolling vane rods 71 and seals 76 have sealed off the action chambers and motive fluids flowing thereinto will rotate the rotor 23 until the seals 76 again move past the exhaust ports 33.

The second motor 50 operates as does the first motor 20; but, as preferred, and as shown in Figs. 3A-3D, the two motors are out of phase by 90° so that as one motor is exhausting motive fluid the other is providing power.

The seals 76 are, in one embodiment, made of polyethylethylketone (PEEK). The rolling vane rods 71 are also made from PEEK. The rotors (23, 25) and stators (21, 51) are preferably made from corrosion resistant materials such as stainless steel.

When a seal 76 in the first motor 20 rotates past an exhaust port 33, the motive fluid that caused the turning exits and flows downward through the stator adaptor 84 (Fig. 1), then through the channels 79, past the exhaust ports 63, the flow channels 65, the bearing housing S (Fig. 4) and subsequently to the drill bit D (Fig. 4). All motive fluid that enters the top sub 11 finally exits to the drill bit D.

During tests, an apparatus similar to the apparatus shown in Fig. 1 was shown to develop the same rotational power as a conventional Moineau motor of approximately three times the length. This is a most significant advantage when operating in a deviated well.

The apparatus of Fig. 1 may be used as a pump by either manually or mechanically turning the drill bit D or housing S in a direction opposite to that of Fig. 2A; or by connecting a rotative mechanism to the rotor 53 and rotating it in a direction opposite to that of Fig. 2A. With the apparatus in a wellbore, this is achieved by jamming the bit into a formations so it does not turn and then rotating the tubular string above the apparatus of Fig. 1.

Various modifications to the embodiment described are envisaged, for example the seal 76 can be made of other durable materials such as copper alloys and steels

such as stainless steel. Stainless steel is particularly useful in high temperature environments and has been successfully tested at 500°F (260°C). This compares with a maximum operating temperature of 250°F (121°C) of
5 conventional Moineau motors. Whereas the first motor 20
and second motor 50 are shown operating in parallel they
could also be operated in series if desired.

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Claims

1. A drilling motor which comprises a stator and a rotor rotatably mounted in said stator, wherein said stator is provided with a rod recess and an exhaust port, wherein said rotor is provided with a rotor channel and at least one channel for conducting motive fluid from said rotor channel to a chamber between said rotor and said stator, and wherein said rod recess is provided with a rod which, in use, forms a seal between said stator and said rotor.
2. A drilling motor as claimed in Claim 1, wherein said rotor is provided with a seal for engagement with the stator.
3. A drilling motor as claimed in Claim 1 or 2, wherein said seal is made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.
4. A drilling motor as claimed in Claim 1, 2 or 3, wherein said rod is made from a material selected from the group consisting plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.
5. A drilling motor as claimed in Claim 1, 2, 3, or 4, wherein said stator is provided with a second rod recess, each of said rod recesses being disposed opposite one another, a second exhaust port, each of said exhaust ports being disposed opposite one another, each of said rod recesses being provided with a respective rod, and wherein said motor is provided with a first seal and a second seal which are disposed opposite one another.

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6. A drilling apparatus comprising two drilling motors as claimed in any one of the preceding Claims, arranged with their respective rotors connected together.

7. A drilling apparatus as claimed in Claim 6, wherein said drilling motors are connected in parallel.

8. A drilling apparatus as claimed in Claim 6, wherein said drilling motors are connected in series.

9. A drilling apparatus as claimed in Claim 6, 7 or 8, wherein said drilling motors are arranged so that, in use, one drilling motor operates out of phase with the other.

10. A drilling apparatus as claimed in claim 9 wherein said drilling motors each have two chambers, said two chambers of the first drilling motor being arranged so as to be 90° out of phase with the two chambers of the second drilling motor.

11. A drilling rig comprising a drill string incorporating a drilling apparatus as claimed in Claim 6, 7, 8 or 9 and a well tool rotatable by said drilling apparatus.

12. A drilling rig as claimed in Claim 11, wherein said well tool is a drill bit.

13. A pump comprising the motor of claim 1.

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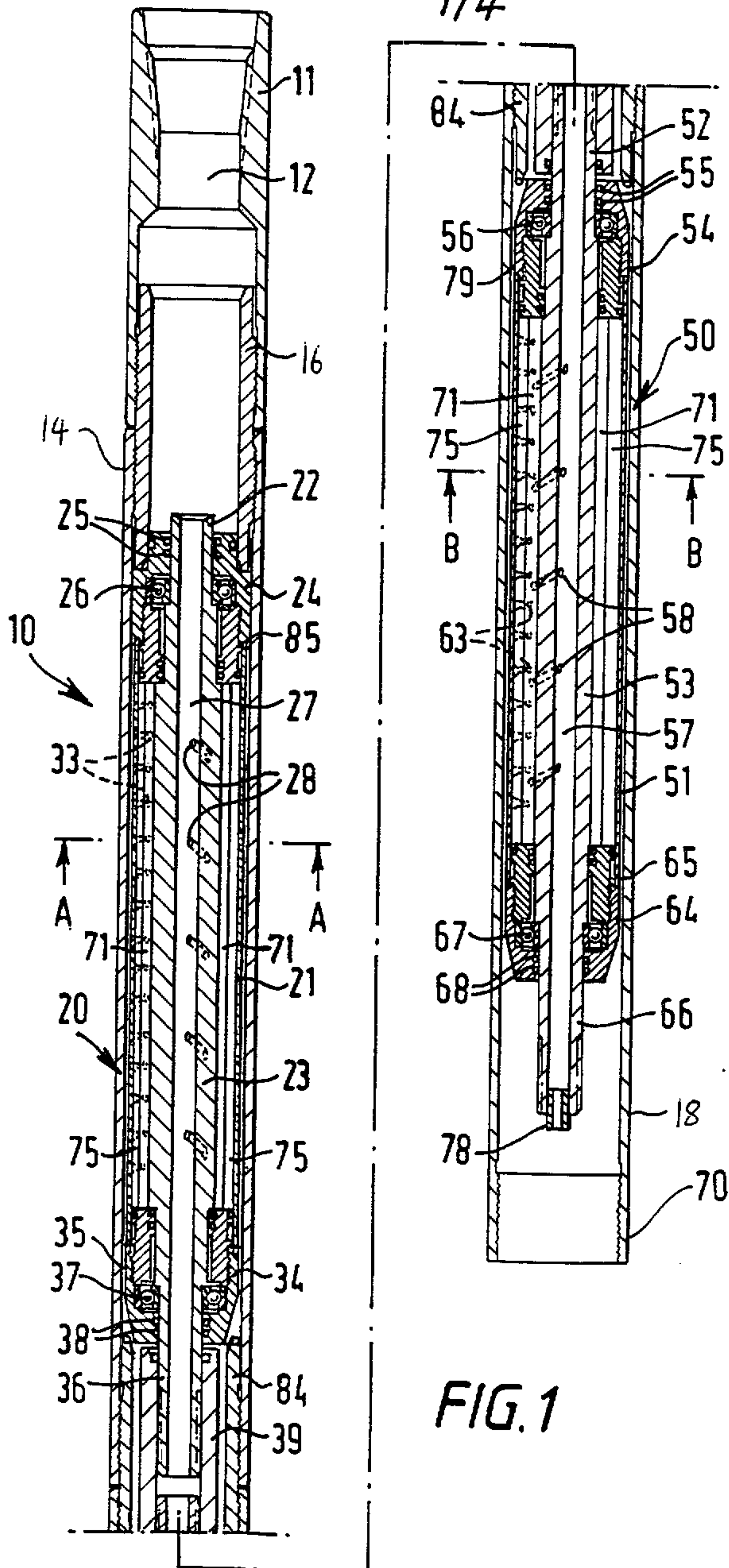


FIG. 1

FIG. 2A

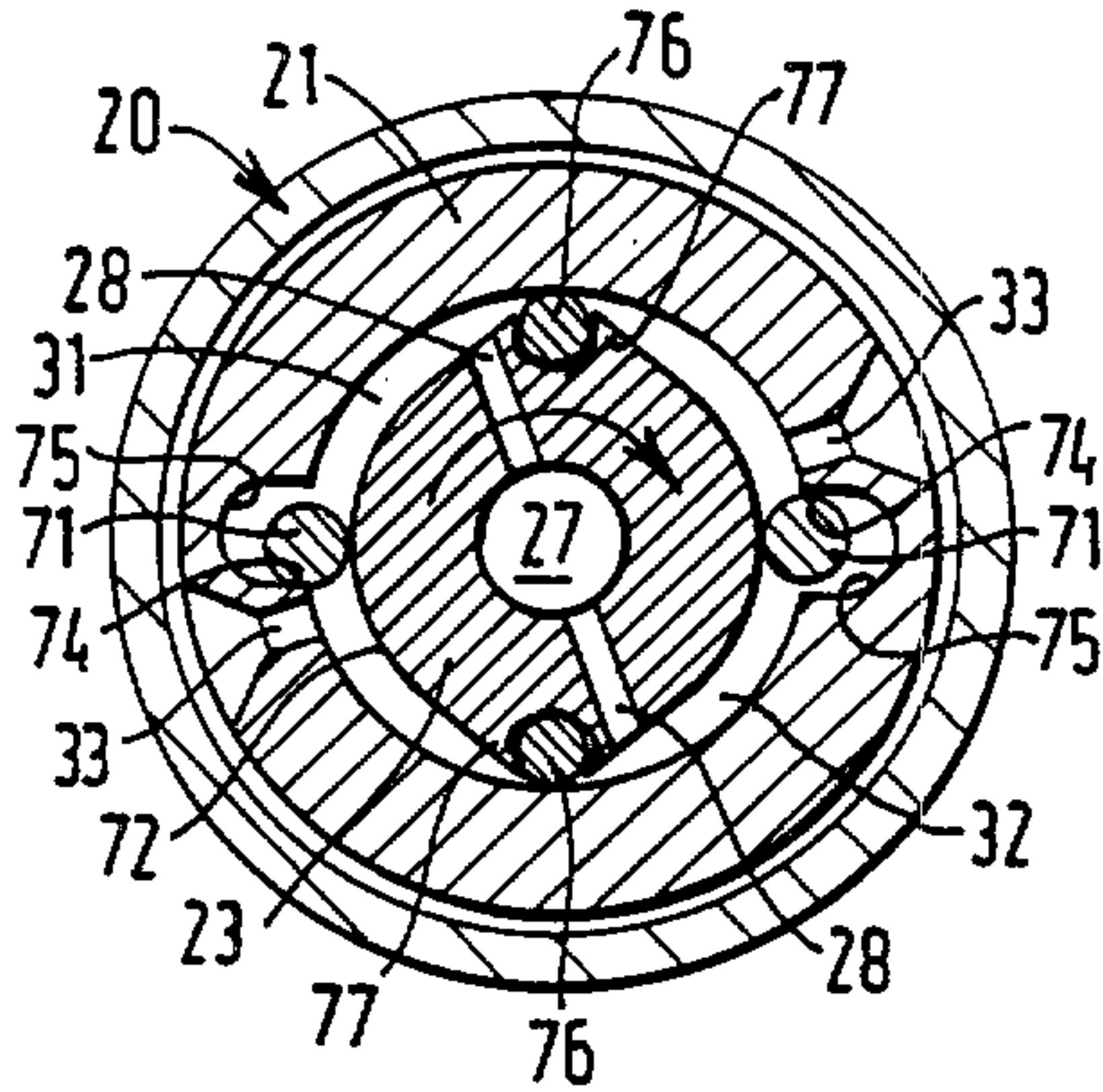


FIG. 2B

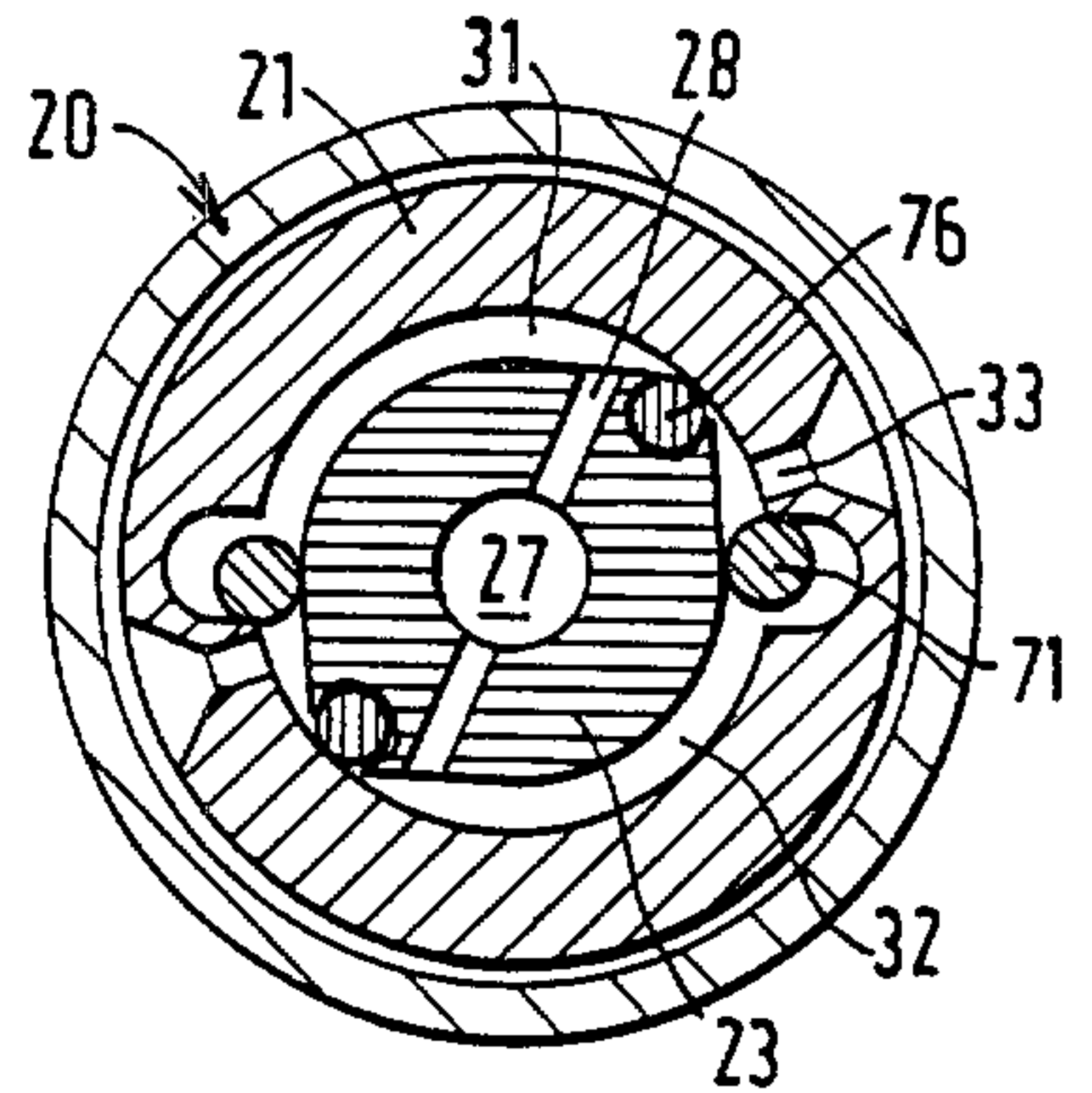


FIG. 2C

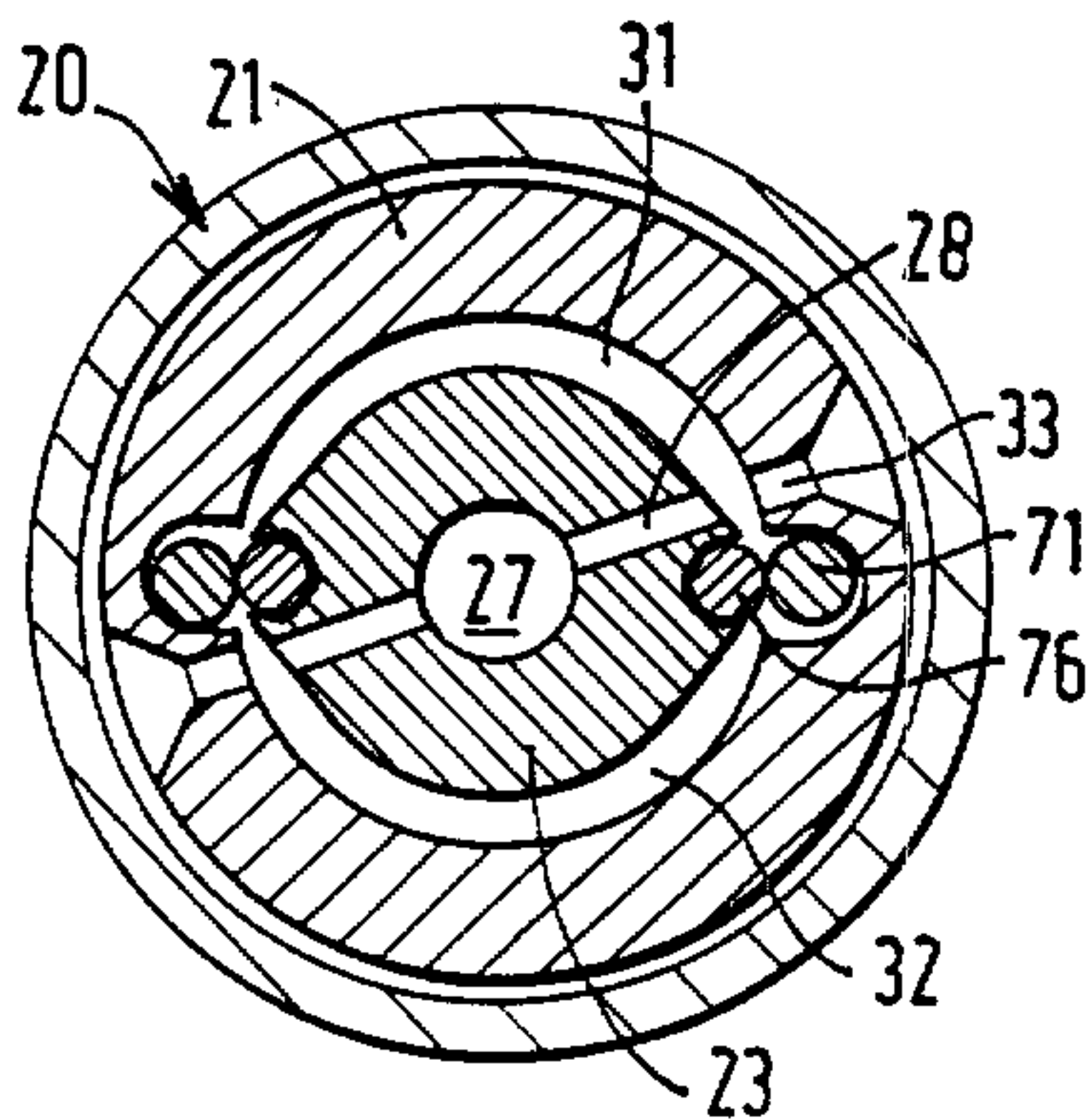


FIG. 2D

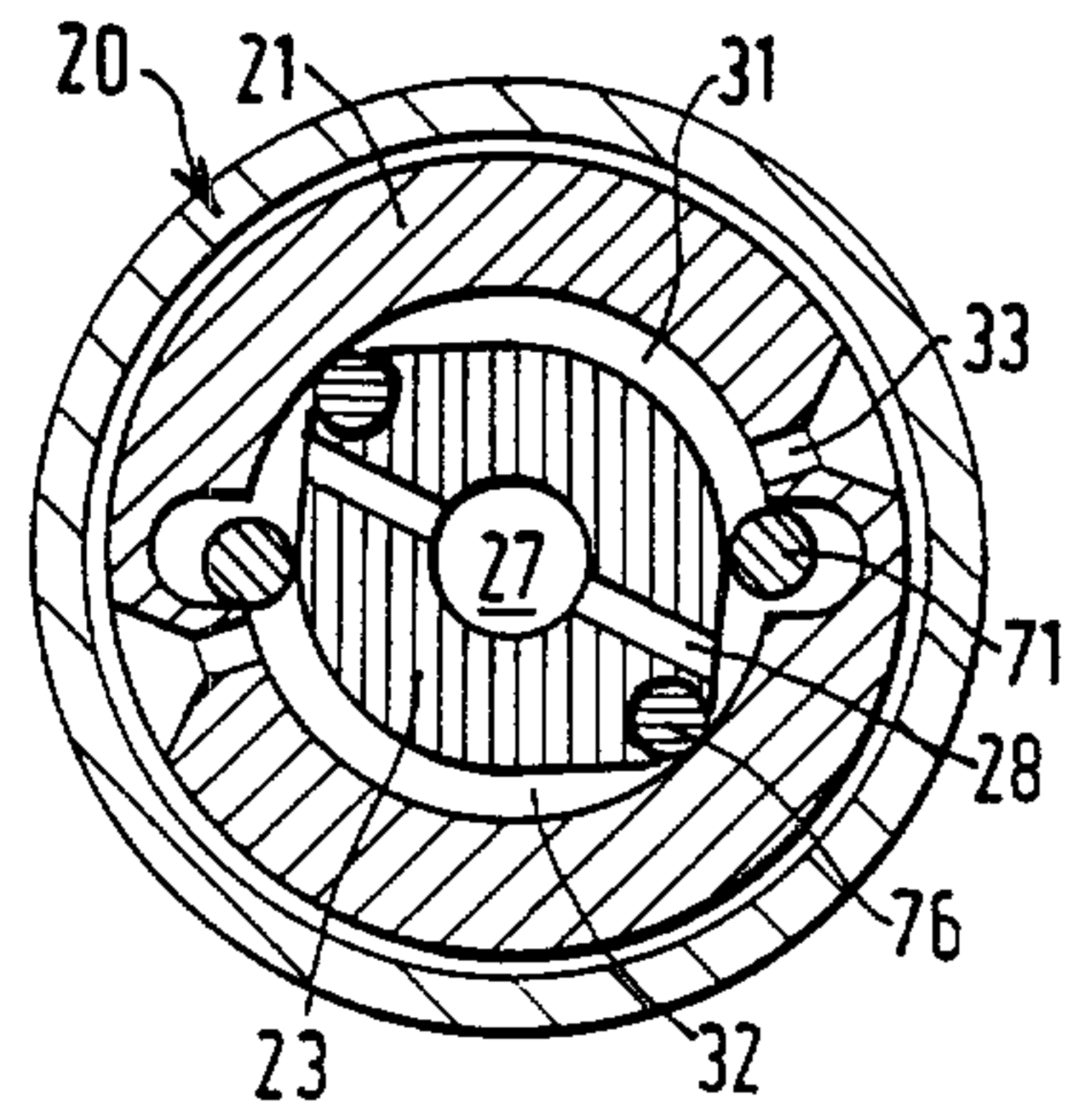


FIG. 3A

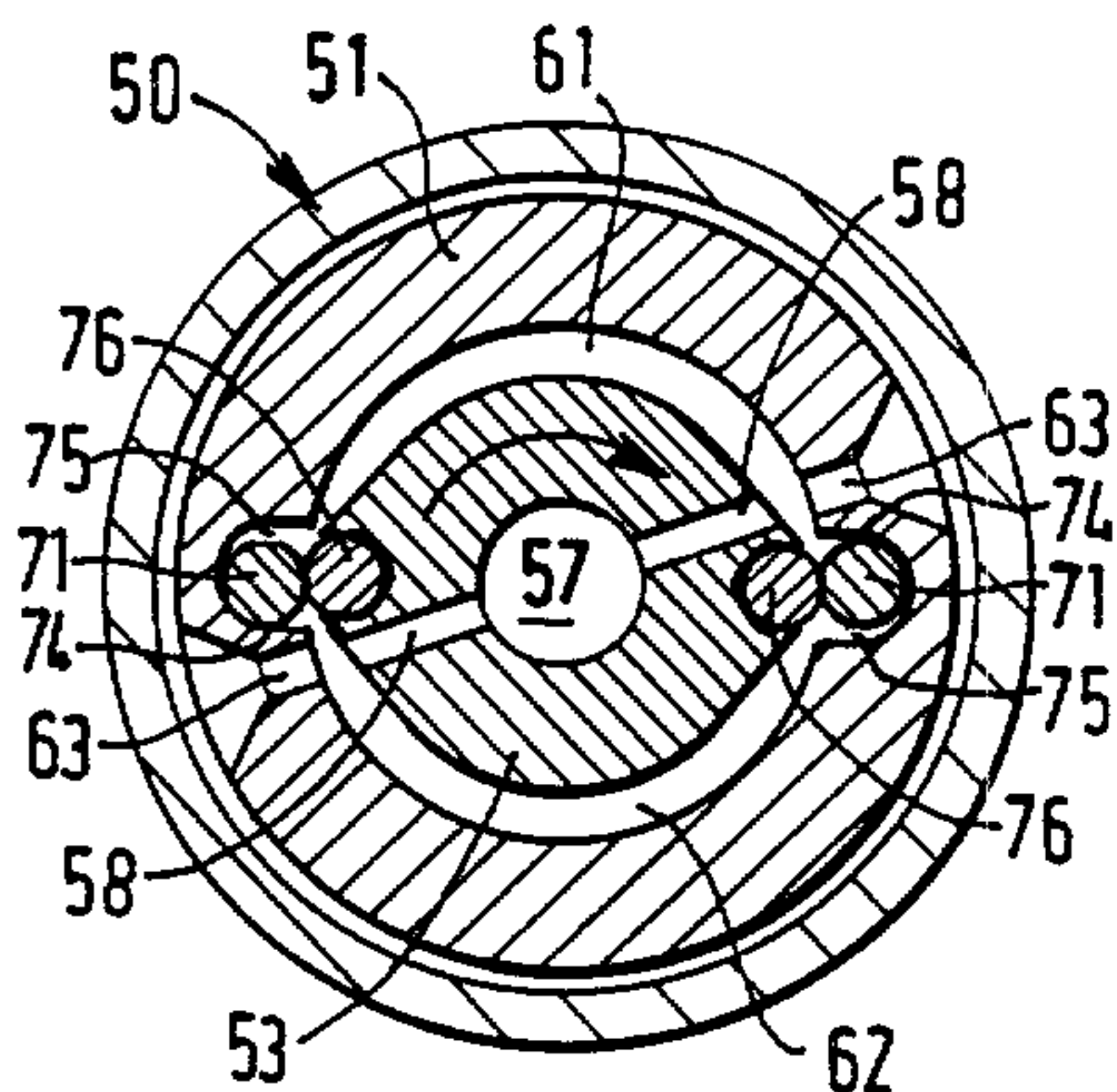


FIG. 3B

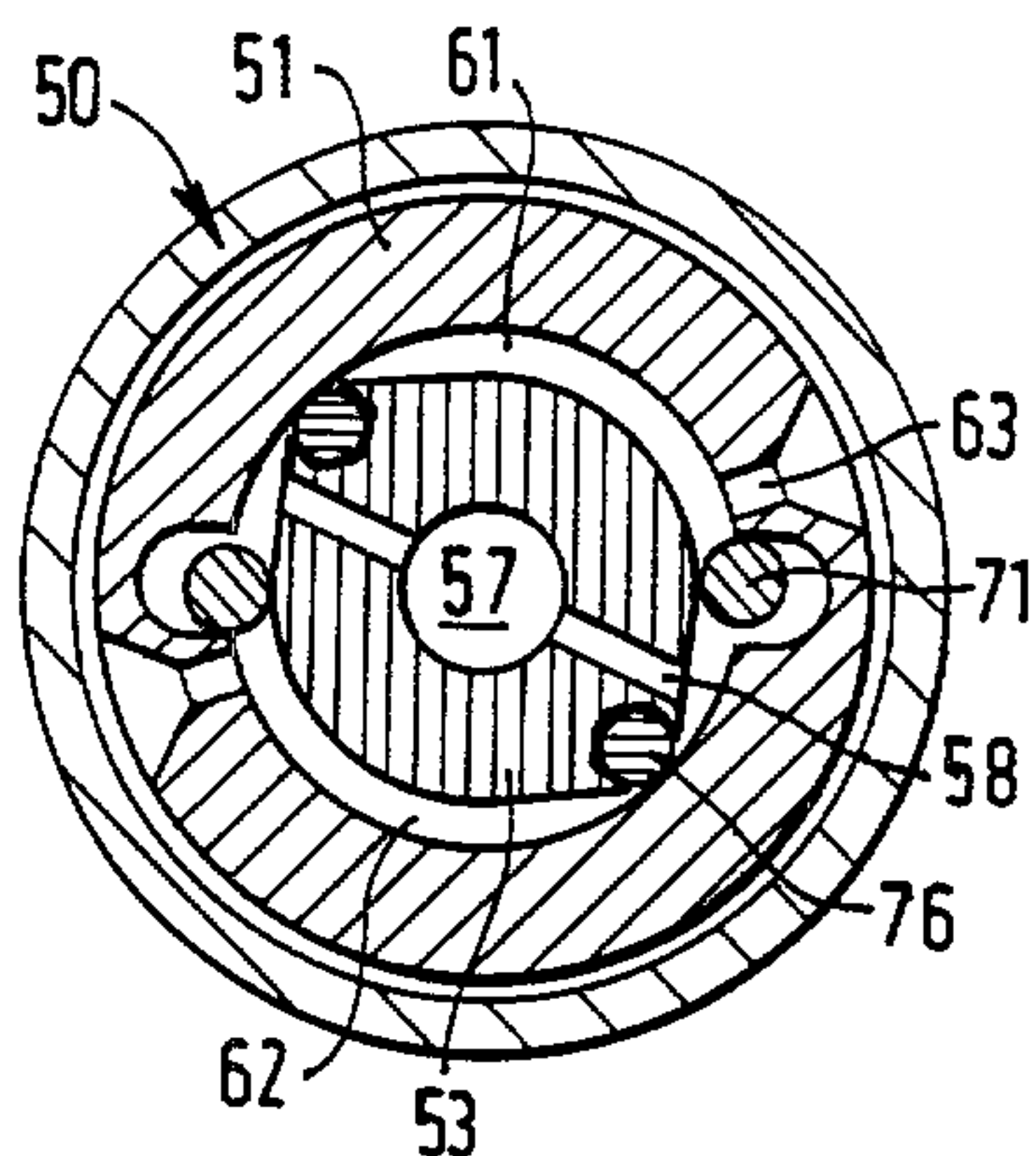


FIG. 3C

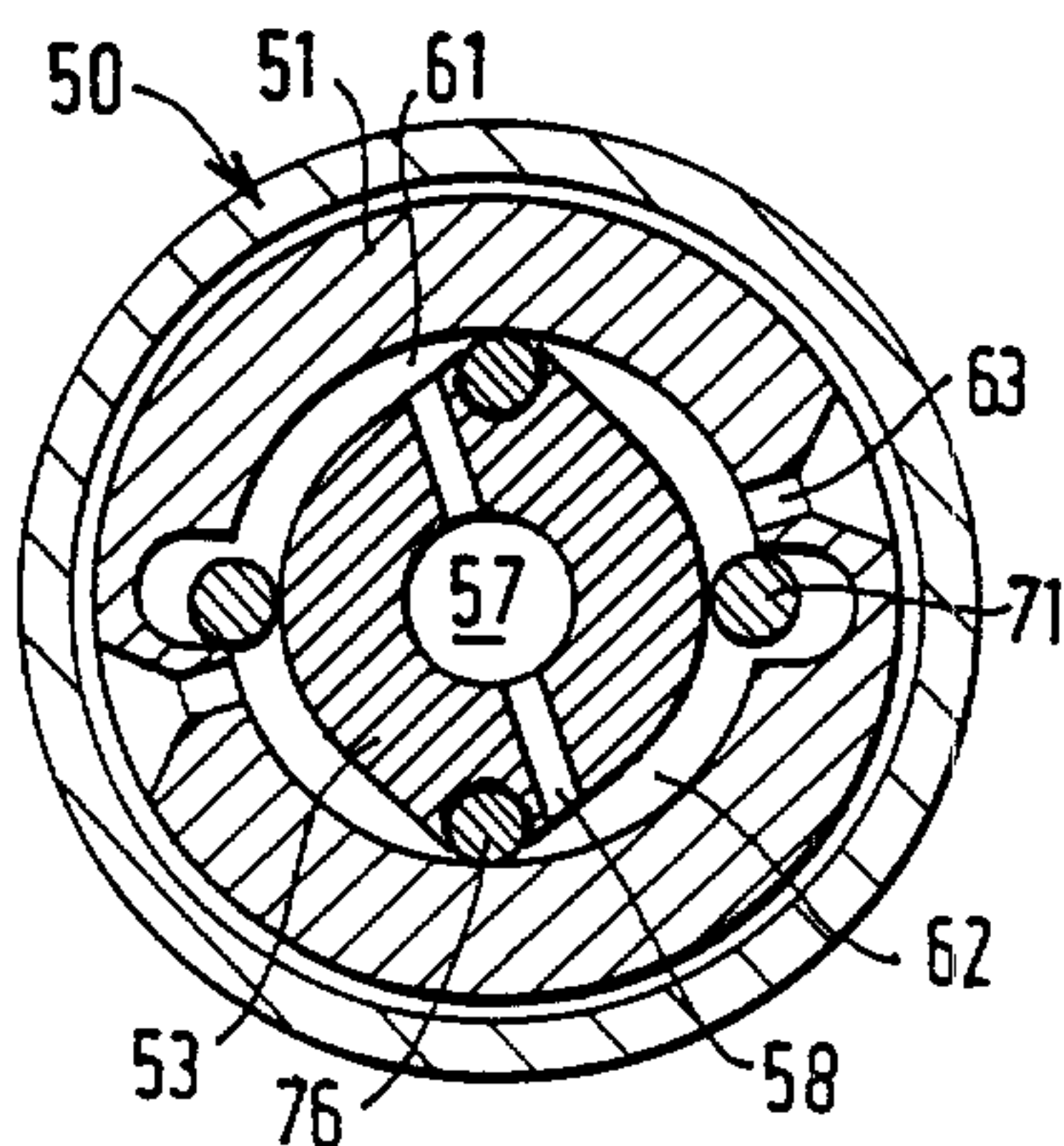
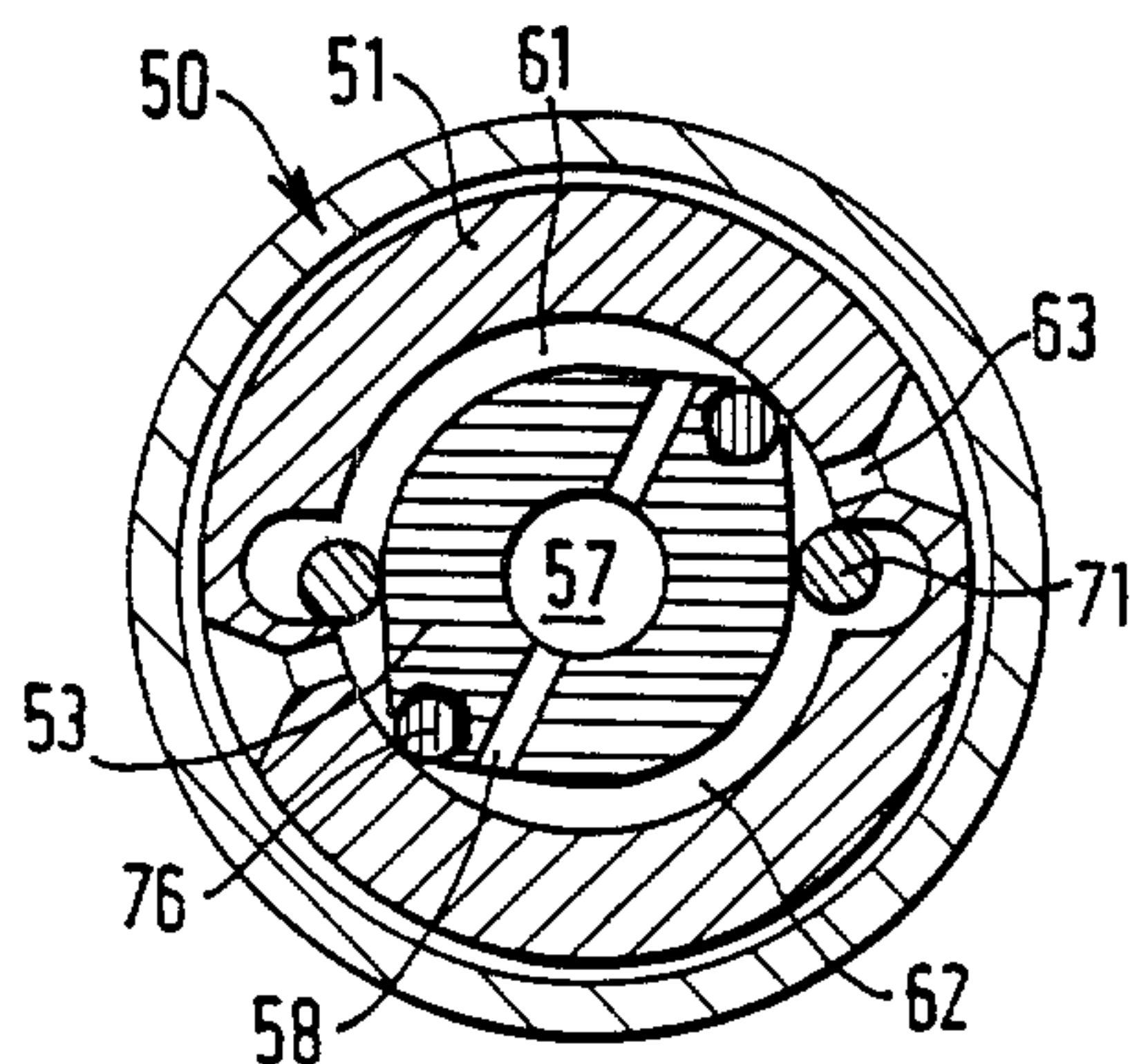


FIG. 3D



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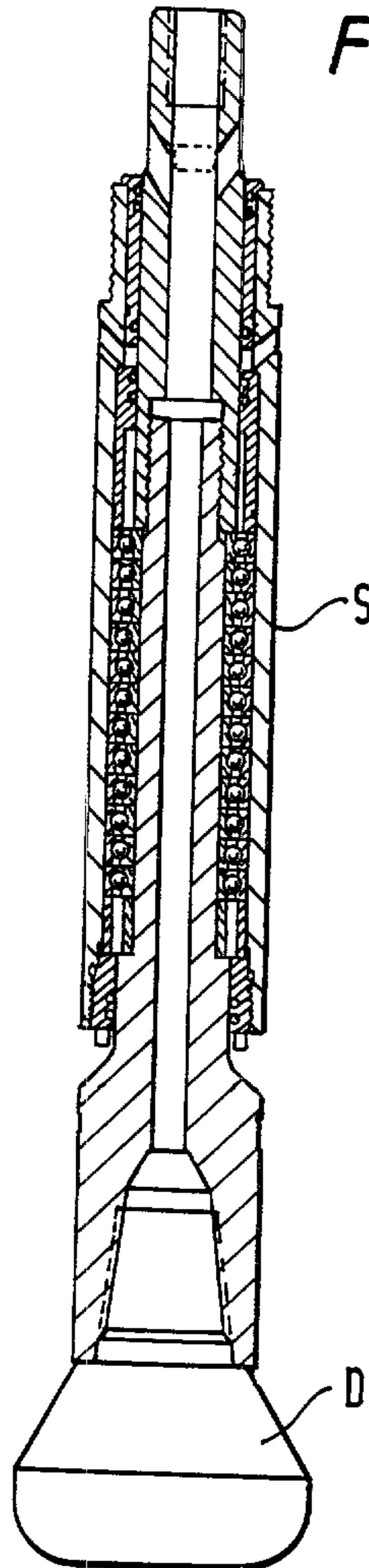


FIG. 4

