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(54) **CYLINDER BLOCK ASSEMBLY FOR HYDRAULIC UNIT**

(57) A cylinder block assembly 400 of a hydraulic unit includes a cylinder block 402 having a plurality of piston bores 404 arranged circumferentially about a central axis A of the cylinder block assembly 400 and extending through a first face 406 of the cylinder block. Each of the piston bores 404 has a pitch diameter defined radially with respect to the central axis A of the cylinder block assembly 400. A second face 412 of the cylinder block 402 has pressure ports 420 that extend from the piston bores 404. The cylinder block assembly 400 further includes a balance plate 414 coupled to the second face 412 of the cylinder block. The balance plate 414 includes apertures 418 that align with the pressure ports 420, where a cylinder block assembly outer length is defined between the first face 406 of the cylinder block and an outer face of the balance plate. A ratio of the pitch diameter to the cylinder block assembly outer length is between 1.24 and 1.27.

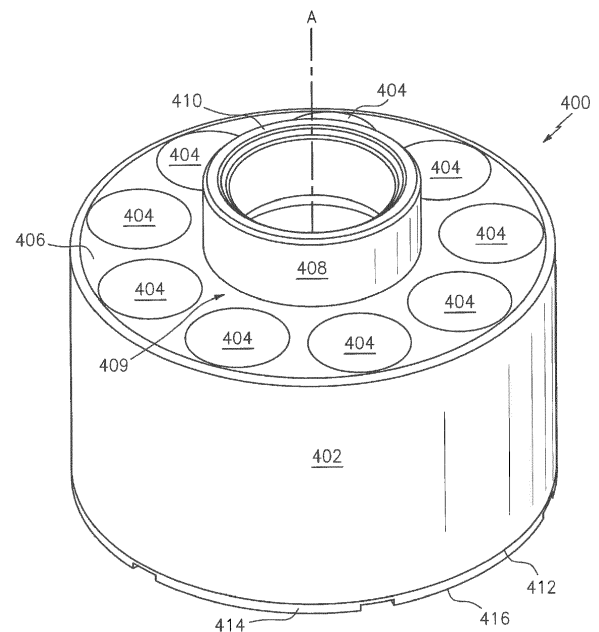


FIG. 4

Description

BACKGROUND OF THE INVENTION

[0001] Embodiments of this invention generally relate to an integrated drive generator, and more particularly, to a cylinder block assembly of a hydraulic unit of an integrated drive generator.

[0002] Aircraft currently rely on electrical, pneumatic, and hydraulic systems for secondary power. A typical electrical system utilizes an integrated drive generator coupled to each engine of an aircraft to provide fixed frequency power to a power distribution system and associated loads. One type of integrated drive generator includes a generator, a hydraulic unit, and a differential assembly arranged in a common housing. The differential assembly is operably coupled to an aircraft engine, such as a gas turbine engine, via an input shaft. The rotational speed of the input shaft varies during operation of the engine. The hydraulic unit cooperates with the differential assembly to provide a constant speed to the generator throughout engine operation.

[0003] Due to engineering designs and requirements, various components of the systems must be designed to operatively function together. For example, various components of the hydraulic unit are configured to appropriately and accurately mate and fit together to enable efficient operation. Constraints such as power, envelope, weight, leakage, operational stresses, environmental stresses, pressure limits, speed limits, material constraints, loads, and the like present a number of design challenges.

BRIEF DESCRIPTION OF THE INVENTION

[0004] According to one embodiment of the invention, a cylinder block assembly of a hydraulic unit includes a cylinder block having a plurality of piston bores arranged circumferentially about a central axis of the cylinder block assembly and extending through a first face of the cylinder block. Each of the piston bores has a pitch diameter defined radially with respect to the central axis of the cylinder block assembly. The cylinder block also includes a second face having a plurality of pressure ports that extend from the piston bores, where each of the pressure ports has a smaller diameter than a piston bore diameter of each of the piston bores. The cylinder block assembly further includes a balance plate coupled to the second face of the cylinder block. The balance plate includes a plurality of apertures that align with the pressure ports, where a cylinder block assembly outer length is defined between the first face of the cylinder block and an outer face of the balance plate. A ratio of the pitch diameter to the cylinder block assembly outer length is between 1.24 and 1.27.

[0005] A method of assembling a hydraulic unit includes biasing a cylinder block assembly toward a port plate. The cylinder block assembly has a plurality of pis-

ton bores arranged circumferentially about a central axis of the cylinder block assembly and extending through a first face of the cylinder block. Each of the piston bores has a pitch diameter defined radially with respect to the central axis of the cylinder block assembly. The cylinder block further includes a second face having a plurality of pressure ports that extend from the piston bores, where each of the pressure ports has a smaller diameter than a piston bore diameter of each of the piston bores. The cylinder block assembly also includes a balance plate coupled to the second face of the cylinder block. The balance plate includes a plurality of apertures that align with the pressure ports, where a cylinder block assembly outer length is defined between the first face of the cylinder block and an outer face of the balance plate proximate the port plate. A ratio of the pitch diameter to the cylinder block assembly outer length is between 1.24 and 1.27. The method also includes arranging a plurality of pistons in the piston bores and interfacing the cylinder block assembly with a shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic diagram of an exemplary power generator system of an aircraft;

FIG. 2 is a cross-sectional schematic view of an example of an integrated drive generator;

FIG. 3 is a cross-sectional schematic view of an example of a hydraulic unit of an integrated drive generator;

FIG. 4 is an isometric view of a cylinder block assembly in accordance with an embodiment of the invention;

FIG. 5 is a side plan view of the cylinder block assembly of FIG. 4;

FIG. 6 is a plan view of a balance plate of the cylinder block assembly of FIG. 4; and

FIG. 7 is a cross-sectional view of the cylinder block assembly of FIG. 4 as viewed along the line A-A of FIG. 6.

[0007] The detailed description explains embodiments of the invention, together with advantages and features, by way of example, with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Referring now to FIG. 1, an example of a generator system 100 is schematically illustrated. The generator system 100 includes a gas turbine engine 102 that is configured to rotationally drive an integrated drive generator 106 through an accessory drive gearbox 104 mounted on the gas turbine engine 102. The accessory drive gearbox 104 is coupled to a spool 108 of the gas turbine engine 102, and the speed of the spool 108 varies throughout the entire operation of the gas turbine engine 102, depending on operational characteristics, such as high altitude cruising flight or take-off of an aircraft in which the generator system 100 is installed. An input shaft 110 is configured to transfer rotational energy to the integrated drive generator 106 from the accessory drive gearbox 104. Those skilled in the art will appreciate that the generator system 100 of FIG. 1 directed to an aircraft is merely presented for illustrative and explanatory purposes and other generator systems and/or engines may be used without departing from the scope of the invention.

[0009] An example of an integrated drive generator 200 including a housing 202 is shown in FIG. 2. In the illustrated embodiment, the integrated drive generator 200 includes an input shaft 204 configured to receive rotational drive from an accessory drive gearbox (see FIG. 1). The rotational speed of the input shaft 204 varies depending upon the operation of the engine (see FIG. 1). To this end, a hydraulic unit 206 cooperates with a differential assembly 208 to convert the variable rotational speed from the input shaft 204 to a fixed rotational output speed that is transferred to a generator 210.

[0010] Referring now to FIG. 3, an exemplary embodiment of a hydraulic unit 300 of an integrated drive generator, such as the integrated drive generator 200 of FIG. 2, is shown. The hydraulic unit 300 includes a variable displacement hydraulic pump 302 and a fixed displacement hydraulic motor 304. The variable displacement hydraulic pump 302 and the fixed displacement hydraulic motor 304 have respective cylinder block assemblies 306 and 308 which are arranged for rotation about a common axis A within housings 310, 311 on opposite sides of a stationary port plate 312 of the hydraulic unit 300. The port plate 312 is formed with one or more kidneys or apertures 314 through which hydraulic fluid communication between the pump 302 and the motor 304 is established during normal operation of the hydraulic unit 300. A biasing mechanism 316 resiliently biases the cylinder block assemblies 306, 308 in the direction of the port plate 312.

[0011] The operation of the hydraulic unit 300 in an integrated drive generator, for example an integrated drive generator of an aircraft, involves transmission of torque from an engine of the aircraft to an input, which rotates an input shaft 318 of the hydraulic unit 300 about axis A. The cylinder block assembly 306 of the pump 302 is connected to the input shaft 318 for rotation therewith.

Pistons 320 within the cylinder block assembly 306 of the pump 302 are displaced during rotation an amount which is a function of the setting of a variable swash plate or wobbler 322 of the pump 302. Pistons 321 within the cylinder block assembly 308 of the motor 304 are displaced during rotation with respect to a fixed swash plate or wobbler 326 of the motor 304. Those of skill in the art will appreciate that any number of pistons and associated apertures may be employed without departing from the scope of the invention. For example, in one embodiment, the system may include nine pistons 320, 321 in each of the motor 304 and the pump 302, and nine apertures 314 may pass through the port plate 312. Further, for example, the number of apertures 314 is not dependent on the number of pistons 320, 321, and in some embodiments there may be five apertures 314 when nine pistons 320, 321 are employed. Thus, the number of pistons 320, 321 and the number apertures 314 may be varied without departing from the scope of the invention.

[0012] Hydraulic fluid under pressure from the hydraulic pump 302 is delivered to the hydraulic motor 304 through the apertures 314 of port plate 312 for rotating the cylinder block assembly 308 and an output shaft 324 to which the cylinder block assembly 308 is fixedly connected. The swash plate or wobbler 326 of the motor 304 is fixedly configured so that an operating speed of the motor 304 is a function of a displacement of the pump 302. The rotary output from output shaft 324 is added to or subtracted from the rotary motion from the engine through a conventional differential gearing of an integrated drive generator for operating an electrical generator at a substantially constant rotational speed. That is, since the speed of the rotation from the aircraft engine to the input shaft 318 of the hydraulic unit 300 will vary, the position of the variable wobbler 322 is adjusted in response to these detected speed variations for providing the necessary reduction or increase in the rotational speed for obtaining a desired constant output speed to the generator. During normal operation, there is a hydrostatic balance of the cylinder block assemblies 306, 308 and port plate 312. Although the hydraulic unit 300 illustrated and described herein refers to the variable unit as a pump 302 and the fixed unit as a motor 304, hydraulic units having other configurations, such as where the variable unit functions as a motor and the hydraulic unit operates as a pump for example, are within the scope of the invention.

[0013] During operation, the wobbler 322 is permitted to turn, rotate, tumble, and/or wobble about a retainer ball 328. The wobbler 322 is configured to wobble, etc., in part, as a result of the movement of the pistons 320, 321, respectively. A retainer ball 330 is configured to turn or rotate with respect to the wobbler 326. Each piston 320, 321 has a ball 332 (ball of piston 320 not labeled for clarity) on one end. The ball 332 of the pistons 320, 321 is retained within a slipper 334. The slipper 334 is retained by a slipper retainer 336. The slipper retainer 336 enables the slipper 334 to be held in contact with the

wobbler 322, 326, thus enabling operational coupling and/or contact between the wobblers 322, 326 and the pistons 320, 321, respectively, of the pump 302 and the motor 304.

[0014] Turning now to FIG. 4, an isometric view of a cylinder block assembly 400 is depicted in accordance with an embodiment of the invention. The cylinder block assembly 400 is an embodiment of the cylinder block assemblies 306 and 308 of FIG. 3. As depicted in FIG. 4, the cylinder block assembly 400 includes a cylinder block 402 and a plurality of piston bores 404 arranged circumferentially about a central axis A of the cylinder block assembly 400 and extending through a first face 406 of the cylinder block 402. A shaft interface 408 extends from an inner portion 409 (i.e., closer to the central axis A) of the first face 406 of the cylinder block 402 and has an outer edge 410. The cylinder block assembly 400 also includes a balance plate 414 that is coupled to a second face 412 of the cylinder block 402. The balance plate 414 has an outer face 416 that defines a balance land to establish hydrostatic balance with the port plate 312 of FIG. 3.

[0015] FIG. 5 is a side plan view of the cylinder block assembly 400 of FIG. 4. A cylinder block assembly total length L1 is defined between the outer edge 410 of the shaft interface 408 and the outer face 416 of the balance plate 414. A cylinder block assembly outer length L2 is defined between the first face 406 of the cylinder block 402 and the outer face 416 of the balance plate 414. In an embodiment, the cylinder block assembly total length L1 is about 1.634 inches (4.150 cm), and the cylinder block assembly outer length L2 is about 1.266 inches (3.216 cm).

[0016] FIG. 6 is a plan view of the balance plate 414 of the cylinder block assembly 400 of FIG. 4. Each of the piston bores 404 has a piston bore axis B, as best seen in FIG. 7. Each of the piston bores 404 also has a pitch diameter D1 defined radially with respect to the central axis A of the cylinder block assembly 400 such that each piston bore axis B is radially offset from the central axis A by a value of $D1/2$. The balance plate 414 includes a plurality of apertures 418 that align with pressure ports 420, as best seen in FIG. 7, where both the apertures 418 and pressure ports 420 have a diameter D5. The outer face 416 of the balance plate 414 defines a balance land having balance land outer diameter D2 and a balance land inner diameter D3, as best seen in FIG. 7. In an embodiment, the pitch diameter D1 is about 1.592 inches (4.044 cm), the balance land outer diameter D2 is about 1.977 inches (5.022 cm), and the balance land inner diameter D3 is about 1.207 inches (3.066 cm).

[0017] FIG. 7 is a cross-sectional view of the cylinder block assembly 400 of FIG. 4 as viewed along the line A-A of FIG. 6. As can be seen in FIG. 7, the second face 412 of the cylinder block 402 includes a plurality of pressure ports 420 that extend from the piston bores 404. Each of the piston bores 404 has a piston bore diameter D4, where the diameter D5 of each of the pressure ports

420 is smaller than the piston bore diameter D4. A piston relief 422 having a piston relief diameter D6 is defined between each pairing of the piston bores 404 and the pressure ports 420. Also, as can be seen in FIGS. 6 and 7, the shaft interface 408 has a smaller diameter D7 than the pitch diameter D1. In an embodiment, the piston bore diameter D4 is about 0.46 inches (1.168 cm), and the piston relief diameter D6 is about 0.476 inches (1.209 cm).

[0018] A number of ratios are defined between multiple features of the cylinder block assembly 400 of FIGS. 4-7. In an embodiment, a ratio of the pitch diameter D1 to the cylinder block assembly outer length L2 is between 1.24 and 1.27. A ratio of the pitch diameter D1 to the piston bore diameter D4 is between 3.44 and 3.48. A ratio of the cylinder block assembly outer length L2 to the piston bore diameter D4 is between 2.73 and 2.77. A ratio of the balance land outer diameter D2 to the pitch diameter D1 is between 1.23 and 1.25. A ratio of the balance land outer diameter D2 to the piston bore diameter D4 is between 4.28 and 4.32. A ratio of the balance land inner diameter D3 to the pitch diameter D1 is between 0.75 and 0.77. A ratio of the balance land inner diameter D3 to the piston bore diameter D4 is between 2.60 and 2.65. A ratio of the balance land outer diameter D2 to the balance land inner diameter D3 is between 1.62 and 1.65. A ratio of the piston relief diameter D6 to the piston bore diameter D4 is between 1.02 and 1.05. A ratio of the cylinder block assembly total length L1 to the cylinder block assembly outer length L2 is between 1.28 and 1.30.

[0019] A method of assembling a hydraulic unit, such as the hydraulic unit 300 of FIG. 3, includes biasing a cylinder block assembly, such as one of the cylinder block assemblies 306 and 308 of FIG. 3, toward port plate 312 using, for example, biasing mechanism 316. As previously described in reference to the cylinder block assembly 400 of FIGS. 4-7, the cylinder block 402 includes a plurality of piston bores 404 arranged circumferentially about a central axis A of the cylinder block assembly 400, and the piston bores 404 extend through the first face 406 of the cylinder block 402, where each of the piston bores 404 has a pitch diameter D1 defined radially with respect to the central axis A of the cylinder block assembly 400. The cylinder block 402 also includes a second face 412 having a plurality of pressure ports 420 that extend from the piston bores 404, where each of the pressure ports 420 has a smaller diameter D5 than a piston bore diameter D4 of each of the piston bores 404. Balance plate 414 is coupled to the second face 412 of the cylinder block 402, where the balance plate 414 includes a plurality of apertures 418 that align with the pressure ports 420. When installed in hydraulic unit 300 of FIG. 3, the outer face 416 of the balance plate 414 is proximate the port plate 312. Pistons 320, 321 of FIG. 3 can be arranged in the piston bores 404. The cylinder block assembly 400 also interfaces with a shaft, such as the input shaft 318 or the output shaft 324 of FIG. 3, through shaft interface 408 that extends from the first face 406 of the

cylinder block 402.

[0020] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations or substitutions but which are commensurate with the scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments.

[0021] Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A cylinder block assembly (400) of a hydraulic unit, the cylinder block assembly comprising:
 - a cylinder block (402) having a plurality of piston bores (404) arranged circumferentially about a central axis (A) of the cylinder block assembly (400) and extending through a first face (406) of the cylinder block, each of the piston bores (404) having a pitch diameter defined radially with respect to the central axis (A) of the cylinder block assembly, the cylinder block (402) further comprising a second face (412) having a plurality of pressure ports (420) that extend from the piston bores (404), wherein each of the pressure ports (420) has a smaller diameter than a piston bore diameter of each of the piston bores (404); and a balance plate (414) coupled to the second face (412) of the cylinder block (402), the balance plate (414) comprising a plurality of apertures (418) that align with the pressure ports (420), wherein a cylinder block assembly outer length is defined between the first face (406) of the cylinder block and an outer face of the balance plate (414), and a ratio of the pitch diameter to the cylinder block assembly outer length is between 1.24 and 1.27.
2. The cylinder block assembly of claim 1, wherein a ratio of the pitch diameter to the piston bore diameter is between 3.44 and 3.48.
3. The cylinder block assembly of claims 1 or 2, wherein a ratio of the cylinder block assembly outer length to the piston bore diameter is between 2.73 and 2.77.
4. The cylinder block assembly of any of claims 1-3, wherein the outer face of the balance plate defines a balance land having a balance land inner diameter and a balance land outer diameter, and a ratio of the balance land outer diameter to the pitch diameter is between 1.23 and 1.25.
5. The cylinder block assembly of claim 4, wherein a ratio of the balance land outer diameter to the piston bore diameter is between 4.28 and 4.32.
6. The cylinder block assembly of claim 4, wherein a ratio of the balance land inner diameter to the pitch diameter is between 0.75 and 0.77.
7. The cylinder block assembly of claim 4, wherein a ratio of the balance land inner diameter to the piston bore diameter is between 2.60 and 2.65.
8. The cylinder block assembly of claim 4, wherein a ratio of the balance land outer diameter to the balance land inner diameter is between 1.62 and 1.65.
9. The cylinder block assembly of any preceding claim, wherein a piston relief (422) having a piston relief diameter is defined between each pairing of the piston bores (404) and the pressure ports (420), and a ratio of the piston relief diameter to the piston bore diameter is between 1.02 and 1.05.
10. The cylinder block assembly of any preceding claim, further comprising a shaft interface (408) that extends from the first face (406) of the cylinder block, the shaft interface (408) having a smaller diameter than the pitch diameter, wherein a cylinder block assembly total length is defined between an outer edge of the shaft interface (408) and the outer face of the balance plate, and a ratio of the cylinder block assembly total length to the cylinder block assembly outer length is between 1.28 and 1.30.
11. A method of assembling a hydraulic unit, the method comprising:
 - biasing a cylinder block assembly (400) toward a port plate (312), the cylinder block assembly having a plurality of piston bores (404) arranged circumferentially about a central axis (A) of the cylinder block assembly and extending through a first face (406) of the cylinder block (402), each of the piston bores (404) having a pitch diameter defined radially with respect to the central axis of the cylinder block assembly, the cylinder block (402) further comprising a second face (412) having a plurality of pressure ports (420) that extend from the piston bores (404), wherein each of the pressure ports (420) has a smaller diameter than a piston bore diameter of each of the piston bores (404), and a balance plate (414) coupled to the second face (412) of the cylinder block, the balance plate (414) comprising a plurality of apertures (418) that align with the pres-

sure ports (420), wherein a cylinder block assembly outer length is defined between the first face (406) of the cylinder block and an outer face of the balance plate (414) proximate the port plate (312), and a ratio of the pitch diameter to the cylinder block assembly outer length is between 1.24 and 1.27; 5

arranging a plurality of pistons in the piston bores (404); and

interfacing the cylinder block assembly (400) with a shaft. 10

12. The method of claim 11, wherein a ratio of the pitch diameter to the piston bore diameter is between 3.44 and 3.48, and a ratio of the cylinder block assembly outer length to the piston bore diameter is between 2.73 and 2.77. 15
13. The method of claims 11 or 12, wherein the outer face of the balance plate (414) defines a balance land having a balance land inner diameter and a balance land outer diameter, a ratio of the balance land outer diameter to the pitch diameter is between 1.23 and 1.25, a ratio of the balance land outer diameter to the piston bore diameter is between 4.28 and 4.32, and a ratio of the balance land outer diameter to the balance land inner diameter is between 1.62 and 1.65. 20 25
14. The method of any of claims 11-13, wherein a piston relief (422) having a piston relief diameter is defined between each pairing of the piston bores (404) and the pressure ports (420), and a ratio of the piston relief diameter to the piston bore diameter is between 1.02 and 1.05. 30 35
15. The method of any of claims 11-14, wherein the cylinder block assembly (400) further comprises a shaft interface (408) that extends from the first face (406) of the cylinder block, the shaft interface (408) having a smaller diameter than the pitch diameter, wherein a cylinder block assembly total length is defined between an outer edge of the shaft interface and the outer face of the balance plate (414), and a ratio of the cylinder block assembly (400) total length to the cylinder block assembly outer length is between 1.28 and 1.30. 40 45

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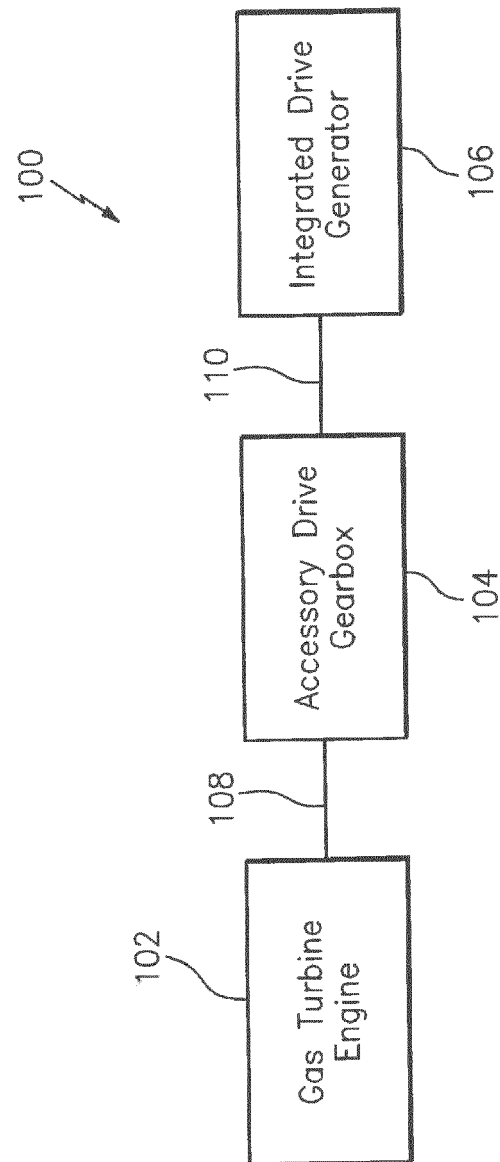


FIG. 1

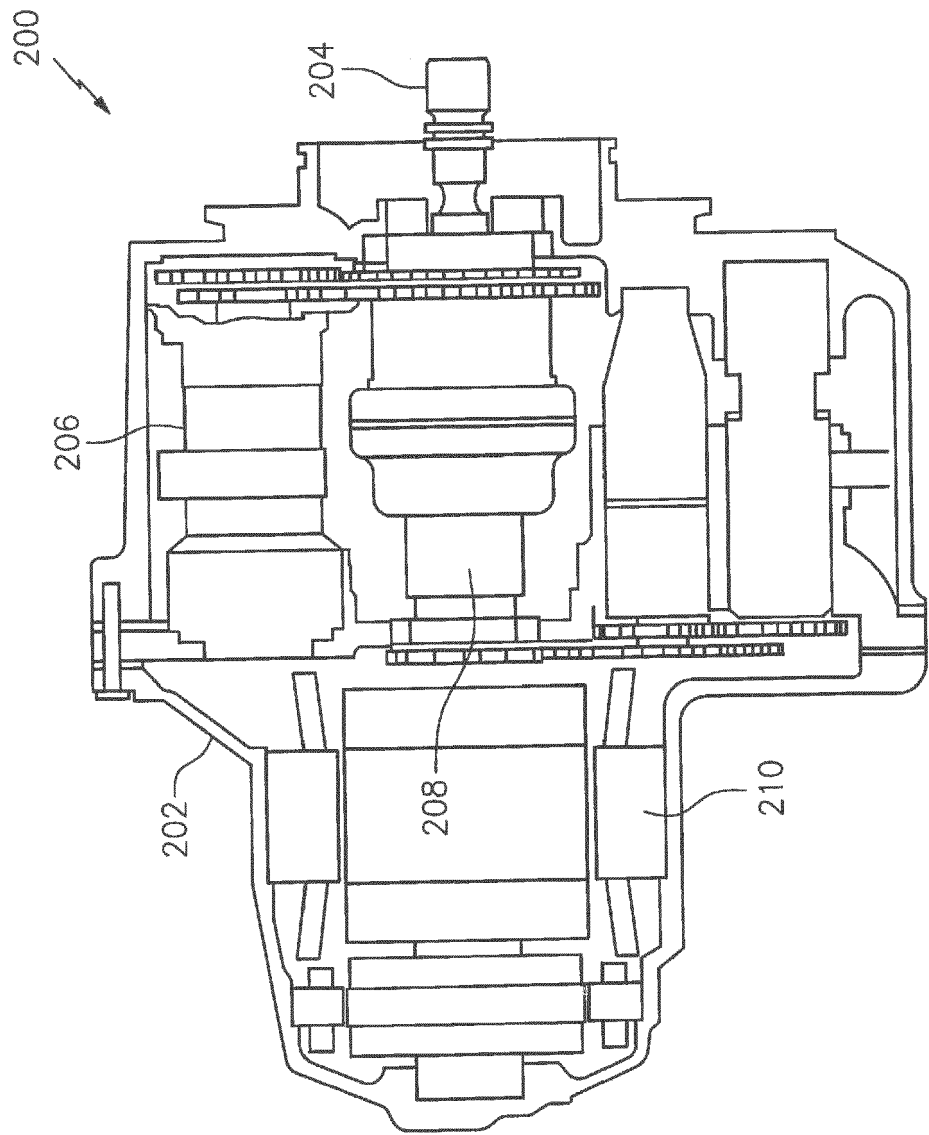


FIG. 2

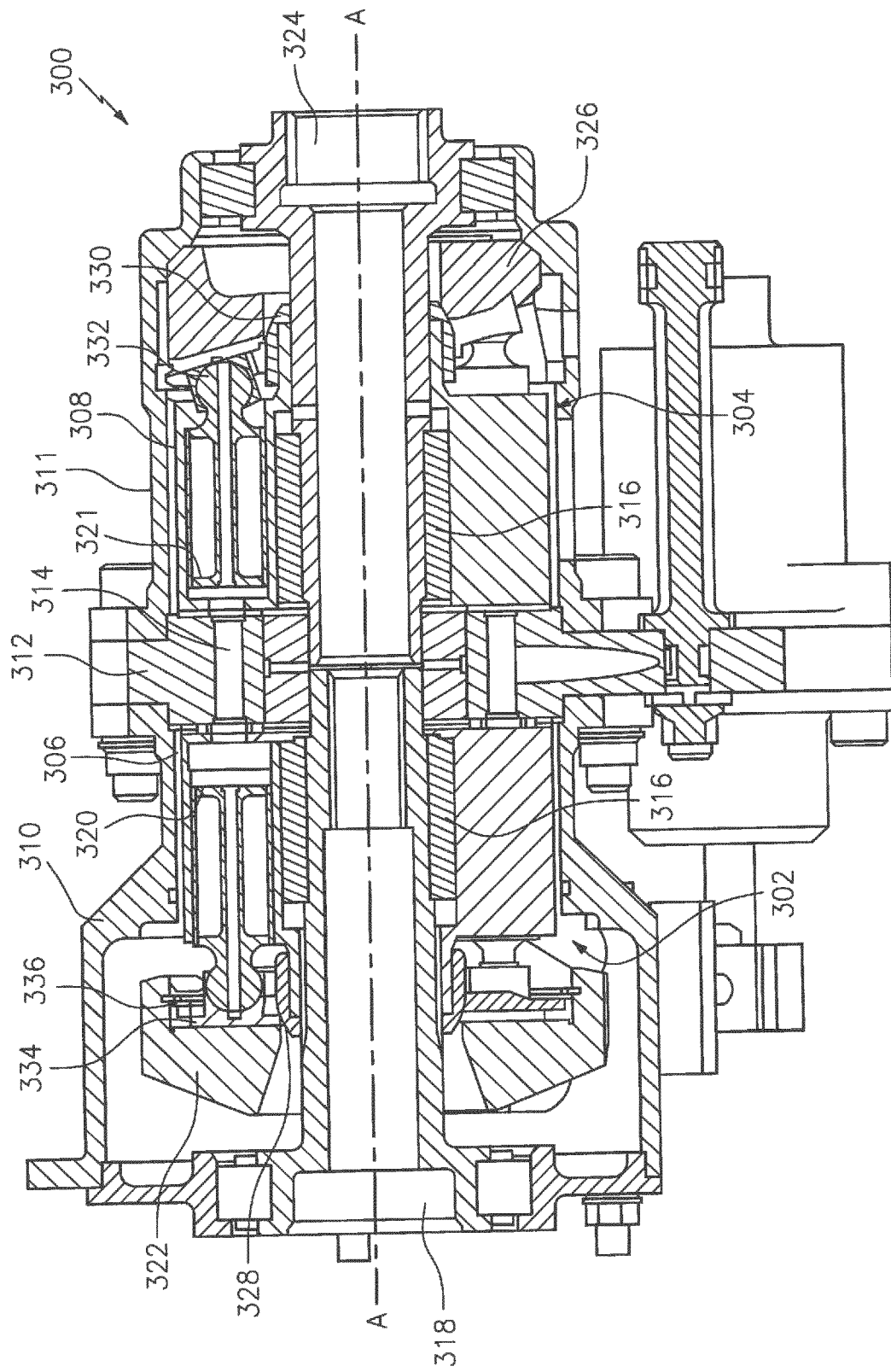


FIG. 3

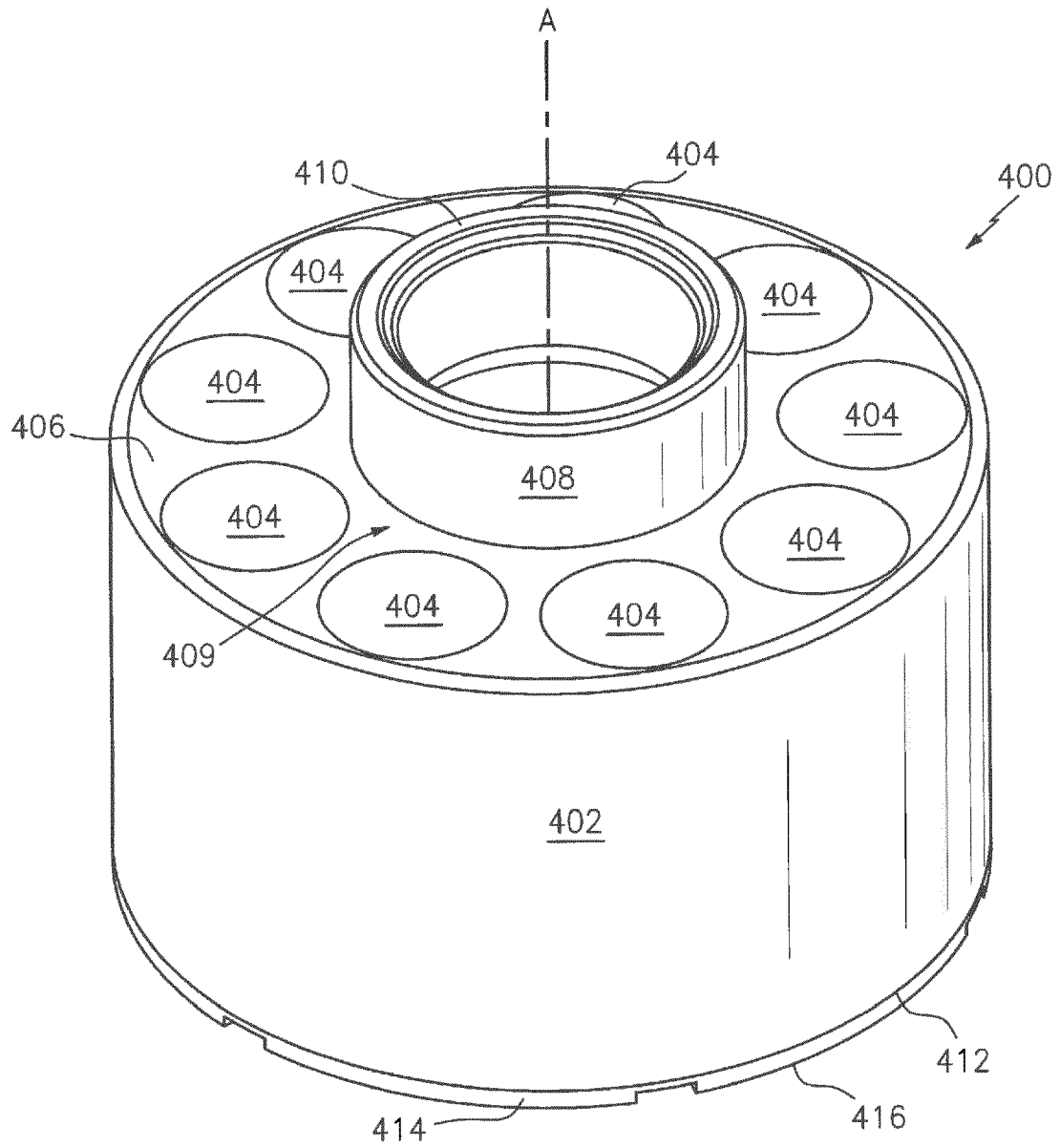


FIG. 4

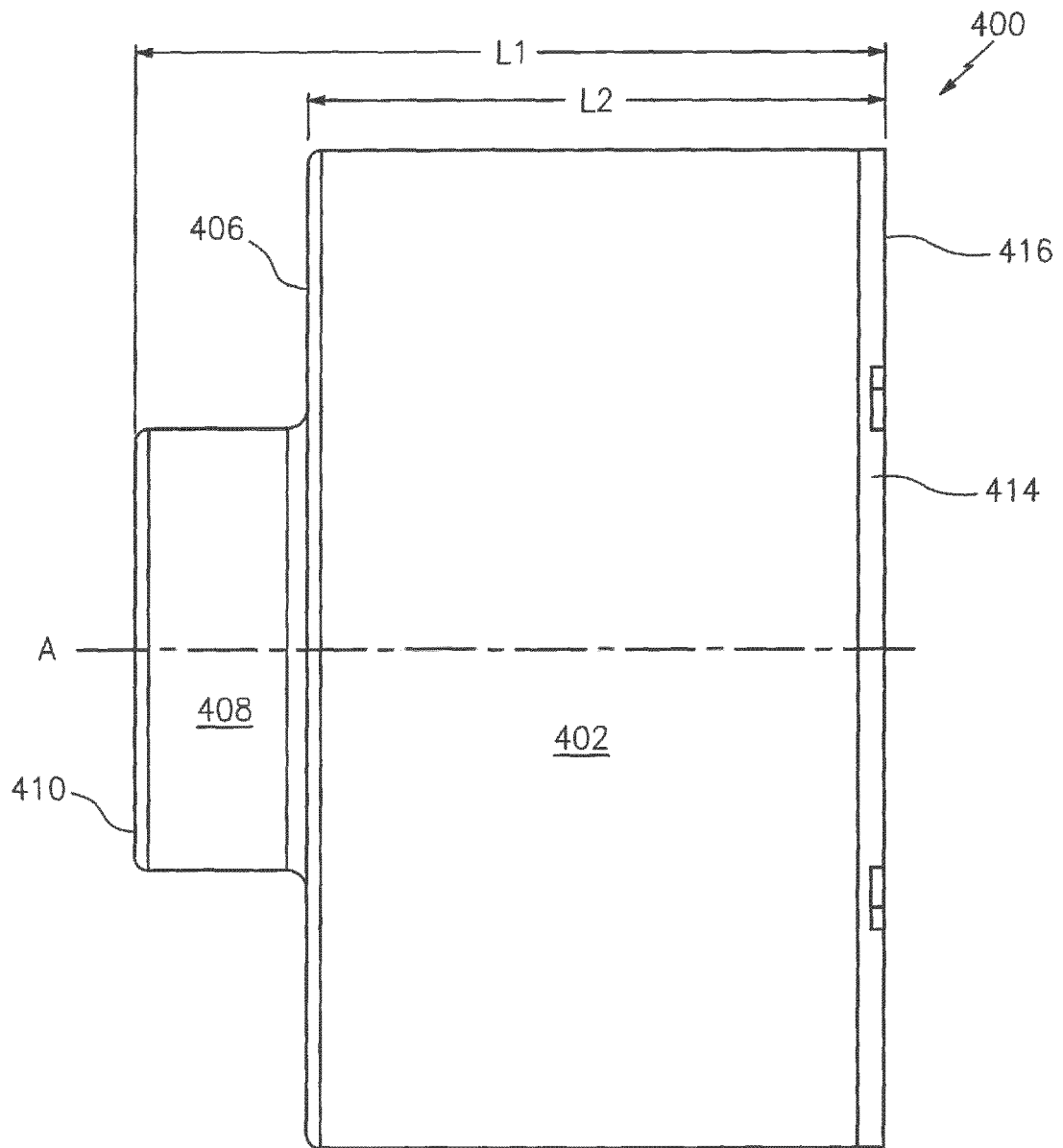


FIG. 5

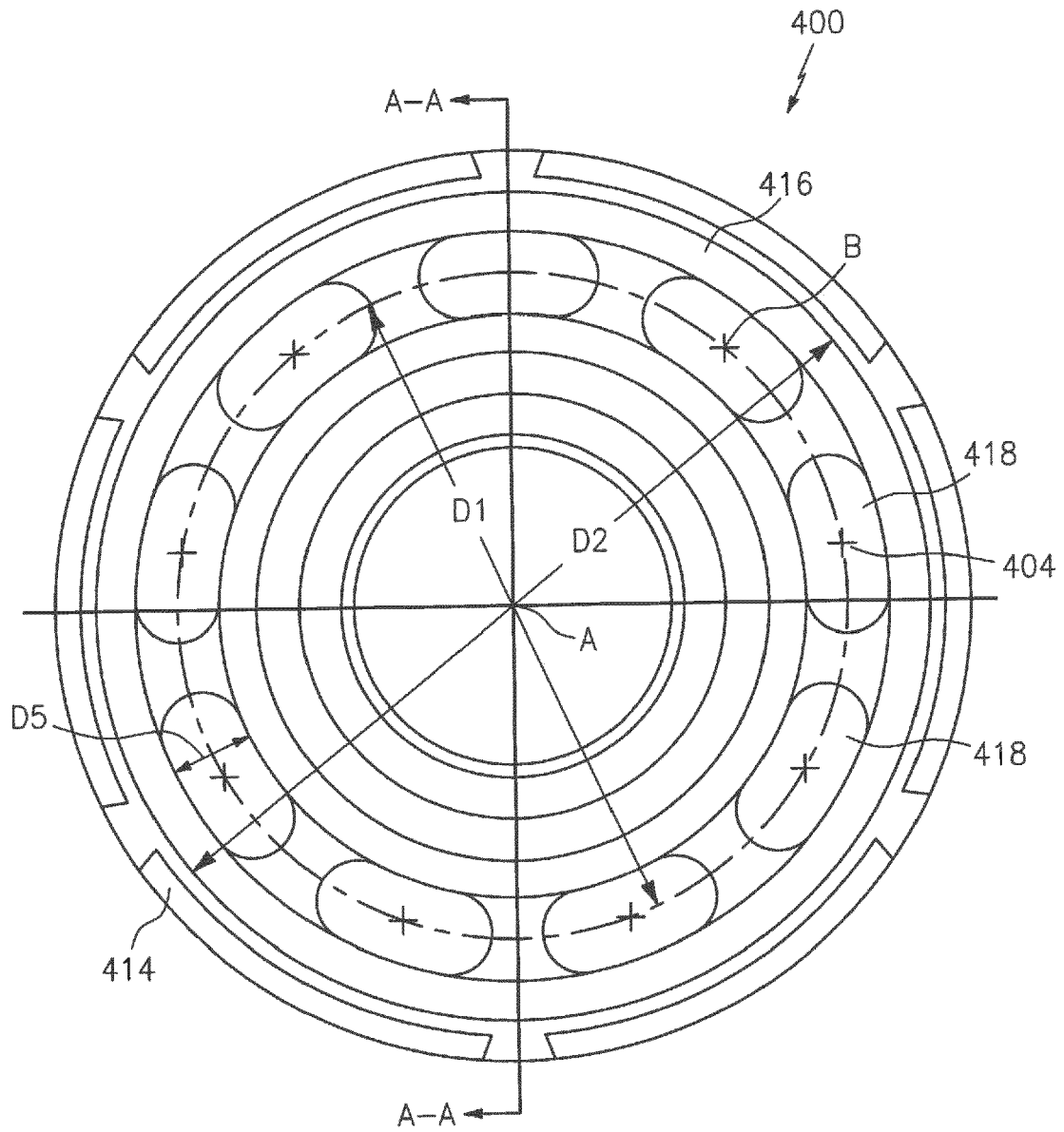


FIG. 6

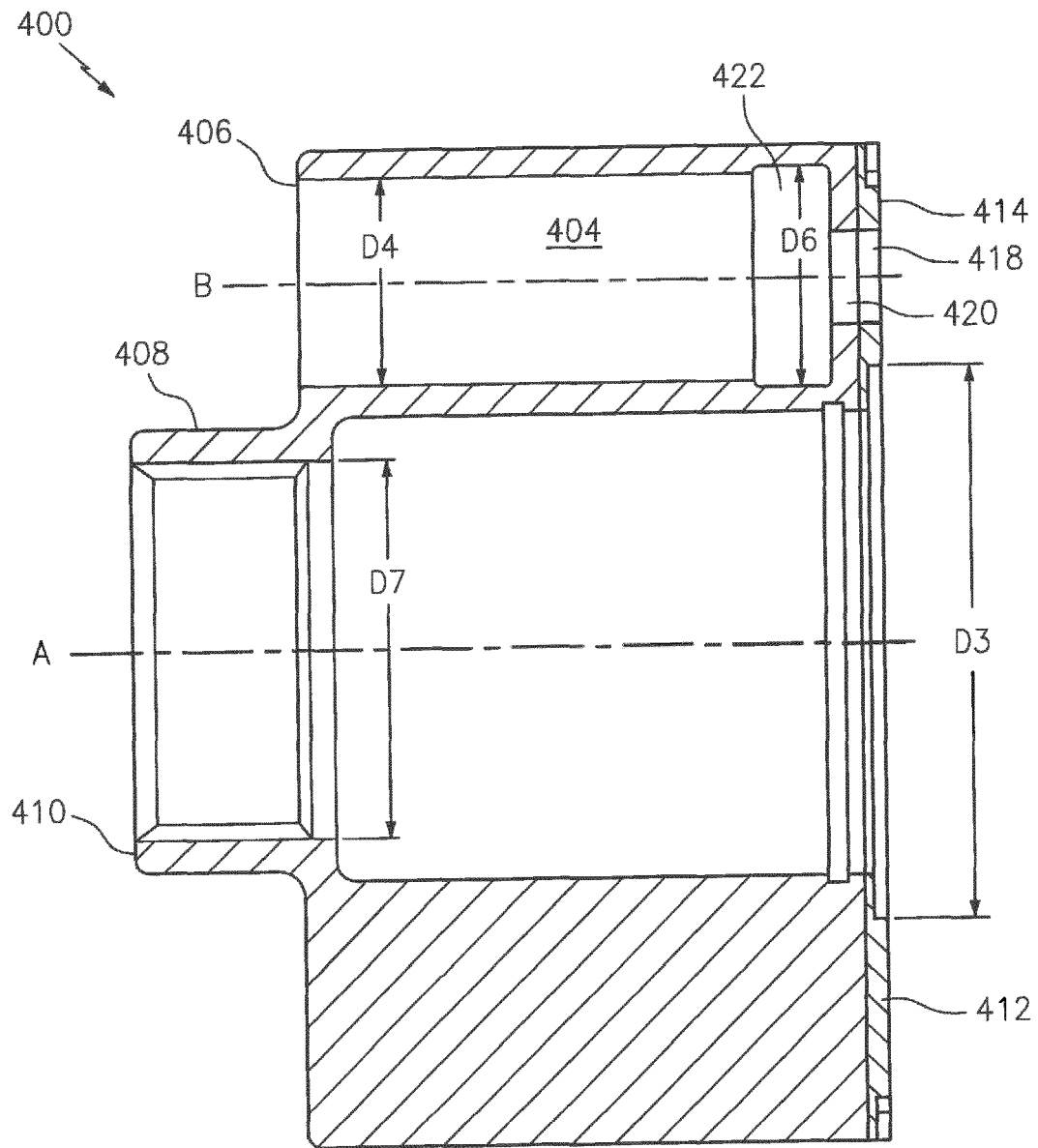


FIG. 7



EUROPEAN SEARCH REPORT

Application Number
EP 16 16 0853

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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			F04B F16H F03C F02C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 August 2016	Examiner Meritano, Luciano
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 16 16 0853

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