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(54) CYLINDER BARREL

(57) In accordance with at least one aspect of this disclosure, a system comprises, a cylinder barrel configured to rotate within a pump housing. In embodiments, the cylinder barrel includes a main cylindrical body (112), a center recess (114) defined within the main cylindrical body (112) configured to seat a drive shaft (106) therein, and a plurality of bores (116) defined in the main cylindrical body (112), extending in an axial direction, wherein the plurality of bores (116) are spaced apart circumferentially relative to one another about the main cylindrical body (112) radially outward of the center recess (114). Each of the plurality of bores (116) are configured to seat a respective piston (110) therein and allow fluid flow therethrough. In embodiments, the main cylindrical body (112) is of silicon nitride.

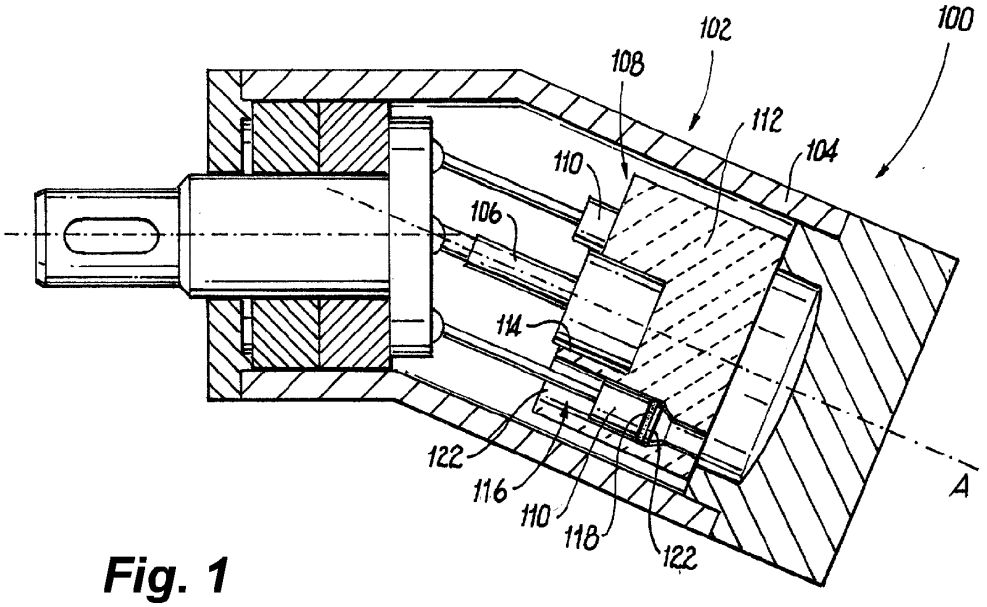

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to pumps, in particular, cylinder barrels for pumps.

BACKGROUND

[0002] Traditional cylinder barrels, e.g., for piston pumps, are made of tungsten carbide, which provides excellent wear resistance in a fuel pump application. However, tungsten carbide cylinder barrels are also very dense and heavy, which can be a draw back in certain applications where the weight of the components must be carefully considered.

[0003] There remains a need for a highly wear resistant material which is lighter and/or less dense than traditional materials. This disclosure provides a solution for this need.

SUMMARY

[0004] In accordance with at least one aspect of this disclosure, a system comprises, a cylinder barrel configured to rotate within a pump housing. In embodiments, the cylinder barrel includes a main cylindrical body, a center recess defined within the main cylindrical body configured to seat a drive shaft therein, and a plurality of bores defined in the main cylindrical body, extending in an axial direction, wherein the plurality of bores are spaced apart circumferentially relative to one another about the main cylindrical body radially outward of the center recess. Each of the plurality of bores are configured to seat a respective piston therein and allow fluid flow therethrough. In embodiments, the main cylindrical body is of silicon nitride.

[0005] In embodiments, the system can further include the pump, including each respective piston seated within the respective bore of the plurality of bores. In embodiments, each respective piston further includes a ring disposed at an end thereof configured to form a hydrodynamic seal with an inner surface of the respective bore. In certain embodiments, the ring can be of tool steel. In certain embodiments, a friction coefficient between the ring and the inner surface of the respective bore can be about 0.11.

[0006] In embodiments, the pump can be or can include a piston pump. In certain embodiments, the piston pump can be or can include a bent axis variable displacement piston pump. In certain embodiments, the plurality of bores can include at least 7 bores. In certain embodiments, the plurality of bores can include up to 13 bores.

[0007] In accordance with at least one aspect of this disclosure, a method includes forming a silicon nitride cylinder barrel of a piston pump, and installing the cylinder barrel into the piston pump. In embodiments, forming the silicon nitride cylinder barrel can further include, forming a main cylindrical body, forming a center recess configured to seat a drive shaft therein, forming a plurality of bores each extending in an axial direction through the main cylindrical body, the plurality of bores forming a pattern disposed circumferentially about the main cylindrical body radially outward of the center recess, configured to seat a respective piston therein and allow fluid flow therethrough.

[0008] The method can further include, operating the piston pump. In embodiments, during operation of the piston pump, the plurality of bores can be configured to remain substantially the same diameter throughout the life of the cylinder barrel.

[0009] These and other features of the embodiments of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

Fig. 1 is a schematic cross sectional side elevation view of a system in accordance with this disclosure, showing an embodiment of a pump;
Fig. 2 is a perspective view of a cylinder barrel configured to use in the pump of Fig. 1;
Fig. 3 is a bottom up view of the cylinder barrel of Fig. 2; and
Fig. 4 is a cross sectional side elevation view of the cylinder barrel of Fig. 2.

DETAILED DESCRIPTION

[0011] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, an illustrative view of an embodiment of a system in accordance with the disclosure is shown in Fig. 1 and is designated generally by reference character 100. Other embodiments and/or aspects of this disclosure are shown in Figs. 2-4.

[0012] In accordance with at least one aspect of this disclosure, e.g., as shown in Fig. 1, a system 100 can include a pump 102. In embodiments, the pump 102 can be or include a piston pump, and in certain embodiments, the pump can be or include a bent axis variable displacement piston pump (e.g., shown in Fig. 1). The pump 102 can include, at least, a pump housing 104, a drive shaft 106, a cylinder barrel 108, and a plurality of pistons 110. The cylinder barrel 108 can be operatively connected to the drive shaft 106 to rotate within the pump housing 104.

[0013] With reference now to Figs. 1-4, in embodiments, the cylinder barrel 108 can include a main cylindrical body 112 defining a barrel axis. In certain embodiments, the main cylindrical body can be formed monolithically. A center recess 114 can be defined within the main cylindrical body 112 configured to seat the drive shaft 106 therein, along the barrel axis A. A plurality of bores 116 can be defined in the main cylindrical body 112, extending in an axial direction through the main cylindrical body 112 (e.g., in a direction parallel to the barrel axis A). As shown, the plurality of bores 116 can be spaced apart circumferentially relative to one another about the main cylindrical body 112, and radially outward of the center recess 114. Each of the plurality of bores 116 can be configured to seat a respective piston therein (e.g., piston 110) and allow fluid flow therethrough. During operation of the pump 102, the respective pistons 108 translate axially along the barrel axis A within the respective bores 116 to selectively change an amount of flow through the respective bore 116, and ultimately the total displacement through the pump 102. In certain embodiments, the plurality of bores 116 can include at least 7 bores, for example, and up to 13 bores. An embodiment of the cylinder barrel 108 having 9 bores 116 is shown.. Any suitable number of bores 116 is contemplated herein.

[0014] In embodiments, each respective piston 110 further includes a piston ring 118 disposed at an end 120 thereof (or integrally formed thereon at an end 120 thereof) configured to form a hydrodynamic seal with an inner surface 122 of the respective bore 116. In certain embodiments, the piston 110 can be of tool steel and the piston ring 118 can be of tool steel. In certain embodiments, only the piston ring 118 is of tool steel. In embodiments, the main cylindrical body 108 is entirely of silicon nitride. A friction coefficient between the piston ring 118 and the inner surface 122 of the respective bore 116 can be about 0.11 when hydrodynamically lubricated. The selection of materials for the main cylindrical body 108 and the piston rings 118 (e.g., lubricated silicon nitride and tool steel, respectively) can allow for about 15% reduction in friction coefficient, as compared to a lubricated tool steel piston ring and a tungsten carbide cylindrical body (friction coefficient of 0.13), for example. As tungsten carbide parts wear, tool steel piston ring and tungsten carbide cylindrical body interfaces can become poorly lubricated and increase in friction coefficient towards unlubricated values of 0.19. Although the wear life of silicon nitride on tool steel has been shown to be an order of magnitude higher than tungsten carbide-tool steel interfaces, as wear occurs between silicon nitride cylindrical barrels and tool steel piston rings, the friction coefficient will tend towards an unlubricated value of about 0.15 (about a 25% decrease compared to the unlubricated tungsten carbide-tool steel value of about 0.19).

[0015] In accordance with at least one aspect of this disclosure, a method can include forming a silicon nitride cylinder barrel (e.g., cylinder barrel 108) of a piston pump (e.g., pump 102), and installing the cylinder barrel into the piston pump. In embodiments, forming the silicon nitride cylinder barrel can further include, forming a main cylindrical body (e.g., body 112), forming a center recess (e.g., recess 114) configured to seat a drive shaft therein, forming a plurality of bores (e.g., bores 116) each extending in an axial direction through the main cylindrical body, the plurality of bores forming a pattern disposed circumferentially about the main cylindrical body radially outward of the center recess, configured to seat a respective piston (e.g., piston 110) therein and allow fluid flow therethrough.

[0016] The method can further include, operating the piston pump. In embodiments, during operation of the piston pump, the plurality of bores can be configured to remain substantially the same diameter throughout the life of the cylinder barrel, i.e. the bore should remain substantially the same size due to the silicon nitrides natural resistance to wear in high friction applications.

[0017] Embodiments provide for a lower density main cylindrical body, which can reduce the overall weight of the pump. The silicon nitride cylindrical body is configured to withstand the load demands of the pump. Embodiments having a silicon nitride cylinder barrel are naturally more lubricious based on material and wear properties silicon nitride derives from its crystal structure. In combination with its lubricity, engineered versions of silicon nitride can have high strength and high toughness to survive service conditions and also reduce part degradation which provides slower wearing cylinder barrels which are rotated or rubbed against mated surfaces. This can increase the total number service hours of the cylinder barrel and even the pump as a whole.

[0018] Those having ordinary skill in the art understand that any numerical values disclosed herein can be exact values or can be values within a range. Further, any terms of approximation (e.g., "about", "approximately", "around") used in this disclosure can mean the stated value within a range. For example, in certain embodiments, the range can be within (plus or minus) 20%, or within 10%, or within 5%, or within 2%, or within any other suitable percentage or number as appreciated by those having ordinary skill in the art (e.g., for known tolerance limits or error ranges).

[0019] The articles "a", "an", and "the" as used herein and in the appended claims are used herein to refer to one or to more than one (i.e., to at least one) of the grammatical object of the article unless the context clearly indicates otherwise. By way of example, "an element" means one element or more than one element.

[0020] The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, i.e., "one or more" of the elements so conjoined. Oth-

er elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to "A and/or B", when used in conjunction with open-ended language such as "comprising" can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

[0021] As used herein in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of' or "exactly one of," or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used herein shall only be interpreted as indicating exclusive alternatives (i.e., "one or the other but not both") when preceded by terms of exclusivity, such as "either," "one of," "only one of," or "exactly one of."

[0022] Any suitable combination(s) of any disclosed embodiments and/or any suitable portion(s) thereof are contemplated herein as appreciated by those having ordinary skill in the art in view of this disclosure.

[0023] The embodiments of the present disclosure, as described above and shown in the drawings, provide for improvement in the art to which they pertain. While the apparatus and methods of the subject disclosure have been shown and described, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the scope of the subject disclosure.

Claims

1. A system, comprising:

a cylinder barrel (108) configured to rotate within a pump housing (104), the cylinder barrel (104) including:

a main cylindrical body (112);
a center recess (114) defined within the main cylindrical body (112) configured to seat a drive shaft (106) therein; and
a plurality of bores (116) defined in the main cylindrical body (112), extending in an axial direction, wherein the plurality of bores (116) are spaced apart circumferentially relative to one another about the main cylindrical body (112) radially outward of the center recess (114), and wherein the plurality of bores (116) are each configured to seat a respective piston (110) therein and allow fluid flow therethrough,

wherein the main cylindrical body (112) is of silicon nitride.

2. The system of claim 1, further comprising the pump.

3. The system of claim 2, wherein each respective piston (110) further includes a ring disposed at an end thereof configured to form a hydrodynamic seal with an inner surface of a respective bore.

4. The system of claim 3, wherein the ring is of tool steel.

5. The system of claim 4, wherein a friction coefficient between the ring and the inner surface of the bore is about 0.11.

6. The system of claim 2, wherein the pump is or includes a piston pump (102).

7. The system of claim 6, wherein the piston pump (102) is or includes a bent axis variable displacement piston pump.

8. The system of any preceding claim, wherein the plurality of bores (116) includes at least 7 bores.

9. The system of claim 8, wherein the plurality of bores (116) includes up to 13 bores.

10. A method comprising:

forming a silicon nitride cylinder barrel of a piston pump (102); and
installing the cylinder barrel into the piston pump (102).

11. The method of claim 10, wherein forming the silicon nitride cylinder barrel further includes,

forming a main cylindrical body (112);
forming a center recess (114) configured to seat a drive shaft (106) therein; and
forming a plurality of bores (116) each extending in an axial direction through the main cylindrical body (112), the plurality of bores (116) forming a pattern disposed circumferentially about the main cylindrical body (112) radially outward of the center recess (114), configured to seat a respective piston (110) therein and allow fluid flow therethrough.

12. The method of claim 11, further comprising, operat-

ing the piston pump (102).

13. The method of claim 12, wherein, during operation of the piston pump (102), the plurality of bores (116) remain substantially the same diameter throughout the life of the cylinder barrel.

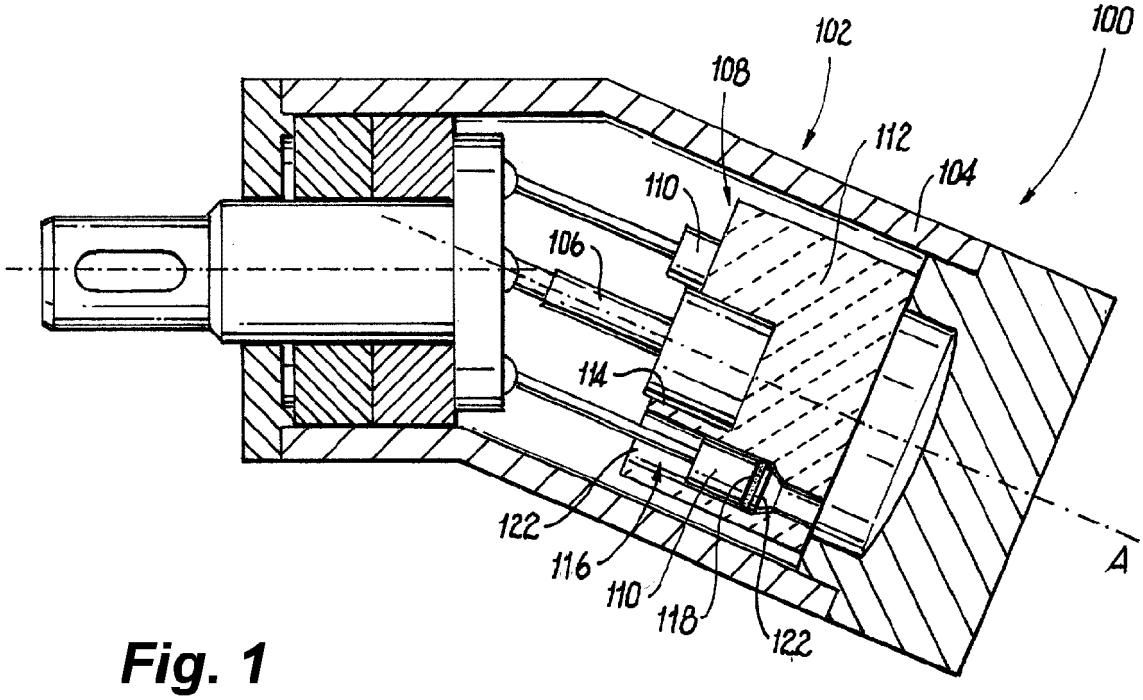
100
102
108
112
104
110
106
114
122
116
110
118
122
A

Fig. 1

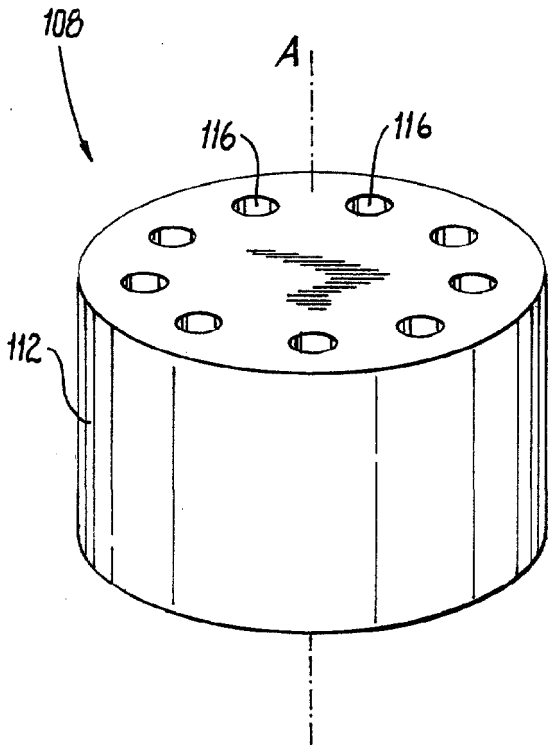
108
A
116
116
112

Fig. 2

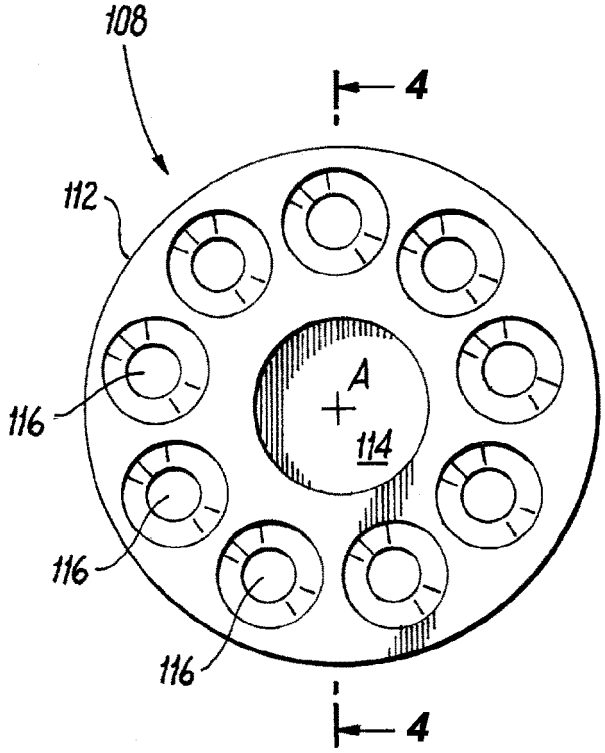

Fig. 3

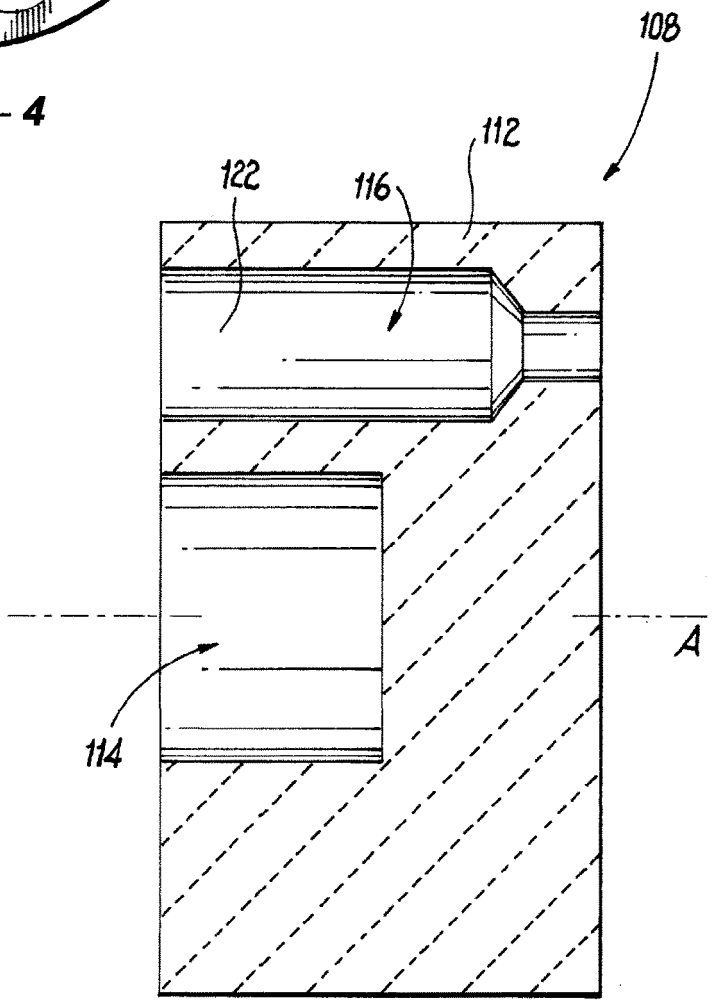

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 1591

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 3 237 754 A1 (PARKER HANNIFIN CORP [US]) 1 November 2017 (2017-11-01) * paragraphs [0016] - [0023]; figures 1-3 * -----	1-13	INV. F04B1/2035
A	JP H04 211497 A (TOSHIBA CORP) 3 August 1992 (1992-08-03) * the whole document * -----	1	
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TECHNICAL FIELDS SEARCHED (IPC)

F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 May 2024	Ziegler, Hans-Jürgen

CATEGORY OF CITED DOCUMENTS

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07-05-2024

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