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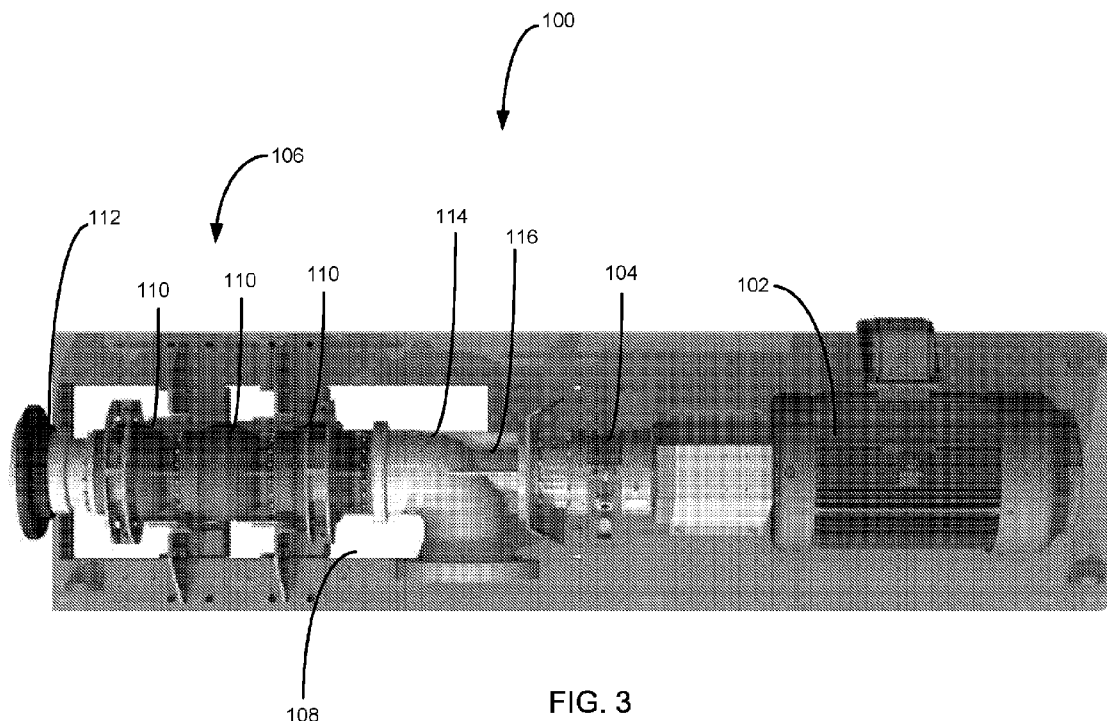


FIG. 3

(57) Abstract: A surface pumping system has a motor and a pump driven by the motor. The pump has a discharge on a first end of the pump, a suction end on a second end of the pump, and a plurality of stages between the suction end and the discharge. Each of the plurality of stages includes an impeller and a diffuser that encases the impeller. Each diffuser is an independent pressure vessel. In some embodiments, the diffuser and impeller in each stage are large and configured for use in low net positive suction head (NPSH) applications.



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High Flow and Low NPSHr Horizontal Pump

Related Applications

[001] This application claims the benefit of United States Provisional Patent Application Serial No. 62/769,456 entitled “High Flow and Low NPSHr Horizontal Pump,” which was filed on November 19, 2018, the disclosure of which is herein incorporated by reference.

Field of the Invention

[002] This invention relates generally to the field of pumping systems, and more particularly, but not by way of limitation, to an improved horizontal pump design for use in low net positive suction head (NPSH) applications.

Background

[003] Horizontal pumping systems are used in various industries for a variety of purposes. Large split casing pumps are often used to move fluids between surface-based storage facilities. In the oil and gas industry, for example, horizontal pumping systems are used to pump fluids, such as water separated from oil, to a remote destination, such as a tank, retention pond or disposal well. Many split casing pumps used in this industry are designed to meet or exceed the standards set forth in API 610. Although generally effective, split casing pumps are expensive, difficult to manufacture and often create large lead times to delivery and installation.

[004] As an alternative to split casing pumps, manufacturers have turned to multistage pumps designed for use in a downhole environment. These multistage pumps are placed on a skid supported frame and used in a horizontal orientation. Typically these horizontal

pumping systems include a pump, a motor, and a suction housing positioned between the pump and the motor. A thrust chamber is also included between the motor and the suction housing. The pump includes a discharge assembly that is connected to downstream piping.

[005] In downhole pumping applications, the pressure of the fluid at the pump inlet is often increased by head pressure created by the column of fluid in the wellbore. In surface-based pumping systems, however, the net positive suction head available (NPSH_A) may be much lower. To match the NPSH_A to the suction pressure required by the pump (NPSH_R), designers have attempted to incorporate a separate “boost pump” that charges the pressure of the fluid to a NPSH_A that matches or exceeds the NPSH_R required by the horizontal pump. The use of a separate boost pump is expensive and requires additional space that may not be available in certain applications.

[006] To overcome the inefficiencies of using a separate boost pump, pump manufacturers have also designed pumping systems that have a primary multistage assembly connected to a separate, external low NPSH stage assembly driven by a common shaft and motor. This approach is disclosed in United States Patent Application Publication No. 2017/0051752 A1, the disclosure of which is herein incorporated by reference. Despite the advancements in the art, there remains a need for a cost-effective surface pumping solution that provides high flow rates in low NPSH_R applications.

Summary of the Invention

[007] In one aspect, the present invention includes a surface pumping system that has a motor and a pump driven by the motor. The pump has a discharge on a first end of the pump, a suction end on a second end of the pump, and a plurality of stages between the

suction end and the discharge. Each of the plurality of stages includes an impeller and a diffuser that encases the impeller. Each diffuser is an independent pressure vessel. In some embodiments, the diffuser and impeller in each stage are large and configured for use in low net positive suction head (NPSH) applications.

[008] In another embodiment, the present invention provides a surface pumping system that has a frame, a motor mounted to the frame, a thrust chamber mounted to the frame adjacent to the motor and a pump mounted to the frame adjacent to the thrust chamber. The pump includes a discharge on a first end of the pump, a shaft seal module connected between the discharge and the thrust chamber, and a suction end on a second end of the pump, where the discharge is between the suction end and the motor. The pump also includes a plurality of pump stages between the suction end and the discharge. Each of the plurality of stages has an impeller and a diffuser that encases the impeller. In this embodiment, each diffuser is an independent pressure vessel. The surface pumping system also includes a shaft that extends from the motor to the impellers through the thrust chamber and the shaft seal module.

[009] In yet another embodiment, the present invention provides a surface pumping system that has a motor and a pump driven by the motor. The pump has a discharge on a first end of the pump, a suction end on a second end of the pump, and a plurality of stages between the suction end and the discharge. Each of the plurality of stages includes an impeller and a diffuser that encases the impeller. In this embodiment, each diffuser is an independent pressure vessel.

Brief Description of the Drawings

[010] FIG. 1 is a side view of a surface pumping system constructed in accordance with an exemplary embodiment of the present invention.

[011] FIG. 2 is a side perspective of the surface pumping system of FIG. 1.

[012] FIG. 3 is a top view of the surface pumping system of FIG. 1.

Detailed Description of the Preferred Embodiments

[013] In accordance with an exemplary embodiment, FIGS. 1-3 show side, perspective and top views, respectively, of a horizontal pumping system 100. The horizontal pumping system 100 includes a motor 102, a thrust chamber 104, and a pump 106. The thrust chamber 104 is connected between the pump 106 and the motor 102. The various components within the horizontal pumping system 100 are supported by a frame 108 that may be configured as a skid suitable for placement on a pad, trailer or any other stable surface capable of supporting the horizontal pumping system 100. In the exemplary embodiment depicted in FIGS. 1-3, the various components of the horizontal pumping system 100 are bolted to the frame 108 such that the horizontal pumping system 100 can be lifted, moved, adjusted and set as a unitary element without the need to realign the individual components of the horizontal pumping system 100.

[014] As used herein, the terms “upstream” and “downstream” provide relative positional references to components within the horizontal pumping system 100 based. Upstream components will be understood to be positioned closer to the suction end 112, while downstream components are positioned at a greater distance from the suction end 112 in the direction of fluid flow away from the suction end 112. Although the preferred embodiments are depicted in connection with a horizontal pumping system 100, it will be

appreciated that the preferred embodiments may also find utility in other pumping systems, including surface-mounted vertical pumping systems.

[015] The pump 106 includes one or more turbomachinery stages 110, a suction end 112 and a discharge 114. As depicted, the pump 106 is configured as an “end-suction” pump in which the suction end 112 is positioned on the opposite end of the pump 106 from the thrust chamber 104. The discharge 114 is positioned between the stages 110 and the thrust chamber 104. Generally, the motor 102 drives the pump 106 through one or more shafts (not visible) that extend through the thrust chamber 104 and discharge 114 to the stages 110. The motor 102 can be configured as a 4-pole motor that operates in response to an input current that has a higher frequency than the current applied to conventional 2-pole and 3-pole motors. In one embodiment, the motor 102 is configured to rotate at no more than about 1,750 revolutions per minute (RPM). In other embodiments, the motor 102 is an internal combustion engine that produces torque to drive the pump 106. In certain embodiments, it may be desirable to deploy gearboxes or additional transmission components between the motor 102 and the pump 106. In yet other embodiments, the motor 102 is configured as a 2-pole or 3-pole electric motor.

[016] As best depicted in FIG. 3, the discharge 114 includes a shaft seal module 116 that supports and seals the shaft as it enters the discharge 114. The shaft seal module 116 includes one or more shaft seals (not shown) that prevent high pressure fluid from being released from the discharge 114 through the shaft seal module 116. These design features are more commonly found in vertical turbine pumps.

[017] Pumped fluids are provided to the suction end 112 from an inlet conduit and pressurized by the pump stages 110. Each of the pump stages 110 includes a diffuser 118

and an impeller 120 contained within the diffuser 118. Unlike conventional multistage surface pumping systems, the diffusers 118 are not contained within a separate external housing. In this way, the diffusers 118 are each configured as an independent pressure vessel that can be sized without restriction to a common external housing found in conventional multistage pumps. This permits the diffuser 118 and the impeller 120 to be enlarged and configured for optimal operation under low net positive suction head (NPSH) conditions while also providing high flow rate operation. Additionally, this permits each stage 110 to be sized differently from the other stages 110 in the pump 106.

[018] In some embodiments, the pump 106 has a larger diffuser 118 and impeller 120 on the stage 110 closest to the suction end 112 to manage lower NPSH at the suction end. In other embodiments, the pump 106 has a smaller diffuser 118 and impeller 120 on the stage 110 closest to the suction end 112. In yet other embodiments, the pump 106 has a larger diffuser 118 and impeller 120 in the intermediate stages 110 between smaller stages 110 located adjacent the suction end 112 and the discharge 114. In higher pressure applications, the pump 106 may optionally include an external housing (not depicted) that reinforces the various components of the pump 106 against elevated internal pressures.

[019] In some embodiments, the stages 110 are configured as large, mixed flow stages. Suitable stages 110 are found in vertical turbine pump applications often used in steam-based power generation facilities. The impellers 120 are designed to provide an increase in the pressure of the pumped fluid while minimizing cavitation. In other embodiments, the stages 110 are configured as radial flow stages. In yet other embodiments, the pump 106 includes a combination of mixed flow stages 110 and radial flow stages 110.

[020] The surface pumping system 100 is well suited to pump large volumes of fluid between surface facilities. Suitable applications include the movement of fluids between storage containers, retention ponds and naturally occurring bodies of water. Because the surface pumping system 100 is configured for high volume operation, the surface pumping system 100 can also be used to provide the fluid feed on hydraulic fracturing operations. In these applications, the surface pumping system 100 can be used to transfer “frac” fluid from a storage facility to the high pressure triplex pumps commonly used in hydraulic fracturing operations.

[021] It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and functions of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in detail, especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed. It will be appreciated by those skilled in the art that the teachings of the present invention can be applied to other systems without departing from the scope and spirit of the present invention.

What is claimed is:

1. A surface pumping system comprising:
a motor; and
a pump driven by the motor, wherein the pump comprises:
a discharge on a first end of the pump;
a suction end on a second end of the pump, wherein the discharge is
between the suction end and the motor;
a plurality of stages between the suction end and the discharge, wherein
each of the plurality of stages comprises:
an impeller; and
a diffuser that encases the impeller, wherein each diffuser is an
independent pressure vessel.
2. The surface pumping system of claim 1, wherein the surface pumping
system further comprises a shaft assembly and wherein the shaft assembly is driven by
the motor and wherein impeller of the plurality of stages is connected to the shaft
assembly.
3. The surface pumping system of claim 1, wherein the diffuser of each stage
does not include a separate housing around the diffuser.
4. The surface pumping system of claim 1, wherein at least one of the
plurality of stages is configured as a mixed flow stage.

5. The surface pumping system of claim 4, wherein at least one of the plurality of stages is configured as a radial flow stage.

6. The surface pumping system of claim 1, wherein the plurality of stages comprises a first stage, a second stage and a third stage.

7. The surface pumping system of claim 6, wherein the first stage comprises a diffuser having a first outer diameter and wherein the second stage comprises a diffuser having a second outer diameter that is smaller than the first outer diameter.

8. The surface pumping system of claim 6, wherein the first stage is configured as a mixed flow stage and the second stage is configured as a radial flow stage.

9. A surface pumping system comprising:

a motor; and

a pump driven by the motor, wherein the pump comprises:

a discharge on a first end of the pump;

a suction end on a second end of the pump;

a plurality of stages between the suction end and the discharge, wherein

each of the plurality of stages comprises:

an impeller; and

a diffuser that encases the impeller, wherein each diffuser is an independent pressure vessel.

10. The surface pumping system of claim 9, wherein the discharge is between the suction end and the motor.

11. The surface pumping system of claim 9, wherein the pump further comprises a shaft seal module connected to the discharge of the pump.

12. The surface pumping system of claim 11, wherein the surface pumping system further comprises a thrust chamber between the motor and the pump and wherein the shaft seal module is connected between the discharge of the pump and the thrust chamber.

13. A surface pumping system comprising:

a frame;

a motor mounted to the frame;

a thrust chamber mounted to the frame adjacent to the motor;

a pump mounted to the frame adjacent to the thrust chamber and wherein the pump comprises:

a discharge on a first end of the pump;

a shaft seal module connected between the discharge and the thrust chamber;

a suction end on a second end of the pump, wherein the discharge is between the suction end and the motor; and

a plurality of stages between the suction end and the discharge, wherein each of the plurality of stages comprises:

an impeller; and

a diffuser that encases the impeller, wherein each diffuser is an independent pressure vessel; and

a shaft, wherein the shaft extends from the motor to the impellers through the thrust chamber and the shaft seal module.

14. The surface pumping system of claim 13, wherein the shaft comprises a plurality of interconnected shaft segments.

15. The surface pumping system of claim 14, wherein the diffuser of each stage does not include a separate housing around the diffuser.

16. The surface pumping system of claim 13, wherein at least one of the plurality of stages is configured as a mixed flow stage.

17. The surface pumping system of claim 16, wherein at least one of the plurality of stages is configured as a radial flow stage.

18. The surface pumping system of claim 13, wherein the plurality of stages comprises a first stage, a second stage and a third stage.

19. The surface pumping system of claim 18, wherein the first stage comprises a diffuser having a first outer diameter and wherein the second stage comprises a diffuser having a second outer diameter that is smaller than the first outer diameter.

20. The surface pumping system of claim 19, wherein the first stage is configured as a mixed flow stage and the second stage is configured as a radial flow stage.

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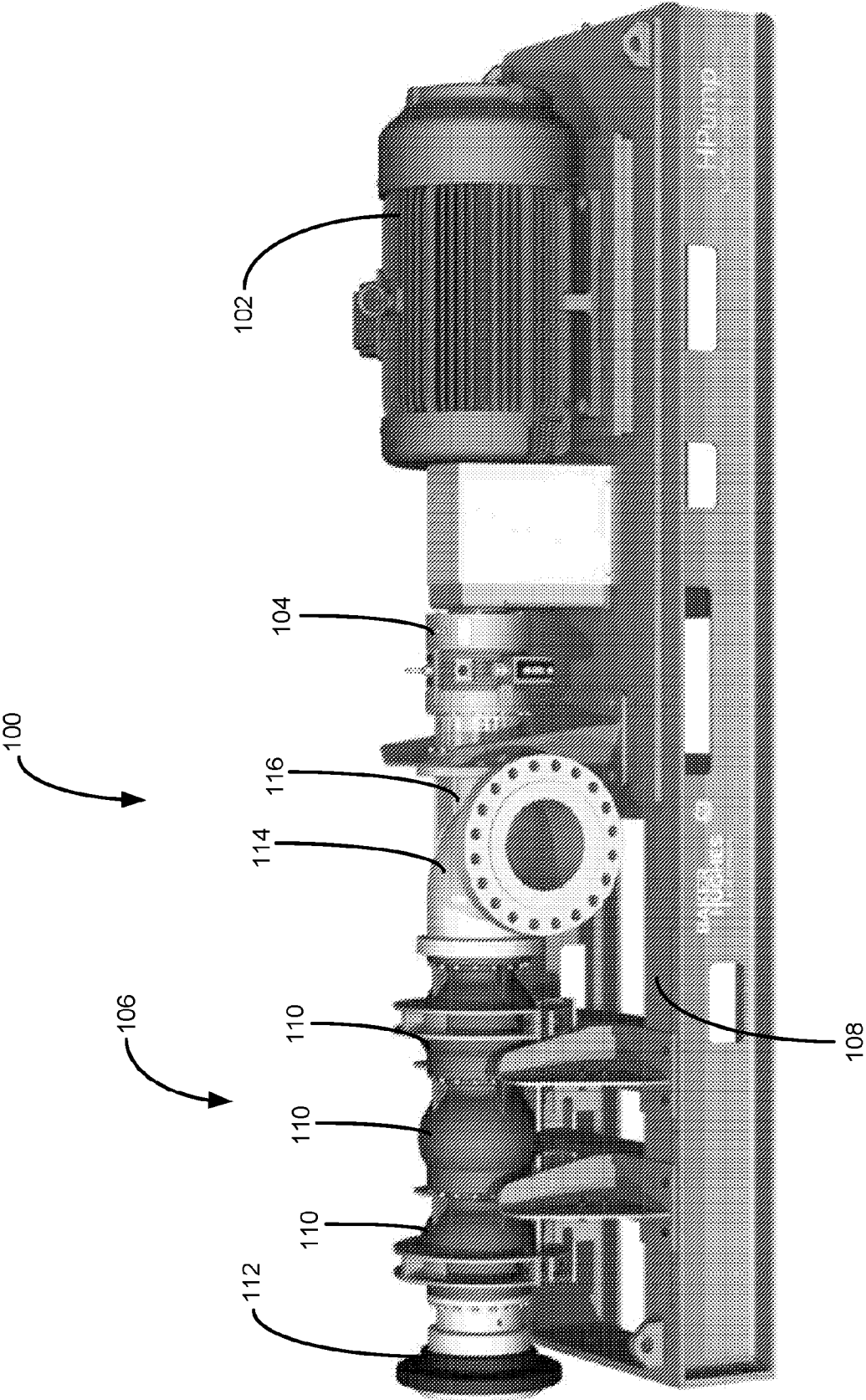
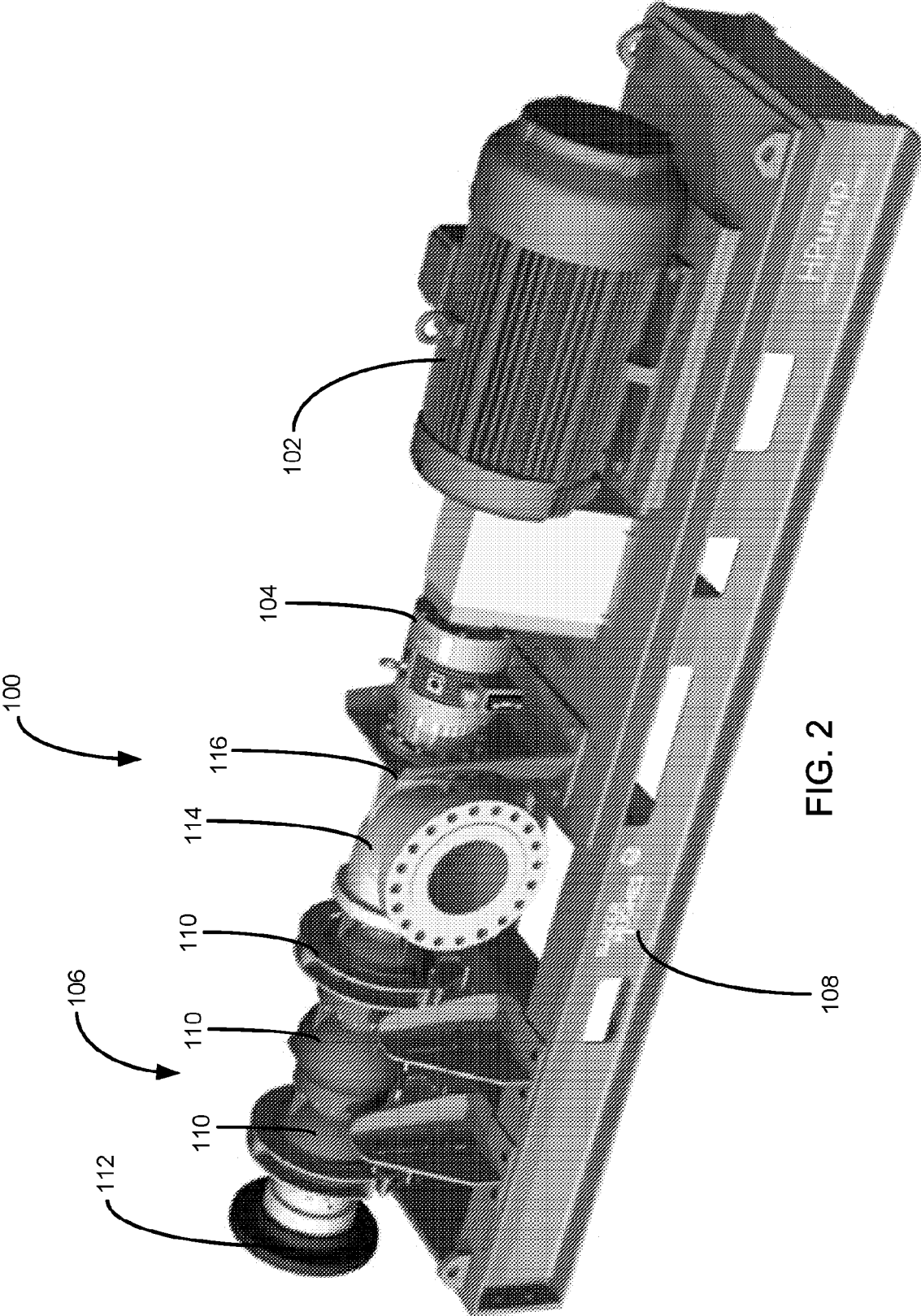


FIG. 1



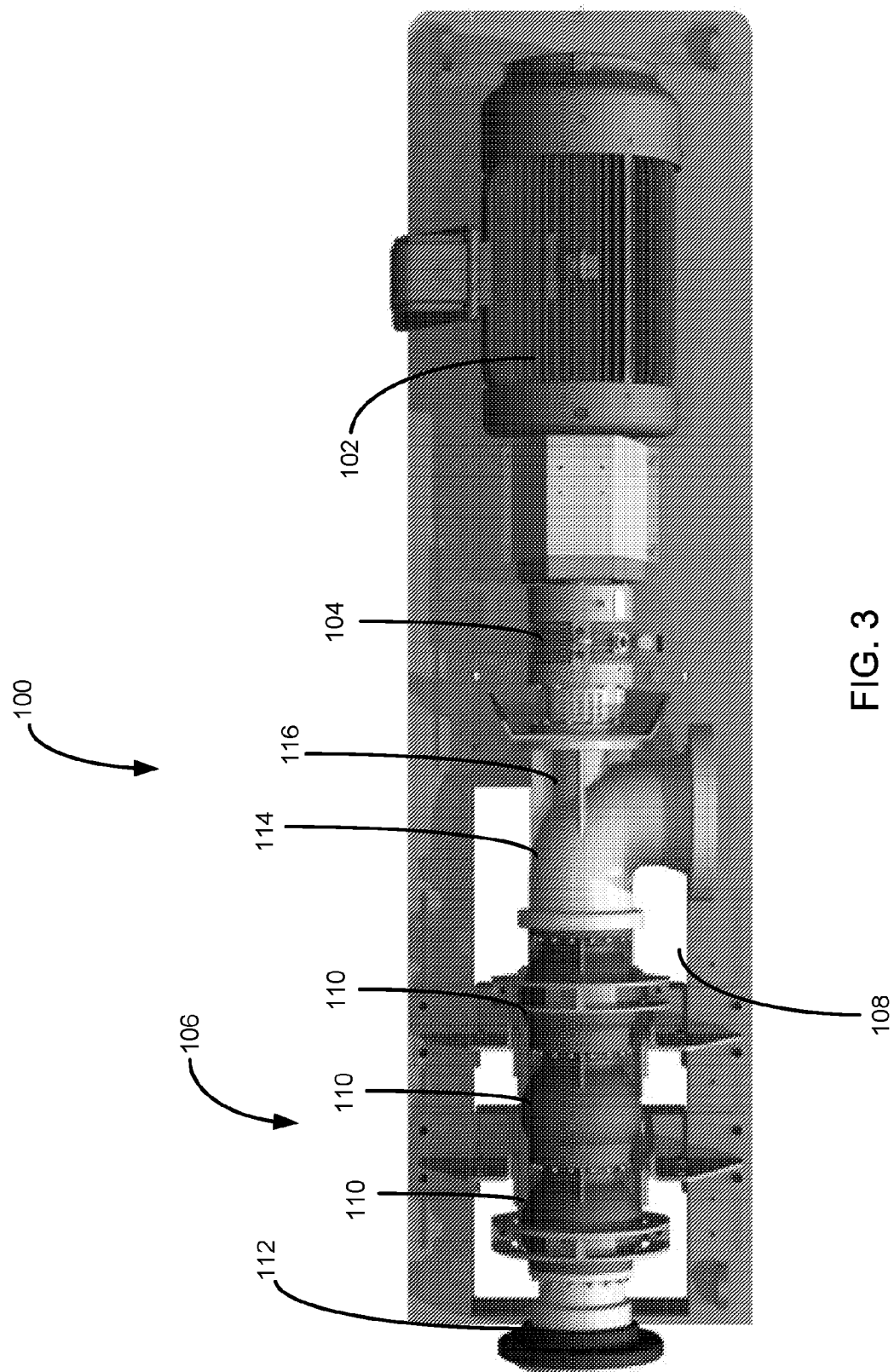


FIG. 3

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC - F04D 17/08, F04D 29/04, F04D 29/046, F04D 29/047, F04D 29/06 (2020.01)

CPC - F04D 29/0465, F04D 29/047, F04D 29/061, F05B 2240/52, F05C 2203/08, F04D 29/0462, F04D 29/628, F04D 13/086, F04D 29/606

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,779,434 A (DE LONG) 14 July 1998 (14.07.1998), entire document	1-4, 6, 9-16, 18
Y		5, 7-8, 17, 19-20
Y	US 2012/0093636 A1 (HOMSTVEDT et al.) 19 April 2012 (19.04.2012), entire document	5, 7-8, 17, 19-20
A	US 2003/0219347 A1 (MASCOLA) 27 November 2003 (27.11.2003), entire document	1-20
A	US 8,246,251 B1 (GARDNER) 21 August 2012 (21.08.2012), entire document	1-20
A	US 2009/0035159 A1 (SPEER et al.) 5 February 2009 (05.02.2009), entire document	1-20
A	US 2015/0030470 A1 (GE OIL & GAS ESP, INC. et al.) 29 January 2015 (29.01.2015), entire document	1-20
A	US 2010/0284830 A1 (BURNS, SR. et al.) 11 November 2010 (11.11.2010), entire document	1-20
A	US 2008/0085185 A1 (TOWSLEY et al.) 10 April 2008 (10.04.2008), entire document	1-20
A	US 2007/0086906 A1 (HORLEY et al.) 19 April 2007 (19.04.2007), entire document	1-20

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