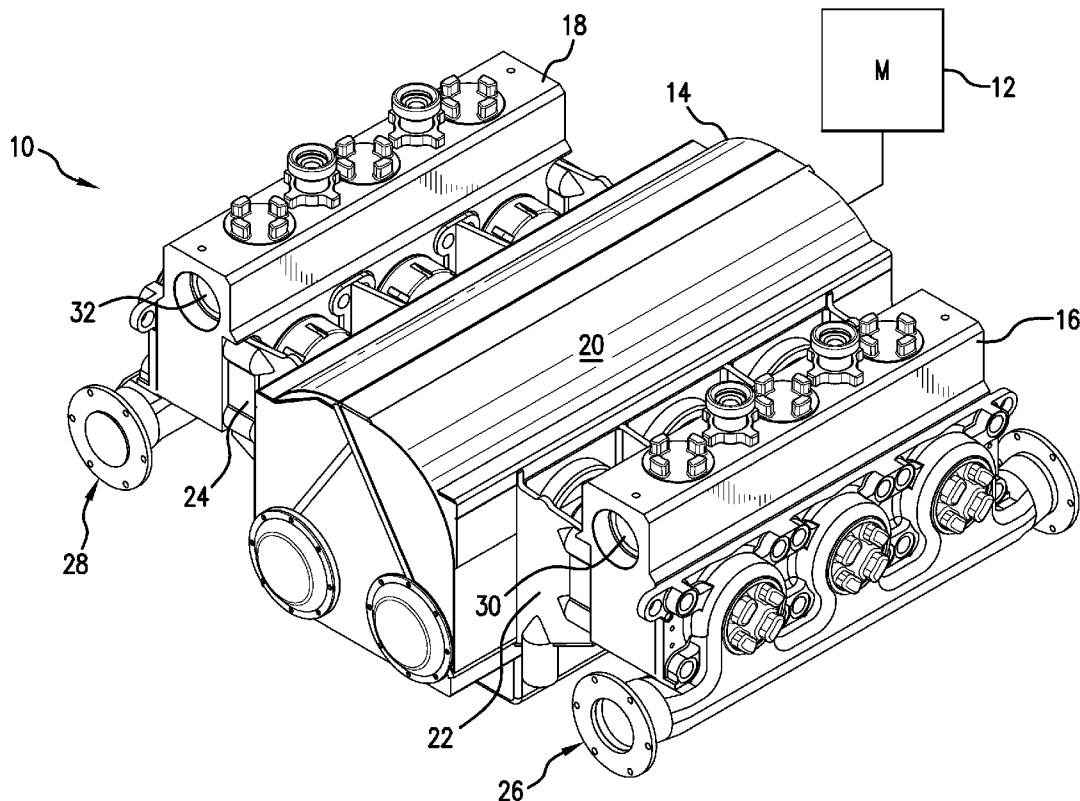




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(19) **United States**(12) **Patent Application Publication**
Burnette(10) **Pub. No.: US 2014/0147291 A1**(43) **Pub. Date: May 29, 2014**(54) **RECIPROCATING PUMP ASSEMBLY AND METHOD THEREOF**(71) Applicant: **Baker Hughes Incorporated**, Houston, TX (US)(72) Inventor: **Blake C. Burnette**, Tomball, TX (US)(73) Assignee: **BAKER HUGHES INCORPORATED**, Houston, TX (US)(21) Appl. No.: **13/687,558**(22) Filed: **Nov. 28, 2012****Publication Classification**(51) **Int. Cl.**
F04B 9/04 (2006.01)
F04B 47/00 (2006.01)(52) **U.S. Cl.**CPC **F04B 9/042** (2013.01); **F04B 47/00** (2013.01)USPC **417/53**; 417/364; 417/343(57) **ABSTRACT**

A reciprocating pump assembly including a first fluid assembly; a second fluid assembly; and, a power assembly operable by a prime mover. A prime mover including one of an engine and a motor. The power assembly interposed between and shared by the first fluid assembly and the second fluid assembly. The power assembly including at least one rotatable crankshaft operating the first and second fluid assemblies. Also included is a method of pumping fluid for a downhole operation.



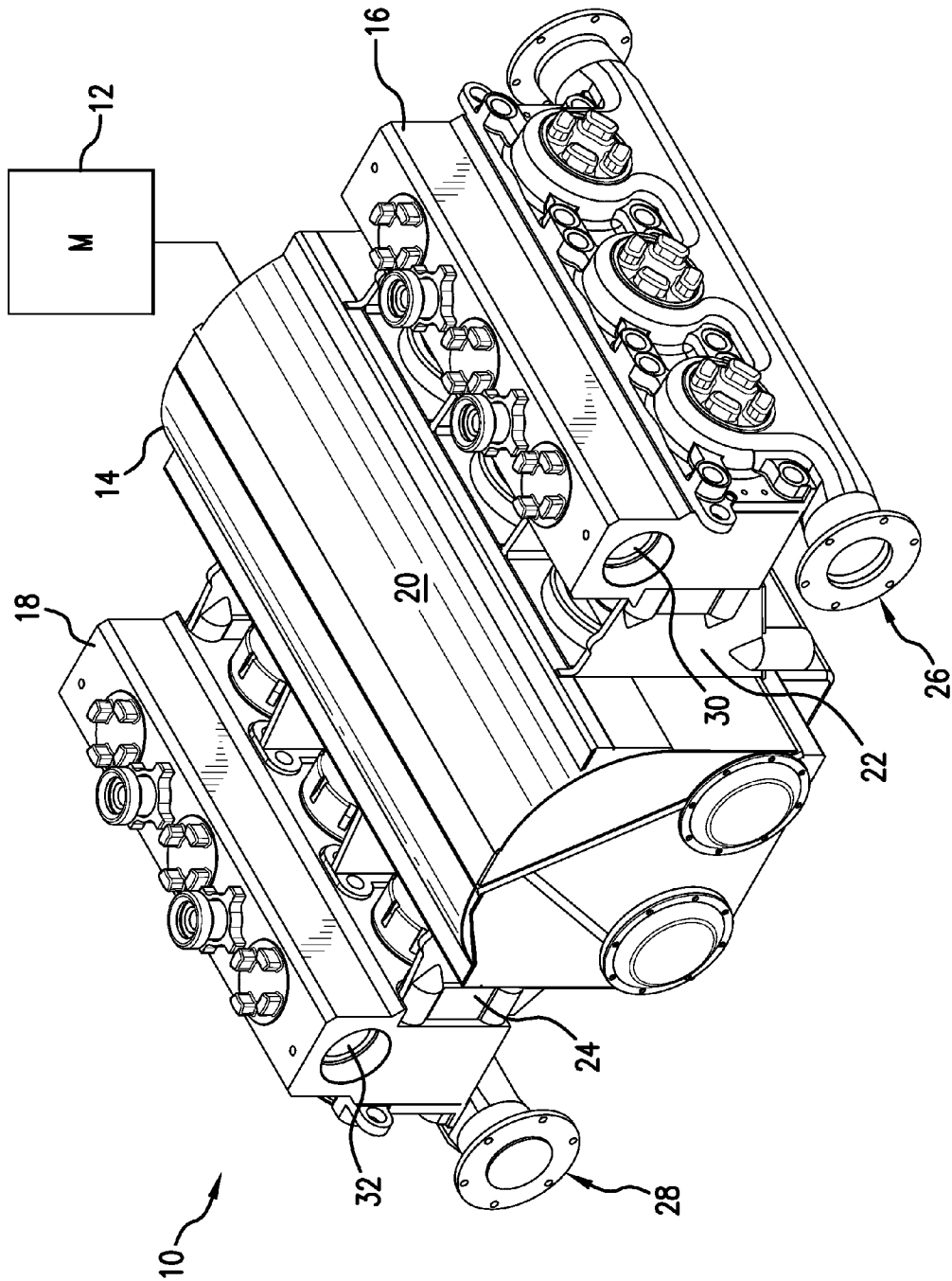


FIG. 1

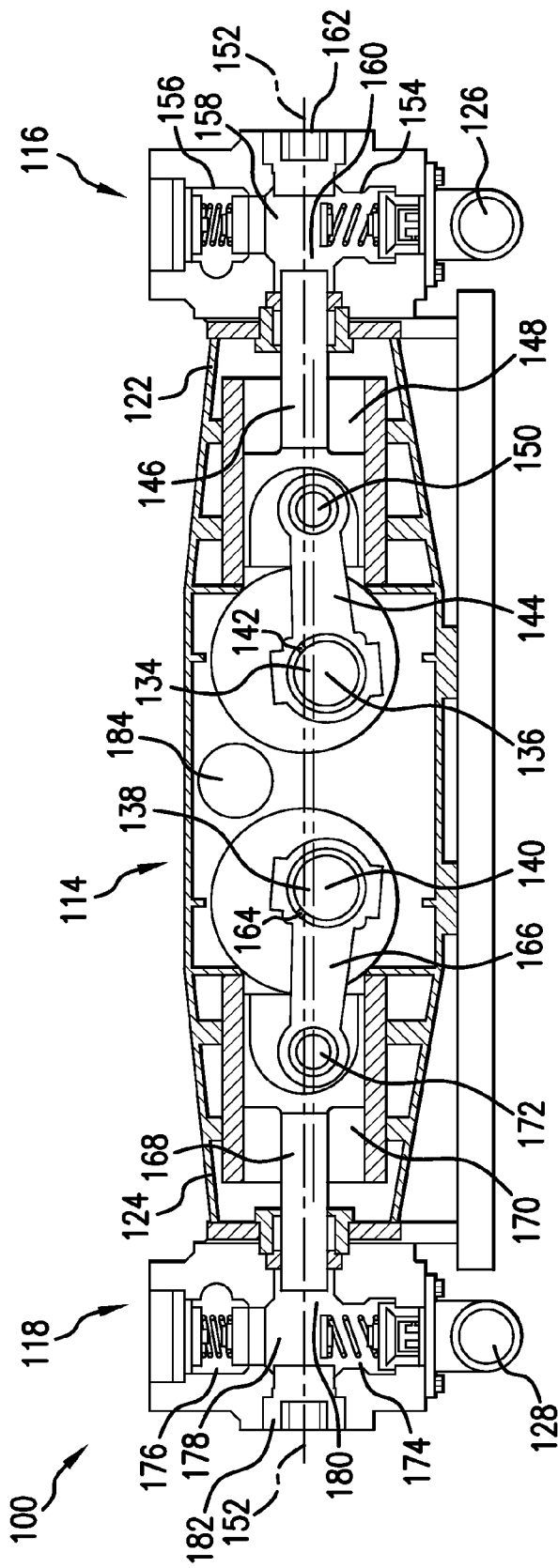


FIG. 2

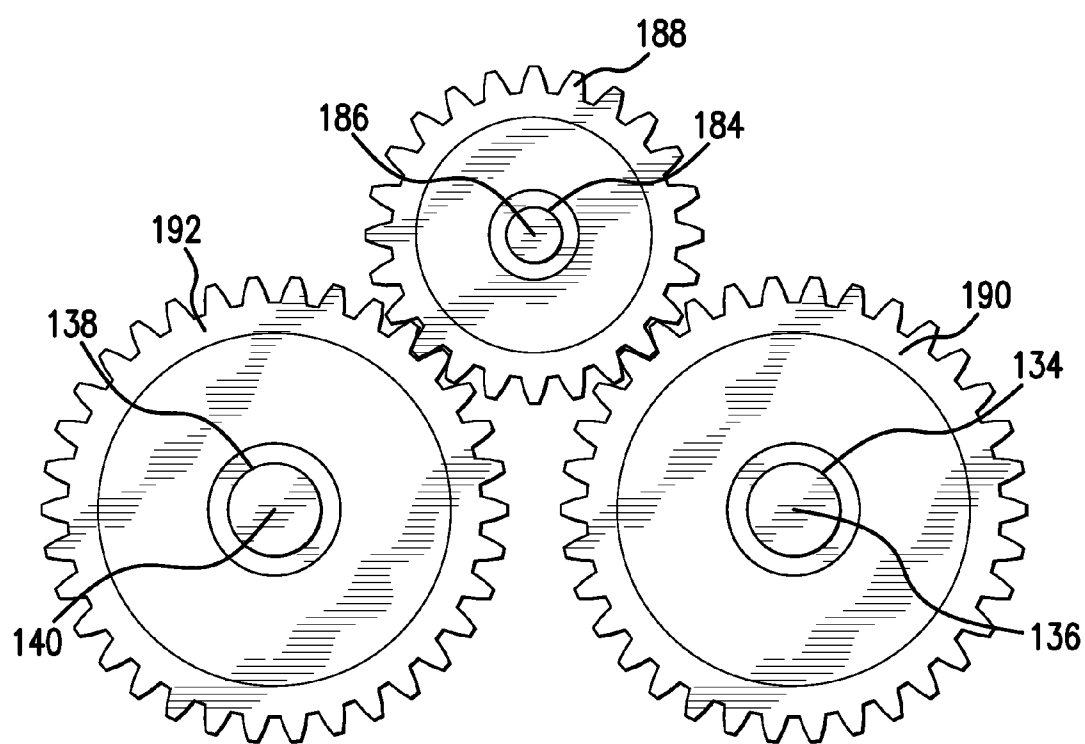


FIG.3

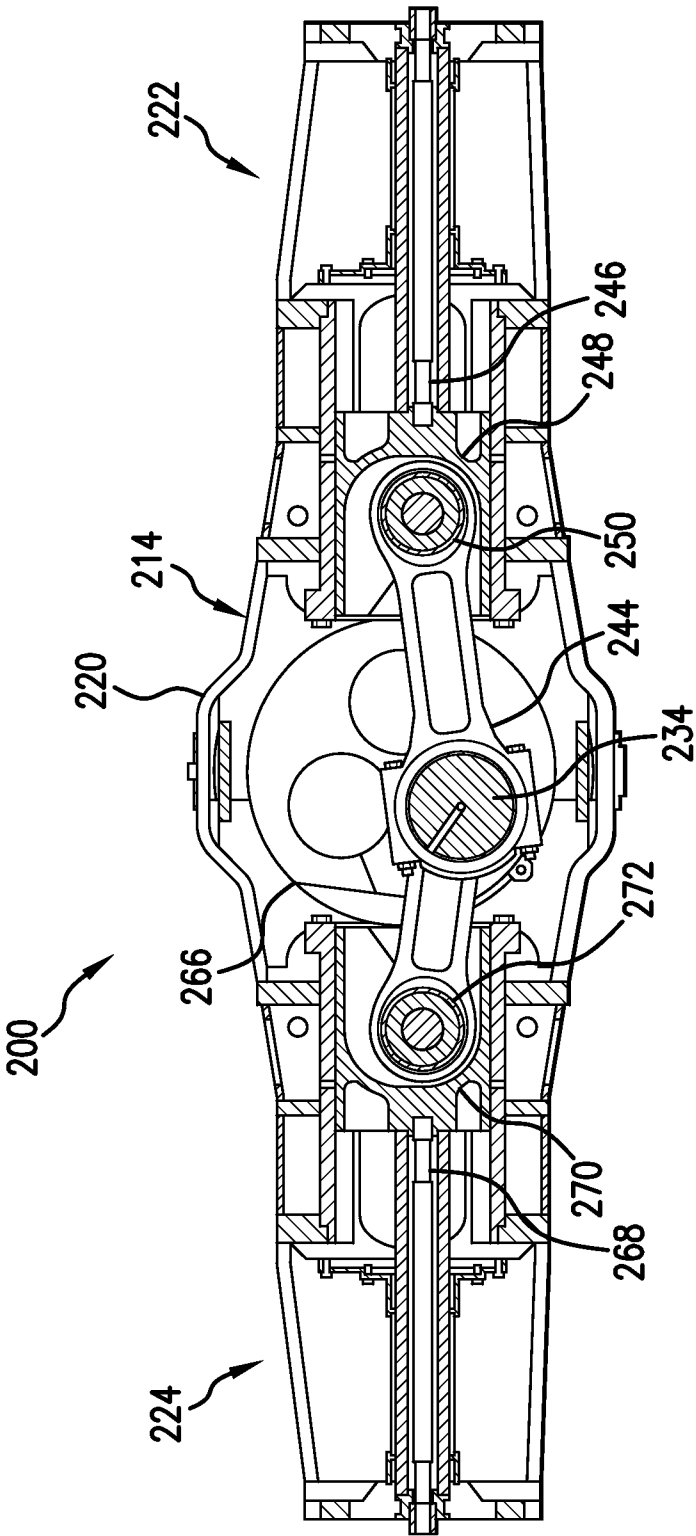


FIG. 4

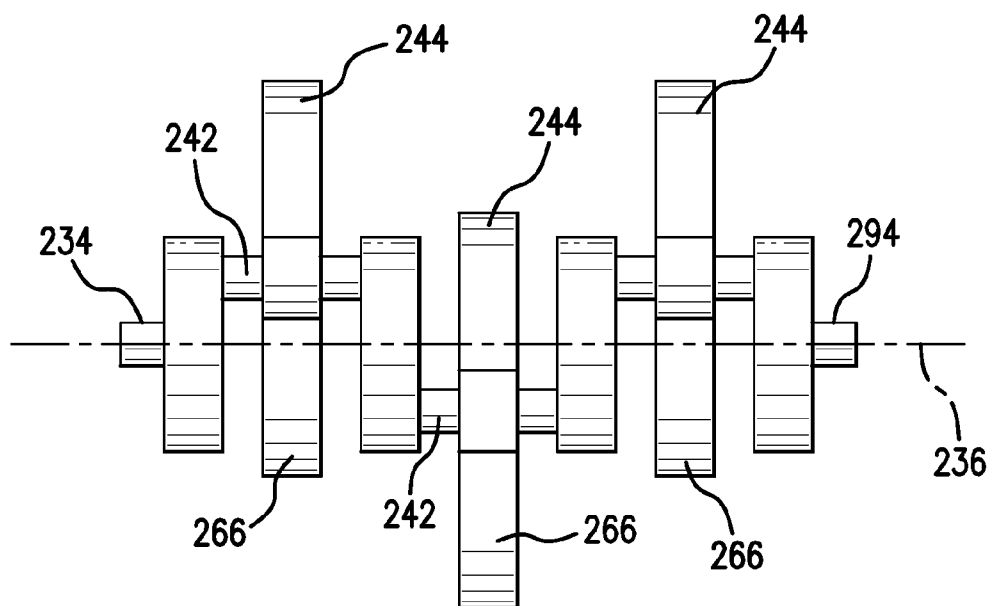


FIG. 5

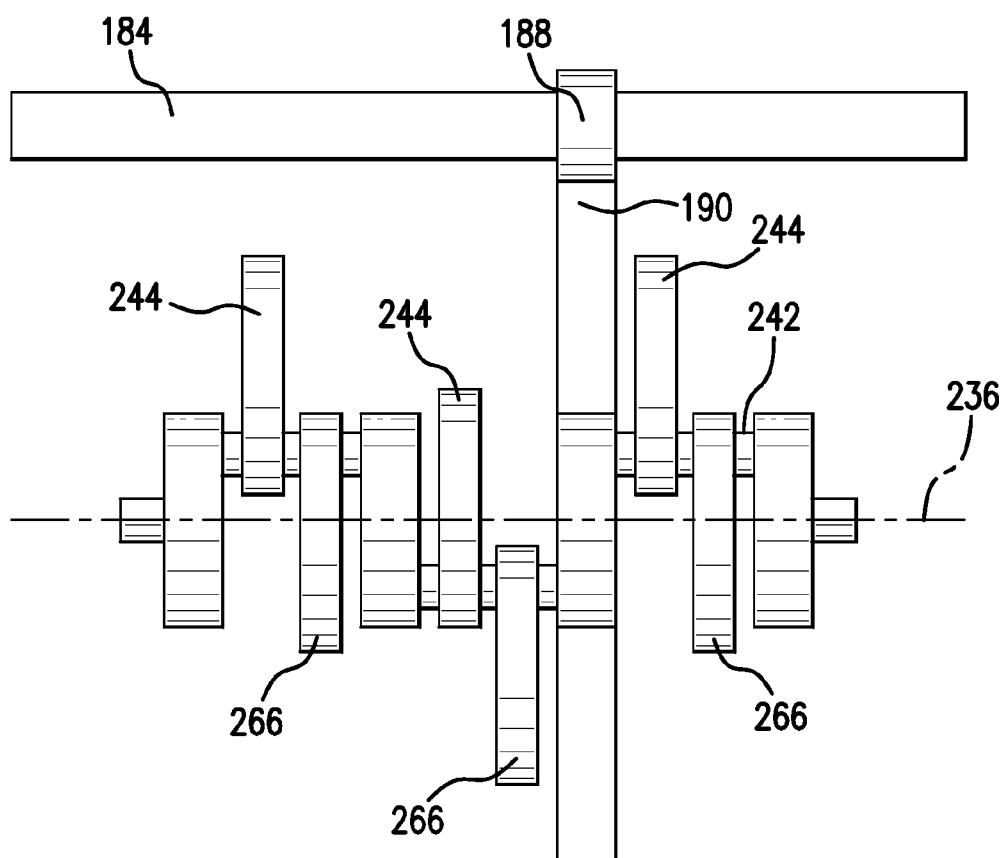


FIG. 6

RECIPROCATING PUMP ASSEMBLY AND METHOD THEREOF

BACKGROUND

[0001] In the drilling and completion industry, the formation of boreholes for the purpose of production or injection of fluid is common. The boreholes are used for exploration or extraction of natural resources such as hydrocarbons, oil, gas, water, and alternatively for CO₂ sequestration. To increase the production from a borehole, the production zone can be fractured to allow the formation fluids to flow more freely from the formation to the borehole. The fracturing operation includes pumping fluids at high pressure towards the formation to form formation fractures. To retain the fractures in an open condition after fracturing pressure is removed, the fractures must be physically propped open, and therefore the fracturing fluids commonly include solid granular materials, such as sand, generally referred to as proppants. Other components of the fracturing fluids typically include water, gel, or other chemical additives.

[0002] The pressure required for hydraulic fracturing of a formation, for example, often requires fracturing fluid to be pumped at pressures of 10,000 to 15,000 psi in order to create a fracture in the formation. To pump the fracturing fluids at the high pressures required for fracturing, crankshaft driven positive displacement pumps are used. The crankshaft driven positive displacement pumps include a fluid end and a power end. The fluid end includes a number of plungers driven by a crankshaft toward and away from a chamber in order to affect a high or low pressure on the chamber. The fluid end receives relatively low pressure fluid, and pressurizes the fluid to provide higher pressurized fracturing fluid at the required pressure for fracturing within the borehole. The power end includes or is attached to a pump powering mechanism also known as a prime mover, commonly an electric motor, which connects to a pinion shaft to drive the power end.

[0003] The art would be receptive to improved apparatus and methods for hydraulic fluid fracturing pumps.

BRIEF DESCRIPTION

[0004] A reciprocating pump assembly including a first fluid assembly; a second fluid assembly; and, a power assembly operable by a prime mover including one of an engine and a motor, the power assembly interposed between and shared by the first fluid assembly and the second fluid assembly, the power assembly including at least one rotatable crankshaft operating the first and second fluid assemblies.

[0005] A method of pumping fluid for a downhole operation using the reciprocating pump assembly of Claim 1, the method including employing a prime mover to rotate the at least one crankshaft; moving a first piston in the first fluid assembly via the at least one crankshaft; and, substantially simultaneously moving a second piston in the second fluid assembly via the at least one crankshaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0007] FIG. 1 shows a perspective view of an exemplary embodiment of a reciprocating pump assembly;

[0008] FIG. 2 shows a cross-sectional view of an exemplary embodiment of a reciprocating pump assembly;

[0009] FIG. 3 shows a cross-sectional view of an exemplary embodiment of first and second crankshafts and a pinion shaft;

[0010] FIG. 4 shows a cross-sectional view of another exemplary embodiment of a reciprocating pump assembly;

[0011] FIG. 5 shows a cross-sectional view of an exemplary embodiment of a crankshaft and connecting rods for the reciprocating pump assembly of FIG. 4; and,

[0012] FIG. 6 shows a cross-sectional view of an exemplary embodiment of a crankshaft, connecting rods, and a pinion shaft for the reciprocating pump assembly of FIG. 4.

DETAILED DESCRIPTION

[0013] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0014] With reference to FIG. 1, a positive displacement pump, in particular a reciprocating pump assembly 10 is shown. The pump 10 is usable for a fracturing application in which fracturing fluid, such as, but not limited to a proppant filled slurry, is pumped downhole into a borehole for creating and potentially propping fractures in a formation. While particularly suited for a fracturing application, other applications may also employ the pump 10. The pump 10 shown in FIG. 1, while usable with any prime mover 12, is particularly designed to take advantage of higher HP prime movers. The prime mover 12 could be an electric motor or an internal combustion engine, such as a diesel engine, although other prime movers are within the scope of these embodiments.

[0015] The pump 10 includes a power assembly 14, sometimes referred to as a power end, and a first fluid assembly 16, sometimes referred to as a fluid end. The pump 10 further advantageously includes a second fluid assembly 18. The power assembly 14 is interposed between the first and second fluid assemblies 16, 18, and because the first and second fluid assemblies 16, 18 are both operated by the power assembly 14, the power assembly 14 is a shared power assembly 14. The power assembly 14 includes a crankshaft housing 20 which houses at least one crankshaft as will be further described below. First and second crosshead assemblies 22, 24 are interposed between the power assembly 14 and the first and second fluid assemblies 16, 18, respectively. The first and second crosshead assemblies 22, 24 convert rotational movement of the power assembly 14 into reciprocating movement to actuate internal pistons or plungers of the fluid assemblies 16, 18. While the illustrated pump includes three internal pistons to pump the fluid in each of the first and second fluid assemblies 16, 18, an alternate number of pistons may be provided. In the exemplary embodiment, the first fluid assembly 16 includes the same number of pistons as the second fluid assembly 18. The first and second fluid assemblies 16, 18 each include an input valve connected to an inlet 26, 28 and an output valve connected to an outlet 30, 32. Withdrawal of a piston during a suction stroke pulls fluid into the fluid assembly 16, 18 through the input valve that is connected to the inlet 26, 28. Subsequently pushed during a power stroke, the piston then forces the fluid under pressure out through the output valve connected to the outlet 30, 32. The prime mover 12 drives the reciprocating pump 10. The prime mover 12 can be located at the crankshaft housing 20 or at another convenient location, and is employed to rotate the crankshaft within the crankshaft housing 20.

[0016] An exemplary embodiment of a reciprocating pump assembly 100 is shown in FIG. 2. The power assembly 114 includes a first crankshaft 134 rotatable about a first longitudinal axis 136 and a second crankshaft 138 rotatable about a second longitudinal axis 140. As illustrated, the first and second longitudinal axes 136, 140 are parallel to each other. The first crankshaft 134 includes a plurality of first eccentrically arranged crankpins 142 (or alternatively a plurality of first eccentric sheaves), and a first connecting rod 144 is connected to each first crankpin 142. The first connecting rods 144 connect the first crankpins 142 to the first pistons 146 via the first crosshead assembly 122. The first connecting rods 144 may be connected to a first crosshead 148 using a first wrist pin 150 that allows the first connecting rods 144 to pivot with respect to the first crosshead 148, which in turn is connected to the first pistons 146. The longitudinal axis 152 of each of the first pistons 146 is perpendicular to the longitudinal axes 136, 140 of the first and second crankshafts 134, 138. When the first crankshaft 134 turns, the first crankpins 142 reciprocate the first connecting rods 144. Moved by the first connecting rods 144, the first crosshead 148 reciprocates inside fixed cylinders. In turn, the first pistons 146 coupled to the first crosshead 148 also reciprocate between suction and power strokes in the first fluid assembly 116. First input valves 154 are connected to the first inlet 126 and first output valves 156 are connected to a first outlet (first outlet 30 shown in FIG. 1). The first fluid assembly 116 includes first vertical passages 158 for passing fluid from each of the first input valves 154 to respective first output valves 156. The first fluid assembly 116 also includes first horizontal passages 160 that are directed along the longitudinal axis 152 of the first pistons 146. The first horizontal passages 160 are in fluid communication with the first vertical passages 158. Withdrawal of a first piston 146 during a suction stroke pulls fluid into the first fluid assembly 116 through a first input valve 154 that is connected to the first inlet 126. Subsequently pushed during a power stroke, a first piston 146 then forces the fluid under pressure out through the first output valve 156 connected to the first outlet 30. Pairs of the first input valve 154 and first output valves 156 (only one pair shown in FIG. 2) are arranged to extend in a same general direction as the first and second crankshafts 134, 138, such as substantially parallel to the longitudinal axes 136, 140 thereof. First pressure relief valves 162 are further included at a location opposite the first pistons 146, at an end of the first horizontal passages 160 of the first fluid assemblies 116, and is employed if a predetermined pressure threshold is reached within the first horizontal passages 160.

[0017] Likewise, the second crankshaft 138 includes a plurality of second eccentrically arranged crankpins 164 (or alternatively a plurality of second eccentrically arranged sheaves), and a second connecting rod 166 is connected to each second crankpin 164. The second connecting rods 166 connect the second crankpins 164 to the second pistons 168 via the second crosshead assembly 124. The second connecting rods 166 may be connected to a second crosshead 170 using a second wrist pin 172 that allows the second connecting rods 166 to pivot with respect to the second crosshead 170, which in turn is connected to the second pistons 168. The longitudinal axis 152 of each of the second pistons 168 is perpendicular to the longitudinal axes 136, 140 of the first and second crankshafts 134, 138. When the second crankshaft 138 turns, the second crankpins 164 reciprocate the second connecting rods 166. Moved by the second connecting rods

166, the second crosshead 170 reciprocates inside fixed cylinders. In turn, the second pistons 168 coupled to the second crosshead 170 also reciprocate between suction and power strokes in the second fluid assembly 118. Second input valves 174 are connected to a second inlet 128 and second output valves 176 are connected to a second outlet 32 (FIG. 1). The second fluid assembly 118 includes vertical passages 178 for fluid from each of the second input valves 174 to respective second output valves 176. The second fluid assembly 118 also includes second horizontal passages 180 that are directed along a longitudinal axis 152 of the second pistons 168. The second vertical passages 178 are fluidically connected to the second horizontal passages 180. Withdrawal of a second piston 168 during a suction stroke pulls fluid into the second fluid assembly 118 through a second input valve 174 that is connected to the second inlet 128. Subsequently pushed during a power stroke, a second piston 168 then forces the fluid under pressure out through the second output valve 176 connected to the second outlet 32. Second pressure relief valves 182 are further included at a location opposite the second pistons 168, at an end of the second horizontal passages 180 of the second fluid assemblies 118, and are employed if a predetermined pressure threshold is reached within the second horizontal passages 180.

[0018] Further included within the power assembly is a pinion shaft 184 that is rotatable by the prime mover 12. With further reference to FIG. 3, the pinion shaft 184 has a longitudinal axis 186 that is parallel to the longitudinal axes 136, 140 of the first and second crankshafts 134, 138, and which is interposed between the first and second crankshafts 134, 138. While the longitudinal axes 136, 140 of the pinion shaft 184 and the first and second crankshafts 134, 138 could be coplanar in one exemplary embodiment, in the illustrated embodiment, the longitudinal axis 186 of the pinion shaft 184 is not coplanar with the longitudinal axes 136, 140 of the first and second crankshafts 134, 138 to provide a power assembly 114 that occupies a smaller footprint. The pinion shaft 184 includes at least one pinion gear 188, which engages with at least one first bull gear 190 and at least one second bull gear 192 fixedly positioned on the first and second crankshafts 134, 138, respectively. In one exemplary embodiment, there may be a single first bull gear 190 in a central area of the first crankshaft, aligned for engagement with a single pinion gear 188 in a central area of the pinion shaft 184. In another exemplary embodiment, a first bull gear 190 is positioned adjacent each end of the first crankshaft 134 and are aligned for engagement with a pair of pinion gears 188. The second bull gear(s) 192 can be similarly arranged on the second crankshaft 138. Additional numbers of bull gears 190, 192 and pinion gears 188 are also includable in the power assembly 114. Rotation of the pinion shaft 184 by the prime mover 12 at least substantially simultaneously effectuates rotation of the first and second crankshafts 134, 138, thus substantially simultaneously reciprocating each of the first and second pistons 146, 168 in the first and second fluid assemblies 116, 118.

[0019] While the crankshafts 134, 138 may be identical or substantially identical in structure, the initial position of the crankpins 142, 164 affects the initial stroke position of the pistons 146, 168. In this exemplary embodiment, because two separate crankshafts 134, 138 are employed, opposing first and second pistons 146, 168 can be arranged to occupy any stroke position with respect to one another depending on the initial position of corresponding crankpins 142, 164. For

example, a first piston **146** and a corresponding second piston **168** can both be in the suction stroke at the same time or both be in the power stroke at the same time. This would occur if the crankpins **142** in the first crankshaft **134** were arranged in a mirror image of the crankpins **164** in the second crankshaft **138** prior to rotation. Alternatively, a first piston **146** can be in a suction stroke while a corresponding second piston **168** is in a power stroke. This could occur if the crankpins **142**, **164** are initially arranged in the same corresponding positions prior to rotation.

[0020] Another exemplary embodiment of a reciprocating pump assembly **200** is shown in FIG. 4. A power assembly **214** and first and second crosshead assemblies **222**, **224** are depicted. Although first and second pistons **246**, **268** are also depicted, first and second fluid assemblies are not shown in FIG. 4, but can be substantially the same as the first and second fluid assemblies **16**, **18**, and **116**, **118** shown in FIGS. 1 and 2. Different from the embodiment shown in FIG. 2, only a single crankshaft **234** is employed in the crankshaft housing **220**, and the first and second connecting rods **244**, **266** are connected to the same crankshaft **234**. The prime mover **12** (FIG. 1) is employed to rotate the crankshaft **234**, such as through the use of the pinion shaft **184** as shown in FIGS. 2 and 3. The first connector rod **244** engages a first crosshead **248** via first pin **250**, which holds first connector rod **244** longitudinally relative to first crosshead **248**. First piston **246** extends from first crosshead **248** in a longitudinally opposite direction from crankshaft **234**. The first connector rod **244** and first crosshead **248** convert rotational movement of the crankshaft **234** into linear movement of the first piston **246**. Likewise, the second connector rod **266** engages a second crosshead **270** via second pin **272**, which holds second connector rod **266** longitudinally relative to second crosshead **270**. Second piston **268** extends from second crosshead **270** in a longitudinally opposite direction from crankshaft **234**. The second connector rod **266** and second crosshead **270** convert rotational movement of the crankshaft **234** into linear movement of the second piston **268**. The first and second connector rods **244**, **266** may include telescopic extension portions as necessary.

[0021] FIGS. 5 and 6 show two alternate exemplary embodiments for connecting the first and second connecting rods **244**, **266** to the crankshaft **234**. The crankshaft **234** shown in FIGS. 5 and 6 show eccentrically arranged crankpins **242**, however eccentrically arranged crank sheaves (not shown) might also be employed. The crankshaft **234** may be a direct drive crankshaft in which an end **294**, shown in FIG. 5, extends beyond the crankshaft housing **220** for coupling to drive components, such as a gear box. Alternatively, the crankshaft may be driven by a pinion shaft **184**, pinion gear **188**, and bull gear **190** as previously described. While only one bull gear **190** and pinion gear **188** is shown in FIG. 6, a plurality of bull gears **190** and engaging pinion gears **188** may alternatively be employed. In FIG. 5, the first and second connecting rods **244**, **266** are connected to each other and to each respective crank pin **242** such that the first connecting rod **244** is connected to the same portion of the crankpin **242** as the second connecting rod **266**. In this exemplary embodiment, the first and second connecting rods **244**, **266** are substantially coplanar which enables the pistons **246**, **268** to be symmetrically arranged within the first and second fluid assemblies **116**, **118**. In FIG. 6, the first and second connecting rods **244**, **266** are connected to each respective crank pin **242** such that the first connecting rod **244** is connected to a

longitudinally distinct portion of the respective crank pin **242** from a portion of the respective crank pin **242** that the second connecting rod **266** is connected.

[0022] In another exemplary embodiment, a modular design of the reciprocating pump assembly **10** includes first and second fluid assemblies **16**, **18** that are attachable to the power assembly **14** such that the reciprocating pump **10** can be employed with either just a single fluid assembly **16** or **18** or with two fluid assemblies **16** and **18**, thus providing flexibility to the equipment depending on operational requirements.

[0023] By adding a second fluid end to a power end of a reciprocating pump, the amount of HP that the pump can consume is doubled. The structural improvements to the power end to accommodate the first and second fluid assemblies provides a compact design that enables the transportation of the reciprocating pump on a trailer.

[0024] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

What is claimed:

1. A reciprocating pump assembly comprising:
 - a first fluid assembly;
 - a second fluid assembly; and,
 - a power assembly operable by a prime mover including one of an engine and a motor, the power assembly interposed between and shared by the first fluid assembly and the second fluid assembly, the power assembly including at least one rotatable crankshaft operating the first and second fluid assemblies.
2. The reciprocating pump assembly of claim 1, wherein the at least one crankshaft includes a first crankshaft reciprocating a first piston in the first fluid assembly, and a second crankshaft reciprocating a second piston in the second fluid assembly.
3. The reciprocating pump assembly of claim 2, further comprising a pinion shaft rotating the first and second crankshafts.
4. The reciprocating pump assembly of claim 3, wherein longitudinal axes of the first and second crankshafts and the pinion shaft are parallel.

5. The reciprocating pump assembly of claim 3, wherein the pinion shaft includes a pinion gear engaging with a first bull gear on the first crankshaft and a second bull gear on the second crankshaft.

6. The reciprocating pump assembly of claim 3, wherein the power assembly further includes a crankshaft housing enclosing the pinion shaft and both the first and second crankshafts therein.

7. The reciprocating pump assembly of claim 2, wherein the power assembly includes a crankshaft housing enclosing both the first and second crankshafts therein.

8. The reciprocating pump assembly of claim 2, further comprising a first connecting rod connecting the first crankshaft to the first piston and a second connecting rod connecting the second crankshaft to the second piston.

9. The reciprocating pump assembly of claim 1, wherein the at least one crankshaft includes a single crankshaft reciprocating a first piston in the first fluid assembly and reciprocating a second piston in the second fluid assembly.

10. The reciprocating pump assembly of claim 9, further comprising a first connecting rod connecting the single crankshaft to the first piston and a second connecting rod connecting the single crankshaft to the second piston.

11. The reciprocating pump assembly of claim 10, wherein the single crankshaft includes a plurality of eccentrically arranged portions, and the first and second connecting rods are respectively connected to a same portion of the single crankshaft for simultaneously engaging the first and second pistons.

12. The reciprocating pump assembly of claim 1, wherein rotational movement of the at least one crankshaft is converted to linear motion of a first piston in the first fluid assembly, and substantially simultaneously converted to linear motion of a second piston in the second fluid assembly, wherein the linear motion of the first and second pistons is substantially perpendicular to a longitudinal axis of the at least one crankshaft.

13. The reciprocating pump assembly of claim 1, wherein each of the first and second fluid assemblies includes a fluid

inlet receiving fluid at a first pressure and a fluid outlet dispensing fluid at a second pressure greater than the first pressure.

14. The reciprocating pump assembly of claim 1, further comprising a first crosshead assembly interposed between the first fluid assembly and the power assembly, and a second crosshead assembly interposed between the second fluid assembly and the power assembly.

15. The reciprocating pump assembly of claim 1 wherein the first and second fluid assemblies include first and second pistons, and a longitudinal axis of the at least one crankshaft is perpendicular to a longitudinal axis of the first and second pistons.

16. The reciprocating pump assembly of claim 1, wherein the crankshaft is a direct drive crankshaft and an end of the crankshaft extends beyond a crankshaft housing.

17. The reciprocating pump assembly of claim 1, wherein a plurality of input and output valve pairs of the first and second fluid assemblies are arranged in a direction extending substantially parallel to at least one longitudinal axis of the at least one crankshaft assembly.

18. A method of pumping fluid for a downhole operation using the reciprocating pump assembly of claim 1, the method comprising:

employing a prime mover to rotate the at least one crankshaft;

moving a first piston in the first fluid assembly via the at least one crankshaft; and,

substantially simultaneously moving a second piston in the second fluid assembly via the at least one crankshaft.

19. The method of claim 18, further comprising directing fluid at a first pressure into first and second inlets of the first and second fluid assemblies, wherein moving the first and second pistons pressurizes the fluid to a second pressure greater than the first pressure.

20. The method of claim 18, wherein employing a prime mover includes connecting a prime mover to the reciprocating pump assembly, the prime mover having a greater horsepower than a prime mover connected to a reciprocating pump assembly having only a first fluid assembly.

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