US 20150275891A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2015/0275891 A1**

(43) **Pub. Date: Oct. 1, 2015**

Chong

(54) **INTEGRATED MOTOR AND PUMP ASSEMBLY**

(71) Applicant: **Schlumberger Technology Corporation**, Sugar Land, TX (US)

(72) Inventor: **Jonathan Wun Shiung Chong**, Sugar Land, TX (US)

(21) Appl. No.: **14/670,448**

(22) Filed: **Mar. 27, 2015**

Related U.S. Application Data

(60) Provisional application No. 61/973,065, filed on Mar. 31, 2014.

Publication Classification

(51) **Int. Cl.**

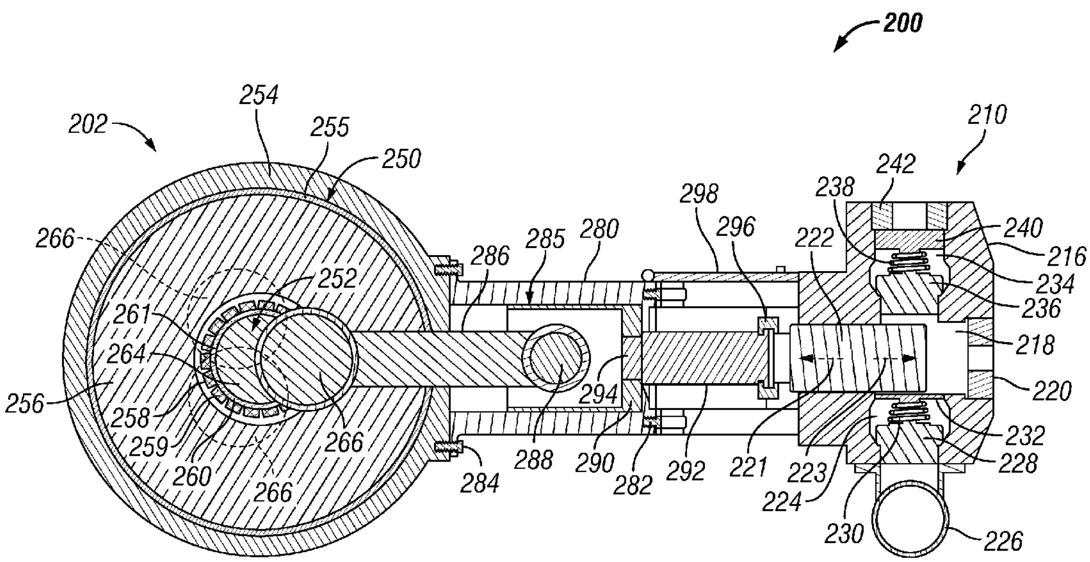
F04B 53/00 (2006.01)
F04B 53/14 (2006.01)
F04B 17/03 (2006.01)
F04B 1/12 (2006.01)
F04B 1/14 (2006.01)

(52) **U.S. Cl.**

CPC ***F04B 53/006*** (2013.01); ***F04B 1/128*** (2013.01); ***F04B 1/148*** (2013.01); ***F04B 17/03*** (2013.01); ***F04B 53/144*** (2013.01)

(57) **ABSTRACT**

A pump assembly that includes a crankshaft having main journals and crankpin journals, rods operatively coupled with the crankpin journals, reciprocating members operatively coupled with the rods, and an electric motor operable to rotate the crankshaft. The electric motor includes a stator and a rotor. The rotor is directly connected with the crankshaft and is operable to rotate the crankshaft to move the plurality of rods and reciprocating members to move a fluid.



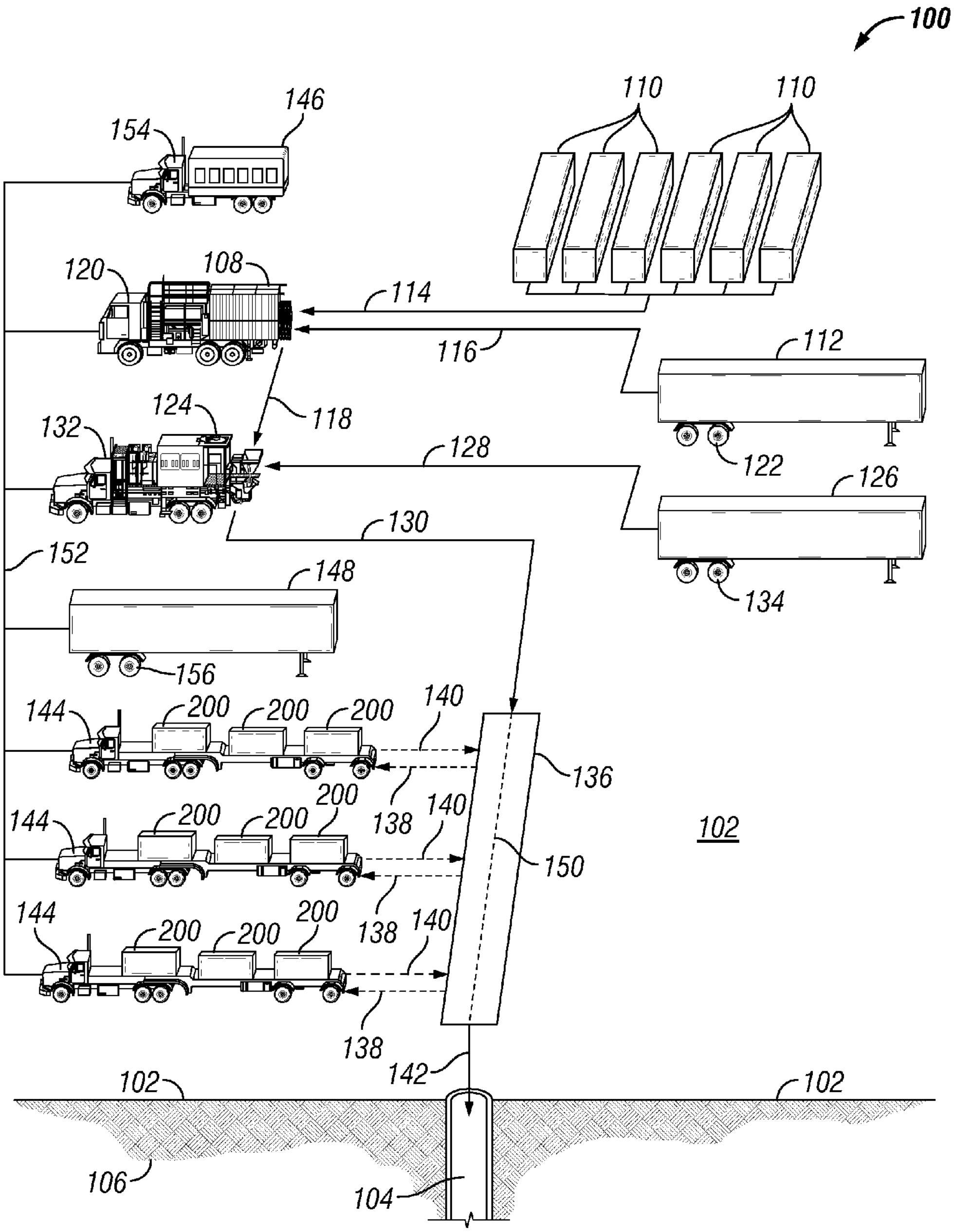

100
110
110
146
154
120
108
114
116
112
122
132
124
118
128
126
134
130
152
148
156
144
200
200
200
140
136
138
144
200
200
200
140
150
102
138
144
200
200
200
140
138
142
102
102
106
104

FIG. 1

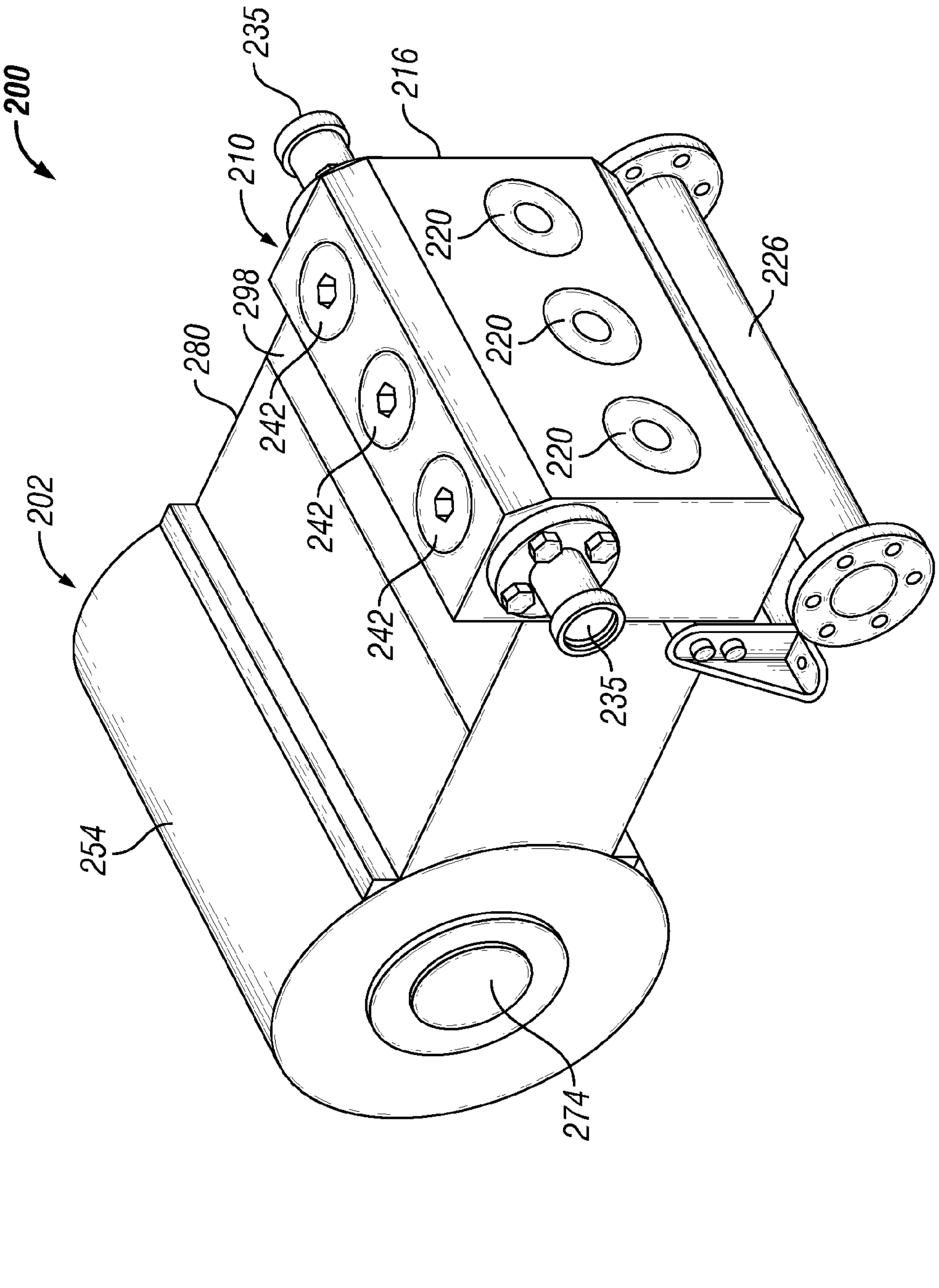

200
202
210
216
220
220
220
226
235
235
242
242
242
242
254
274
280
298

FIG. 2

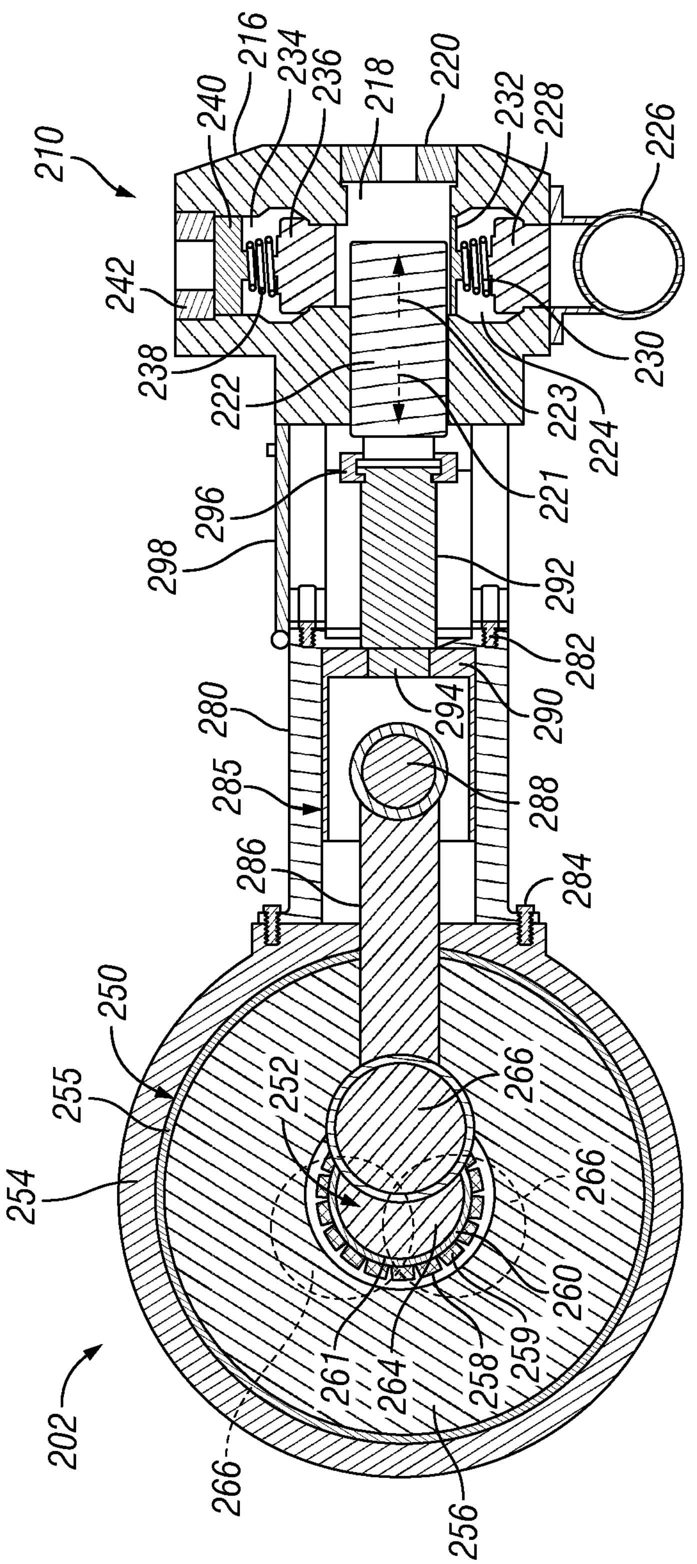

200
210
216
234
236
218
220
232
228
226
240
242
238
222
223
224
221
230
296
298
292
282
280
294
290
285
288
286
284
250
255
254
252
266
261
264
258
259
260
202
256

FIG. 3

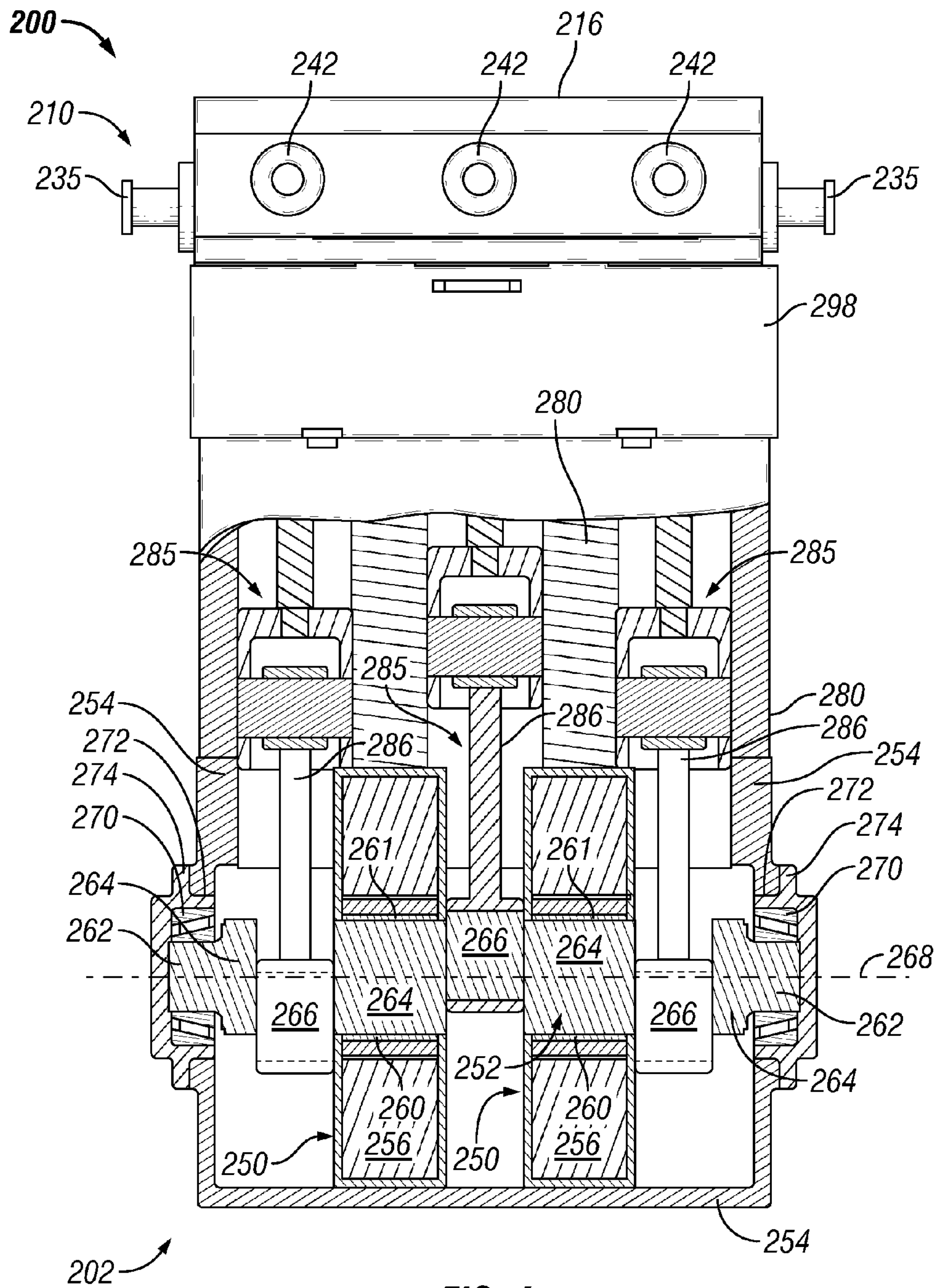

200
210
216
242
242
242
235
235
298
280
285
285
285
286
286
286
280
254
254
272
272
274
274
270
270
264
264
262
262
268
261
261
266
266
266
264
264
252
260
260
256
256
250
250
254
202

FIG. 4

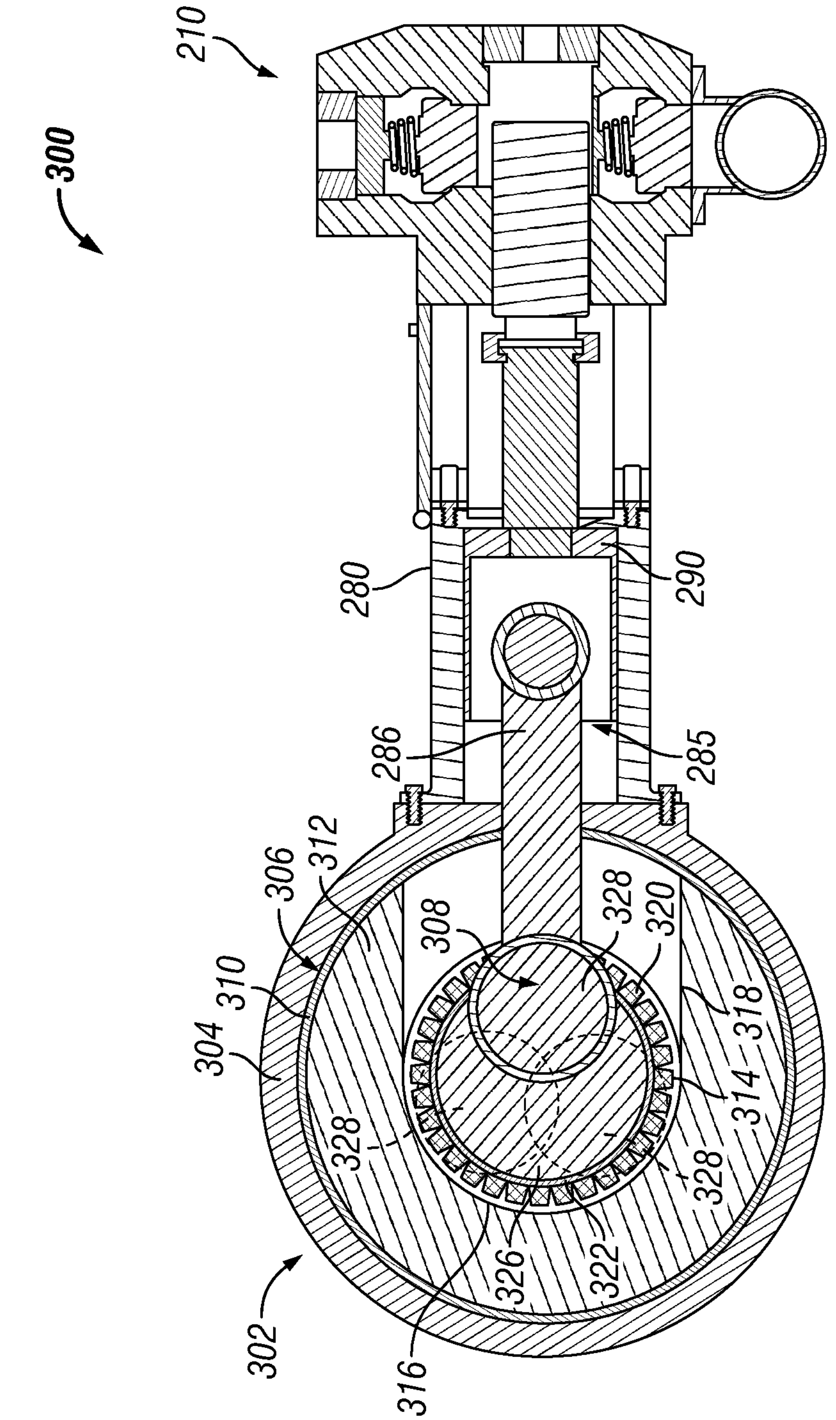

210
300
280
290
286
285
302
304
306
308
310
312
314
316
318
320
322
326
328
328
328
328

FIG. 5

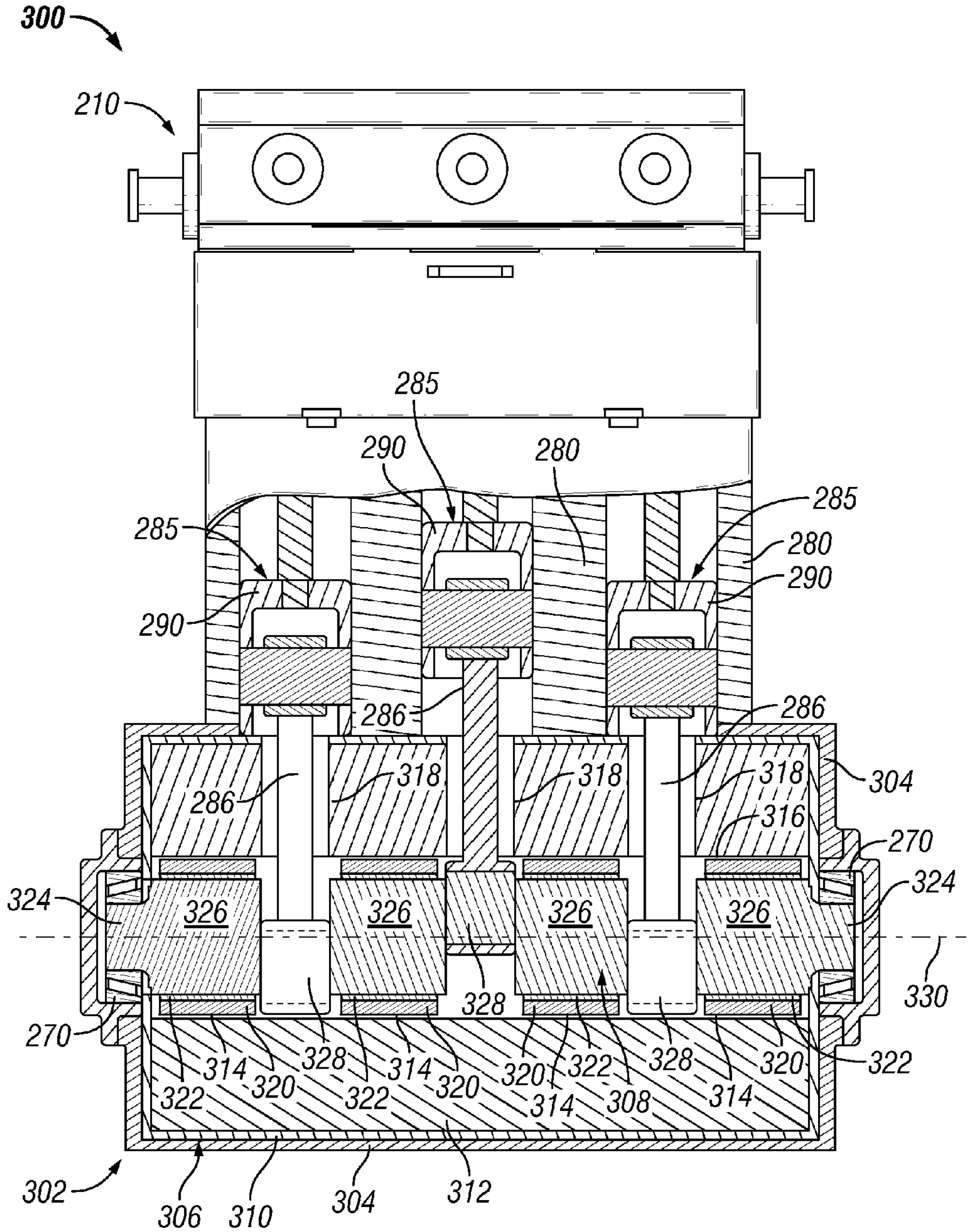

300
210
285
290
280
285
285
280
290
290
286
286
286
318
318
318
304
316
270
324
324
326
326
326
326
328
330
270
328
328
328
314
320
322
322
314
320
322
320
322
314
308
314
320
322
302
306
310
304
312

FIG. 6

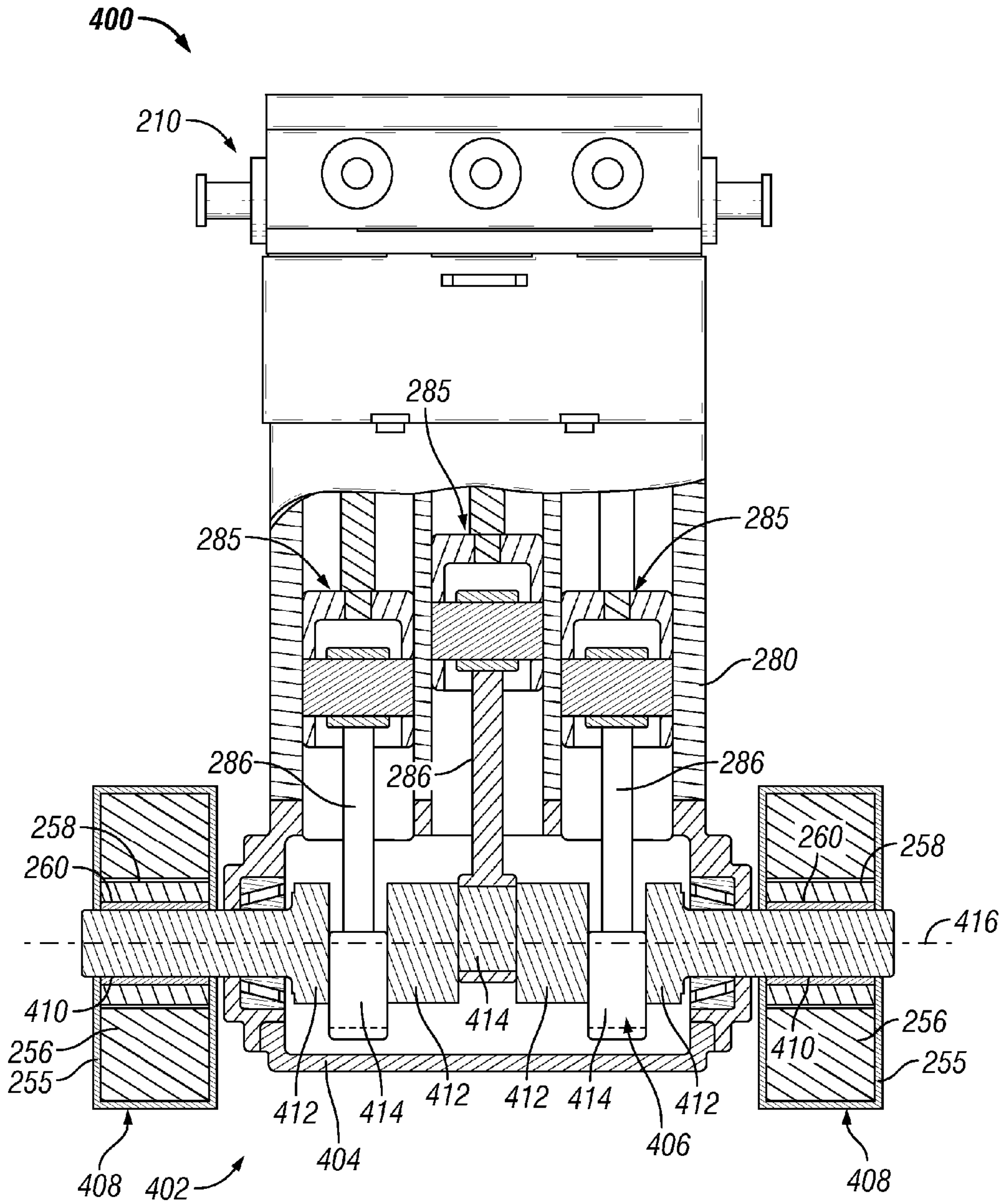

400
210
285
285
285
280
286
286
286
258
260
260
258
416
410
256
255
410
256
255
412
414
412
412
414
412
414
406
404
408
402
408

FIG. 7

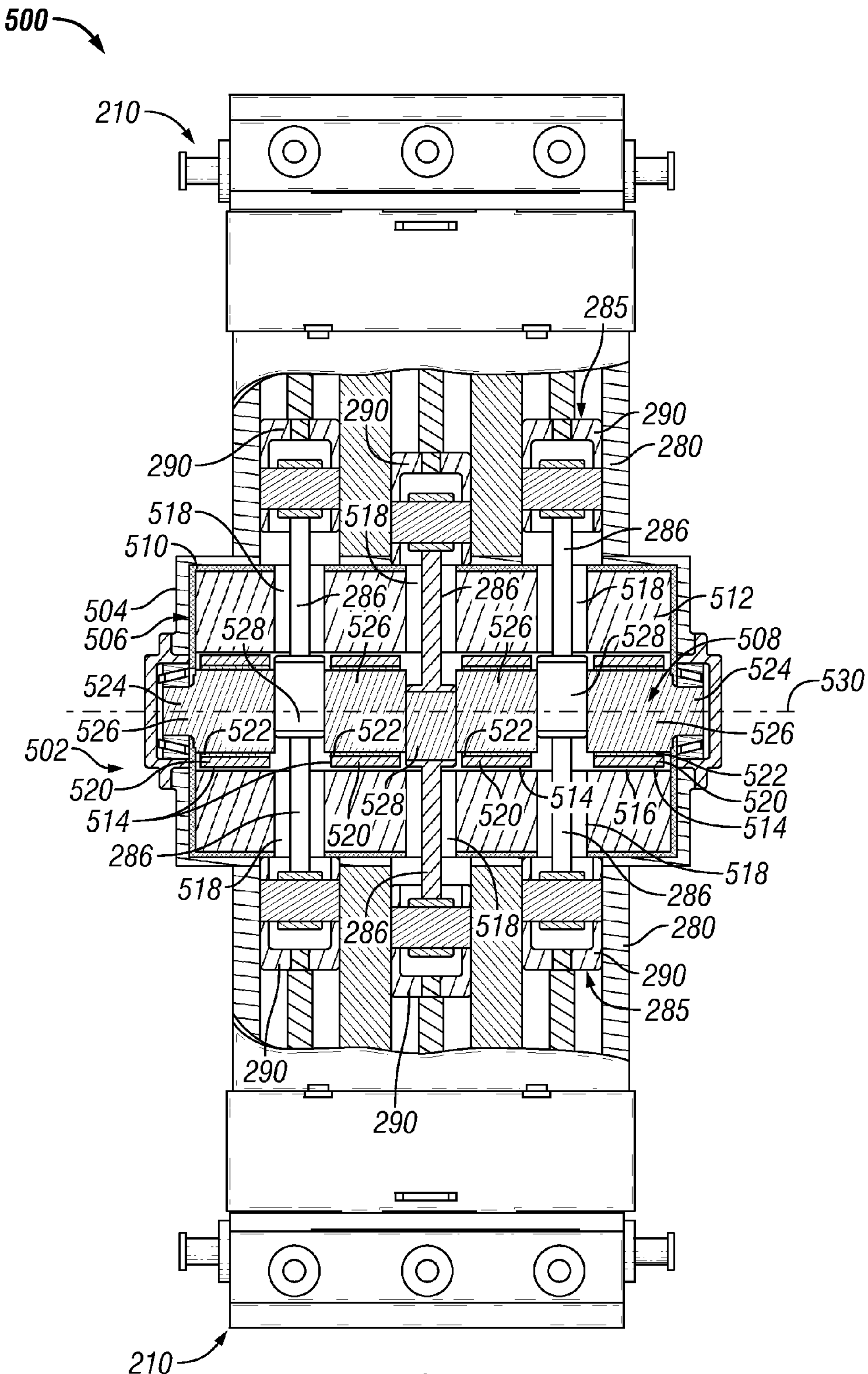

500
210
285
290
290
290
280
518
518
286
510
286
286
518
512
504
506
528
526
526
528
508
524
524
530
526
522
522
522
526
502
522
520
528
514
520
514
516
520
514
286
520
518
518
286
286
518
280
290
285
290
290
210

FIG. 8

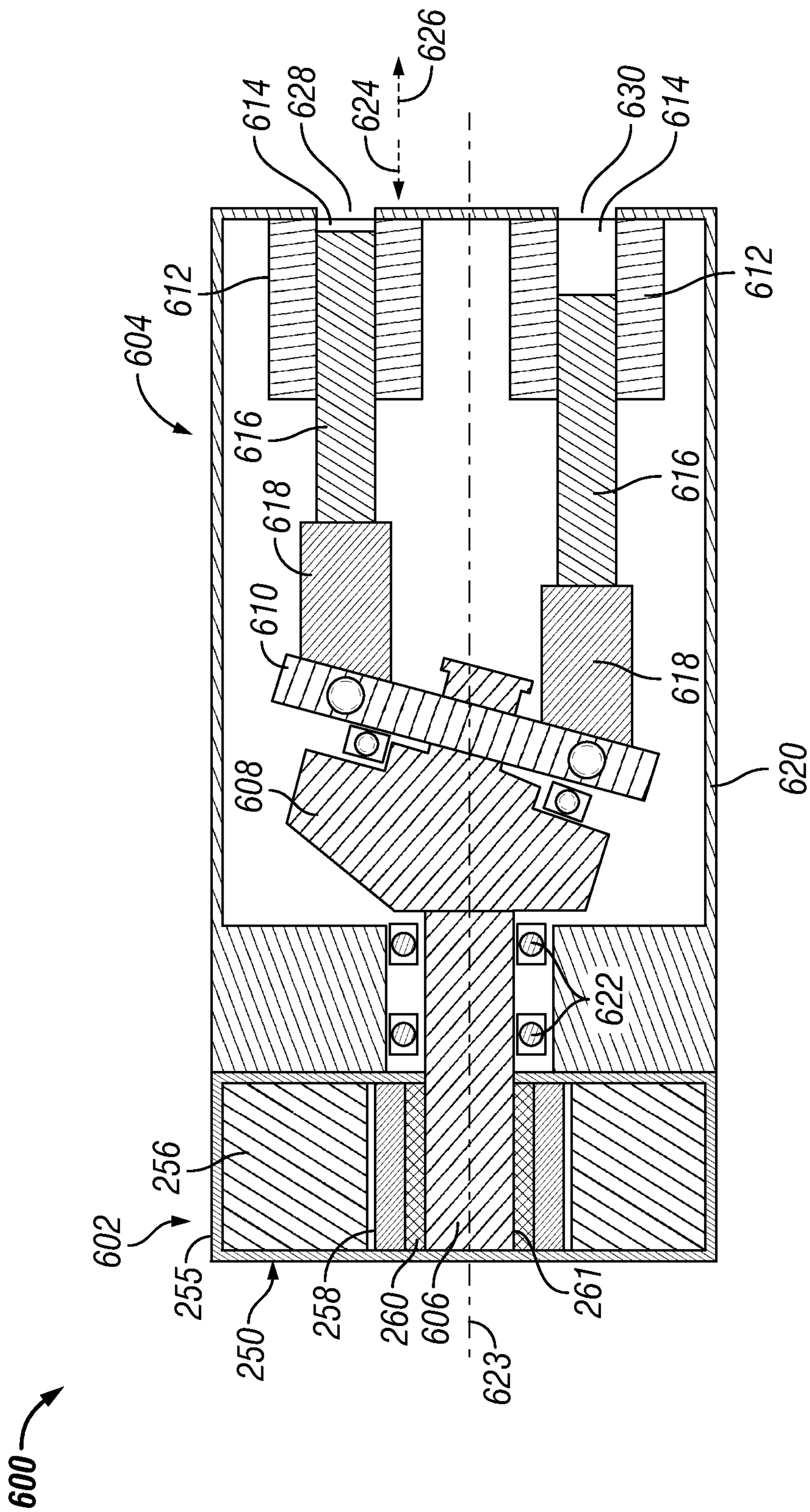

626
614
628
624
630
614
612
612
604
616
616
618
610
618
608
620
622
256
602
255
250
258
260
606
623
261
600

FIG. 9

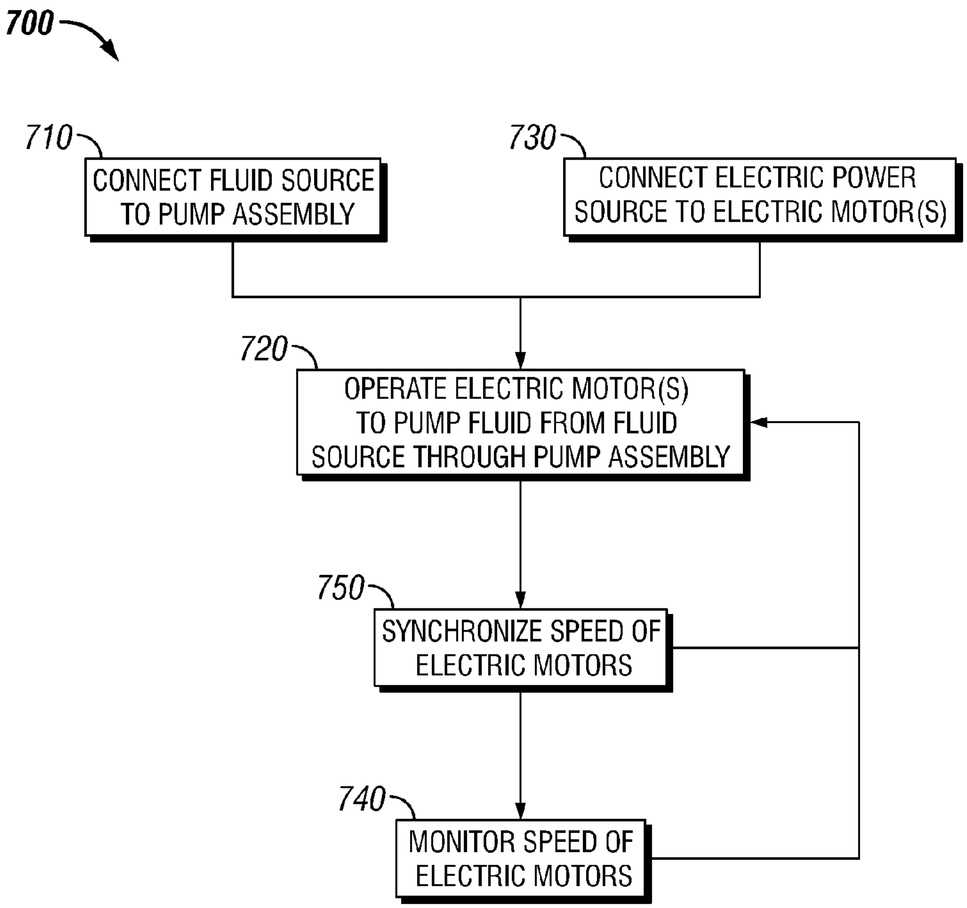

700
710
CONNECT FLUID SOURCE TO PUMP ASSEMBLY
730
CONNECT ELECTRIC POWER SOURCE TO ELECTRIC MOTOR(S)
720
OPERATE ELECTRIC MOTOR(S) TO PUMP FLUID FROM FLUID SOURCE THROUGH PUMP ASSEMBLY
750
SYNCHRONIZE SPEED OF ELECTRIC MOTORS
740
MONITOR SPEED OF ELECTRIC MOTORS

FIG. 10

INTEGRATED MOTOR AND PUMP ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Provisional Application No. 61/973,065 entitled "Integrated Electric Motor Power-end for Reciprocating Pumps," filed Mar. 31, 2014, the entire disclosure of which is hereby incorporated herein by reference.

Background of the Disclosure

[0002] In oilfield operations, reciprocating pumps are utilized at wellsites for large scale, high-pressure operations. Such operations may include drilling, cementing, acidizing, water jet cutting, and hydraulic fracturing of subterranean formations. In some applications, several pumps may be connected in parallel to a single manifold, flow line, or well. Some reciprocating pumps include reciprocating members driven by a crankshaft toward and away from a fluid chamber to alternatingly draw in, pressurize, and expel fluid from the fluid chamber. Hydraulic fracturing of a subterranean formation, for example, may utilize fluid at a pressure exceeding 10,000 PSI.

[0003] The success of pumping operations can be affected by many factors of the pumps, including physical size, weight, energy efficiency, and ability to collectively control individual pumps operating at the wellsite. Reciprocating pumps may have a large physical size and weight to satisfy intended fluid flow rates during oilfield operations. Accordingly, one or more pumps may be mounted on a truck or a skid for transportation to the wellsite. However, due to their size and/or weight, a limited number of pumps may be mounted on a single truck or skid. The pumps may also include a diesel engine or an asynchronous AC electric motor as part of a power section of the pump driving a fluid section of the pump. However, diesel engines and some asynchronous AC electric motors operate at high speeds, such as 1500 to 2000 revolutions per minute (RPM), and the fluid section of the pump operates at low speeds, such as 300 to 400 RPM, a gear box, chain case, or other transmission is included in the power section to operatively couple the engine/motor with the crankshaft. This also increases the size, weight, and cost of the pump(s). Moreover, each engine is individually fueled and controlled, which limits flexibility and control over a collective pumping system when multiple pumps are being operated simultaneously.

SUMMARY OF THE DISCLOSURE

[0004] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify indispensable features of the claimed subject matter, nor is it intended for use as an aid in limiting the scope of the claimed subject matter.

[0005] The present disclosure introduces an apparatus that includes a pump assembly. The pump assembly includes a drive shaft, rods operatively coupled with the drive shaft, reciprocating members each operatively coupled with a corresponding one of the rods, and an electric motor operable to rotate the drive shaft. The electric motor includes a rotor having a rotor shaft. The rotor shaft is connected with the drive shaft and is operable to rotate the drive shaft and thus move the rods and reciprocating members. The rotor shaft and the drive shaft rotate at the same speed. The reciprocating members are operable to move a fluid.

[0006] The present disclosure also introduces an apparatus that includes a pump assembly having a crankshaft. The crankshaft includes main journals and crankpin journals. The pump assembly also includes rods each operatively coupled with a corresponding one of the crankpin journals, reciprocating members each operatively coupled with a corresponding one of the rods, and an electric motor operable to rotate the crankshaft. The electric motor includes a stator and a rotor. The rotor is directly connected with the crankshaft and is operable to rotate the crankshaft and thus move the rods, thereby causing the plurality of reciprocating members to move a fluid.

[0007] The present disclosure also introduces a method that includes connecting a fluid source to a pump assembly. The pump assembly includes a drive shaft, rods operatively coupled with the drive shaft, reciprocating members operatively coupled with the rods, and an electric motor that includes a stator and a rotor that is directly connected with the drive shaft. The method also includes operating the electric motor to rotate the rotor and the drive shaft at the same speed such that the rotating drive shaft moves the rods and reciprocating members to pump the fluid from the fluid source through the pump assembly.

[0008] These and additional aspects of the present disclosure are set forth in the description that follows, and/or may be learned by a person having ordinary skill in the art by reading the materials herein and/or practicing the principles described herein. At least some aspects of the present disclosure may be achieved via means recited in the attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present disclosure is understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[0010] FIG. **1** is a schematic view of at least a portion of apparatus according to one or more aspects of the present disclosure.

[0011] FIG. **2** is a perspective view of a portion of an example implementation of the apparatus shown in FIG. **1** according to one or more aspects of the present disclosure.

[0012] FIG. **3** is a side sectional view of a portion of an example implementation of the apparatus shown in FIG. **1** according to one or more aspects of the present disclosure.

[0013] FIG. **4** is a top partial sectional view of a portion of an example implementation of the apparatus shown in FIG. **3** according to one or more aspects of the present disclosure.

[0014] FIG. **5** is a side sectional view of a portion of an example implementation of the apparatus shown in FIG. **1** according to one or more aspects of the present disclosure.

[0015] FIG. **6** is a top partial sectional view of a portion of an example implementation of the apparatus shown in FIG. **5** according to one or more aspects of the present disclosure.

[0016] FIG. **7** is a top partial sectional view of a portion of an example implementation of the apparatus shown in FIG. **1** according to one or more aspects of the present disclosure.

[0017] FIG. **8** is a top partial sectional view of a portion of an example implementation of the apparatus shown in FIG. **1** according to one or more aspects of the present disclosure.

[0018] FIG. **9** is a schematic view of a portion of an example implementation of the apparatus shown in FIG. **1** according to one or more aspects of the present disclosure.

[0019] FIG. **10** is a flow-chart diagram of at least a portion of a method according to one or more aspects of the present disclosure.

DETAILED DESCRIPTION

[0020] It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for simplicity and clarity, and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact.

[0021] FIG. **1** is a schematic view of at least a portion of an example pumping system **100** according to one or more aspects of the present disclosure. The figure depicts a wellsite surface **102** adjacent to a wellbore **104** and a partial sectional view of a subterranean formation **106** penetrated by the wellbore **104** below the wellsite surface **102**. The pumping system **100** may comprise a first mixer **108** fluidly connected with one or more tanks **110** and a first container **112**. The first container **112** may contain a first material and the tanks **110** may contain a liquid. The first material may be or comprise a hydratable material or gelling agent, such as guar, a polymer, a synthetic polymer, a galactomannan, a polysaccharide, a cellulose, and/or a clay, among other examples, and the liquid may be or comprise an aqueous fluid, which may comprise water or an aqueous solution comprising water, among other examples. The first mixer **108** may be operable to receive the first material and the liquid, as indicated by arrows **114**, **116**, and mix or otherwise combine the first material and the liquid to form a base fluid. The base fluid may be or comprise that which is known in the art as a gel. The first mixer **108** may then discharge the base fluid, as indicated by arrow **118**.

[0022] The first mixer **108** and the first container **112** may each be disposed on corresponding trucks, trailers, and/or other mobile carriers **120**, **122**, respectively, such as may permit their transportation to the wellsite surface **102**. However, the first mixer **108** and/or the first container **112** may be skidded or otherwise stationary, and/or may be temporarily or permanently installed at the wellsite surface **102**.

[0023] The pumping system **100** may further comprise a second mixer **124** fluidly connected with the first mixer **108** and a second container **126**. The second container **126** may contain a second material that may be substantially different than the first material. For example, the second material may be or comprise a proppant material, such as may comprise sand, sand-like particles, silica, quartz, and/or propping agents, among other examples.

[0024] The second mixer **124** may be operable to receive the base fluid from the first mixer **108**, as indicated by arrow **118**, and the second material from the second container **126**, as indicated by arrow **128**, and mix or otherwise combine the base fluid and the second material to form a mixture. The mixture may be or comprise that which is known in the art as a fracturing fluid. The second mixer **124** may then discharge the mixture, as indicated by arrow **130**.

[0025] The second mixer **124** and the second container **126** may each be disposed on corresponding trucks, trailers, and/or other mobile carriers **132**, **134**, respectively, such as may permit their transportation to the wellsite surface **102**. However, the second mixer **124** and/or the second container **126** may be skidded or otherwise stationary, and/or may be temporarily or permanently installed at the wellsite surface **102**.

[0026] The mixture may be communicated from the second mixer **124** to a common manifold **136**, as indicated by arrow **130**. The manifold **136** may comprise a plurality of valves, diverters, and/or other fluid pathways **150** operable to direct the mixture in a predetermined and/or selective manner. The manifold **136**, which may be known in the art as a missile or a missile trailer, may distribute the mixture to one or more pump assemblies **200**. Each pump assembly **200** may receive the mixture from the manifold **136** or another conduit, as indicated by arrows **138**, and discharge the mixture to the manifold **136** or another conduit, as indicated by arrows **140**. The mixture may then be discharged from the manifold **136** into the wellbore **104**, as indicated by arrow **142**, perhaps through various valves, conduits, and/or other hydraulic circuitry fluidly connected between the manifold **136** and the wellbore **104**.

[0027] The pump assemblies **200** may each be mounted on corresponding trucks, trailers, and/or other mobile carriers **144**, such as may permit their transportation to the wellsite surface **102**. However, the pump assemblies **200** may be skidded or otherwise stationary, and/or may be temporarily or permanently installed at the wellsite surface **102**. Although each mobile carrier **144** is shown carrying three pump assemblies **200**, other quantities of pump assemblies **200** are within the scope of the present disclosure. For example, each mobile carrier **144** may carry one, two, four, or more pump assemblies **200**.

[0028] The pumping system **100** may also comprise a control center **146** and a source of electric power **148**, such as may be collectively utilized as a centralized power distribution system operable to control and/or provide electric power to one or more portions of the pumping system **100**. The source of electric power **148** may be or comprise an engine-generator set, such as a gas turbine generator, an internal combustion engine generator, or other sources of electrical power known in the art. Electric power and/or control signals may be communicated between the control center **146**, the source of electric power **148**, and other wellsite equipment via electrical conductors **152** extending therebetween. However, other means of communication, such as wireless communication, is also within the scope of the present disclosure.

[0029] The control center **146** may be utilized to control at least a portion of the pumping system **100** during pumping operations, including the mixers **108**, **124** and the pump assemblies **200**. For example, the control center **146** may be operable to control the production rate of the mixture, such as by increasing or decreasing the flow of the liquid from the tanks **110**, the first material from the first container **112**, the base fluid from the first mixer **108**, the second material from the second container **126**, and/or the mixture from the second mixer **124**. The control center **146** may also be operable to control the speed of individual electrical motors **250**, shown in FIGS. **3**-**9**, such as may be operable to control the speed of the pump assemblies **200** and, therefore, the output flow rate of each pump assembly **200**. The control center **146** may comprise one or more variable speed drives (VSD) (not shown), which may facilitate speed control of the electric motors **250**. In other implementations of the pumping system **100**, the one or more VSDs may be disposed adjacent to or in association with each pump assembly **200** or a fleet of pump assemblies **200**. The control center **146** may also be operable to control the output pressure of the mixture or other fluid discharged from each of the pump assemblies **200**.

[0030] Furthermore, the control center **146** may be operable to pair the valves of the manifold **136** with the pump assemblies **200** to create an interlock between the pump assemblies **200** and the manifold **136**. The control center **146** may also be operable to fluidly connect and disconnect predetermined pump assemblies **200** from the internal fluid pathways **150** through the manifold **136**. The control center **146** may also be operable to control power distribution between the source of electric power **148** and the first mixer **108**, the second mixer **124**, the pump assemblies **200**, and other pumps and/or conveyers (not shown).

[0031] The control center **146** and the source of electric power **148** may be disposed on a corresponding truck, trailer, and/or other mobile carrier **154**, **156**, such as may permit its transportation to the wellsite surface **102**. However, the control center **146** and the source of electric power **148** may be skidded or otherwise stationary, and/or may be temporarily or permanently installed at the wellsite surface **102**.

[0032] FIG. **2** is a perspective view of an example implementation of the pump assembly **200** shown in FIG. **1** according to one or more aspects of the present disclosure. FIG. **3** is a side sectional view of a portion of the pump assembly **200** shown in FIG. **2**. The following description refers to FIGS. **2** and **3**, collectively.

[0033] The pump assembly **200** may be or comprise a reciprocating pump assembly having a power section **202** and a fluid section **210**. The fluid section **210** may comprise a pump housing **216** having a plurality of fluid chambers **218** extending therethrough in a substantially parallel configuration. One end of each fluid chamber **218** may be plugged by a cover plate **220**, which may be threadedly engaged with the pump housing **216**. The opposite end of each chamber **218** may contain a reciprocating member **222** slidably disposed therein. Although the reciprocating member **222** is depicted as a plunger, the reciprocating member **222** may be implemented as a piston, diaphragm, or another reciprocating member.

[0034] Each fluid chamber **218** may be fluidly connected with a corresponding fluid inlet cavity **224** adapted for communicating the fluid into each fluid chamber **218** from a fluid inlet conduit **226**. Each fluid inlet cavity **224** may contain an inlet valve **228**, which may be operable to control the flow of fluid from the fluid inlet conduit **226** to the fluid chamber **218**. Each inlet valve **228** may be biased toward a closed position by a first spring **230**, which may be held in place by an inlet valve stop **232**. Each inlet valve **228** may be actuated to an open position by a selected or predetermined differential pressure between the fluid inlet cavity **224** and the fluid inlet conduit **226**. The fluid inlet conduit **226** may be fluidly connected with a low pressure fluid outlet (not shown) of the manifold **136** or another fluid conduit for supplying the mixture or another fluid to be pumped by the pump assembly **200**.

[0035] Each fluid chamber **218** may also be fluidly connected with a fluid outlet cavity **234** extending through the pump housing **216**, such as may be adapted for communicating pressurized fluid from each fluid chamber **218** into one or more fluid outlet conduits **235**. The fluid outlet cavity **234** may contain therein a plurality of outlet valves **236**, which may be operable to control fluid flow out of the fluid chambers **218** into the fluid outlet cavity **234**. The outlet valves **236** may be biased toward a closed position by a second spring **238**, which may be held in place by an outlet valve stop **240**. The outlet valve **236** may be actuated to an open position by a predetermined differential pressure between the fluid chamber **218** and the fluid outlet cavity **234**. The fluid outlet cavity **234** may be plugged by a plurality of second cover plates **242**, which may be threadedly engaged with the pump housing **216**, while one or both ends of the fluid outlet cavity **234** may be fluidly coupled with the one or more fluid outlet conduits **235**. The fluid outlet conduits **235** may be fluidly connected to a high-pressure inlet (not shown) of the manifold **136** or another destination for the pressurized mixture or fluid.

[0036] During pumping operations, portions of the power section **202** of the pump assembly **200** may rotate to generate a reciprocating linear force, such as may move the reciprocating members **222** longitudinally within the corresponding fluid chambers **218**. With regard to each reciprocating member **222**, as the reciprocating member **222** moves out of the fluid chamber **218**, as indicated by arrow **221**, the pressure of the fluid inside the fluid chamber **218** decreases, thus creating a differential pressure across the fluid inlet valve **228**, which actuates the fluid inlet valve **228** to permit the mixture or other fluid from the fluid inlet conduit **226** to enter the fluid inlet cavity **224** and the fluid chamber **218**. The fluid then enters the fluid chamber **218** as the reciprocating member **222** continues to move longitudinally out of the fluid chamber **218** until the pressure difference between the fluid inside the fluid chamber **218** and the fluid within the fluid inlet conduit **226** is low enough, thus permitting the first spring **230** to actuate the fluid inlet valve **228** to the closed position. As the reciprocating member **222** begins to move longitudinally back into the fluid chamber **218**, as indicated by arrow **223**, the pressure of the fluid inside of fluid chamber **218** begins to increase. The fluid pressure inside the fluid chamber **218** continues to increase as the reciprocating member **222** continues to move into the fluid chamber **218** until the pressure difference between the fluid inside the fluid chamber **218** and the fluid inside the fluid outlet cavity **234** is high enough to compress the second spring **238**, thus actuating the fluid outlet valve **236** to the open position and permitting the pressurized fluid to move into the fluid outlet cavity **234** and the fluid outlet conduit **235**. Thereafter, the fluid may be communicated to the manifold **136**, as depicted in FIG. **1**, or to another destination for pressurized mixture or fluid.

[0037] The fluid flow rate generated by the pump assembly **200** may depend on the physical size of the reciprocating members **222** and fluid chambers **218**, as well as the speed or rate at which the reciprocating members **222** move within the fluid chambers **218**. The speed or rate at which the reciprocating members **222** move is directly related to the rotational speed of the power section **202**, such that the fluid flow rate may be controlled by the rotational speed of the power section **202**.

[0038] The power section **202** of the pump assembly **200** may also comprise a power section housing **254** enclosing an electric motor **250**, which may be disposed about a drive shaft **252**. The electric motor **250** is operable to drive or otherwise rotate the drive shaft **252**. The electric motor **250** may comprise a motor housing **255** enclosing a stator **256** and a rotor **258**. The stator **256** may be or comprise a plurality of field coils or windings, such as may generate a magnetic field when powered by electric current from the source of electric power **148** or another source of electric power. The stator **256** may define an axial opening containing the rotor **258** and through which the drive shaft **252** extends. The rotor **258** may comprise a plurality of windings or permanent magnets **259** fixedly disposed about a rotor shaft **260**. The rotor shaft **260** may be a hollow shaft or comprise an axial bore **261** through which the drive shaft **252** extends. The rotor shaft **260** or another portion of the rotor **258** may be directly and/or otherwise fixedly coupled with the drive shaft **252**, such that the rotor shaft **260** may transmit torque from the rotor **258** directly to the drive shaft **252**. Thus, because the rotor shaft **260** and the drive shaft **252** are directly and/or otherwise fixedly coupled, the rotor shaft **260** and the drive shaft **252** may rotate at the same speed or rate. The electric motors **250** utilized within the scope of the present disclosure may include, for example, synchronous and asynchronous electric motors, such as may be operable to rotate at selected speeds between zero and about 500 RPM, although other speeds are also within the scope of the present disclosure. For example, the electric motors **250** may rotate at speeds between about 300 RPM and about 400 RPM.

[0039] The directly and/or otherwise fixedly coupled relationship between the rotor shaft **260** and the drive shaft **252** may be interpreted to include an implementation of the pump assembly **200** in which the rotor shaft **260** and the drive shaft **252** are in direct contact with each other, thus preventing relative rotation between the rotor shaft **260** and the drive shaft **252** such that the rotor shaft **260** and the drive shaft **252** rotate at the same speed or rate. The directly and/or otherwise fixedly coupled relationship between the rotor shaft **260** and the drive shaft **252** may also be interpreted to include an implementation of the pump assembly **200** in which the rotor shaft **260** and the drive shaft **252** are not in direct contact, but are connected by one or more rigid intervening members collectively fixedly connecting the rotor shaft **260** and the drive shaft **252** together, such as a ring (not shown), in a manner preventing relative rotation between the rotor shaft **260** and the drive shaft **252** such that the rotor shaft **260** and the drive shaft **252** rotate at the same speed or rate. However, the directly and/or otherwise fixedly coupled relationship between the rotor shaft **260** and the drive shaft **252** is not intended to be interpreted to include implementations in which rotation of the drive shaft **252** is facilitated by a transmission, gearbox, gear train, or other similar mechanism operatively connecting the rotor shaft **260** and the drive shaft **252**.

[0040] FIG. **4** is a top partial sectional view of a portion of an example implementation of the pump assembly **200** shown in FIG. **3** according to one or more aspects of the present disclosure. Referring to FIGS. **3** and **4**, collectively, the drive shaft **252** may be implemented as a crankshaft comprising a plurality of support journals **262**, main journals **264**, and crankpin journals **266**. The support and main journals **262**, **264** may extend along a central axis of rotation **268** of the drive shaft **252**, while the crankpin journals **266** may be offset from the central axis of rotation **268** by a predetermined distance and spaced 120 degrees apart with respect to the support journals **262** and main journals **264**.

[0041] FIG. **4** shows an example implementation of the pump assembly **200** comprising two electric motors **250** disposed about the drive shaft **252**. As shown, the rotor shaft **260** of each motor **250** may be disposed about and directly and/or otherwise fixedly connected with two of the main journals **264**, such as may facilitate transfer of torque from the motors **250** directly to the drive shaft **252** to rotate the drive shaft **252** when the motors are powered. To prevent relative rotation between the power section housing **254** and the motors **250**, the power section housing **254** and motor housing **255** may be fixedly coupled together. Although the example implementation of the pump assembly **200** shown in FIG. **4** comprises two electric motors **250**, it is to be understood that other quantities of electric motors **250** may be incorporated as part of the pump assembly **200**. For example, a drive shaft **252** comprising six main journals **264** may comprise one, two, three, four, or more electric motors **250**, which are connected with and/or distributed between the six main journals **264**.

[0042] When two or more separate electric motors **250** are utilized to rotate the drive shaft **252**, the electrical motors **250** may need to be synchronized to run at the same speed by synchronizing the VSDs, such as during ramp up, ramp down, and steady speed motor conditions. Torque limits may also be set on the VSDs to limit and/or prevent twisting or deformation of the drive shaft **252**, such as when the electric motors **250** are not synchronized.

[0043] The drive shaft **252** and the rotor shaft **260** may be directly and/or otherwise fixedly coupled by corresponding threads, set screws, retaining rings, interlocking splines, interlocking keys, interference/press fit, adhesives, and/or other means operable to lock the drive shaft **252** and the rotor shaft **260** together and/or prevent their relative rotation. However, in other implementations of the pump assembly **200**, the drive shaft **252** and the rotor shaft **260** may instead be integrally formed as a single discrete member operable to move as a single unit. For the electric motors **250** to be mounted about the main journals **264**, each motor **250** may comprise a width (i.e., length along the central axis **268**) that may permit mounting between adjacent crankpin journals **266**. However, one or more of the main journals **264** may comprise a width that may permit mounting of a wider electric motor **250** between the adjacent crankpin journals **266**.

[0044] In still other implementations of the pump assembly **200**, the drive shaft **252** may comprise a plurality of discrete and/or otherwise separable portions adapted to be interconnected. For example, the main journals **264** and the crankpin journals **266** may comprise discrete and/or separable members, which may be coupled together to form the drive shaft **252**. These separable main journals **264** and crankpin journals **266** may be fixedly coupled by corresponding threads, bolts, set screws, retaining rings, interlocking splines, interlocking keys, interference/press fit, adhesives, and/or other means operable to couple the separable main journals **264** and crankpin journals **266** together and prevent their relative rotation. Furthermore, the rotor shafts **260** of the electric motor **250** may be or comprise solid members (i.e., not comprising the central bore), which may also be or serve as the separable main journals **264**, such as may be operable to fixedly couple with the separable crankpin journals **266** to form the drive shaft **252**. Such configuration may permit piece-by-piece or modular assembly and/or construction of the drive shaft and/or the power section **202** of the pump assembly **200**.

[0045] As depicted in FIG. **4**, the main journals **264** may comprise an outer diameter that is substantially the same or slightly smaller than the diameter of the axial bore **261** of the rotor shaft **260**, such as may facilitate direct and/or otherwise fixed connection between the main journals **264** and the rotor shaft **260**. However, the electric motor **250** may be configured such that the axial bore **261** extending through the rotor shaft **260** may comprise an inner diameter that is greater than the maximum outer diameter of the drive shaft **252**, or be adapted to simultaneously enclose the three crankpin journals **266**, thus permitting the drive shaft **252** to be translated axially therethrough, such as during assembly and/or maintenance. In such implementations, the inner diameter of the bore **261** may be substantially the same or similar to that of a stator axial opening **316** shown in FIGS. **5** and **6**, and the intermediate member (such as the ring, not shown), may be utilized to extend between and/or fixedly couple the rotor shaft **260** with the main journals **264**.

[0046] The drive shaft **252** and the rotor **258** may be supported in position within the stator **256** by the power section housing **254**, wherein the support journals **262** may extend through opposing openings **272** in the power section housing **254**. To facilitate rotation of the drive shaft **252** within the power section housing **254**, one or more bearings **270** may be disposed about the support journals **262** and against the side surfaces of the openings **272**. A cover plate **274** and/or other means for protection may enclose the bearings **270**.

[0047] Referring again to FIGS. **3** and **4**, the power section housing **254** and the pump housing **216** may be coupled together via an intermediate housing **280**. For example, the pump housing **216** may be fastened with the intermediate housing **280** by a plurality of threaded fasteners **282**, and the intermediate housing **280** may be fastened with the power section housing **254** by another plurality of threaded fasteners **284**. The intermediate housing **280** may further comprise an access door **298**, which may facilitate access to portions of the pump assembly **200**, such as during assembly and/or maintenance of the pump assembly **200**.

[0048] To transform and transmit the rotational motion of the drive shaft **252** to a reciprocating linear motion of the plungers **222**, a plurality of crosshead mechanisms **285**, comprising a plurality of connecting members, may be utilized. For example, each crosshead mechanism **285** may comprise a connecting rod **286** pivotally coupled with a corresponding crankpin journal **266** at one end and with a pin **288** of a crosshead **290** at an opposing end. During pumping operations, inner walls of the intermediate housing **280** may guide each crosshead **290**, such as may reduce or eliminate lateral motion of each crosshead **290**. Each crosshead mechanism **285** may further comprise a piston rod **292** coupling the crosshead **290** with the reciprocating member **222**. The piston rod **292** may be coupled with the crosshead **290** via a threaded connection **294** and with the reciprocating member **222** via a flexible connection **296**.

[0049] For the electric motors **250** to be mounted about the main journals **264**, each motor **250** may comprise a width that may permit mounting between adjacent connecting rods **286** rotatably coupled with adjacent crankpin journals **266**. However, one or more of the main journals **264** may comprise a greater width that may permit mounting of a wider electric motor **250** between adjacent connecting rods **286**. Accordingly, when the electric motors **250** are powered, the rotors **258** transfer torque to the drive shaft **252**, which, in turn, actuate the reciprocating members **222** via the crosshead mechanisms **285** to cause the fluid section **210** to pump fluid from the fluid inlet conduit **226** to the fluid outlet conduit **235**.

[0050] FIG. **5** is a side sectional view of a portion of another example implementation of the pump assembly **200** shown in FIG. **1**, designated herein by reference numeral **300**, according to one or more aspects of the present disclosure. FIG. **6** is a top partial sectional view of a portion of the pump assembly **300** shown in FIG. **5** according to one or more aspects of the present disclosure. For simplicity and clarity, components of the pump assembly **300** comprising the same or similar structure and/or function as corresponding components of the pump assembly **200** will be identified using the same numerals.

[0051] Referring to FIGS. **5** and **6**, collectively, the pump assembly **300** may comprise a fluid section **210**, an intermediate housing **280**, and a plurality of crosshead mechanisms **285**, as described above. The pump assembly **300** may further comprise a power section **302** having a power section housing **304** enclosing an electric motor **306**, which may be disposed about a drive shaft **308**. The electric motor **306** is operable to drive or otherwise rotate the drive shaft **308**. The electric motor **306** comprises a motor housing **310** enclosing a stator **312** and a rotor assembly. The rotor assembly comprises a plurality of rotor sections or rotors **314** surrounded by the stator **312**.

[0052] The stator **312** may be a single-piece or otherwise continuous member comprising one or more field coils or windings enclosed within the motor housing **310**, such as may generate a magnetic field when powered by electric current from the source of electric power **148**. The stator **312** includes an axial opening **316** in which the plurality of rotors **314** and the drive shaft **308** extend. The stator **314** and the motor housing **310** may further comprise a plurality of lateral openings **318** extending from the axial opening **316** to the exterior of the electric motor **306** toward the crossheads **290**. The connecting rods **286** extend through the lateral openings **318** and pivotally couple the drive shaft **308** with the crossheads **290**.

[0053] The rotors **314** comprise a plurality of permanent magnets **320** fixedly disposed about each rotor shaft **322** along the length of each rotor **314**. The rotor shafts **322** may be hollow shafts or comprise a bore through which the drive shaft **308** extends. The rotor shafts **322** or other portion of the rotors **314** are directly and/or otherwise fixedly coupled with the drive shaft **308**, such that the rotor shafts **322** transmit torque from the rotors **314** directly to the drive shaft **308**. To prevent relative rotation between the power section housing **304** and the motor **306**, the power section housing **304** and the motor housing **310** may be fixedly coupled together. Because the rotor shafts **322** and the drive shaft **308** are directly and/or otherwise fixedly coupled, the rotor shafts **322** and the drive shaft **308** may rotate at the same speed or rate. However, the drive shaft **308** and the rotor shafts **322** may instead be integrally formed as a single discrete member operable to move as a single unit.

[0054] FIGS. **5** and **6** show the drive shaft **308** implemented as a crankshaft comprising a plurality of support journals **324**, main journals **326**, and crankpin journals **328**. The support and main journals **324**, **326** may extend along a central axis of rotation **330** of the drive shaft **308**, while the crankpin journals **328** may be offset from the central axis of rotation **330** by a predetermined distance and spaced **120** degrees apart with respect to the support journals **324** and the main journals **326**. Accordingly, the axial opening **316** may comprise an inner diameter that is greater than the maximum outer diameter of the drive shaft **308**, or be otherwise adapted to simultaneously enclose the crankpin journals **328**, such as to permit the crankpin journals **328** and/or the rotors **314** to rotate without contacting the stator **312**.

[0055] The main journals **326** and the rotor shafts **322** may be fixedly coupled, such as described above, while the crankpin journals **328** and the connecting rods **286** may be rotatably coupled, such as described above. The drive shaft **308** and the rotors **314** may be supported in position within the stator **312** by the power section housing **304** and the bearings **270**, such as described above. Accordingly, when the electric motor **306** is powered, the rotors **314** transfer torque to the drive shaft **308**, which, in turn, actuate the reciprocating members via the crosshead mechanisms **285** to cause the fluid section **210** to pump fluid.

[0056] FIG. **7** is a top partial sectional view of a portion of an example implementation of the pump assembly **200** shown in FIG. **1**, designated herein by reference numeral **400**, according to one or more aspects of the present disclosure. For simplicity and clarity, components of the pump assembly **400** comprising the same or similar structure and/or function as corresponding components of the pump assembly **200** will be identified using the same numerals.

[0057] The pump assembly **400** may comprise a fluid section **210**, an intermediate housing **280**, and a plurality of crosshead mechanisms **285**, as described above. The pump assembly **400** may further comprise a power section **402** having a power section housing **404** partially enclosing a drive shaft **406**. The pump assembly may further comprise two or more electric motors **408** coupled with opposing support journals **410** of the drive shaft **406** extending out of the power section housing **404**, wherein the electric motors **408** may be operable to drive or otherwise rotate the drive shaft **406**. The electric motors **408** may comprise the same or similar structure and/or function as the electric motors **250** described above, such as comprising a motor housing **255** enclosing a stator **256** and a rotor **258**.

[0058] Each rotor **258** may comprise a rotor shaft **260** having a bore extending therethrough, such as may contain therein the support journals **410** or end portions of the drive shaft **406**. The rotor shafts **260** or other portion of the rotors **258** are directly and/or otherwise fixedly coupled with the drive shaft **406**, such that the rotor shafts **260** may transmit torque from the rotors **258** directly to the drive shaft **406**. Thus, because the rotor shafts **260** and the drive shaft **406** are directly and/or fixedly coupled, the rotor shafts **260** and the drive shaft **406** may rotate at the same speed or rate. However, the drive shaft **406** and the rotor shafts **260** may instead be integrally formed as a single discrete member operable to move as a single unit. To prevent relative rotation between the power section housing **404** and the motors **408**, the power section housing **404** and motor housing **255** may be fixedly coupled together or to a fixed base (not shown).

[0059] FIG. **7** shows the drive shaft **406** being implemented as a crankshaft comprising a plurality of main journals **412** and crankpin journals **414**. The support and main journals **410**, **412** may extend along the central axis of rotation **416** of the drive shaft **406**, while the crankpin journals **414** may be offset from the central axis of rotation **416** by a predetermined distance and spaced **120** degrees apart with respect to the support journals **410** and the main journals **412**.

[0060] The support journals **410** and the rotor shafts **260** may be fixedly coupled, such as described above, while the crankpin journals **414** and connecting rods **286** may be rotatably coupled, such as described above. The drive shaft **406** may be supported in position within the power section **402** by the power section housing **404** and the bearings **270**, such as described above. Accordingly, when the electric motors **408** are powered, the rotors **258** transfer torque to the drive shaft **406**, which, in turn, actuate the reciprocating members via the crosshead mechanisms **285** to cause the fluid section **210** to pump fluid.

[0061] The pump assembly **200** shown in FIG. **1** may be further implemented with multiple fluid sections **210**, such that each pump assembly **200** may comprise a fluid section **210** on opposing sides of a centrally located power section **202**, **302**, **402**. For example, FIG. **8** is a top partial sectional view of a portion of such an implementation of the pump assembly **200** shown in FIG. **1**, designated herein by reference numeral **500**, according to one or more aspects of the present disclosure. For simplicity and clarity, components of the pump assembly **500** comprising the same or similar structure and/or function as corresponding components of the pump assembly **200** will be identified using the same numerals.

[0062] The pump assembly **500** may comprise opposing fluid sections **210**, intermediate housings **280**, and crosshead mechanisms **285**, as described above. The pump assembly **500** may further comprise a power section **502** having a power section housing **504** enclosing an electric motor **506**, which may be disposed about a drive shaft **508**. The electric motor **506** is operable to drive or otherwise rotate the drive shaft **508**. The electric motor **506** may comprise a motor housing **510** enclosing a stator **512** and a rotor assembly. The rotor assembly comprises a plurality of rotor sections or rotors **514** surrounded by the stator **512**.

[0063] The stator **512** may be a single-piece or continuous member comprising one or more field coils or windings enclosed within the motor housing **510**, such as may generate a magnetic field when powered by electric current from the source of electric power **148** or another source of electric power. The stator **512** may include an axial opening **516** through which the plurality of rotors **514** and the drive shaft **508** extend. The stator **514** and the motor housing **510** may further comprise a plurality of opposing lateral openings **518** extending from the axial opening **516** to the exterior of the electric motor **506** toward the crossheads **290**. The lateral openings **518** may permit the opposing connecting rods **286** to extend therethrough and pivotally couple the drive shaft **508** with the crossheads **290**.

[0064] The rotors **514** comprise a plurality of permanent magnets **520** fixedly disposed about the rotor shafts **522**. Each rotor shaft **522** may be a hollow shaft or comprise a bore through which the drive shaft **508** extends. The rotor shafts **522** or other portion of the rotors **514** may be directly and/or otherwise fixedly coupled with the drive shaft **508**, such that the rotor shafts **522** transmit torque from the rotors **514** directly to the drive shaft **508**. To prevent relative rotation between the power section housing **504** and the motor **506**, the power section housing **504** and motor housing **510** may be fixedly coupled together. Because the rotor shafts **522** and the drive shaft **508** are directly and/or otherwise fixedly coupled, the rotor shafts **522** and the drive shaft **508** rotate at the same speed or rate. However, the drive shaft **508** and the rotor shafts

522 may instead be integrally formed as a single discrete member operable to move as a single unit.

[0065] FIG. **8** shows the drive shaft **508** implemented as a crankshaft comprising a plurality of support journals **524**, main journals **526**, and crankpin journals **528**. The support and main journals **524**, **526** may extend along the central axis of rotation **530** of the drive shaft **508**, while the crankpin journals **528** may be offset from the central axis of rotation **530** by a predetermined distance and spaced **120** degrees apart with respect to the support journals **524** and the main journals **526**. Accordingly, the axial opening **516** may comprise an inner diameter that is greater than the maximum outer diameter of the drive shaft **508**, or be adapted to simultaneously enclose the crankpin journals **528**, such as to permit the crankpin journals **528** and/or the rotors **514** to rotate without contacting the stator **512**.

[0066] The main journals **526** and the rotor shafts **522** may be fixedly coupled, such as described above, while the crankpin journals **528** and the connecting rods **286** may be rotatably coupled, such as may permit each connecting rod **286** to pivot independently of the opposing connecting rod **286**. The drive shaft **508** and the rotors **514** may be supported in position within the stator **512** by the power section housing **504** and bearings **270**, such as described above. Accordingly, when the electric motor **506** is powered, the rotors **514** may transfer torque directly to the drive shaft **508**, which, in turn, may actuate the reciprocating members via the crosshead mechanisms **285** to cause the opposing fluid sections **210** to pump fluid.

[0067] FIG. **8** shows the pump assembly **500** comprising two fluid sections **210** connected with a single power section **502**. The power section **502** may comprise a similar structure and/or function as the power section **302** described above. However, it should be understood that other implementations of the pump assemblies **200**, **300**, **400**, **500** comprising multiple fluid sections **210** connected with a single power section (comprising the same or similar structure and/or function as the power sections **202**, **402** described above) are also within the scope of the present disclosure.

[0068] Although FIG. **8** shows two fluid sections **210** connected to a single power section **502** and spaced **180** degrees apart with respect to the central axis of rotation **530**, in other implementations, the pump assembly **500** may comprise additional fluid sections **210** connected to a single centrally-located power section **502**. For example, the pump assembly **500** may comprise three fluid sections **210**, each connected to the centrally-located power section **502** in the same or similar manner as showed in FIG. **8** and spaced 120 degrees apart with respect to the central axis of rotation **530**. In another implementation, the pump assembly **500** may comprise four fluid sections **210**, each connected to the centrally-located power section **502** in the same or similar manner as shown in FIG. **8** and spaced ninety degrees apart with respect to the central axis of rotation **530**. Other implementations of the pump assembly **500** comprising additional quantities of fluid sections **210** coupled with the centrally-located power section **502** are also within the scope of the present disclosure.

[0069] Although FIGS. **2-8** show the pump assembly **200** as a triplex reciprocating pump assembly comprising three fluid chambers **218** and three reciprocating members **222**, other implementations within the scope of the present disclosure may include the pump assembly **200** as or comprising a quintuplex reciprocating pump assembly comprising five fluid chambers **218** and five reciprocating members **222**, or other numbers of fluid chambers **218** and reciprocating members **222**. It is also noted that the electric motors **250**, **306**, **408**, **506** described above may be or comprise liquid cooled motors, such as in implementations in which one or more water jacket configurations (not shown) may be utilized to remove heat from the electric motors during operations.

[0070] In still other implementations of the pumping system **100**, two or more adjacent pump assemblies **200** within a pump fleet may be operatively coupled together, such as to help synchronize the pumps and/or facilitate torque sharing between the pump assemblies **200**. For example, two or more adjacent pump assemblies **200** may comprise drive shafts **252** extending past the housing **254** or the cover plate **274**. The two or more adjacent pump assemblies **200** may be positioned such that the drive shafts **252** are aligned substantially along their central axes of rotation **268** to permit the drive shafts **252** to be coupled together. The drive shafts **252** may be coupled by means known in the art, including chain couplings, jaw couplings, rigid couplings, flexible couplings, spline shafts, and universal joints, among other examples.

[0071] FIG. **9** is a schematic view of a portion of another example implementation of the pump assembly **200** shown in FIG. **1**, designated herein by reference numeral **600**, according to one or more aspects of the present disclosure. For simplicity and clarity, components of the pump assembly **600** comprising the same or similar structure and/or function as the corresponding components of the pump assembly **200** will be identified using the same numerals.

[0072] The pump assembly **600** may comprise a power section **602** coupled with a fluid section **604**. The power section **602** may comprise a motor **250** having a motor housing **255** enclosing a stator **256** and a rotor **258**. The fluid section **604** may comprise a drive shaft **606** coupled with a rotary swash plate **608**, which may be coupled with a swing swash plate **610**. The fluid section **604** may further comprise a plurality of cylinders **612**, each defining a fluid chamber **614** therein, and a plurality of reciprocating members **616** slidably movable within the fluid chambers **614**. The swing swash plate **610** may be coupled with the plurality of reciprocating members **616** by a plurality of connecting rods **618**. The drive shaft **606**, the rotary and swing swash plates **608**, **610**, the connecting rods **618**, the reciprocating members **616**, and the cylinders **612** may be enclosed within a fluid section housing **620**. The motor housing **255** and the fluid section housing **620** may be fixedly coupled, such as may prevent relative motion therebetween during operations. The pump assembly **600** may further comprise one or more bearings **622** disposed about the drive shaft **606** and against the fluid section housing **620**, such as may facilitate low friction rotation of the drive shaft **606** about a central axis of rotation **623** with respect to the fluid section housing **620**. The one or more bearings **622** may further support the drive shaft **606** in position within the fluid section housing **620**.

[0073] The electric motor **250** may be coupled with a portion of the drive shaft **606** extending out of the fluid section housing **620**, and the electric motor **250** may be operable to drive or otherwise rotate the drive shaft **606**. For example, the rotor **258** may comprise a rotor shaft **260** having an axial bore **261** through which the portion of the drive shaft **606** extending out of the fluid section housing **620** may extend. The rotor shaft **260** or other portion of the rotor **258** is directly and/or otherwise fixedly coupled with the drive shaft **606**, such that the rotor shaft **260** transmits torque from the rotor **258** directly to the drive shaft **606**. Because the rotor shaft **260** and the drive shaft **606** are directly and/or otherwise fixedly coupled, the rotor shaft **260** and the drive shaft **606** rotate at the same speed or rate. However, the drive shaft **606** and the rotor shaft **260** may instead be integrally formed as a single discrete member operable to move as a single unit.

[0074] During pumping operations, the rotating drive shaft **606** rotates the rotary swash plate **608**, which, in turn, swings the swing swash plate **610**, causing the connecting rods **618** and the reciprocating members **616** to oscillate back and forth, as indicated by arrows **624**, **626**. The oscillating movement of the reciprocating members **616** sequentially draws and discharges fluid into and out of the fluid chambers **614** through inlet and outlet ports **628**, **630**. The pressurized fluid may be communicated from the pump assembly **600** to the high-pressure inlet (not shown) of the manifold **136** or to another destination.

[0075] FIG. **10** is a flow-chart diagram of at least a portion of a method **700** according to one or more aspects of the present disclosure. The method **700** may be performed utilizing at least a portion of one or more implementations of the apparatus shown in one or more of FIGS. **1-9** and/or otherwise within the scope of the present disclosure.

[0076] The method **700** comprises connecting (**710**) a fluid source to a pump assembly. For example, the fluid source may be the manifold **136** shown in FIG. **1**, and the pump assembly may be substantially similar to one or more of the pump assemblies **200**, **300**, **400**, **500**, **600** shown in FIGS. **1-9**. Thus, the pump assembly may comprise a drive shaft, a plurality of rods operatively coupled with the drive shaft, a plurality of reciprocating members operatively coupled with a plurality of rods, and an electric motor comprising a stator and a rotor that is directly and/or otherwise fixedly coupled with the drive shaft, wherein these components are as described above. The electric motor is then operated (**720**) to rotate the rotor and the drive shaft at the same speed, such that the rotating drive shaft moves the plurality of rods and reciprocating members to pump the fluid from the fluid source through the pump assembly.

[0077] As described above, the electric motor may comprise an axial bore extending through the rotor, and the drive shaft may extend through the axial bore. Thus, the rotating drive shaft rotates within the axial bore. Similarly, the drive shaft may comprise a crankshaft having a plurality of crankpin journals, operatively coupled with the plurality of rods, and a plurality of main journals, connected with the rotor. The electric motor may comprise a plurality of openings extending laterally from the axial bore, and operating (**720**) the electric motor to rotate the rotor and the crankshaft may move the plurality of rods through the plurality of openings.

[0078] As also described above, the drive shaft may be a crankshaft, the electric motor may be a first electric motor, the stator may be a first stator, the rotor may be a first rotor, and the pump assembly may further comprise a second electric motor comprising a second stator and a second rotor, wherein the first and second electric motors may be separated by a space, and the second rotor is directly connected with the crankshaft. In such implementations, operating (**720**) the electric motor may comprise operating the first and second electric motors to rotate the first and second rotors and the crankshaft at the same speed, wherein the rotating crankshaft moves the plurality of rods through the space between the first and second electric motors. The method (**700**) may further comprise electrically connecting (**730**) the first and second electric motors to an electric power source, such as the electric power source **148** shown in FIG. **1**. The method (**700**) may further comprise synchronizing (**750**) the speed of the first and second electric motors and monitoring (**740**) speed of the first and second electric motors.

[0079] In view of the entirety of the present disclosure, including the figures and the claims, a person having ordinary skill in the art should readily recognize that the present disclosure introduces an apparatus comprising: a pump assembly, comprising: a drive shaft; a plurality of rods operatively coupled with the drive shaft; a plurality of reciprocating members each operatively coupled with a corresponding one of the plurality of rods; and an electric motor operable to rotate the drive shaft, wherein the electric motor comprises a rotor having a rotor shaft, wherein the rotor shaft is connected with the drive shaft, wherein the rotor shaft is operable to rotate the drive shaft and thus move the plurality of rods and reciprocating members, wherein the rotor shaft and the drive shaft rotate at the same speed, and wherein the plurality of reciprocating members are operable to move a fluid.

[0080] The plurality of reciprocating members may comprise a plurality of pistons, plungers, or diaphragms.

[0081] The rotor may further comprise a plurality of permanent magnets.

[0082] The electric motor may rotate at speeds between about zero RPM and 500 RPM. For example, the electric motor may rotate at speeds between about 300 and 400 RPM.

[0083] The pump assembly may not comprise a transmission operatively connecting the rotor shaft and the drive shaft.

[0084] The rotor shaft and the drive shaft may be integral portions of a single discrete member.

[0085] The pump assembly may further comprise: a housing disposed about the electric motor; and a bearing disposed intermediate the drive shaft and the housing.

[0086] The pump assembly may further comprise a housing disposed about the plurality of rods and/or reciprocating members, and the electric motor may be connected with the housing.

[0087] The pump assembly may further comprise a swashplate connected with the drive shaft, and the plurality of rods may be operatively coupled with the swash plate.

[0088] The drive shaft may comprise a crankshaft, such as may comprise a plurality of main journals connected with the rotor shaft. In such implementations, the electric motor may be one of a plurality of electric motors collectively operable to rotate the crankshaft, each of the plurality of electric motors may comprise a rotor having a rotor shaft and a plurality of magnets, the rotor shaft of each of the plurality of electric motors may be connected with the crankshaft, the rotor shaft of each of the plurality of electric motors may be operable to rotate the crankshaft and thus move corresponding ones of the plurality of rods, the rotor shaft of each of the plurality of electric motors and the crankshaft may rotate at the same speed, the rotor shaft of at least one of the plurality of electric motors may comprise an axial bore extending therethrough, the crankshaft may extend though the axial bore, and at least one of the plurality of electric motors may be disposed between two or more of the plurality of rods. In implementations in which the drive shaft comprises a crankshaft, the crankshaft may comprise a plurality of crankpin journals operatively coupled with a corresponding one of the plurality of rods, the crankshaft may comprise a plurality main journals each connected with a rotor shaft of a corresponding one of the plurality of electric motors, and at least one of the plurality of electric motors may be disposed between two or more of the plurality of crankpin journals.

[0089] The rotor shaft may comprise an axial bore extending longitudinally therethrough, and the drive shaft may extend through the axial bore. In such implementations, the drive shaft may comprise a crankshaft, the crankshaft may comprise a plurality of crankpin journals operatively coupled with a corresponding one of the plurality of rods, the crankshaft may comprise a plurality of main journals connected with the rotor shaft, the electric motor may further comprise a plurality of openings extending laterally from the axial bore, and the plurality of rods and/or crankpin journals may extend into the plurality of openings.

[0090] In at least one implementation, the electric motor may be a first electric motor, the rotor may be a first rotor, the rotor shaft may be a first rotor shaft, the plurality of magnets may comprise a plurality of first magnets, the pump assembly may further comprise a second electric motor operable to rotate the drive shaft, the second electric motor may comprise a second rotor having a second rotor shaft and a plurality of second magnets, the second rotor shaft may be connected with the drive shaft, the second rotor shaft may be operable to rotate the drive shaft and thus move the plurality of rods, and the second rotor shaft and the drive shaft may rotate at the same speed. In such implementation, the first rotor shaft may comprise a first axial bore extending longitudinally therethrough, the second rotor shaft may comprise a second axial bore extending therethrough, the drive shaft may be disposed within the first and second axial bores, and at least one of the first and second electric motors may be disposed between two or more of the plurality of rods.

[0091] The present disclosure also introduces an apparatus comprising: a pump assembly, comprising: a crankshaft comprising a plurality of main journals and a plurality of crankpin journals; a plurality of rods each operatively coupled with a corresponding one of the plurality of crankpin journals; a plurality of reciprocating members each operatively coupled with a corresponding one of the plurality of rods; and an electric motor operable to rotate the crankshaft, wherein the electric motor comprises a stator and a rotor, wherein the rotor is directly connected with the crankshaft, and wherein the rotor is operable to rotate the crankshaft and thus move the plurality of rods, thereby causing the plurality of reciprocating members to move a fluid.

[0092] The plurality of reciprocating members may comprise a plurality of pistons, plungers, or diaphragms.

[0093] The rotor may further comprise a plurality of permanent magnets.

[0094] The electric motor may rotate at speeds between about zero RPM and 500 RPM. For example, the electric motor may rotate at speeds between about 300 RPM and 400 RPM.

[0095] The pump assembly may further comprise: a housing disposed about the electric motor; and a bearing disposed intermediate the crankshaft and the housing.

[0096] The pump assembly may further comprise a housing disposed about the plurality of rods and/or reciprocating members, and the electric motor may be connected with the housing.

[0097] The rotor may further comprise a rotor shaft, and the rotor shaft may be connected with the crankshaft. The rotor shaft may be connected with at least one of the plurality of main journals. The rotor shaft may comprise an axial bore extending longitudinally therethrough, and the crankshaft may extend through the axial bore. The plurality of crankpin journals may be operatively coupled with a corresponding one of the plurality of rods, the plurality of main journals may be connected with the rotor shaft, the electric motor may further comprise a plurality of openings extending laterally from the axial bore, and the plurality of rods and/or crankpin journals may extend into the plurality of openings. The pump assembly may not comprise a transmission operatively connecting the rotor shaft and the crankshaft. The rotor shaft and the crankshaft may be integral portions of a single discrete member. The crankshaft may comprise a plurality of main journals connected with the rotor shaft. The electric motor may be one of a plurality of electric motors operable to rotate the crankshaft, the rotor shaft may be operable to rotate the crankshaft and thus move the plurality of rods and reciprocating members, the rotor shaft and the crankshaft may rotate at the same speed, at least one rotor shaft may comprise an axial bore extending therethrough, the crankshaft may extend though the axial bore, and at least one of the plurality of electric motors may be disposed between two or more of the plurality of rods. The crankshaft may comprise a plurality of crankpin journals operatively coupled with a corresponding one of the plurality of rods, the crankshaft may comprise a plurality main journals connected with a corresponding rotor shaft, and at least one of the plurality of electric motors may disposed between two or more of the plurality of crankpin journals. The electric motor may be a first electric motor, the rotor may be a first rotor, the rotor shaft may be a first rotor shaft, the pump assembly may further comprise a second electric motor operable to rotate the crankshaft, the second electric motor may comprise a second rotor having a second rotor shaft, the second rotor shaft may be connected with the crankshaft, the second rotor shaft may be operable to rotate the crankshaft and thus move the plurality of rods and reciprocating members, and the second rotor shaft and the crankshaft may rotate at the same speed. The first rotor shaft may comprise a first axial bore extending longitudinally therethrough, the second rotor shaft may comprise a second axial bore extending therethrough, the crankshaft may be disposed within the first and second axial bores, and at least one of the first and second electric motors may be disposed between two or more of the plurality of rods.

[0098] The present disclosure also introduces a method comprising: connecting a fluid source to a pump assembly comprising: a drive shaft; a plurality of rods operatively coupled with the drive shaft; a plurality of reciprocating members operatively coupled with a plurality of rods; and an electric motor comprising a stator and a rotor that is directly connected with the drive shaft; and operating the electric motor to rotate the rotor and the drive shaft at the same speed such that the rotating drive shaft moves the plurality of rods and reciprocating members to pump the fluid from the fluid source through the pump assembly.

[0099] The electric motor may comprise an axial bore extending through the rotor, the drive shaft may extend through the axial bore, and the rotating drive shaft may rotate within the axial bore. The drive shaft may comprise a crankshaft, the crankshaft may comprise a plurality of crankpin journals operatively coupled with the plurality of rods, the crankshaft may comprise a plurality of main journals connected with the rotor, the electric motor may comprise a plurality of openings extending laterally from the axial bore, and operating the electric motor to rotate the rotor and the crankshaft may move the plurality of rods through the plurality of openings.

[0100] The drive shaft may be a crankshaft, the electric motor may be a first electric motor, the stator may be a first stator, the rotor may be a first rotor, the pump assembly may further comprise a second electric motor comprising a second stator and a second rotor, the first and second electric motors may be separated by a space, the second rotor may be directly connected with the crankshaft, and the method may further comprise operating the second electric motor to rotate the second rotor and the crankshaft at the same speed, wherein the rotating crankshaft may move the plurality of rods through the space between the first and second electric motors. The method may further comprise electrically connecting the first and second electric motors to an electric power source. The method may further comprise: synchronizing the speed of the first and second electric motors; and monitoring speed of the first and second electric motors. The first electric motor may comprise a first axial bore extending through the first rotor, the second electric motor may comprise a second axial bore extending through the second rotor, the crankshaft may extend through the first and second axial bores, and the rotating crankshaft may rotate within the first and second axial bores. The crankshaft may comprise a plurality of crankpin journals operatively coupled with the plurality of rods, the crankshaft may comprise a first main journal coupled with the first rotor, the crankshaft may comprise a second main journal coupled with the second rotor, and the rotating crankshaft may move at least one of the plurality of crankpin journals through the space between the first and second electric motors.

[0101] The foregoing outlines features of several embodiments so that a person having ordinary skill in the art may better understand the aspects of the present disclosure. A person having ordinary skill in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same functions and/or achieving the same benefits of the embodiments introduced herein. A person having ordinary skill in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions and alterations herein without departing from the spirit and scope of the present disclosure.

[0102] The Abstract at the end of this disclosure is provided to comply with 37 C.F.R. §1.72(b) to permit the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

What is claimed is:

1. An apparatus, comprising:
a pump assembly, comprising:
a drive shaft;
a plurality of rods operatively coupled with the drive shaft;
a plurality of reciprocating members each operatively coupled with a corresponding one of the plurality of rods; and
an electric motor operable to rotate the drive shaft, wherein the electric motor comprises a rotor having a rotor shaft, wherein the rotor shaft is connected with the drive shaft, wherein the rotor shaft is operable to rotate the drive shaft and thus move the plurality of rods and reciprocating members, wherein the rotor shaft and the drive shaft rotate at the same speed, and wherein the plurality of reciprocating members are operable to move a fluid.

2. The apparatus of claim **1** wherein the rotor further comprises a plurality of permanent magnets.

3. The apparatus of claim **1** wherein the pump assembly does not comprise a transmission operatively connecting the rotor shaft and the drive shaft.

4. The apparatus of claim **1** wherein the rotor shaft and the drive shaft are integral portions of a single discrete member.

5. The apparatus of claim **1** wherein the pump assembly further comprises a swashplate connected with the drive shaft, and wherein each of the plurality of rods is operatively coupled with the swash plate.

6. The apparatus of claim **1** wherein the drive shaft comprises a crankshaft that includes a plurality of main journals connected with the rotor shaft.

7. The apparatus of claim **1** wherein:
the drive shaft comprises a crankshaft;
the electric motor is one of a plurality of electric motors collectively operable to rotate the crankshaft;
each of the plurality of electric motors comprises a rotor having a rotor shaft and a plurality of magnets;
the rotor shaft of each of the plurality of electric motors is connected with the crankshaft;
the rotor shaft of each of the plurality of electric motors is operable to rotate the crankshaft and thus move a corresponding one of the plurality of rods;
the rotor shaft of each of the plurality of electric motors and the crankshaft rotate at the same speed;
the rotor shaft of at least one of the plurality of electric motors comprises an axial bore extending therethrough;
the crankshaft extends though the axial bore; and
at least one of the plurality of electric motors is disposed between two or more of the plurality of rods.

8. The apparatus of claim **1** wherein:
the drive shaft comprises a crankshaft;
the electric motor is one of a plurality of electric motors collectively operable to rotate the crankshaft;
the crankshaft comprises a plurality of crankpin journals each operatively coupled with a corresponding one of the plurality of rods;
the crankshaft comprises a plurality main journals each connected with a rotor shaft of a corresponding one of the plurality of electric motors; and
at least one of the plurality of electric motors is disposed between two or more of the plurality of crankpin journals.

9. The apparatus of claim **1** wherein the rotor shaft comprises an axial bore extending longitudinally therethrough, and wherein the drive shaft extends through the axial bore.

10. The apparatus of claim **1** wherein:
the electric motor is a first electric motor;
the rotor is a first rotor;
the rotor shaft is a first rotor shaft;
the plurality of magnets comprises a plurality of first magnets;
the pump assembly further comprises a second electric motor operable to rotate the drive shaft;
the second electric motor comprises a second rotor having a second rotor shaft and a plurality of second magnets;
the second rotor shaft is connected with the drive shaft;

the second rotor shaft is operable to rotate the drive shaft and thus move the plurality of rods; and

the second rotor shaft and the drive shaft rotate at the same speed.

11. The apparatus of claim **10** wherein:

the first rotor shaft comprises a first axial bore extending longitudinally therethrough;

the second rotor shaft comprises a second axial bore extending therethrough;

the drive shaft is disposed within the first and second axial bores; and

at least one of the first and second electric motors is disposed between two or more of the plurality of rods.

12. An apparatus, comprising:

a pump assembly, comprising:

a crankshaft comprising a plurality of main journals and a plurality of crankpin journals;

a plurality of rods each operatively coupled with a corresponding one of the plurality of crankpin journals;

a plurality of reciprocating members each operatively coupled with a corresponding one of the plurality of rods; and

an electric motor operable to rotate the crankshaft, wherein the electric motor comprises a stator and a rotor, wherein the rotor is directly connected with the crankshaft, and wherein the rotor is operable to rotate the crankshaft and thus move the plurality of rods, thereby causing the plurality of reciprocating members to move a fluid.

13. The apparatus of claim **12** wherein the rotor further comprises a plurality of permanent magnets.

14. The apparatus of claim **12** wherein the rotor further comprises a rotor shaft, and wherein the rotor shaft is connected with the crankshaft and at least one of the plurality of main journals.

15. The apparatus of claim **14** wherein the rotor shaft comprises an axial bore extending longitudinally therethrough, and wherein the crankshaft extends through the axial bore.

16. A method, comprising:

connecting a fluid source to a pump assembly comprising:

a drive shaft;

a plurality of rods operatively coupled with the drive shaft;

a plurality of reciprocating members operatively coupled with the plurality of rods; and

an electric motor comprising a stator and a rotor that is directly connected with the drive shaft; and

operating the electric motor to rotate the rotor and the drive shaft at the same speed such that the rotating drive shaft moves the plurality of rods and reciprocating members to pump the fluid from the fluid source through the pump assembly.

17. The method of claim **16** wherein:

the electric motor comprises an axial bore extending through the rotor;

the drive shaft extends through the axial bore;

the rotating drive shaft rotates within the axial bore;

the drive shaft comprises a crankshaft;

the crankshaft comprises a plurality of crankpin journals operatively coupled with the plurality of rods;

the crankshaft comprises a plurality of main journals connected with the rotor;

the electric motor comprises a plurality of openings extending laterally from the axial bore; and

operating the electric motor to rotate the rotor and the crankshaft moves the plurality of rods through the plurality of openings.

18. The method of claim **16** wherein:

the drive shaft is a crankshaft;

the electric motor is a first electric motor;

the stator is a first stator;

the rotor is a first rotor;

the pump assembly further comprises a second electric motor comprising a second stator and a second rotor;

the first and second electric motors are separated by a space;

the second rotor is directly connected with the crankshaft; and

the method further comprises operating the second electric motor to rotate the second rotor and the crankshaft at the same speed, wherein the rotating crankshaft moves the plurality of rods through the space between the first and second electric motors.

19. The method of claim **18** further comprising electrically connecting the first and second electric motors to an electric power source.

20. The method of claim **18** further comprising:

synchronizing the speed of the first and second electric motors; and

monitoring speed of the first and second electric motors.

* * * * *