US008997904B2

(12) **United States Patent**
Cryer et al.

(10) **Patent No.: US 8,997,904 B2**
(45) **Date of Patent: Apr. 7, 2015**

(54) **SYSTEM AND METHOD FOR POWERING A HYDRAULIC PUMP**

(75) Inventors: **Robert Douglas Cryer**, Erie, PA (US); **George J. Wnukoski**, Erie, PA (US); **David Kamensky**, West Chester, OH (US); **Ramesh Krishnan**, Mississauga (CA); **William Halli**, Erie, PA (US); **Alexey Gaev**, Erie, PA (US); **Ryan Martorella**, Erie, PA (US); **Tarun Shivlani**, Erie, PA (US)

(73) Assignee: **General Electric Company**, Schenectady, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 188 days.

(21) Appl. No.: **13/541,980**

(22) Filed: **Jul. 5, 2012**

(65) **Prior Publication Data**

US 2014/0010671 A1 Jan. 9, 2014

(51) **Int. Cl.**

B60K 17/28	(2006.01)
B60K 6/485	(2007.10)
B60W 10/30	(2006.01)
F04B 17/03	(2006.01)
F04B 17/05	(2006.01)
F04B 17/06	(2006.01)
F04B 47/02	(2006.01)

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

CPC ***B60K 6/485*** (2013.01); ***B60W 10/30*** (2013.01); ***F04B 17/03*** (2013.01); ***F04B 17/05*** (2013.01); ***F04B 17/06*** (2013.01); ***F04B 47/02*** (2013.01); *Y02T 10/6226* (2013.01)

(58) **Field of Classification Search**

USPC ..... 166/280.1, 177.5, 308.2; 290/1 R, 2, 52; 180/53.1, 53.5; 141/231

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,791,682 A 2/1974 Mitchell
4,254,752 A 3/1981 Friddell

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1900973 A1 3/2008
WO WO2012/137068 A2 10/2012

OTHER PUBLICATIONS

Search Report and Written Opinion from corresponding PCT Application No. PCT/US2013/044748 dated Sep. 30, 2013.

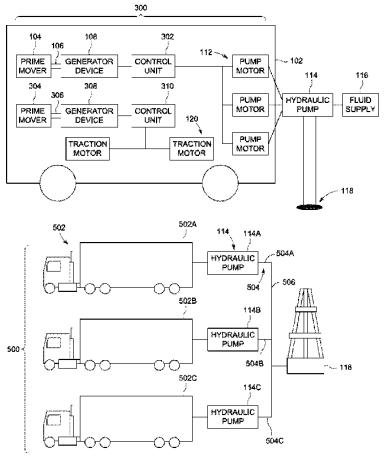
(Continued)

Primary Examiner — Hau Phan
Assistant Examiner — Bryan Evans
(74) *Attorney, Agent, or Firm* — GE Global Patent Operation; John A. Kramer

(57) **ABSTRACT**

A hydraulic pump powering system includes a mobile vehicle, a first electric current generator device, and one or more electric pump motors. The mobile vehicle has first and second prime movers. The first electric current generator device is disposed onboard the mobile vehicle and is configured to be mechanically coupled with the first prime mover to convert movement created by the first prime mover into first electric current. The one or more electric pump motors are configured to receive the first electric current to power a hydraulic pump. The second prime mover is configured to generate movement that is converted into a propulsive force that propels the mobile vehicle. The one or more electric pump motors are configured to receive the first electric current in order to power the hydraulic pump to pump a fluid into a pumping location located off-board the mobile vehicle.

14 Claims, 8 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,322,410	A		6/1984	Anderson, Jr.
4,864,914	A		9/1989	LeMoine
5,441,340	A		8/1995	Baten
5,590,958	A		1/1997	Baten
5,649,418	A	*	7/1997	Ludwig 60/801
6,006,839	A		12/1999	Dearing
2002/0125052	A1		9/2002	Naruse et al.
2007/0204991	A1	*	9/2007	Loree et al. 166/280.1
2009/0236156	A1		9/2009	Promersberger et al.
2010/0181065	A1		7/2010	Ladva et al.
2010/0219007	A1		9/2010	Dalum et al.

OTHER PUBLICATIONS

Wadman, B. W., "2000 HP Gas Turbine Fracturing Rig", Diesel and Gas Turbine Progress, Diesel Engines, Milwaukee, US, vol. 32, No. 8, pp. 36-37, Aug. 1, 1966.

Evolution Well Services, Evolution Well Services Advances Fracturing Operations With An Electrically Powered System, Jun. 4, 2012, Calgary, Alberta, CA.

Joanne Liou, HongHua Group introduces 6,000-hp integrated shale gas system, Drilling Contractor, May 21, 2012.

Unknown, Honghua Group To Launch Integrated Shale Gas Exploitation Solution At OTC 2012, PR Newswire, United Business Media, May 1, 2012, Houston, Texas, USA.

* cited by examiner

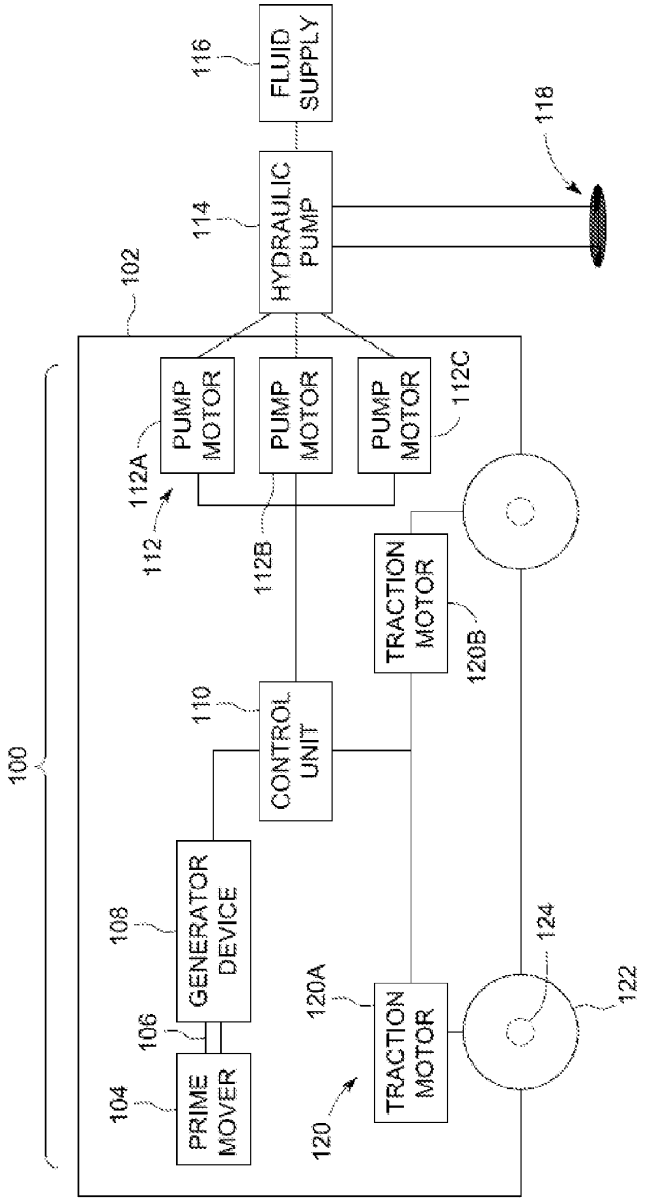

100
102
104
PRIME MOVER
106
108
GENERATOR DEVICE
110
CONTROL UNIT
112
112A
PUMP MOTOR
112B
PUMP MOTOR
112C
PUMP MOTOR
114
HYDRAULIC PUMP
116
FLUID SUPPLY
118
120
120A
TRACTION MOTOR
120B
TRACTION MOTOR
122
124

FIG. 1

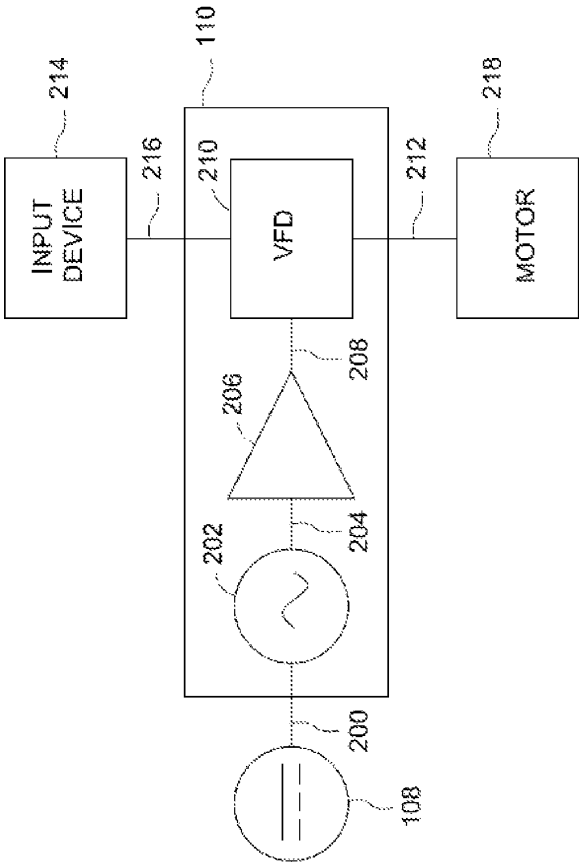

214
110
218
INPUT DEVICE
216
210
VFD
212
MOTOR
208
206
204
202
200
108

FIG. 2

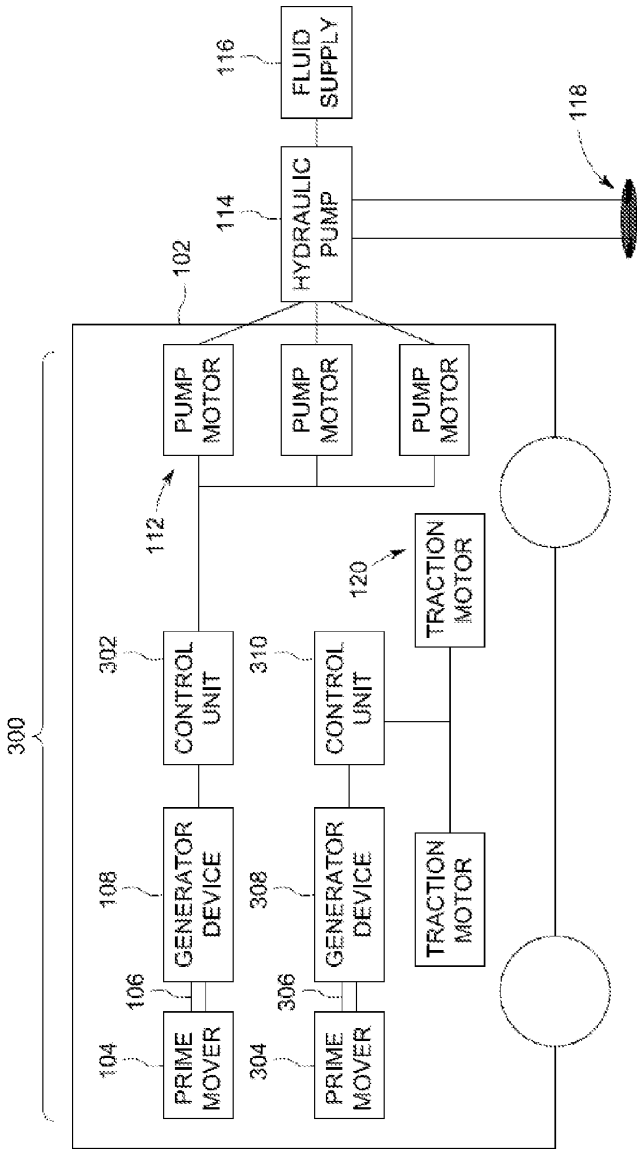

300
102
104
PRIME MOVER
106
108
GENERATOR DEVICE
112
114
HYDRAULIC PUMP
116
FLUID SUPPLY
118
120
TRACTION MOTOR
302
CONTROL UNIT
304
PRIME MOVER
306
308
GENERATOR DEVICE
310
CONTROL UNIT
PUMP MOTOR
PUMP MOTOR
PUMP MOTOR
TRACTION MOTOR

FIG. 3

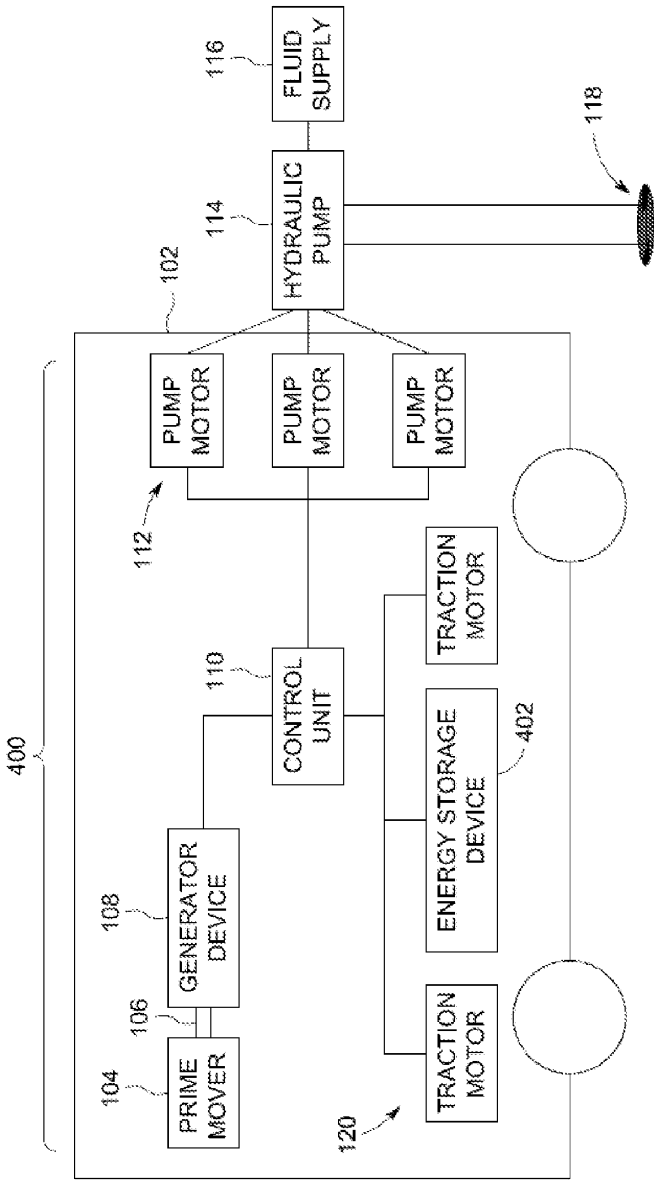

400
FLUID SUPPLY
116
118
HYDRAULIC PUMP
114
102
PUMP MOTOR
PUMP MOTOR
PUMP MOTOR
112
CONTROL UNIT
110
TRACTION MOTOR
ENERGY STORAGE DEVICE
402
GENERATOR DEVICE
108
106
PRIME MOVER
104
TRACTION MOTOR
120

FIG. 4

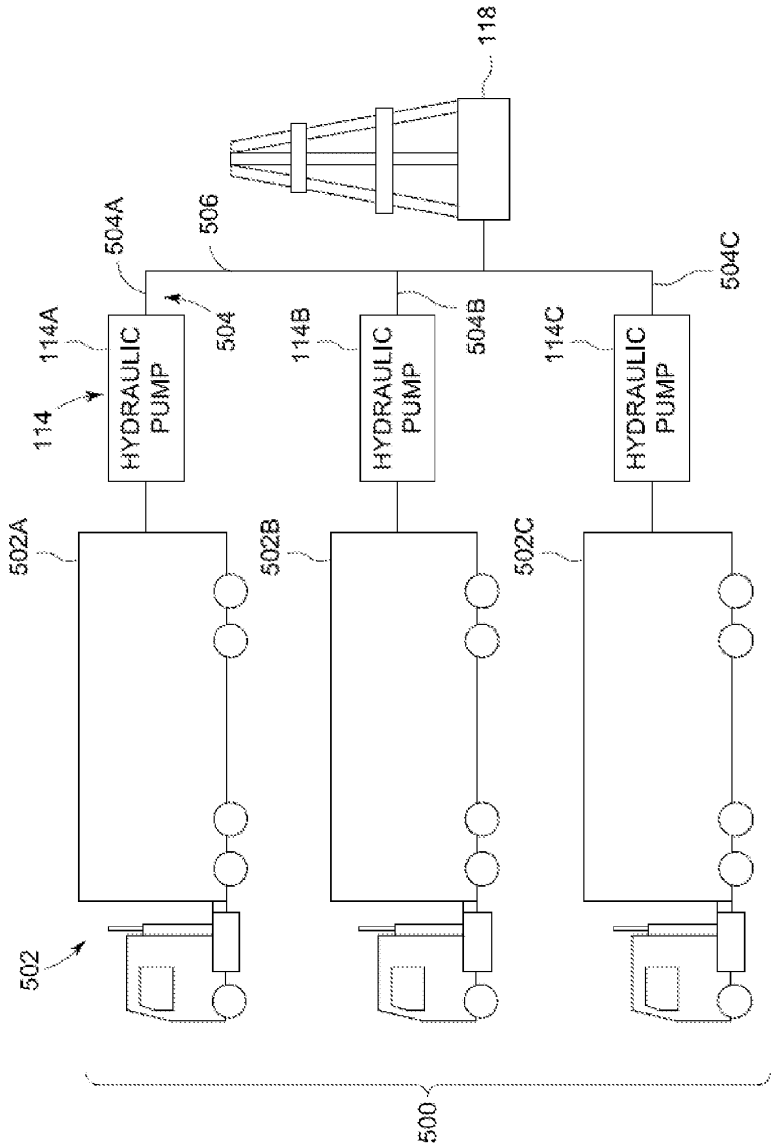

118
506
504A
504
504B
504C
114A
114B
114C
114
HYDRAULIC PUMP
HYDRAULIC PUMP
HYDRAULIC PUMP
502A
502B
502C
502
500

FIG. 5

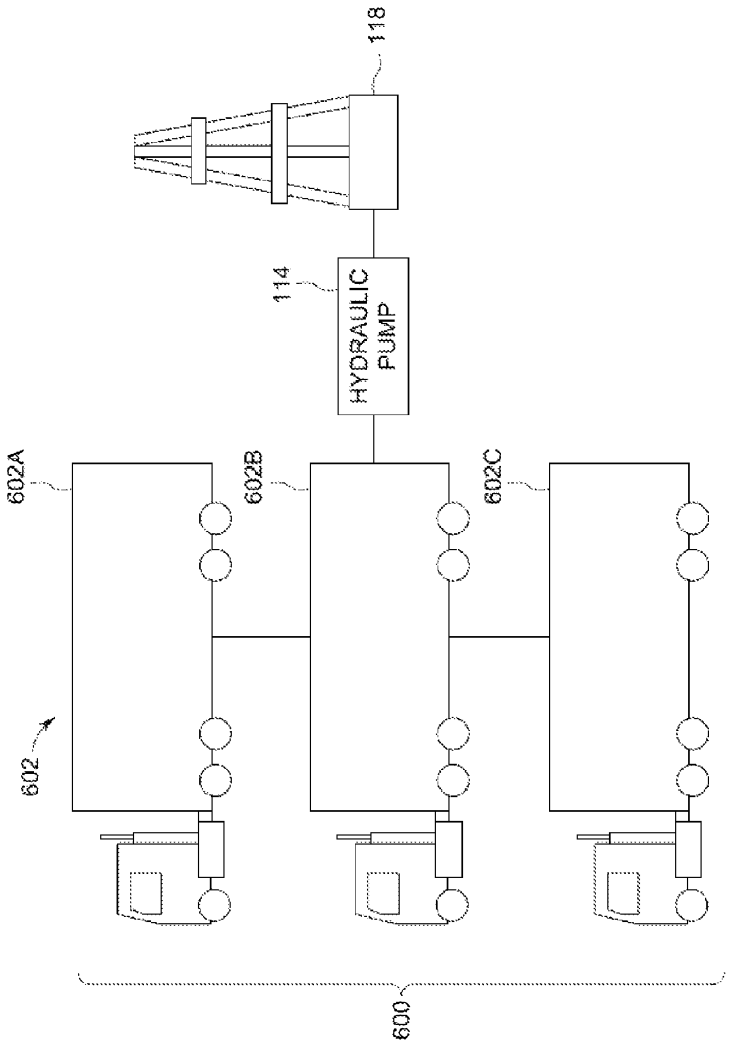


FIG. 6

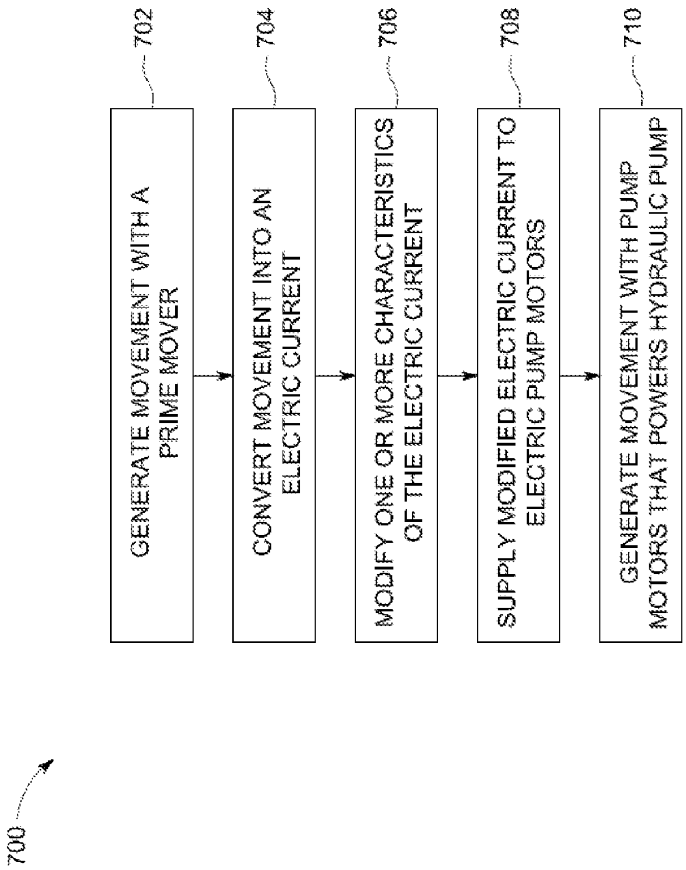

700
702
GENERATE MOVEMENT WITH A PRIME MOVER
704
CONVERT MOVEMENT INTO AN ELECTRIC CURRENT
706
MODIFY ONE OR MORE CHARACTERISTICS OF THE ELECTRIC CURRENT
708
SUPPLY MODIFIED ELECTRIC CURRENT TO ELECTRIC PUMP MOTORS
710
GENERATE MOVEMENT WITH PUMP MOTORS THAT POWERS HYDRAULIC PUMP

FIG. 7

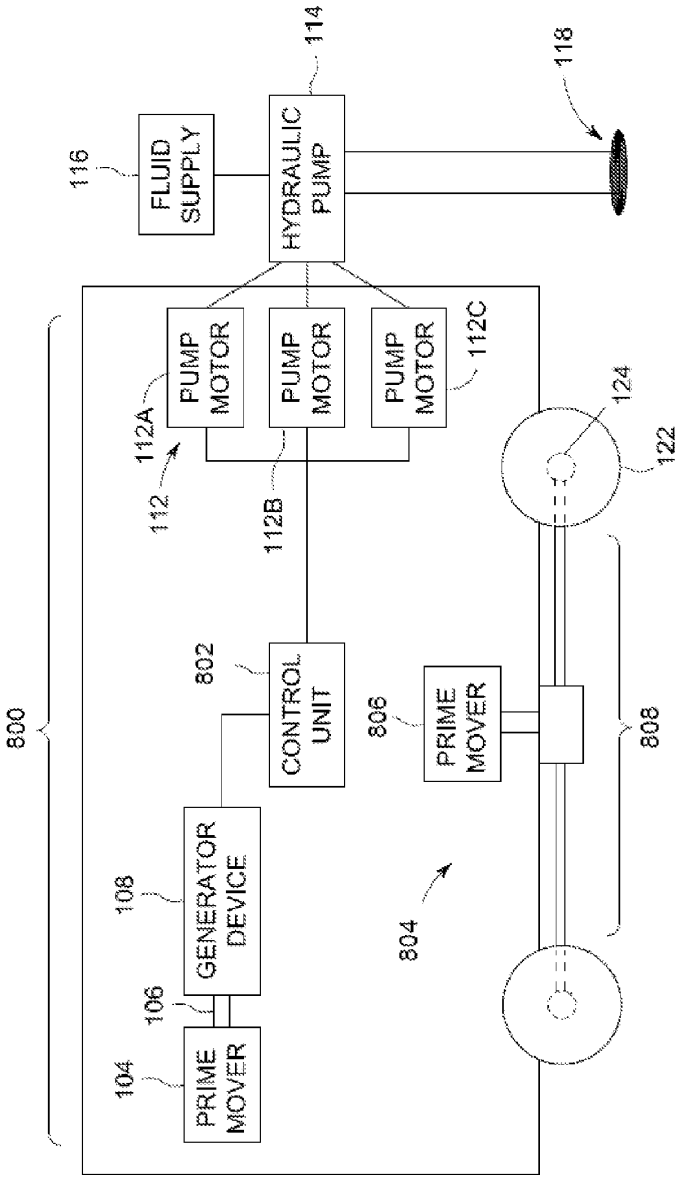

800
116
FLUID SUPPLY
114
HYDRAULIC PUMP
118
112
112A
PUMP MOTOR
PUMP MOTOR
PUMP MOTOR
112C
112B
124
122
802
CONTROL UNIT
806
PRIME MOVER
808
804
108
GENERATOR DEVICE
106
104
PRIME MOVER

FIG. 8

SYSTEM AND METHOD FOR POWERING A HYDRAULIC PUMP

FIELD

Embodiments of the inventive subject matter described herein relate to powering hydraulic pumps.

BACKGROUND

Hydraulic pumps are used to pump fluids from one location to another. For example, hydraulic pumps may be used in hydraulic fracturing to pump fracturing fluid ("fracking fluid") into a well and beneath the surface of the earth to extract resources such as natural gas from within the earth. In another example, cement pumps can be used for a variety of other pressure pumping services, such as pumping cement to a location where the cement is used to form a structure, provide an anchor or secure a casing of a bore that goes into a well, and the like. Other types of pumps, such as mud pumps that carry lubricant to flush drill cuttings from a well, also may be used.

Known systems used to power these hydraulic pumps include mechanical transmissions that mechanically couple a prime mover with the hydraulic pumps. For example, some known systems include a diesel engine as the prime mover, which creates rotational power or movement. This power or movement is transferred through a manual or automatic mechanical and/or hydraulic transmission that includes one or more shafts, gears, pinions, or the like, that are coupled with the diesel engine or other prime mover. The mechanical transmission changes the speed and/or torque of the rotational movement created by the prime mover.

The mechanical transmission also is mechanically coupled with the hydraulic pump by one or more gears, shafts, pinions, or the like. The rotational movement from the prime mover that is modified by the mechanical transmission is provided to the hydraulic pump, such as by coupling an output shaft of the mechanical transmission with the pump to cause the pump to reciprocate (or other means of positive displacement) and force a fluid from one location to another (e.g., into a well).

At least one shortcoming of using such a mechanical transmission is that the mechanical components of the transmission may be limited in how much power can be transferred from the prime mover to the hydraulic pump. Some known mechanical transmissions are limited in the power that can be provided to the hydraulic pumps due to design limitations on the gears, pinions, shafts, torque converters, and the like, that are restricted based upon available space for the mechanical transmissions, gear ratios of the mechanical transmissions, or the like. For example, some known mechanical transmissions that couple a shaft connected with a diesel engine to one or more gears for powering a hydraulic pump may be able to provide up to 2250 or 2500 horsepower (HP), but not in excess of these amounts. The volume of fluid that is pumped by the hydraulic pump (e.g., the fluid flow) is based on this HP that is used to power the hydraulic pump. As a result, the volume of fluid that can be pumped by the hydraulic pump can be limited.

One attempted solution to increase the amount of fluid flow that is provided by the hydraulic pumps is to fluidly couple several hydraulic pumps that are powered by different systems together so that the cumulative flow of the fluid that is generated by the hydraulic pumps is increased. Given the large sizes of the mechanical transmissions and the limits on power that can be provided by the mechanical transmissions, however, a relatively large number of such mechanical transmissions and the vehicles that carry the transmissions may be needed to supply adequate power to the hydraulic pumps. As a result, many of these vehicles, transmissions, and pumps may need to be located in relatively close proximity at a pumping location (e.g., wellhead) which can create a large degree of congestion at or near the pumping location.

BRIEF DESCRIPTION

In one embodiment, another hydraulic pump powering system includes a mobile vehicle, a first electric current generator device, and one or more electric pump motors. The mobile vehicle has first and second prime movers. The first electric current generator device is disposed onboard the mobile vehicle and is configured to be mechanically coupled with the first prime mover to convert movement created by the first prime mover into first electric current. The term "coupled" (and forms thereof) can include a direct coupling between two components or objects, or an indirect coupling between the two components, with one or more intermediate components disposed therebetween. The term "electric current" can include one or more forms of electric energy, such as direct current or voltage, alternating current (having fixed or variable frequencies), an electric data signal, or other electric output. The one or more electric pump motors are configured to receive the first electric current to power a hydraulic pump. The second prime mover is configured to generate movement that is converted into a propulsive force that propels the mobile vehicle and the one or more electric pump motors are configured to be powered by the first electric current in order to power the hydraulic pump to pump a fluid into a pumping location located off-board the mobile vehicle.

In another embodiment, another hydraulic pump powering system includes a mobile vehicle, an electric current generator device, a control unit, one or more electric traction motors, and one or more electric pump motors. As used herein, the term "unit" includes a hardware and/or software system that operates to perform one or more functions. For example, a unit may include a computer processor, controller, or other logic-based device that performs operations based on instructions stored on a tangible and non-transitory computer readable storage medium, such as a computer memory. Alternatively, a unit may include a hard-wired device that performs operations based on hard-wired logic of the device. The units shown in the attached figures may represent the hardware that operates based on software or hardwired instructions, the software that directs hardware to perform the operations, or a combination thereof.

The mobile vehicle includes a prime mover. The electric current generator device is disposed onboard the mobile vehicle and is mechanically coupled with the prime mover. The electric current generator device is configured to convert movement of the prime mover into a first electric current. The control unit is disposed onboard the mobile vehicle and is configured to convert the first electric current from the electric current generator device into a modified electric current. The control unit may automatically operate and/or may be controlled by manual inputs. The one or more electric traction motors are coupled with at least one of axles or wheels of the mobile vehicle. The one or more electric traction motors are configured to propel the mobile vehicle. The one or more electric pump motors are disposed onboard the mobile vehicle and are configured to power a hydraulic pump to pump a fluid into a pumping location disposed off-board the mobile vehicle. The control unit is configured to control when the modified electric current is supplied to the one or more

U.S. Well - Exhibit 2015
Liberty v. U.S. Well - IPR2024-01274
Page 11 of 22

electric traction motors to propel the mobile vehicle and when the modified electric current is supplied to the one or more electric pump motors to power the hydraulic pump.

In another embodiment, another hydraulic pump powering system includes a mobile vehicle, an electric current generator device, one or more electric pump motors, one or more electric traction motors, and a control unit. The electric current generator device is mechanically coupled with a prime mover of the mobile vehicle to generate electric current. The one or more electric pump motors are disposed on board the vehicle and are configured to receive the electric current and to power a hydraulic pump using the electric current. The one or more electric traction motors are disposed on board the vehicle and are configured to receive the electric current to propel the vehicle. The control unit is disposed onboard the vehicle and is configured to control a frequency of the electric current that is supplied to the one or more electric pump motors in order to control flow of a fluid that is pumped into a pumping location disposed off-board of the vehicle by the hydraulic pump.

In another embodiment, a method (e.g., for powering a hydraulic pump) includes converting movement of a prime mover disposed onboard a mobile vehicle into an electric current, directing the electric current to one or more electric traction motors of the vehicle to propel the vehicle during a first time period, and directing the electric current to one or more electric pump motors disposed onboard the mobile vehicle to power the hydraulic pump disposed off-board the vehicle during a second time period. The electric current is directed to the one or more electric pump motors to pump a fluid into a pumping location that is disposed off-board the mobile vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference is now made briefly to the accompanying drawings, in which:

FIG. **1** is a schematic view of one embodiment of a mobile hydraulic pump powering system;

FIG. **2** is a circuit diagram of one embodiment of a control unit shown in FIG. **1**;

FIG. **3** is a schematic view of another embodiment of a mobile hydraulic pump powering system;

FIG. **4** is a schematic view of another embodiment of a mobile hydraulic pump powering system;

FIG. **5** illustrates one embodiment of a scalable mobile hydraulic pump powering system;

FIG. **6** illustrates one embodiment of a distributed mobile hydraulic pump powering system;

FIG. **7** is a flowchart of one embodiment of a method for electrically powering a hydraulic pump; and

FIG. **8** is a schematic view of another embodiment of a mobile hydraulic pump powering system.

DETAILED DESCRIPTION

In accordance with one or more embodiments described herein, a hydraulic pump powering system is provided that includes a power source that generates or provides electric energy (e.g., such as electric current, which can include direct current and/or alternating current, an electric signal, or other electric output), electric power transmission or conversion components that modify the electric current (e.g., increase or decrease voltage, modify a frequency of the current, and the like), and pumps that are used to deliver pressurized fluids for one or more purposes, such as hydraulic fracturing, well stimulation, and the like. As one example, the power source can include a prime mover such as an internal combustion engine or gas turbine that rotates and produces torque at a controllable speed. In one embodiment, the prime mover includes a turbine that is powered by natural gas. Alternatively, the prime mover can include another device, such as an internal combustion engine. The power transmission components may be electronic components, such as electric alternators or generators that produce electric power (e.g., alternating current having fixed or variable frequency or direct current, such as a voltage) that is directed to a variable-frequency drive, which can modify the current and deliver the modified current to drive one or more electric motors. The electric motors can be mechanically coupled with one or more hydraulic pumps (e.g., reciprocating pumps, positive-displacement pumps, or other pumps) to power the pumps and force highly pressurized fluids, mixtures, gels, and the like, for fracturing or other stimulation of a well that extends into the earth for opening geological formations to extract one or more resources, such as natural gas, oil, and the like. Additionally or alternatively, the systems may power pumps that deliver other fluids to an area, such as cement pumps that supply cement to a building location or drilling location, mud pumps that deliver slurries, mud, and the like, or other pumps.

The use of electric transmissions and electric pump motors can reduce the space consumed by the systems that power a hydraulic pump. For example, the electric transmissions and pump motors described herein can provide the same or greater power to a hydraulic pump as mechanical transmissions (e.g., systems that use gears, pinions, and the like, to translate mechanical movement from a prime mover into mechanical movement that powers the hydraulic pump) while taking up less space at a pumping location, such as a wellhead. Additionally, the systems described herein can be combined to increase the power supplied to the hydraulic pump while taking up less space at the pumping location than multiple combined systems that use mechanical transmissions.

The use of electric transmissions and electric pump motors can reallocate the distribution of equipment at or near a wellhead. For example, the prime movers that generate movement used to create electric current and/or the generators or alternators that create the electric current can be disposed farther from the wellhead relative to hydraulic or mechanical systems. As a result, other equipment can be moved to the locations previously occupied by the prime movers and mechanical transmissions.

Removing the mechanical transmission that translates movement between the engine and the hydraulic pump also can reduce or eliminate the mechanical limitations on the power that can be provided to the hydraulic pump to pump the fluid at the pumping location. For example, discrete gear ratios used in the mechanical transmission may no longer be required and a more continuous power output may be provided by the electrically powered pump motors. With some prime movers (e.g., diesel engines as one example), the amount of HP that can be generated may be significant. Electrically transferring the energy generated by these prime movers to electric pump motors that power a hydraulic pump can eliminate or increase the limitations on the amount of HP that is transferred to the hydraulic pump for powering the pump. For example, the HP that can be provided to the hydraulic pump by a single prime mover and via an electrical transmission may be in excess of 2500 HP. As one example, the HP can be increased up to 2700 HP. In another embodiment, the HP can be increased up to 3000 HP. In yet another embodiment, the HP can be increased up to 3500 HP. Alternatively, another HP may be provided, such as a HP that is greater, below, or between one or more of the preceding enumerated HP.

U.S. Well - Exhibit 2015
Liberty v. U.S. Well - IPR2024-01274
Page 12 of 22

FIG. **1** is a schematic view of one embodiment of a hydraulic pump powering system **100**. The system **100** may be disposed onboard a mobile vehicle **102** that is capable of propelling itself such that the system **100** can be moved between a variety of different locations. Alternatively, the system **100** may be disposed onboard a trailer that is coupled with the mobile vehicle **102** that pulls or pushes the trailer between the different locations. For example, the vehicle **102** may represent a truck pulling a trailer with the system **100** disposed onboard the truck and/or trailer. As used herein, the term "vehicle" can refer to the component that includes the propulsion subsystem (e.g., the engine, motors, and the like) that propel the vehicle (e.g., the truck, automobile, or the like) and/or the combination of the component that includes the propulsion subsystem and a trailer that is coupled thereto and on which the system **100** is disposed. Alternatively, the vehicle **102** may represent another type of vehicle, such as a rail vehicle, a marine vessel, another off-highway vehicle, or other type of vehicle.

In the illustrated embodiment, the system **100** includes or is joined with a prime mover **104**. The prime mover **104** includes one or more assemblies that convert energy from one form to another, such as an engine (e.g., an internal combustion engine) or turbine (e.g., a turbine powered by natural gas) that converts stored energy from fuel into movement (e.g., rotation) of a shaft **106**. The prime mover **104** can represent an internal combustion engine that rotates the shaft **106** and produces torque at an engine speed. The engine of the prime mover **104** can be a reciprocating engine (e.g., that uses compression ignition, spark ignition, and the like), a rotating turbine design, an external combustion engine (e.g., steam engine), an internal combustion engine (e.g., reciprocating piston design, rotating turbine design, and the like), or another type of engine. In another embodiment, the prime mover **104** may not be disposed onboard the vehicle. For example, the prime mover **104** may be disposed onboard another vehicle and coupled with the system **100**.

The prime mover **104** is connected with an electric power transmission subsystem that converts the movement generated by the prime mover **104** into electric energy (e.g., current) that powers one or more electric pump motors **112** (e.g., pump motors **112**A-C). The electric power transmission subsystem includes an electric current generator device **108** that converts movement created by the prime mover **104** into electric current. For example, the generator device **108** of the system **100** may include or represent a generator that creates direct current from rotation of the shaft **106**, an alternator that creates alternating current from rotation of the shaft **106**, or another device that generates electric current based on movement created by the prime mover **104**. In one embodiment, the generator device **108** can be a self-excited, field-excited, or other alternator or generator.

The electric current created by the prime mover **104** and the generator device **108** is supplied to control unit **110**. Alternatively or additionally, a power storage device, such as one or more batteries, fuel cells, and the like, may be used in addition to or in place of the prime mover **104** and generator device **108** to supply the electric current to the control unit **110**. For example, the combination of the prime mover **104** and the generator device **108** may represent an onboard power storage device that supplied electric current to the control unit **110**.

The control unit **110** receives the electric current created by the generator device **108** and modifies the electric current. The control unit **110** can modify the electric current by changing one or more characteristics of the current, such as a frequency of the current, a voltage, and the like. For example, in one embodiment, the control unit **110** may receive a direct current (e.g., having zero frequency) from the generator device **108**. The control unit **110** may increase or decrease the voltage of the direct current (e.g., using one or more transformers and the like) and/or convert the direct current into an alternating current having a designated number of phases, a designated frequency, and/or a designated power. An alternator may be included in the control unit **110** to change the direct current received from the generator device **108** into an alternating current, for example.

The control unit **110** may then convert the alternating current into a second direct current. For example, the control unit **110** may include one or more inverters that convert the alternating current created by the alternator into a second direct current. This second direct current may differ from the first direct current that is created by the generator device **108**. For example, the second direct current from the inverters may have a different energy (e.g., voltage) or other electric characteristic than the first direct current from the generator device **108**.

The control unit **110** may then again modify this second direct current into another alternating current, such as a variable frequency alternating current. The variable frequency alternating current may have a frequency that is controlled by the control unit **110**. The control unit **110** may vary the frequency of the alternating current in order to control the speeds at which one or more electric motors operate. For example, the variable frequency alternating current from the control unit **110** may be supplied to the electric motors to power the motors. The control unit **110** may increase the frequency of the variable frequency alternating current in order to increase the speed of the motors and/or decrease the frequency to decrease the speed of the motors. In one embodiment, the control unit **110** may vary the frequency of the alternating current based on manual input from an operator of the system **100**. Additionally or alternatively, the control unit **110** may automatically control the frequency. For example, the control unit **110** may change the frequency over time to match one or more previously designated frequencies. The control unit **110** can automatically change the frequency in response to input provided by one or more sensors or other devices. For example, the control unit **110** may receive analog and/or digital input signals from sensors, such as pressure transducers that measure the pressure of the fluid being pumped by the system **100**. The control unit **110** can automatically change the frequency of the current based on these input signals. As one example, if the input signal indicates that the pressure of the fluid being pumped has decreased below a designated threshold, the control unit **110** may increase the frequency of the current in order to increase the speed of the pump motors. Conversely, if the input signal indicates that the pressure has increased above a designated threshold (the same or a different threshold), the control unit **110** may decrease the frequency of the current to decrease the speed of the pump motors and/or turn off the pump motors.

In one embodiment, the generator device **108** outputs a direct current (e.g., a voltage) that is conveyed to a silicon-controlled rectifier (SCR) of the control unit **110**. The SCR converts the voltage (e.g., by controlling when the voltage flows through the control unit **110**) before supplying the voltage to the pump motors **112** that include DC motors. In another embodiment, the generator device **108** outputs an alternating current that is supplied to a rectifier of the control unit **110**. The rectifier converts the alternating current into a direct current (e.g., a voltage) that is supplied to an SCR of the control unit **110**. The SCR then controls the flow of the voltage to the pump motors **112** that include DC motors. In

another embodiment, the generator device **108** outputs an alternating current that is supplied to a rectifier of the control unit **110**. The rectifier converts the alternating current into a direct current (e.g., a voltage) that is supplied to an inverter of the control unit **110**. The inverter converts the voltage into an alternating current that is supplied to a variable frequency device (VFD) of the control unit **110**. The VFD controls the frequency of the alternating current that is then supplied to the pump motors **112**.

The system **100** includes the pump motors **112** that receive the current that is output from the control unit **110**. For example, the pump motors **112** may be conductively coupled with the control unit **110** by one or more conductive pathways (e.g., cables, buses, and the like). The current that is output from the control unit **110** may be referred to as modified current. While three pump motors **112** are shown, alternatively, the system **100** may include a different number of pump motors **112**, such as a single pump motor **112**, two pump motors **112**, or four or more pump motors **112**.

The control unit **110** can supply a relatively large amount of electric energy (e.g., direct current or voltage, alternating current having fixed or variable frequencies, and the like) to power the pump motors **112**. For example, the control unit **110** can supply at least 700 kilowatts of electric power to the pump motors **112**. As another example, the control unit **110** can supply at least 750 kilowatts to the pump motors **112**. In another example, the control unit **110** can supply at least 1000 kilowatts to the pump motors **112**. Alternatively, the control unit **110** can supply at least 1500 kilowatts to the pump motors **112**. In another embodiment, the control unit **110** can supply at least 1850 kilowatts to the pump motors **112**. The control unit **110** alternatively may supply a different electric power to the pump motors **112**.

With respect to voltage, the control unit **110** can supply at least 400 volts to the pump motors **112**. As another example, the control unit **110** can supply at least 600 volts to the pump motors **112**. In another example, the control unit **110** can supply at least 690 volts to the pump motors **112**. The control unit **110** alternatively may supply a different voltage to the pump motors **112**.

The pump motors **112** can be mechanically coupled with one or more hydraulic pumps **114** in order to power the hydraulic pumps **114**. For example, the pump motors **112** may be connected with the hydraulic pump **114** by one or more shafts, axles, or other components such that rotation of the pump motors **112** causes the hydraulic pump **114** to pump (e.g., force) fluid from a fluid supply **116** into a pumping location **118**. The hydraulic pump **114** may be one or more of a variety of pumps, such as a reciprocating pump, a positive-displacement pump, or another pump.

In the illustrated embodiment, the hydraulic pump **114** is fluidly coupled with the fluid supply **116** that represents one or more containers of fluid. The hydraulic pump **114** can be powered by the pump motors **112** to load a fluid, such as fracturing fluid, mixture, or another fluid, from the fluid supply **116** into the pumping location **118** (e.g., via one or more conduits). The pumping location **118** can represent a wellhead of a well, such as an oil or gas well. The fluid may be pumped into the pumping location **118** to extract one or more resources from beneath the pumping location **118**, such as natural gas from rock layers beneath the surface of the earth. Alternatively or additionally, the hydraulic pump **114** may be used to pump fluid out of the pumping location **118**. The speed at which the pump motors **112** operate may be controlled by the frequency of the alternating current that powers the pump motors **112**. For example, the pump motors **112** may be alternating current induction motors. Alternatively, the pump motors **112** may be permanent magnet motors, switched reluctance motors, a direct current motor, or another type of motors.

The hydraulic pump **114** can be powered by the pump motors **112** to pump a relatively large amount of fluid at the pumping location **118**. For example, the hydraulic pump **114** can be powered by the pump motors **112** to pump fluid at a rate of at least two gallons (or 7.5 liters) per minute per revolution of the hydraulic pump **114**. As another example, the hydraulic pump **114** can be powered by the pump motors **112** to pump fluid at a rate of at least 2.5 gallons (or 9.5 liters) per minute per revolution of the hydraulic pump **114**. In another embodiment, the hydraulic pump **114** can be powered by the pump motors **112** to pump fluid at a rate of at least 2.75 gallons (or 10.4 liters) per minute per revolution of the hydraulic pump **114**. Alternatively, the hydraulic pump **114** can be powered by the pump motors **112** to pump fluid at another rate.

The vehicle **102** may be sized to move in relatively close proximity to the pumping location **118** (e.g., within a few dozen or hundred feet or meters) in order to power the hydraulic pump **114** that is disposed at the pumping location **118**. For example, the vehicle **102** may drive or otherwise move up to the hydraulic pump **114**. An operator may couple the pump motors **112** disposed onboard the vehicle **102** with the hydraulic pump **114** so that the pump motors **112** can power the hydraulic pump **114**.

In the illustrated embodiment, the control unit **110** also may be conductively coupled with one or more traction motors **120** (e.g., traction motors **120**A, **120**B) of the vehicle **102**. While two traction motors **120** are shown, alternatively, a single traction motor **120** or more than two traction motors **120** may be provided onboard the vehicle **102**. The traction motors **120** are connected with wheels **122** and/or axles **124** of the vehicle **102**. The traction motors **120** may be powered by the modified current provided by the control unit **110** in order to rotate the axles **124** and/or wheels **122** of the vehicle **102** to cause the vehicle **102** to propel itself along a surface, such as the surface of the earth, a road, a waterway, a track, and the like. For example, at least some of the movement created by the prime mover **104** may be converted into electric energy (e.g., current) that is supplied to the traction motors **120** for generating a propulsive force that propels the vehicle **102** along a surface. The control unit **110** provides the modified current to both the pump motors **112** and the traction motors **120** in the illustrated embodiment to both power the hydraulic pump **114** and the propel the vehicle **102**. The control unit **110** may include one or more switches, contactors, and the like, to control which motors **112**, **120** receive the modified current. For example, when the vehicle **102** is moving toward the pumping location **118**, the control unit **110** may supply the modified current to the traction motors **120** and not to the pump motors **112**. When the vehicle **102** is at the pumping location **118**, the control unit **110** may then supply the modified current to the pump motors **112** and not to the traction motors **120**.

The system **100** shown in FIG. **1** may be able to power the hydraulic pump **114** to pump relatively large amounts of fluid. For example, a single mobile vehicle **102** having the system **100** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 200 gallons (or 757 liters) of fluid per minute. As another example, a single mobile vehicle **102** having the system **100** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 300 gallons (or 1,135 liters) of fluid per minute. In another embodiment, a single mobile vehicle **102** having the

system **100** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 380 gallons (or 1,438 liters) of fluid per minute. Alternatively, a single mobile vehicle **102** having the system **100** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump a different amount of fluid per minute.

FIG. **2** is a circuit diagram of one embodiment of the control unit **110** shown in FIG. **1**. The control unit **110** can receive first direct current **200** from the generator device **108**, as described above. An alternator **202** of the control unit **110** may receive the first direct current **200**. The alternator **202** may convert this first direct current **200** into an alternating current **204** that is supplied to an inverter **206**. The inverter **206** converts the alternating current **204** into a second direct current **208**. The inverter **206** may generate the second direct current **208** to have a designated voltage. For example, the inverter **206** may be formed and/or connected with the alternator **202** such that the inverter **206** creates the second direct current **208** having a designated voltage or a voltage within a designated range, independent or regardless of the frequency and/or phases of the alternating current **204** received from the alternator **202**.

A variable frequency device **210** of the control unit **110** receives the second direct current **208** from the inverter **206** and forms a variable frequency alternating current **212** from the second direct current **208**. In one embodiment, the variable frequency device **210** represents or includes a variable frequency drive having one or more diodes, capacitors, inverters, and the like, that operate to convert the direct current **208** into the alternating current **212** having a designated frequency. The variable frequency device **210** may automatically change the direct current **208** to the variable frequency alternating current **212** by generating the alternating current **212** to have a designated frequency (e.g., predetermined or based on an input signal from a sensor) without manual input. Alternatively, the variable frequency device **210** may generate the alternating current **212** to have a frequency that is selected by an input device **214**. The input device **214** can include a keyboard, touch screen, stylus, electronic mouse, microphone, wireless device, or other device that receives input from a human operator to control the frequency of the alternating current **212**. For example, the input device **214** may be disposed onboard the vehicle **102** and receive the input from the operator disposed onboard the vehicle **102** (shown in FIG. **1**) that indicates a designated frequency of the alternating current **212**. The input device **214** can communicate a control signal **216** to the variable frequency device **210** that represents or includes this designated frequency.

As described above, the variable frequency alternating current **212** is supplied from the control unit **110** (e.g., from the variable frequency device **210**) to an electric motor **218** to power the motor **218**. The motor **218** shown in FIG. **2** may represent one or more of the pump motors **112** and/or traction motors **120** shown in FIG. **1**. The speed at which the motor **218** operates can be controlled by changing the frequency of the alternating current **212** that powers the motor **218**, also as described above. In another embodiment, the control unit **110** may generate a direct current that is supplied to the pump motors **112** to power the motors **112**.

FIG. **3** is a schematic view of another embodiment of a hydraulic pump powering system **300**. The system **300** may be similar to the system **100** shown in FIG. **1**. For example, the system **300** may be disposed onboard the vehicle **102**. Similar to the system **100**, the system **300** may include the prime mover **104**, shaft **106**, and generator device **108** that are coupled with a control unit **302**. The control unit **302** may be similar to the control unit **110** shown in FIG. **1** in that the control unit **302** may convert current received from the generator device **108** into a variable frequency alternating current that is supplied to the pump motors **112** for powering the hydraulic pump **114**, as described above.

One difference between the control unit **302** of FIG. **3** and the control unit **110** of FIG. **1** is that the control unit **302** may not power the traction motors **120** of the vehicle **102**. For example, the control unit **302** may be used to control the frequency of the alternating current used to power the motors **112** and, as a result, speed of the pump motors **112**, but not the frequency of the current supplied to the traction motors **120** or the speed of the motors **120**. Instead, a second prime mover **304**, shaft **306**, generator device **308**, and control unit **310** may be provided. The prime mover **304** may be similar to the prime mover **104**, the shaft **306** may be similar to the shaft **106**, and the generator device **308** may be similar to the generator device **108**. For example, the prime mover **304** may rotate the shaft **306** and the generator device **308** may create an electric current based on this rotation of the shaft **306**. Alternatively, a single prime mover **104** or **304** and shaft **106** or **306** may be provided, with the generator devices **108**, **308** both coupled with the same shaft **106** or **306** to separately generate electric currents.

The control unit **310** may be similar to the control units **110** and/or **302** in that the control unit **310** may receive a direct current from the generator device **308**, modify the current (such as by changing the current to an alternating current and controlling a frequency of the alternating current), and supply the modified current to the traction motors **120** to power the motors **120** and control the speeds of the motors **120**, as described above in connection with the control unit **110**. In the illustrated embodiment, the generator device **108** and control unit **302** used to power and control the pump motors **112** are separate from the generator device **308** and control unit **310** used to power and control the traction motors **120**. The generator device **308** and control unit **310** may be part of a propulsion subsystem of the vehicle **102** that is used to propel the vehicle **102** while the generator device **108** and the control unit **110** is part of the system **300** that is used to power the pump motors **112**, as described above.

The system **300** shown in FIG. **3** may be able to power the hydraulic pump **114** to pump relatively large amounts of fluid. For example, a single mobile vehicle **102** having the system **300** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 200 gallons (or 757 liters) of fluid per minute. As another example, a single mobile vehicle **102** having the system **300** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 300 gallons (or 1,135 liters) of fluid per minute. In another embodiment, a single mobile vehicle **102** having the system **300** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 380 gallons (or 1,438 liters) of fluid per minute. Alternatively, a single mobile vehicle **102** having the system **300** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump a different amount of fluid per minute.

FIG. **8** is a schematic view of another embodiment of a hydraulic pump powering system **800**. The system **800** may be similar to the system **100** shown in FIG. **1**. For example, the system **800** may be disposed onboard the vehicle **102**. In one embodiment, the system **800** is disposed onboard the same vehicle **102** that also includes a propulsion subsystem **804** that acts to propel the vehicle **102**. In another embodiment,

the system **800** is disposed onboard a trailer or other vehicle that is coupled with the vehicle **102** having the propulsion subsystem **804**.

The system **800** may include the prime mover **104**, shaft **106**, and generator device **108** that are coupled with a control unit **802**. The control unit **802** may be similar to the control unit **110** and/or **302** shown in FIGS. **1** and **3** in that the control unit **802** may convert current received from the generator device **108** into a variable frequency alternating current that is supplied to the pump motors **112** for powering the hydraulic pump **114**, as described above.

One difference between the system **800** and the system **300** is that the system **800** is used with a vehicle **102** that is not propelled by electric current generated by a prime mover and electric current generator device. For example, the vehicle **102** may include the propulsion subsystem **804** that includes a prime mover **806** that is mechanically interconnected with the wheels **122** and/or axles **124** of the vehicle **102** by a transmission system **808**. The transmission system **808** can include mechanical gears **810**, shafts **812** (e.g., a driveshaft), and the like, for translating rotary movement created by the prime mover **806** into rotation of the axles **124** and wheels **122** to propel the vehicle **102**. The prime mover **806** can represent an engine, such as an internal combustion engine, as one example.

In operation, the prime mover **806** of the propulsion subsystem **804** generates movement that is converted into a propulsive force that propels the vehicle **102**. For example, the rotary movement created by the prime mover **806** is mechanically translated (e.g., using gears and the like) into a propulsive force that rotates the wheels **122** to propel the vehicle **102** by the transmission system **808**. The movement generated by the prime mover **806** is not used to power the pump motors **112** or the hydraulic pump **114** in the illustrated embodiment. The prime mover **104** of the powering system **800**, however, generates movement that is converted into electric energy that is used to power the pump motors **112**, which power the hydraulic pump **114**, as described above. By keeping the powering system **800** and the propulsion subsystem **804** separate from each other, the powering system **800** may be more easily added to an existing vehicle **102**. For example, the powering system **800** may be added to an existing vehicle **102**, such as by loading the system **800** onboard a trailer that is pulled by the vehicle **102**.

The system **800** shown in FIG. **8** may be able to power the hydraulic pump **114** to pump relatively large amounts of fluid. For example, a single mobile vehicle **102** having the system **800** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 200 gallons (or 757 liters) of fluid per minute. As another example, a single mobile vehicle **102** having the system **800** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 300 gallons (or 1,135 liters) of fluid per minute. In another embodiment, a single mobile vehicle **102** having the system **800** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 380 gallons (or 1,438 liters) of fluid per minute. Alternatively, a single mobile vehicle **102** having the system **800** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump a different amount of fluid per minute.

FIG. **4** is a schematic view of another embodiment of a hydraulic pump powering system **400**. The system **400** may be similar to the system **100** shown in FIG. **1**. For example, the system **400** may be disposed onboard the vehicle **102**. Similar to the system **100**, the system **400** may include the prime mover **104**, shaft **106**, and generator device **108** that are coupled with the control unit **110**. As described above, the control unit **110** may convert current received from the generator device **108** into a variable frequency alternating current that is supplied to the pump motors **112** for powering the hydraulic pump **114**, as described above. The control unit **110** also may provide the alternating current to the traction motors **120** for propelling the vehicle **102**. Alternatively, another propulsion subsystem of the vehicle **102** may power the traction motors **120**, as described above in connection with FIG. **3**.

The system **400** shown in FIG. **4** may be able to power the hydraulic pump **114** to pump relatively large amounts of fluid. For example, a single mobile vehicle **102** having the system **400** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 200 gallons (or 757 liters) of fluid per minute. As another example, a single mobile vehicle **102** having the system **400** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 300 gallons (or 1,135 liters) of fluid per minute. In another embodiment, a single mobile vehicle **102** having the system **400** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump at least 380 gallons (or 1,438 liters) of fluid per minute. Alternatively, a single mobile vehicle **102** having the system **400** disposed onboard the vehicle **102** and coupled with the hydraulic pump **114** may power the pump **114** to pump a different amount of fluid per minute.

One difference between the system **400** of FIG. **4** and the system **100** of FIG. **1** is that the system **400** includes an onboard energy storage device **402**. The energy storage device **402** may include a battery, flywheel, capacitor, fuel cell, and the like, that stores energy for powering one or more loads of the vehicle **102**. For example, the energy storage device **402** may provide electric current to the traction motors **120** to power the traction motors **120** and propel the vehicle **102** and/or to the pump motors **112** to power the hydraulic pump **114** or pumps **114**.

The control unit **110** may output the variable frequency alternating current to the energy storage device **402** and the energy storage device **402** may modify the alternating current for storage in the device **402**. For example, the energy storage device **402** may convert the alternating current to a direct current for storage in the device **402**. Alternatively, the control unit **110** may output a direct current to the energy storage device **402** instead of an alternating current.

The energy storage device **402** may be used to power one or more of the pump motors **112**. For example, instead of using electric current generated by the generator device **108** from movement created the prime mover **104** to power the pump motors **112**, the energy storage device **402** may power the pump motors **112**. Alternatively, the energy storage device **402** may supplement the current that is supplied to the pump motors **112** from the generator device **108** so that the pump motors **112** receive additional electric current above the electric current that is obtained from the generator device **108**. The energy storage device **402** can supply direct current to the control unit **110**, which may convert the direct current into a variable frequency alternating current, as described above. For example, the direct current that is supplied from the energy storage device **402** to the control unit **110** may be received similar to the direct current that is received from the generator device **108**. The direct current may be modified into an alternating current, then changed into a direct current, and then modified into the variable frequency alternating current that is supplied to the pump motors **112**, as described above.

Additionally or alternatively, the energy storage device **402** may power one or more of the traction motors **120** to supplement or replace the electric current provided from the generator device **108**.

The electric current that is output from the control unit **110** may be used to charge the energy storage device **402**. Additionally or alternatively, the energy storage device **402** may be charged using one or more regenerative techniques, such as by regenerating energy from braking of the vehicle using the traction motors and charging the energy storage device **402** with this energy. In one embodiment, the control unit **110** may apply a cyclic loading technique that involves cycling between directing the electric current to the energy storage device **402** and one or more of the pump motors **112** and/or traction motors **110** at different time periods.

In one embodiment, the electric current that is output by the control unit **110** also is used to power one or more other electric loads, such as auxiliary loads of the vehicle. An "auxiliary load" includes an electric load that consumes electric current to perform work other than propelling the vehicle. Examples of such loads include, but are not limited to, radiator blowers, air compressors, air conditioners, power steering, power brakes, and the like. Other examples of such loads can include equipment that mixes the fluid that is pumped by the system, such as a fracking fluid blender.

As shown in FIGS. **1** through **4**, the powering system that generates, converts, and supplies electric energy to the pump motors **112** for powering the hydraulic pump **114** may be disposed onboard the vehicle **102**. For example, the prime mover, shaft, generator device, control unit, and pump motors **112** all may be disposed onboard the same vehicle **102**. Alternatively, two or more of the components of the powering system may be disposed on different vehicles **102** and connected by one or more conductors (e.g., cables) or conduits (e.g., manifolds).

FIG. **5** illustrates one embodiment of a scalable hydraulic pump powering system **500**. The system **500** may be similar to one or more of the powering systems **100**, **300**, **400** shown in FIGS. **1**, **3**, and **4**. For example, the system **500** may be used to generate and/or convert electric energy (e.g., current) for powering electric pump motors (e.g., motors **112** shown in FIG. **1**) that power hydraulic pumps **114** (e.g., the pumps **114**A-C). While three vehicles **502** are shown in FIG. **5**, alternatively, two vehicles **502** or more than three vehicles **502** may be provided.

Similar to the systems **100**, **300**, **400**, the system **500** may include one or more prime movers, generator devices, and control units that operate to create and/or modify electric current to power the pump motors **112** (shown in FIG. **1**) that are mechanically coupled with the hydraulic pumps **114** to cause the hydraulic pumps **114** to direct pressurized fluids into the pumping location **118**. For example, each vehicle **502** shown in FIG. **5** may represent the vehicle **102**, **302**, and/or **402** (shown in FIGS. **1**, **3**, and **4**). The vehicles **502** may separately drive (e.g., power) different hydraulic pumps **114**. For example, the vehicle **502**A may generate electric current that powers onboard pump motors **112** (shown in FIG. **1**) on the vehicle **502**A that power the hydraulic pump **114**A to pump pressurized fluid through one or more conduits **504** (e.g., conduits **504**A) that are fluidly coupled with a manifold **506**. The vehicles **502**B, **502**C may similarly power onboard pump motors **112** of the vehicles **502**B, **502**C that power the hydraulic pumps **114**B, **114**C to pump additional pressurized fluid through conduits **504** (e.g., conduits **504**B, **504**C) that also are fluidly coupled with the manifold **506**.

The manifold **506** directs the pressurized fluids that are pumped from the hydraulic pumps **114**A-C into the pumping location **118**. For example, the manifold **506** can combine the pressurized fluids that are separately pumped by the vehicles **502** and the hydraulic pumps **114** before directing the combined pressurized fluids into the pumping location **118**. The combined volume and/or flow of the fluids that are pumped by the vehicles **502** and the hydraulic pumps **114** into the manifold **506** may be greater than the volume and/or flow of the fluids that are pumped by a single combination of a vehicle **502** and hydraulic pump **114** and/or by a fewer number of vehicles **502** and/or pumps **114**. For example, the volume and/or pressure of the pumped fluid may be greater when several vehicles **502** separately power the hydraulic pumps **114** that are fluidly coupled with each other. The capacity of the vehicles **502** and hydraulic pumps **114** to pump greater amounts and/or flows of fluids into the pumping location **118** can be increased by fluidly coupling additional hydraulic pumps **114** to the manifold **506** (where the hydraulic pumps **114** are powered by additional or the same vehicles **502**).

FIG. **6** illustrates one embodiment of a distributed hydraulic pump powering system **600**. The system **600** may be similar to one or more of the powering systems **100**, **300**, **400**, **500** shown in FIGS. **1**, **3**, **4**, and **5**. The system **600** may be used to generate and/or convert electric energy (e.g., current) for powering electric pump motors (e.g., motors **112** shown in FIG. **1**) that power one or more hydraulic pumps **114**. In contrast to the systems **100**, **300**, **400**, **500**, the system **600** is distributed among plural vehicles **602** (e.g., the vehicles **602**A-C). For example, not all of the components that generate electric current, modify the electric current, and/or use the electric current to power the hydraulic pump **114** may be disposed onboard a single vehicle. Instead, the components may be distributed among several vehicles **602**.

As one example, the power generating components that generate the electric current (e.g., the prime mover **104** and the generator device **108** shown in FIG. **1**, the energy storage device **402** shown in FIG. **4**, and the like) may be disposed onboard the first vehicle **602**A. The power transmission components that transmit (e.g., modify and/or control) the electric current (e.g., the control unit **110** shown in FIG. **1**) may be disposed on a separate vehicle **602**C. The pump components that power the hydraulic pump **114** (e.g., the pump motors **112** shown in FIG. **1**) may be disposed on another separate vehicle **602**B. Alternatively, the components may be distributed differently and/or among other vehicles **602**. By "separate," it is meant that the components may be located onboard the vehicles **602** that are not mechanically coupled with each other such that the vehicles **602** may independently propel themselves to the pumping location **118**, where the components may then be electrically and/or fluidly coupled with each other.

One or more of the vehicles **602** in the system **600** may be located relatively far from one or more other vehicles **602** in the system **600** during operation. For example, the first vehicle **602**A may be located between two or more pumping locations separated by a significant distance, such as a mile (or 1.6 kilometers) or more from each other. Alternatively, the pumping locations may be separated by a smaller or larger distance. Different groups of vehicles **602**B, **602**C may be located at these separated pumping locations to receive electric energy from the vehicle **602**A to power the hydraulic pumps **114** at each of the pumping locations.

In one embodiment, one or more of the vehicles **602** may be standby or backup vehicles **602** that include additional components of the powering systems disclosed herein for use in the event that one or more components of the powering system used to power the hydraulic pump **114** fails or needs to be replaced. For example, a vehicle **602** may include backup

U.S. Well - Exhibit 2015
Liberty v. U.S. Well - IPR2024-01274
Page 17 of 22

pump motors **112** that can be connected with the output of the control unit **110** on another vehicle **602** in the event that other pump motors **112** on another vehicle **602** fail or otherwise stop working. Alternatively, the standby or backup vehicles **602** may carry one or more other standby or backup components, such as a backup prime mover, generator device, and/or control unit.

FIG. **7** is a flowchart of one embodiment of a method **700** for electrically powering a hydraulic pump. The method **700** may be used in conjunction with one or more embodiments of the systems **100**, **300**, **400**, **500**, **600** shown in FIGS. **1** and **3-6**. At **702**, movement is generated by a prime mover. For example, an engine, turbine, or other device may generate movement such as rotation of a shaft.

At **704**, the movement generated by the prime mover is converted into an electric current. For example, an alternator or generator may be coupled with the shaft that is moved by the prime mover. The alternator can create an alternating current or the generator can create a direct current from the rotation of the shaft by the prime mover.

At **706**, one or more characteristics of the electric current are modified. For example, the voltage of the current may be increased (e.g., stepped up) or decreased (e.g., stepped down). As another example, the direct current may be changed into an alternating current. The frequency and/or phase of the alternating current can be controlled based on manual input or may be automatically controlled, as described above.

At **708**, the modified electric current is supplied to electric pump motors. The electric current powers the pump motors. For example, the electric current can power the motors to generate rotary movement of an object, such as a shaft, axle, or the like. As described above, the frequency of the alternating current that is supplied to the pump motors can be varied to control the speed at which the pump motors operate.

At **710**, the movement that is created by the pump motors generates movement of a hydraulic pump. For example, the shaft, axle, or other component that is rotated by one or more electric pump motors can be connected with the hydraulic pump such that the hydraulic pump uses the rotation to pump fluid (e.g., fracking fluid, slurry, cement, or the like) into a pumping location.

In another embodiment, another hydraulic pump powering system includes a mobile vehicle, a first electric current generator device, and one or more electric pump motors. The mobile vehicle has first and second prime movers. The first electric current generator device is disposed onboard the mobile vehicle and is configured to be mechanically coupled with the first prime mover to convert movement created by the first prime mover into first electric current. The one or more electric pump motors are configured to receive the first electric current to power a hydraulic pump. The second prime mover is configured to generate movement that is converted into a propulsive force that propels the mobile vehicle. The one or more electric pump motors are configured to receive the first electric current in order to power the hydraulic pump to pump a fluid into a pumping location located off-board the mobile vehicle.

In one aspect, the first prime mover is configured to generate more than 2500 horsepower of power to generate the first electric current using the first electric current generator device.

In one aspect, the first prime mover is configured to generate more than 2750 horsepower of power to generate the first electric current using the first electric current generator device.

In one aspect, the first prime mover is configured to generate more than 3000 horsepower of power to generate the first electric current using the first electric current generator device.

In one aspect, the first prime mover is configured to generate more than 3500 horsepower of power to generate the first electric current using the first electric current generator device.

In one aspect, the system also includes a second electric current generator device and one or more electric traction motors. The second electric current generator device is disposed onboard the mobile vehicle and is configured to be mechanically coupled with the second prime mover to convert movement created by the second prime mover into second electric current. The one or more electric traction motors are configured to be powered by the second electric current to generate the propulsive force that propels the mobile vehicle.

In one aspect, the one or more electric pump motors are configured to be powered by the first electric current to generate movement that powers the hydraulic pump without being mechanically coupled with the first prime mover by one or more gears and/or transmissions.

In one aspect, the first electric current generator device includes an alternator configured to convert the movement created by the first prime mover into an alternating electric current.

In one aspect, at least one of the first or second prime movers comprises at least one of an engine or a turbine.

In one aspect, the system also includes a control unit disposed onboard the mobile vehicle and configured to control a frequency of the first electric current in order to control a speed at which the one or more electric pump motors operate.

In one aspect, the control unit is configured to convey at least a portion of the first electric current to an energy storage device of the vehicle that also powers the one or more traction motors of the mobile vehicle that are powered to provide the propulsive force that propels the mobile vehicle.

In one aspect, the control unit includes an alternator configured to convert the first electric current received from the first electric current generator device into a direct current, an inverter configured to convert the direct current into an alternating current, and a variable frequency drive (VFD) device configured to modify a frequency of the alternating current to form a modified electric current that is supplied to the one or more electric pump motors.

In one aspect, the VFD device is configured to modify the frequency of the alternating current in order to control a speed at which the one or more electric pump motors operate.

In one aspect, the one or more electric pump motors include one or more traction motors that also are configured to be coupled with one or more wheels or axles of the mobile vehicle to propel the mobile vehicle.

In one aspect, the one or more electric pump motors include at least one of an alternating current induction motor, a permanent magnet motor, a switched reluctance motor, or a direct current motor.

In one aspect, the one or more electric pump motors are configured to power the hydraulic pump to pump fracturing fluid into a drill site at the pumping location.

In another embodiment, another hydraulic pump powering system includes a mobile vehicle, an electric current generator device, a control unit, one or more electric traction motors, and one or more electric pump motors. The mobile vehicle includes a prime mover. The electric current generator device is disposed onboard the mobile vehicle and is mechanically coupled with the prime mover. The electric current generator device is configured to convert movement of the prime mover

into a first electric current. The control unit is disposed onboard the mobile vehicle and is configured to convert the first electric current from the electric current generator device into a modified electric current. The one or more electric traction motors are coupled with at least one of axles or wheels of the mobile vehicle. The one or more electric traction motors are configured to propel the mobile vehicle. The one or more electric pump motors are disposed onboard the mobile vehicle and are configured to power a hydraulic pump to pump a fluid into a pumping location disposed off-board the mobile vehicle. The control unit is configured to control when the modified electric current is supplied to the one or more electric traction motors to propel the mobile vehicle and when the modified electric current is supplied to the one or more electric pump motors to power the hydraulic pump.

In one aspect, the one or more electric pump motors are configured to be powered by the modified electric current to generate movement that powers the hydraulic pump without being mechanically coupled with the prime mover by one or more gears and/or transmissions.

In one aspect, the electric current generator device includes an alternator configured to convert the movement created by the prime mover into the first electric current, and the first electric current includes an alternating electric current.

In one aspect, the prime mover comprises at least one of an engine or a turbine, and wherein the electric current generator device is configured to be coupled with a shaft connected to the prime mover to convert rotation of the shaft by the at least one of the engine or the turbine into the first electric current.

In one aspect, the control unit is configured to control a frequency of the first electric current to create the modified electric current in order to control a speed at which the one or more electric pump motors operate.

In one aspect, the control unit is configured to convey at least a portion of the modified electric current to an energy storage device disposed onboard the mobile vehicle that also powers the one or more traction motors.

In one aspect, the one or more electric pump motors are configured to power the hydraulic pump to pump fracturing fluid into a drill site at the pumping location.

In another embodiment, another hydraulic pump powering system includes a mobile vehicle, an electric current generator device, one or more electric pump motors, one or more electric traction motors, and a control unit. The electric current generator device is mechanically coupled with a prime mover of the mobile vehicle to generate electric current. The one or more electric pump motors are disposed on board the mobile vehicle and are configured to receive the electric current and to power a hydraulic pump using the electric current. The one or more electric traction motors are disposed on board the mobile vehicle and are configured to receive the electric current to propel the mobile vehicle. The control unit is disposed onboard the mobile vehicle and is configured to control a frequency of the electric current that is supplied to the one or more electric pump motors in order to control flow of a fluid that is pumped into a pumping location disposed off-board of the mobile vehicle by the hydraulic pump.

In another embodiment, a method (e.g., for powering a hydraulic pump) includes converting movement of a prime mover disposed onboard a mobile vehicle into an electric current, directing the electric current to one or more electric traction motors of the mobile vehicle to propel the mobile vehicle during a first time period, and directing the electric current to one or more electric pump motors disposed onboard the mobile vehicle to power the hydraulic pump disposed off-board the mobile vehicle during a second time period. The electric current is directed to the one or more electric pump motors to pump a fluid into a pumping location that is disposed off-board the mobile vehicle.

In one aspect, converting the movement of the prime mover into the first electric current includes creating an alternating current from rotation of a shaft connected to the prime mover that comprises at least one of an engine or a turbine.

In one aspect, the method also includes modifying a frequency of the electric current to control a speed at which the one or more electric pump motors operate.

In one aspect, the method also includes directing the electric current to an energy storage device disposed onboard the mobile vehicle that also powers the one or more traction motors.

In one aspect, directing the electric current to the one or more electric pump motors includes powering the hydraulic pump to pump fracturing fluid into a drill site at the pumping location.

In one aspect, the first and second time periods are non-overlapping time periods.

In another embodiment, another hydraulic pump powering system includes a mobile vehicle, an electric current generator device, a control unit, and one or more electric pump motors. The mobile vehicle has a gas turbine disposed onboard the mobile vehicle. The electric current generator device is on board the vehicle and is mechanically coupled with the gas turbine to convert movement created by the gas turbine into electric current. The control unit is configured to receive the electric current and to modify the electric current into a modified current. The one or more electric pump motors are on board the vehicle and are configured to receive the modified current. The control unit is configured to output the modified current for powering the one or more electric pump motors to power at least one hydraulic pump to pump hydraulic fracturing fluid into a pumping location located off-board the mobile vehicle.

In one aspect, the gas turbine is powered by natural gas.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the inventive subject matter without departing from its scope. While the dimensions and types of materials described herein are intended to define the parameters of the inventive subject matter, they are by no means limiting and are exemplary embodiments. Many other embodiments will be apparent to one of ordinary skill in the art upon reviewing the above description. The scope of the inventive subject matter should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. §112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

This written description uses examples to disclose several embodiments of the inventive subject matter and also to enable one of ordinary skill in the art to practice the embodiments of inventive subject matter, including making and using any devices or systems and performing any incorpo-

rated methods. The patentable scope of the inventive subject matter is defined by the claims, and may include other examples that occur to one of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

The foregoing description of certain embodiments of the present inventive subject matter will be better understood when read in conjunction with the appended drawings. To the extent that the figures illustrate diagrams of the functional blocks of various embodiments, the functional blocks are not necessarily indicative of the division between hardware circuitry. Thus, for example, one or more of the functional blocks (for example, processors or memories) may be implemented in a single piece of hardware (for example, a general purpose signal processor, microcontroller, random access memory, hard disk, and the like). Similarly, the programs may be stand alone programs, may be incorporated as subroutines in an operating system, may be functions in an installed software package, and the like. The various embodiments are not limited to the arrangements and instrumentality shown in the drawings.

As used herein, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to "one embodiment" of the present inventive subject matter are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments "comprising," "including," or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property.

The invention claimed is:

1. A hydraulic pump powering system comprising:

a first mobile vehicle having a first gas turbine disposed onboard the first mobile vehicle;

a first electric current generator device onboard the first mobile vehicle and mechanically coupled with the first gas turbine to convert movement created by the first gas turbine into first electric current;

a first control unit configured to receive the first electric current and to modify the first electric current into a first modified current; and

one or more first electric pump motors onboard the first mobile vehicle and configured to receive the first modified current, wherein the first control unit is configured to output the first modified current for powering the one or more first electric pump motors to power at least a first hydraulic pump disposed off-board the first mobile vehicle to pump hydraulic fracturing fluid into a pumping location located off-board the first mobile vehicle.

2. The system of claim **1**, further comprising

a second mobile vehicle having a second prime mover disposed onboard the second mobile vehicle;

a second electric current generator device onboard the second mobile vehicle and mechanically coupled with the second prime mover to convert movement created by the second prime mover into second electric current;

a second control unit configured to receive the second electric current and to modify the second electric current into a second modified current; and

one or more second electric pump motors onboard the second mobile vehicle and configured to receive the second modified current, wherein the second control unit is configured to output the second modified current for powering the one or more second electric pump motors to power at least a second hydraulic pump disposed off-board the second mobile vehicle as the first modified current is output from the first control unit of the first mobile vehicle to pump the hydraulic fracturing fluid.

3. The system of claim **2**, further comprising a manifold fluidly coupling the at least a first hydraulic pump and the at least a second hydraulic pump with each other and with the pumping location.

4. The system of claim **2**, wherein the second prime mover is a second gas turbine.

5. The system of claim **1**, wherein the first control unit also is configured to divert at least a portion of the first electric current to one or more traction motors of the first mobile vehicle.

6. The system of claim **1**, wherein the first control unit also is configured to divert at least a portion of the first electric current to an energy storage device disposed onboard the first mobile vehicle.

7. The system of claim **1**, wherein the first gas turbine is configured to generate more than 2500 horsepower of power to generate the first electric current using the first electric current generator device.

8. The system of claim **1**, wherein the one or more first electric pump motors are configured to be powered by the first electric current to generate movement that powers the at least a first hydraulic pump without being mechanically coupled with the first gas turbine by one or more gears and/or transmissions.

9. The system of claim **1**, wherein the one or more first electric pump motors include one or more traction motors that also are configured to be coupled with one or more wheels or axles of the first mobile vehicle.

10. The system of claim **1**, wherein the one or more first electric pump motors are configured to power the at least a first hydraulic pump to pump the fracturing fluid into a drill site at the pumping location.

11. The system of claim **1**, wherein the first control unit is configured to output the first modified current at a power level of at least 700 kilowatts for powering the one or more first electric pump motors.

12. The system of claim **1**, wherein the one or more first electric pump motors are configured generate mechanical power in excess of 2500 horsepower (HP) for powering the at least a first hydraulic pump to pump hydraulic fracturing fluid into the pumping location located off-board the first mobile vehicle at a rate of at least 2 gallons per minute per revolution of the at least a first hydraulic pump.

13. The system of claim **1**, wherein the first control unit is configured to output the first modified current at a voltage of at least 400 volts for powering the one or more first electric pump motors.

14. The system of claim **1**, wherein the first electric current generator device, the first control unit, and the one or more first electric pump motors disposed on the first mobile vehicle are configured to power the at least a first hydraulic pump to pump at least 200 gallons per minute.

* * * * *

U.S. Well - Exhibit 2015
Liberty v. U.S. Well - IPR2024-01274
Page 20 of 22

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,997,904 B2
APPLICATION NO. : 13/541980
DATED : April 7, 2015
INVENTOR(S) : Cryer et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

IN THE SPECIFICATION

In Column 13, Line 15, delete "traction motors 110" and insert -- traction motors 120 --, therefor.

IN THE CLAIMS

In Column 20, Line 50, in Claim 12, delete "configured generate" and insert -- configured to generate --, therefor.

Signed and Sealed this
Twenty-ninth Day of December, 2015

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,997,904 B2
APPLICATION NO. : 13/541980
DATED : April 7, 2015
INVENTOR(S) : Cryer et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

IN THE SPECIFICATION

In Column 13, Line 15, delete "traction motors 110" and insert -- traction motors 120 --, therefor.

IN THE CLAIMS

In Column 20, Line 50, in Claim 12, delete "configured generate" and insert -- configured to generate --, therefor.

Signed and Sealed this
Twenty-ninth Day of December, 2015

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office