US009410410B2

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

(10) **Patent No.:** **US 9,410,410 B2**
(45) **Date of Patent:** **Aug. 9, 2016**

(54) **SYSTEM FOR PUMPING HYDRAULIC FRACTURING FLUID USING ELECTRIC PUMPS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 229 days.

(21) Appl. No.: **13/679,689**

(22) Filed: **Nov. 16, 2012**

(65) **Prior Publication Data**

US 2014/0138079 A1 May 22, 2014

(51) **Int. Cl.**
E21B 43/26 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 43/26*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 43/26
USPC 166/308.1, 177.5
See application file for complete search history.

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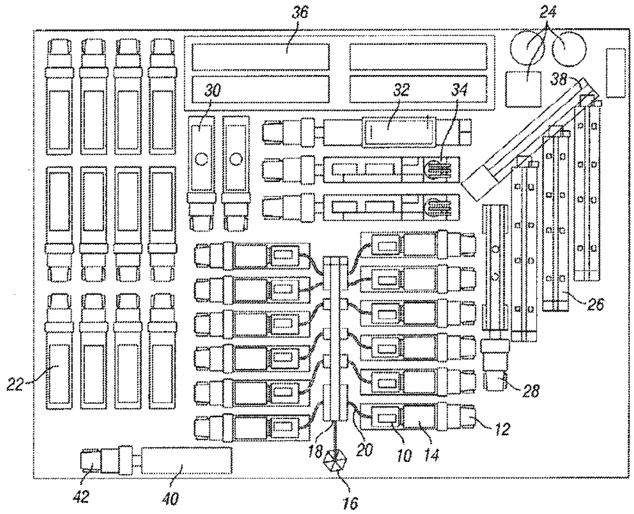
(57) **ABSTRACT**

A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a plurality of electric pumps fluidly connected to the well, and configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the and fractures the formation. The system can also include a plurality of natural gas powered generators electrically connected to the plurality of electric pumps to provide electrical power to the pumps.

21 Claims, 2 Drawing Sheets



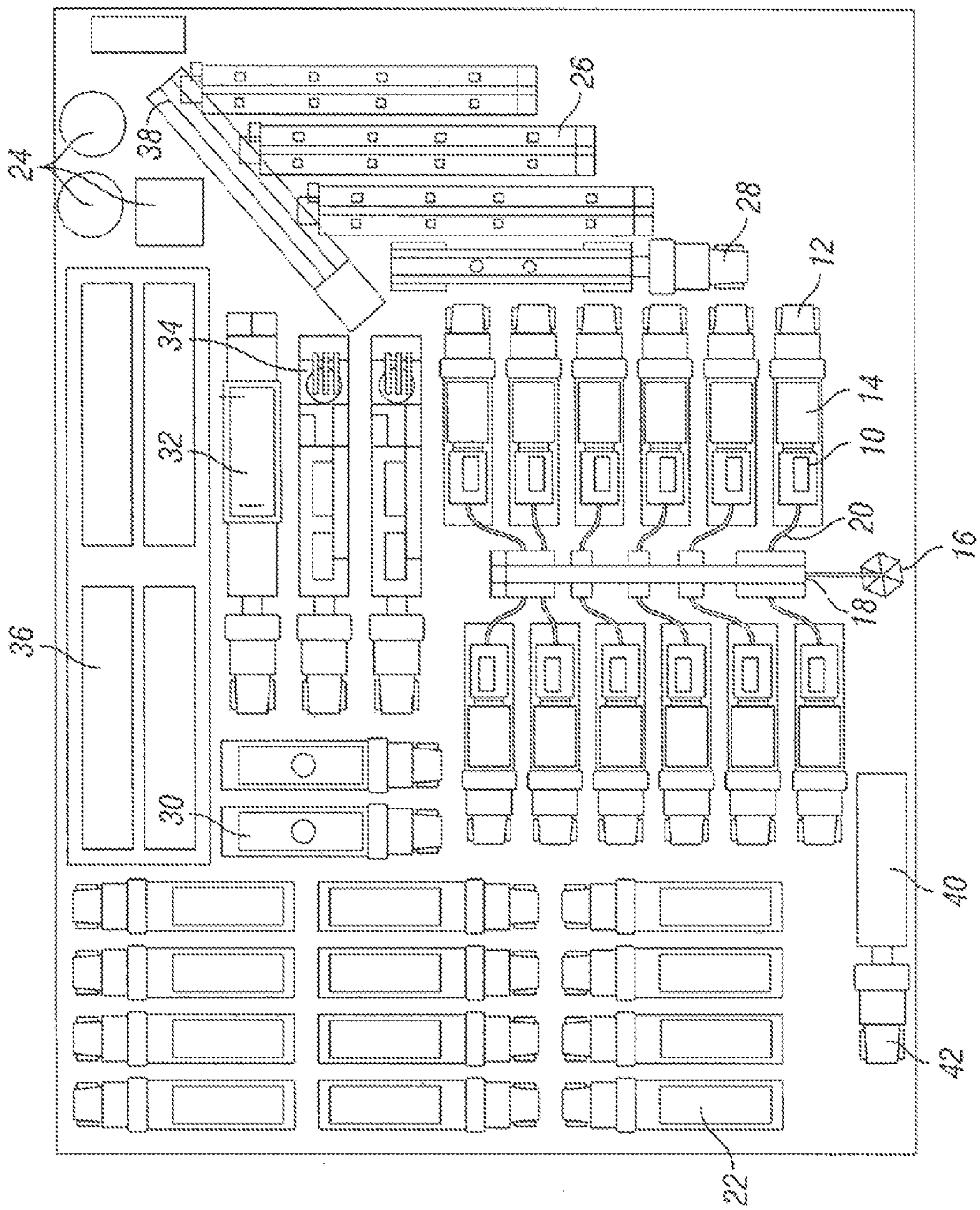


FIG. 1

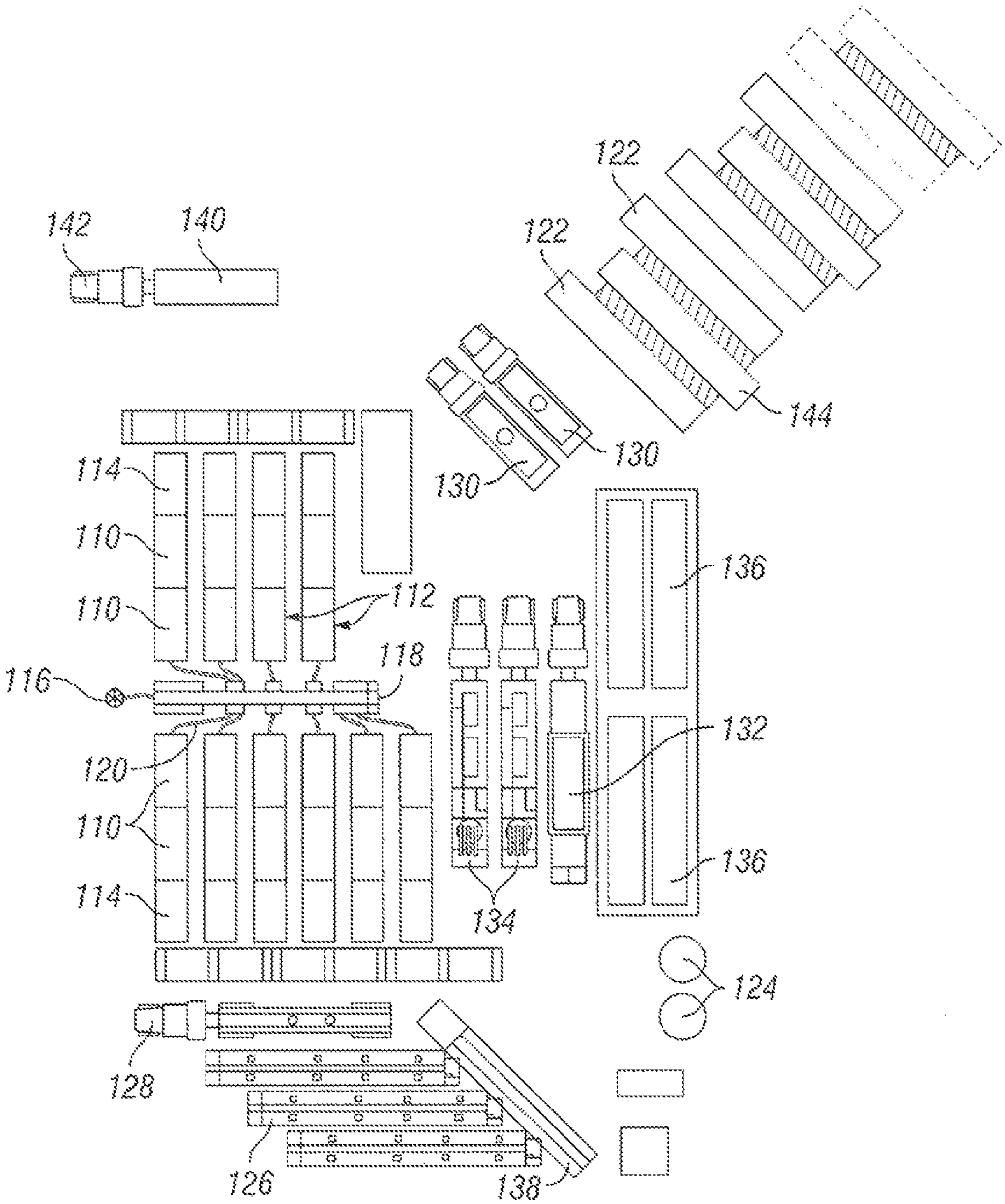

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FIG. 2

SYSTEM FOR PUMPING HYDRAULIC FRACTURING FLUID USING ELECTRIC PUMPS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This technology relates to hydraulic fracturing in oil and gas wells. In particular, this technology relates to pumping fracturing fluid into an oil or gas well using pumps powered by electric motors.

2. Brief Description of Related Art

Hydraulic fracturing has been used for decades to stimulate production from conventional oil and gas wells. The practice consists of pumping fluid into a wellbore at high pressure. Inside the wellbore, the fluid is forced into the formation being produced. When the fluid enters the formation, it fractures, or creates fissures, in the formation. Water, as well as other fluids, and some solid proppants, are then pumped into the fissures to stimulate the release of oil and gas from the formation.

Fracturing rock in a formation requires that the fracture fluid be pumped into the wellbore at very high pressure. This pumping is typically performed by large diesel-powered pumps. Such pumps are able to pump fracturing fluid into a wellbore at a high enough pressure to crack the formation, but they also have drawbacks. For example, the diesel pumps are very heavy, and thus must be moved on heavy duty trailers, making transport of the pumps between oilfield sites expensive and inefficient. In addition, the diesel engines required to drive the pumps require a relatively high level of expensive maintenance. Furthermore, the cost of diesel fuel is much higher than in the past, meaning that the cost of running the pumps has increased.

What is needed therefore, is a pump system for hydraulic fracturing fluid that overcomes the problems associated with diesel pumps.

SUMMARY OF THE INVENTION

Disclosed herein is a system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a plurality of electric pumps fluidly connected to the well, and configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation. The system also includes a plurality of generators electrically connected to the plurality of electric pumps to provide electrical power to the pumps. At least some of the plurality of generators can be powered by natural gas, in addition, at least some of the plurality of generators can be turbine generators.

In one embodiment, the system further includes an A/C console and a variable frequency drive that controls the speed of the pumps. Furthermore, the electric pumps, as well as the electric generators, can be mounted on vehicles, and can be ported from one well to another. The vehicles can be trucks and can have at least five axles.

Further disclosed herein is a system for fracturing a rock formation in an oil or gas well by pumping hydraulic fracturing fluid into the well that includes a pump, an electric motor, a variable frequency drive, and a natural gas powered electric generator. The pump is configured for pumping the hydraulic fracturing fluid into the well, and then from the well into the

motor can have a high-strength steel or steel alloy shaft attached to the pump and configured to drive the pump. The variable frequency drive can be connected to the electric motor to control the speed of the motor. In addition, the natural gas powered generator, which can be a turbine generator, can be connected to the electric motor and provide electric power to the electric motor.

In one embodiment, the pump can be a triplex or a quinteplex pump, optionally rated at about 2250 hydraulic horsepower or more. In addition, the pump can also have 4.5 inch diameter plungers with an eight inch stroke. In another embodiment, the electric motor can have a maximum continuous power output of about 1500 brake horsepower, 1750 brake horsepower, or more, and a maximum continuous torque of about 8750 lb-ft or more. Furthermore, the electric motor can have a high temperature rating of about 1100 degrees C. or more, and a shaft composed of 4340 alloy steel.

In another embodiment, variable frequency drive can frequently perform electric motor diagnostics to prevent damage to the electric motor if it becomes grounded or shorted. In addition, the variable frequency drive can include power semiconductor heat sinks having one or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat.

Also disclosed herein is a system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a trailer for attachment to a truck. Two or more electric pumps can be attached to the trailer and are fluidly connected to the well, the electric pumps configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation. One or more electric motors are attached to the electric pumps to drive the pumps. The electric motors can also be attached to the trailer. A natural gas powered generator is provided for connection to the electric motor to provide electric power to the electric motor. The system of claim can further include a variable frequency drive attached to the trailer and connected to the electric motor to control the speed of the motor. In addition, the system can include a skid to which at least one of the electric pumps, the one or more electric motors, and the variable frequency drives are attached.

Also disclosed herein is a process for stimulating an oil or gas well by hydraulically fracturing a formation in the well. The process includes the steps of pumping fracturing fluid into the well with an electrically powered pump at a high pressure so that the fracturing fluid enters and cracks the formation, the fracturing fluid having at least a liquid component and a solid proppant, and inserting the solid proppant into the cracks to maintain the cracks open, thereby allowing passage of oil and gas through the cracks. The process can further include powering the electrically powered pump with a natural gas generator, such as, for example, a turbine generator.

BRIEF DESCRIPTION OF THE DRAWINGS

The present technology will be better understood on reading the following detailed description of nonlimiting embodiments thereof, and on examining the accompanying drawing, in which:

FIG. **1** is a schematic plan view of equipment used in a

FIG. **2** is a schematic plan view of equipment used in a hydraulic fracturing operation, according to an alternate embodiment of the present technology.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The foregoing aspects, features, and advantages of the present technology will be further appreciated when considered with reference to the following description of preferred embodiments and accompanying drawing, wherein like reference numerals represent like elements. In describing the preferred embodiments of the technology illustrated in the appended drawing, specific terminology will be used for the sake of clarity. However, the technology is not intended to be limited to the specific terms used, and it is to be understood that each specific term includes equivalents that operate in a similar manner to accomplish a similar purpose.

FIG. **1** shows a plan view of equipment used in a hydraulic fracturing operation. Specifically, there is shown a plurality of pumps **10** mounted to pump vehicles **12**. The pump vehicles **12** can be trucks having at least five axles. In the embodiment shown, the pumps **10** are powered by electric motors **14**, which can also be mounted to the pump vehicles **12**. The pumps **10** are fluidly connected to the wellhead **16** via the missile **18**. As shown, the pump vehicles **12** can be positioned near enough to the missile **18** to connect fracturing fluid lines **20** between the pumps **10** and the missile **18**. The missile **18** is then connected to the wellhead **16** and configured to deliver fracturing fluid provided by the pumps **10** to the wellhead **16**.

In some embodiments, each electric motor **14** can be capable of delivering about 1500 brake horsepower (BHP), 1750 BHP, or more, and each pump **10** can optionally be rated for about 2250 hydraulic horsepower (HHP) or more. In addition, the components of the system, including the pumps **10** and the electric motors **14**, can be capable of operating during prolonged pumping operations, and in temperature in a range of about 0 degrees C. or less to about 55 degrees C. or more. In addition, each electric motor **14** can be equipped with a variable frequency drive (VFD), and an A/C console, that controls the speed of the electric motor **14**, and hence the speed of the pump **10**.

The electric motors **14** of the present technology can be designed to withstand an oilfield environment. Specifically, some pumps **10** can have a maximum continuous power output of about 1500 BHP, 1750 BHP, or more, and a maximum continuous torque of about 8750 lb-ft or more. Furthermore, electric motors **14** of the present technology can include class H insulation and high temperature ratings, such as about 1100 degrees C. or more. In some embodiments, the electric motor **14** can include a single shaft extension and huh for high tension radial loads, and a high strength 4340 alloy steel shaft, although other suitable materials can also be used.

The VFD can be designed to maximize the flexibility, robustness, serviceability, and reliability required by oilfield applications, such as hydraulic fracturing. For example, as far as hardware is concerned, the VFD can include packaging receiving a high rating by the National Electrical Manufacturers Association (such as nema 1 packaging), and power semiconductor heat sinks having one or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat. Furthermore, with respect to control capabilities, the VFD can provide complete monitoring and protection of drive internal operations while communicating with an operator via one or more user interfaces.

prevent damage to a grounded or shorted electric motor **14**. The electric motor diagnostics can be disabled, if desired, when using, for example, a low impedance or high-speed electric motor.

In some embodiments, the pump **10** can optionally be a 2250 HHP triplex or quinteplex pump. The pump **10** can optionally be equipped with 4.5 inch diameter plungers that have an eight (8) inch stroke, although other size plungers can be used, depending on the preference of the operator. The pump **10** can further include additional features to increase its capacity, durability, and robustness, including, for example, 6.353 to 1 gear reduction, autuofrettaged steel or steel alloy fluid end, wing guided slush type valves, and rubber spring loaded packing.

In addition to the above, certain embodiments of the present technology can include a skid (not shown) for supporting some or all of the above-described equipment. For example, the skid can support the electric motor **14** and the pump **10**. In addition, the skid can support the VFD. Structurally, the skid can be constructed of heavy-duty longitudinal beams and cross-members made of an appropriate material, such as, for example, steel. The skid can further include heavy-duty lifting lugs, or eyes, that can optionally be of sufficient strength to allow the skid to be lifted at a single lift point.

Referring back to FIG. **1**, also included in the equipment is a plurality of electric generators **22** that are connected to, and provide power to, the electric motors **14** on the pump vehicles **12**. To accomplish this, the electric generators **22** can be connected to the electric motors **14** by power lines (not shown). The electric generators **22** can be connected to the electric motors **14** via power distribution panels (not shown). In certain embodiments, the electric generators **22** can be powered by natural gas. For example, the generators can be powered by liquefied natural gas. The liquefied natural gas can be converted into a gaseous form in a vaporizer prior to use in the generators. The use of natural gas to power the electric generators **22** can be advantageous because, where the well is a natural gas well, above ground natural gas vessels **24** can already be placed on site to collect natural gas produced from the well. Thus, a portion of this natural gas can be used to power the electric generators **22**, thereby reducing or eliminating the need to import fuel from offsite. If desired by an operator, the electric generators **22** can optionally be natural gas turbine generators, such as those shown in FIG. **2**.

FIG. **1** also shows equipment for transporting and combining the components of the hydraulic fracturing fluid used in the system of the present technology. In many wells, the fracturing fluid contains a mixture of water, sand or other proppant, acid, and other chemicals. Examples of fracturing fluid components include acid, anti-bacterial agents, clay stabilizers, corrosion inhibitors, friction reducers, gelling agents, iron control agents, pH adjusting agents, scale inhibitors, and surfactants. Historically, diesel has at times been used as a substitute for water in cold environments, or where a formation to be fractured is water sensitive, such as, for example, clay. The use of diesel, however, has been phased out over time because of price, and the development of newer, better technologies.

In FIG. **1**, there are specifically shown sand transporting vehicles **26**, an acid transporting vehicle **28**, vehicles for transporting other chemicals **30**, and a vehicle carrying a hydration unit **32**, such as, for example, a water pump. Also shown are fracturing fluid blenders **34**, which can be configured to mix and blend the components of the hydraulic frac-

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