US010079457B2

(12) **United States Patent**
Yuratich

(10) **Patent No.: US 10,079,457 B2**
(45) **Date of Patent: Sep. 18, 2018**

(54) **METHODS AND APPARATUS FOR RENDERING ELECTRICAL CABLES SAFE**

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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 0 days.

(21) Appl. No.: **15/422,368**

(22) Filed: **Feb. 1, 2017**

(65) **Prior Publication Data**

US 2018/0219328 A1 Aug. 2, 2018

(51) **Int. Cl.**

H01R 4/24	(2018.01)
H01R 13/655	(2006.01)
H02K 5/22	(2006.01)
H02K 11/40	(2016.01)
H01R 4/2408	(2018.01)
E21B 43/12	(2006.01)
H01R 9/03	(2006.01)
H01R 12/59	(2011.01)
H01R 4/48	(2006.01)

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

CPC ***H01R 13/655*** (2013.01); ***E21B 43/128*** (2013.01); ***H01R 4/2408*** (2013.01); ***H02K 5/225*** (2013.01); ***H02K 11/40*** (2016.01); *H01R 4/4818* (2013.01); *H01R 9/032* (2013.01); *H01R 12/596* (2013.01)

(58) **Field of Classification Search**

CPC H01R 4/4818; H01R 12/596; H01R 9/032
USPC 439/439, 98, 99
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,201,433 A *	5/1980	Caldwell	H01R 4/646	439/98
6,591,055 B1 *	7/2003	Eslambolchi	G02B 6/2558	385/136
7,507,106 B2 *	3/2009	Keswani	H01R 4/4818	439/439
7,922,516 B2 *	4/2011	Temblador	H01R 4/2408	439/391
8,262,405 B1 *	9/2012	Bishop	H01R 4/4836	439/439
2005/0282429 A1 *	12/2005	Trumper	H01R 4/4818	439/439

* cited by examiner

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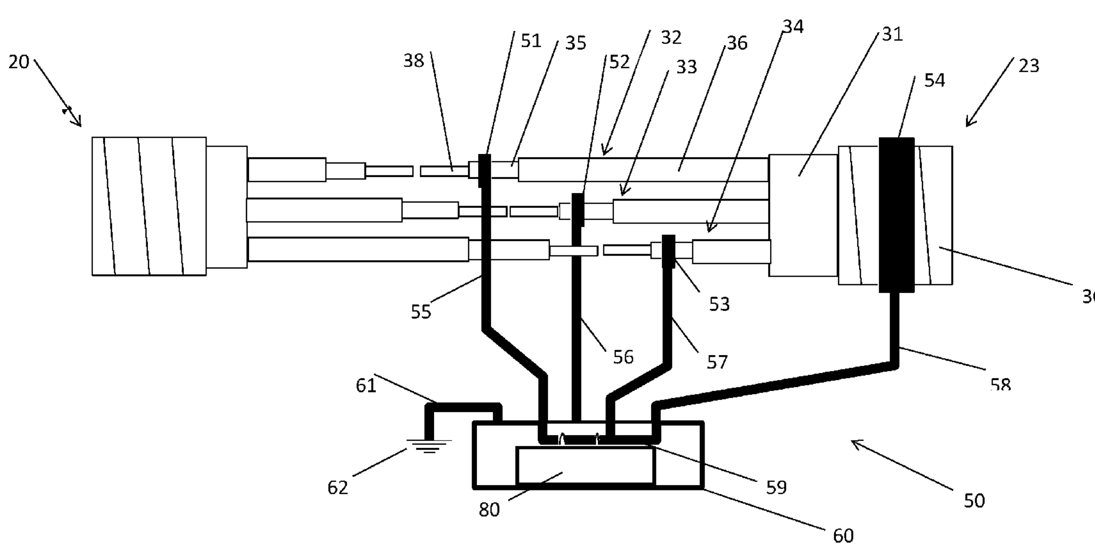
(57) **ABSTRACT**

A "safe grounding apparatus" (SGA) for safely grounding or neutralizing the electrical conductors for permanent magnet motor (PMM) powered artificial lift systems and methods of practicing the same are disclosed. The SGA of the present invention ameliorates some of the dangers associated with PMM's. Methods of shorting, grounding, testing and monitoring the electrical conductors of a permanent magnet motor in order to safely manipulate the conductors are also disclosed.

20 Claims, 4 Drawing Sheets



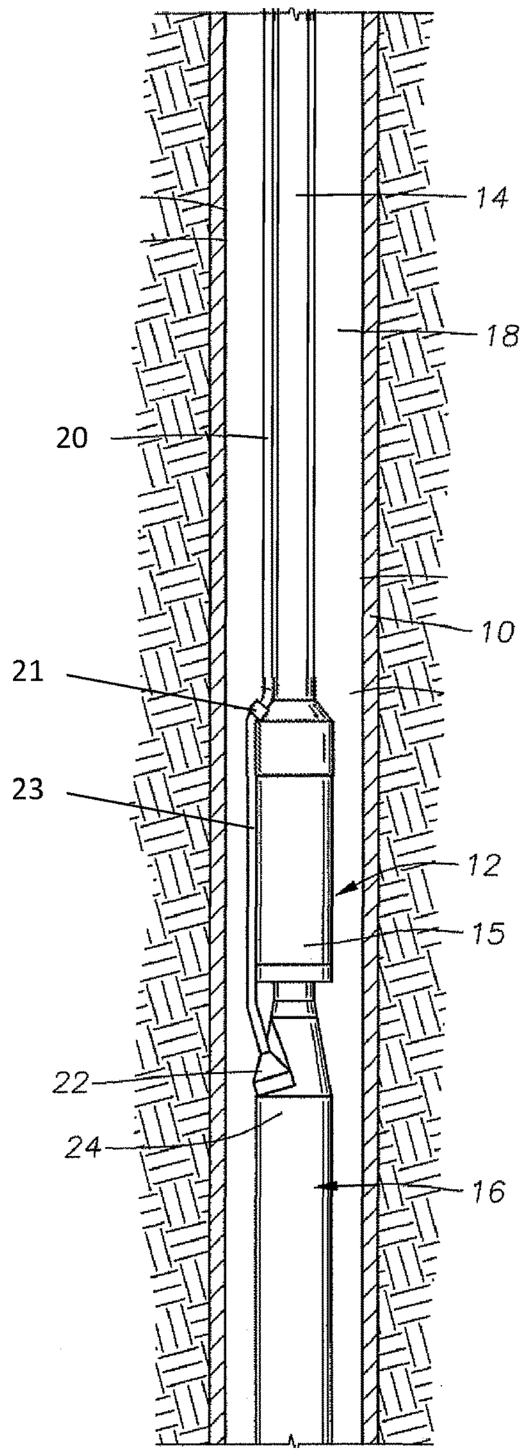
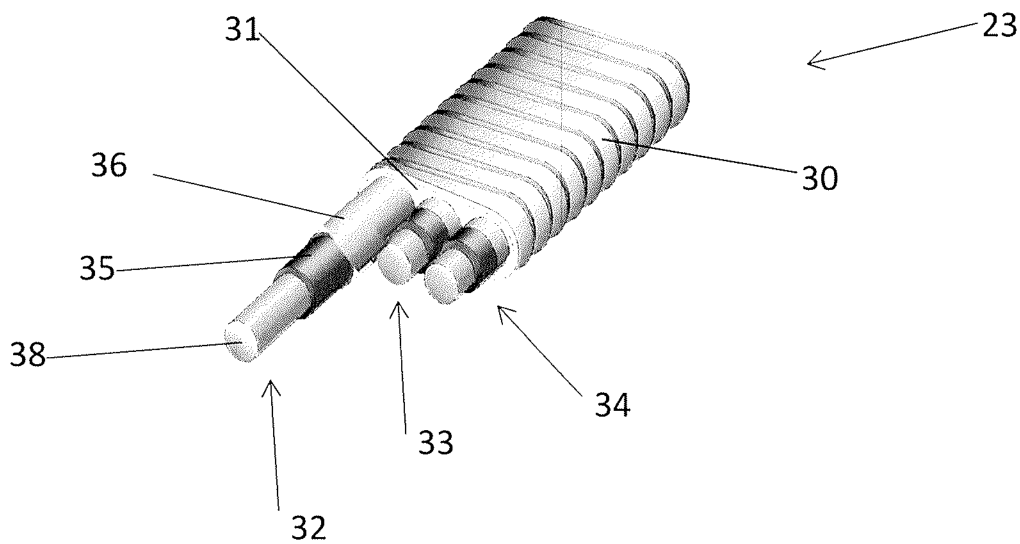


FIG. 1



(Prior Art)

FIG. 2

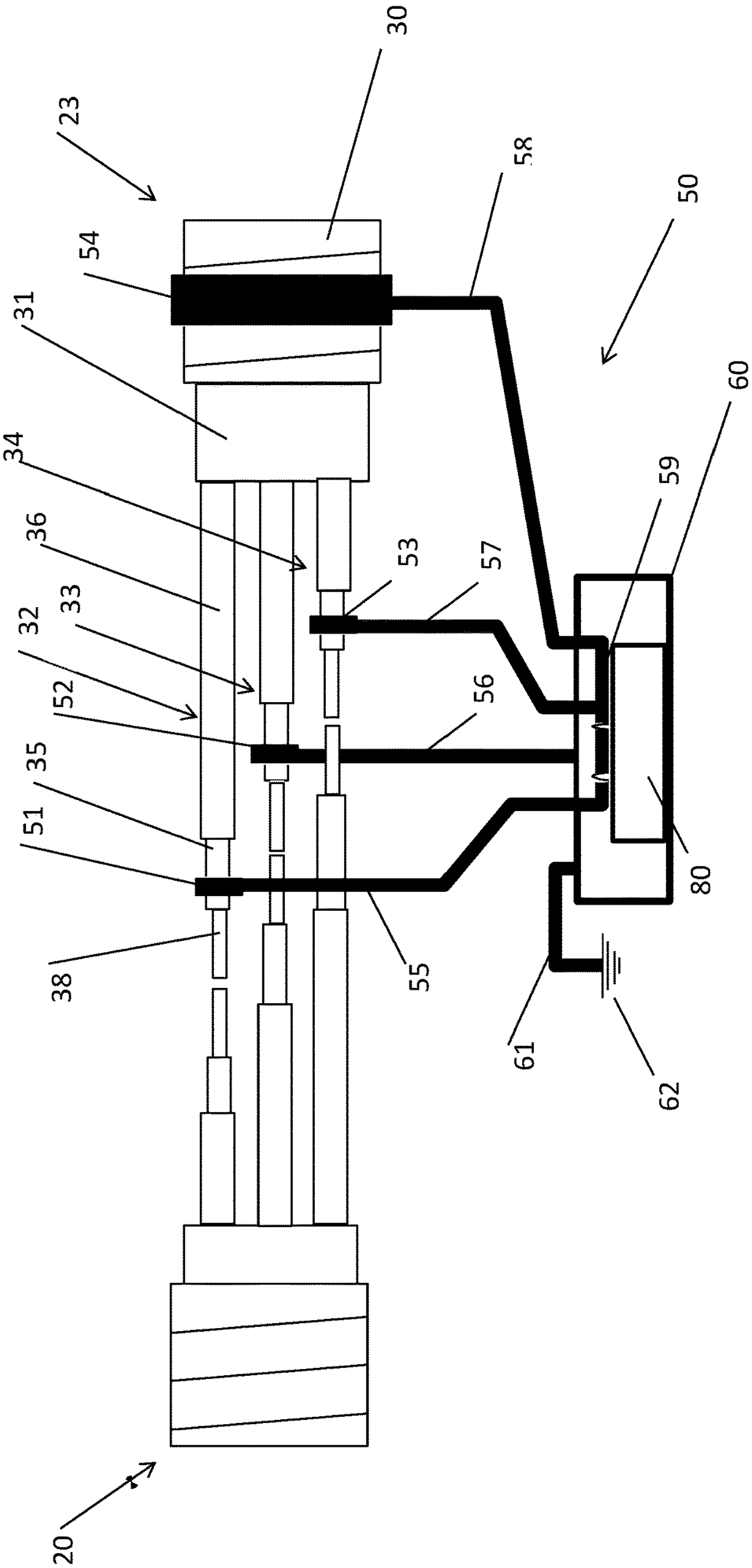


FIG. 3

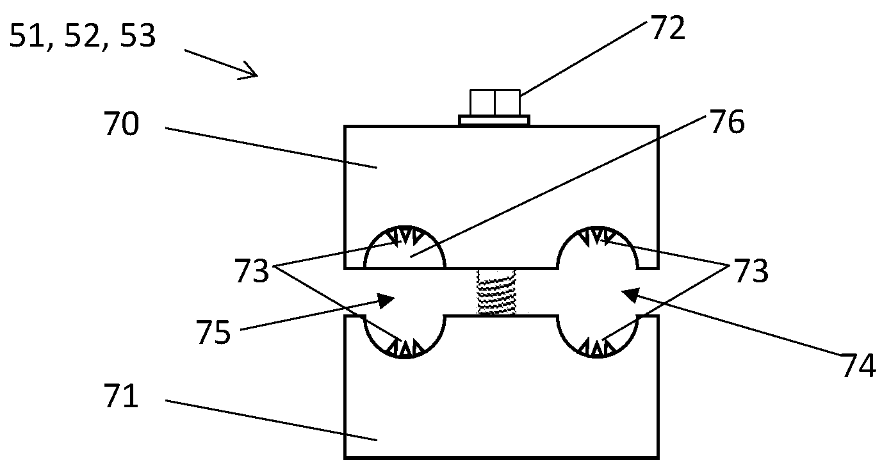


FIG. 4

METHODS AND APPARATUS FOR RENDERING ELECTRICAL CABLES SAFE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to artificial lift systems used to pump fluids from wells and, and more particularly, to an apparatus and method for rendering a MLE of a motor safe from electrical shock hazards.

Description of the Related Art

Hydrocarbon reservoirs produce fluid from boreholes drilled therein when the reservoir pressure is greater than the flowing pressure at the point of entry to the borehole necessary to lift the fluid to surface. When this condition is not attained it is known in the prior art to operate electric motors to drive pumps downhole, in situ, a method generally known as electric submersible pumping (ESP). The pump increases the flowing pressure sufficiently to lift the fluids to surface.

Most prior art motors used to drive ESPs have been of the three-phase alternating current asynchronous squirrel cage induction type. A power cable including electrical conductors extends from a power source at the surface and runs along the production tubing downhole to the motor. The electrical conductors of the cable are affixed to the motor before installation utilizing a connection commonly referred to as a "pot head". The section of the power cable that includes the pot head is commonly referred to as the extension (MLE). The MLE is typically spliced in the field to one or more sections sometimes referred to as the power cable. Such splices are well known in the industry, such as those described in United States Patent Application number 20130052055, the disclosure of which is incorporated herein in its entirety.

There exist other embodiments of ESP systems in the prior art that utilize permanent magnet motors such as those described in U.S. patent application Ser. No. 15/356,167, the disclosure of which is incorporated herein in its entirety. Such permanent magnet motors may also use three-phase AC power and similar MLEs, pot heads and power cables. However, ESP systems utilizing permanent magnet motors differ from induction motor systems in that when the motor shaft rotates (in the absence of supply power) it acts as a generator and can impress a significant voltage across the cable conductors, resulting in an electrical shock hazard for anyone touching the conductors. The motor may be rotated by, among other things, fluid running through the pump in certain situations such as while running the system in hole, removing the system from the hole or simply the draining of the production fluid from above the pump during a power failure or power shutdown. In addition, unlike centrifugal pumps, progressive cavity pumps do not pass fluid freely and breakout friction must be overcome in order to rotate. When running in, the tubing connected to such progressive cavity pumps remains essentially void of fluid and at low pressure, while well pressure builds on the bottom of the pump. At some depth the friction may be overcome and the pump will suddenly turn. The aforementioned hazards during running in are infrequent and may not occur and therefore makes the hazards sudden and unexpected. In such situations a technician or operator may be unaware that the motor is rotating and may be producing significant voltage. It should be appreciated by those skilled in the art that in such situations the manual manipulation of the electrical conductors of the cable, such as during a splicing operation, of a permanent magnet motor poses a significant risk of electrical shock and sparking. Sparking may even cause explosions if certain gases are present in the environment near the splicing operation.

What is needed is an apparatus and method that renders a power cable of a permanent magnet motor ESP system safe for splicing and other operations.

SUMMARY OF THE INVENTION

In accordance with some aspects of the present disclosure, systems and methods related to a novel artificial lift system are disclosed.

Various embodiments of an apparatus for attachment to a plurality of power conductors electrically coupled to a permanent magnet motor are disclosed.

In some aspects of the present invention, the apparatus is a safe grounding apparatus (SGA) and includes a plurality of shorting conductors electrically coupled to the power conductors; and a connection for electrically shorting the shorting conductors.

In still other aspects of the present invention, the SGA includes a ground connector for grounding the power connectors to earth.

In yet other aspects of the present invention the SGA includes a module for monitoring physical conditions of the permanent magnet motor including voltage, resistance, speed and frequency.

In yet other aspects of the present invention a method includes rendering a plurality of conductors electrically coupled to a permanent magnet motor safe.

In still other aspects of the present invention a method includes rendering a plurality of power conductors electrically coupled to a permanent magnet motor safe includes electrically coupling a plurality of shorting conductors to the power conductors and shorting the shorting conductors. The method further includes grounding the shorting conductors.

In still further aspects of the present invention a method includes monitoring the power conductors for various electrical attributes.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above-recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. **1** is side representation of an artificial lift system within a wellbore including embodiments of the present invention;

FIG. **2** is a perspective view of a prior art power cable;

FIG. **3** is a schematic representation of an electrical grounding system of an embodiment of the present invention; and

FIG. **4** is an end view of a piercing clamp in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

In the following detailed description of the embodiments, reference is made to the accompanying drawings, which form a part hereof, and within which are shown by way of illustration specific embodiments by which the examples described herein may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the disclosure.

The examples disclosed herein relate to a "safe grounding apparatus" (SGA) for safely grounding, neutralizing (or shorting), testing and monitoring the electrical conductors for permanent magnet motor (PMM) powered artificial lift systems and methods of practicing the same. The SGA of the present invention ameliorates some of the dangers associated with PMMs. The present invention provides a method of shorting, grounding and monitoring the electrical conductors of a permanent magnet motor in order to manipulate the conductors, for example, to splice the motor lead end (MLE) of a cable to a power cable. Referring to FIG. **1**, there is shown a well **18** having a casing **10** and an ESP **12** coupled to a permanent magnet motor (PMM) **16** disposed in the well. ESP **12** is typical of the prior art and includes a pump and seals (not shown) and is further hydraulically connected to production pipe **14** to pump production fluids to the surface. PMM **16** may be a three phase, alternating current, type permanent magnet motor known in the prior art. MLE **23** may be comprised of an armored cable having three insulated electrical conductors enclosed therein, as will be described in more detail herein below. MLE **23** is mechanically and electrically connected to PMM **16** at pot head connector **22** in motor housing **24**. Initially, MLE **23** extends upwardly along ESP **12** for several feet and in some cases for one hundred or more feet depending on the pump length and particular installation. Motor lead **23** is electrically connected to power cable **20** by connection **21** which connection may comprise a mechanical splice as will be explained more fully hereinafter. Power cable **20** may also be comprised of an armored cable having three insulated electrical conductors enclosed therein and extends upwardly toward the surface. For purposes of clarity and convention, the length of cable electrically attached to PMM **16** will be referred to herein as an MLE. For example, once an MLE is spliced to a section power cable the entire spliced length will continue to be referred to as an MLE. As successive sections of power cables **20** may be spliced to MLE **23** and may include another splice connection **21** (not shown) and the MLE increases in length and is ultimately connected to a power source, and may include a variable frequency drive at the surface (not shown).

Now referring to FIG. **2** there is shown a typical ESP power cable which is shown as MLE **23**. Such ESP power cables may be flat as shown or may be round and may be comprised of various protective, insulative and conductive materials. An exemplary disclosure of ESP power cables for use with the present invention can be found at Petrowiki at the url address http://petrowiki.org/ESP_power_cable#cite_ref-r1_1-0, the disclosure of which is incorporated herein in its entirety. Still referring to FIG. **2**, insulated conductors **32**, **33**, **34** include conductor **38** which is typically comprised of a solid copper (or other efficient electrically conducting material) core but may be comprised of a plurality of smaller strands. Core **38** is typically enclosed within a layer of insulation **35** which is comprised of an electrically insulating material such as EPDM or FEP or the like. In the embodiment of MLE **23** shown there is also a metallic lead protective layer **36** (comprised of lead or a lead alloy) disposed around insulation **35**. The three insulated conductors **32**, **33**, **34** are encapsulated within a protective insulating jacket **31** which protects lead insulation **36** and insulation **35** and may comprised of a nitrile or EPDM rubber material. MLE **23** is overwrapped with metallic armor **30** which may be comprised of a galvanized steel and provides mechanical protection to insulated conductors **32**, **33**, **34**. For purposes of simplicity and clarity, and without departing from the scope of the present invention, MLE **23** and power cable **20** as used herein can be assumed to be comprised of the elements described immediately above with reference to FIG. **2**.

It is known in the prior art to mechanically connect PMM **16**, ESP **12** and at least a few sections of production pipe **14** at the surface. It is further known to attach pot head **22** to PMM **16** and MLE **23** to the side of ESP at the surface. With the various components assembled at the surface as described, an operator lowers the assembly into well **18**. There are various situations within the art that necessitate the placement of a splice connection **21** in the embodiment described. For instance, a first splice connection **21** between MLE and power cable **20** is typically made on site as ESP **12** and PMM **16** are positioned within well **18**. An operator further attaches successive sections of production pipe **14**, continues to lower the assembled components into well **18**, and makes splice connections **21** as needed until ESP **12** is positioned at a predetermined depth within the well. In addition, MLE **23** may be damaged, either during installation in the well or thereafter, and necessitate that a splice connection **21** be placed to restore electrical connectivity to PMM **16**. A typical splice connection **21** may comprise any known connector including as described herein above with reference to US20130052055.

As described herein above, and with reference to FIG. **2**, a typical splice connection **21** of the prior art is a field splice connector that may require trimming or cutting the cable end, removing the wound armor **30**, stripping back the protective insulating jacket **31**, preparing the conductors **38** by removing layers **35**, **36**, installing a conducting splice member such as a ferrule crimp, and the use of insulating and amalgamating tapes for encapsulating the splice. The process may take two hours or more. Many of these steps require a skilled technician to use his bare hands exposing him to the potential of a shock hazard. As will be described more fully herein below, the present invention ensures that at all times during a splicing operation there is no hazardous voltage present on the conductors **38** being worked on. Since PMM **16** is the voltage source of concern, the afore mentioned hazards are prevented by the present invention at the splice end of MLE **23**. In order to facilitate existing safe working practices for splicing, and to guard against certain failure modes of the hazard prevention means, additional steps are taken with the section of power cable yet to be spliced as disclosed herein above and below.

Referring now to FIG. **3**, there is shown MLE **23** previously prepared for such a field splice to power supply cable **20** and an embodiment of an SGA **50** in accordance with the present invention. Shown in the figure is MLE **23** which is connected to PMM **16** via pot head connector **22** (FIG. **1**). As described herein above with reference to FIG. **2**, MLE **23** may comprise, metallic armor **30**, a protective insulating jacket **31** inside of which are disposed three insulated conductors **32**, **33**, **34**. As is known in the art, electrical current is carried by conductors **38** to and from the motor, and as described herein above if the shaft of PMM **16** is rotating a significant voltage may be present within insulated conductors **32**, **33**, **34**.

As discussed herein above, and as will be appreciated by those skilled in the art, that while splicing MLE **23** to power cable **20** the conductors **38** are exposed and present hazards such as shock and sparking. The primary voltage hazard arises when contact is made across two conductors **38**. It is an aspect of the present invention that if conductors **38** are shorted together there can be no voltage across them. If the shaft of PMM **16** is rotating, the internal generator voltage of the motor will however drive a current through a short circuit of conductors **38**, limited by the impedance of the motor winding and the shorted conductors. The present invention takes advantage of the known characteristic of permanent magnet motors, that this current flow will result in a braking torque and advantageously a reduction in the speed of the motor and pump. The current flow may be detected as hereinbelow described so as to provide an indication of rotation and hence a warning to stop work as a further safety precaution.

Still referring to FIG. **3**, an embodiment of SGA **50** is shown connected to MLE **23** to render the insulated conductors **32**, **33**, **34** safe. It is an important aspect of the present invention that SGA **50** be positioned between an operator and PMM **16**. Clamp **51** may comprise a piercing type clamp that when positioned as shown on insulation **35** of insulated conductor **32** it pierces through the insulation and makes electrical contact with conductor **38**. In some embodiments of the present invention clamp **51** may be installed over multiple layers of insulation such as insulation **35** and metallic lead protection **36** and wherein the clamp pierces the multiple layers of insulation and makes contact with conductor **38**. Clamp **51** is electrically coupled to conductor **55** which is in turn connected to bus bar **57** mounted inside of enclosure **60**. Clamps **52, 53** are similarly in electrical contact with conductors **38** of insulated conductors **33**, **34** and are respectively coupled to conductors **56**, **57** and connected to bus bar **57**. SGA **50** further includes clamp **54** electrically coupled to metallic armor **30** which is electrically connected to bus bar **59** via conductor **58**. As described herein below, the present invention provides an additional safety feature in that junction box **60**, as well as bus bar **59**, may be electrically grounded via conductor **61** run to a suitable ground **62**. As one skilled in the art can appreciate, with SGA **50** of the present invention installed as described any electrical potential in motor lead cable **23** is shorted and may further be run to ground **62** rendering insulated conductors **32, 33, 34** safe to handle. Although the embodiment of SGA **50** is shown with piercing clamps **51**, **52**, **53**, separate conductors **56**, **57**, **58** and an enclosure **60**, any assembly of components that short pairs of conductors **38** and which may also run the conductors and armor **30** to ground is within the scope of the present invention.

Given the aforementioned description of SGA **50** if the exemplary pair of conductors **38** are isolated from earth, and only one conductor is touched by an operator then no shock or sparking hazards can result. However, if an earth fault on one of the conductors **38** occurs in PMM **16** or MLE **23** during work on the MLE then a hazard exists from the other conductors to earth **62**. It should be appreciated that this secondary fault case is well known in electrical installation practice using the "IT" floating power system. In normal electrical installations this secondary fault is not immediately hazardous and an insulation monitor may be used to detect and warn of its occurrence. It should be further appreciated however that when working on conductors **38** in utilizing the present invention there may be an immediate touch hazard. Therefore, certain embodiments of the present invention preferably includes a further step of shorting the conductors **38** to ground **62** via conductor **61**. Although armor **30** is inevitably in contact with metallic parts of the production tubing, and therefore likely in contact with ground, it is preferable to explicitly ground it as with conductor **58**.

Example Methods of Employing an SGA of the Present Invention

The reliability of splices and other means of connection is an essential part of the economics of artificial lift systems and ESP's in particular, wherein the loss of production and rig costs associated with a repair are extremely costly. Therefor it is a further objective of the present invention to allow existing established practice for induction type motors to be followed as closely as possible when permanent magnet motors are used. The splicing operation of the exemplary method described herein below closely resembles that practiced in the art of induction motor driven ESP systems.

An exemplary method of employing the SGA **50** of the present invention is illustrated with reference to FIGS. **3** and **4**. With PMM **16** installed within 18 (FIG. **1**) MLE **23** is prepared for splicing to power cable **20** by installing SGA **50** onto the MLE as will be described directly herein below. Prior to splicing, MLE **23** is typically presented to an operator as a straight cable that has been terminated by, for example, sawing. The operator, while using insulated gloves, removes a portion of wound armor **30**, strips back the protective insulating jacket **31**, and exposes the insulated conductors **32-34**.

Referring now to FIG. **4** there is shown an exemplary embodiment of piercing clamps **51**, **52**, **53** that may be installed, preferably while wearing gloves. Piercing clamps **51**, **52**, **53** may advantageously comprise a modified version of piercing clamp IPC 1/0-#2 manufactured and offered for sale by Ilsco Kupler®. The piercing clamps include an insulating top block **70**, an insulating bottom block **71**, and isolated clamping bolt **72**. Upper block **70** and lower block **71** include a metal bar (not shown), which metal bar includes teeth **73** mounted on either end of the bar, within conductor terminals **74**, **75** formed within the upper and lower block pairs. The aforementioned modification of the piercing block includes the removal of a bulkhead and a second pair of toothed bars as a single piercing position is desired to minimize damage to insulation **35**. During installation of SGA **50**, each of the conductors **38** of the three insulated conductors **32-34** and shorting conductors **55-57** are connected to separate piercing clamps in respective pairs as shown in FIG. **3**. An end of a shorting conductor **55-57**, which shorting conductor may advantageously be insulated, is inserted within conductor channel **75** of piercing clamp and against bulkhead **76**. Similarly an insulated end of a conductor **38** of MLE **23** is inserted into and through conductor channel **74** of the piercing clamp. Bolt **72** is tightened to urge bottom block **71** towards top block **70** and forcing teeth **73** to penetrate insulation **35** of the respective insulated conductor and making electrical contact with the conductor **38** encapsulated therein. It should be noted that the clamp should be positioned on the insulation **35** as close as practicable to the point to which the insulation of conductor will subsequently be trimmed back. This allows the piercing holes in the insulation caused by teeth **73** to be easily sealed and protected as part of the normal splicing operations to seal the splice. Once SGA **50** is installed as described the shock and spark hazards have been neutralized and the splicing operation may continue with less caution. As is normally practiced in the art, the operator prepares the conductors **38** for splicing by removing insulation layers **35**, 36 to expose the conductors. It should be noted that such an embodiment of a piercing clamp may accommodate all commonly employed submersible pump conductor sizes. Alternative embodiments of the piercing clamp described above include a device that may have molded shorting and earth connections and a more compact piercing/cutting head, that may preferably be installed without tools, such as lever operated.

Power cable **20** may be comprised of the same or similar components as MLE **23** as described herein above. The same operation of preparing power cable **20** for splicing may typically performed on each end the power cable at least to expose the conductors. In the art it is common practice, and necessary for safely practicing the present invention, to short the conductors of the uphole end of power cable **20**, using a terminal block for instance. If a second SGA is used in place of the terminal block, the present invention has the advantage of monitoring the splice during the completion of the splice. Once SGA **50** is installed as described, power cable **20** may be brought into position as shown in FIG. **3**. In such a position MLE **23** may be spliced to power cable **20** by, for example, installing a conducting splice member, such as a ferrule crimp (not shown), onto conductors **38** of both MLE **23** and power cable **20**. The piercing clamps **51-53** may then be removed one-by-one and then, using insulating and amalgamating tapes, the splice is encapsulated and completed. The danger of shock and sparking does not exist at this stage of the splicing operation because MLE **23** is shorted at opposite uphole end. Splice connection **21** may alternatively be performed by any known method included those disclosed herein before. It is within the scope of the present invention that the same SGA **50** and method described herein above may be used to join subsequent lengths of power cables **20** to each other at for instance, penetrators, joints and wellhead outlets.

The embodiment of SGA **50** in FIG. **3** may advantageously also include a module **80** mounted within junction box **60**. Module **80** may be variously connected to bus bar **59** and/or the shorting conductors **55-57** and to various testing and monitoring devices such as devices to measure voltage, current and impedance. Module **80** may further include a display or other device to demonstrate the connectivity and thereby the effectiveness of SGA **50** to render the electrical conductors safe.

With reference to FIG. **3** in general, and module **80** specifically, various embodiments of the present invention referred to herein above will be described. It is advantage of the present invention that SGA **50** has the ability to continuously monitor the continuity of the shorted conductors **38**, such that operators can be instantly warned of a protection fault such as by indicators and annunciators included in module **80** (not shown). It is a further advantage of the present invention to be able to detect whether the shaft of PMM **16** is actually turning, since personnel can then cease work temporarily as a further safety measure. Yet another advantage of the present invention is the ability to measure the speed of rotation of the shaft of PMM **16** since the internal voltage of a PMM is exactly proportional to speed and so can be determined. At sufficiently low speed the voltage will not be hazardous. The ability to determine rotational speed as well as the shorted motor current may give valuable insight into the nature of the cause of rotation.

It should be appreciated by those skilled in the art that in the shorted system of the present invention, for each motor phase there is a continuous loop through the motor winding, the motor star point and back up through the other phase connections. Taking advantage of these inherent properties, various conditions of PMM **16** may be realized, monitored, measured and otherwise employed to provide further safety to operators.

As an example of the foregoing, for continuity one of the shorting conductors, say **55** for example, may be passed through the core of a small transformer (not shown). The transformer primary can be energized by a simple oscillator circuit, causing current to be induced in a phase conductor, returning via the other shorting conductors **56**, **57**. A low value resistance, perhaps only a few milliohms, can be inserted in series with each of the shorting conductors **56**, **57**, and the voltage drops across them may be sensed using known methods. There will no voltage on a connection that is open circuit. The frequency of the oscillator should be high enough for the transformer to work well but low enough that the series inductance of the motor windings presents too high an impedance to allow a measurable current flow.

Again, and as another example, for detection of rotation of the shaft of PMM **16**, it will be apparent a rotating motor shaft will generate current into a short circuit in proportion to its internal voltage (emf) and series impedances. This alternating current is measurable from the voltage drop across the aforementioned resistances. The current readily reaches many amperes and can be distinguished from the continuity circuit by frequency range and large amplitude. It is known that the frequency of the current from PMM **16** is inherently an exact indicator of speed. An alternative embodiment to utilizing resistances, other current transducers such as flux gate and hall effect sensors as made by LEM (lem.com) may be used.

An important aspect of all the aforementioned methods of motor current measurement is that they work continuously from DC through the maximum frequency of the motor. These methods work for ESP systems using permanent magnet motors having used for PCPs as well as centrifugal pumps. As an example, a 4-pole motor rotating at 1800 rpm generates current at a frequency of 60 Hz but at 180 rpm it is only 6 Hz. A motor wound for say 600V operation at 180 rpm would produce a hazardous 60V at 18 rpm (48V being a widely accepted maximum safe voltage). However at 18 rpm the frequency of the current would be only 0.6 Hz. This example shows the advantages of the features of module **80** of the present invention. Conventional widely available handheld meters would be ineffective at performing such monitoring in that are designed to either measure DC or to measure AC above a few Hz. Even on DC+AC ranges the same limitation applies. At 0.6 Hz there may be a slight indication when set to DC or DC+AC but on AC there will no reading at all.

It should be noted that the present invention further includes the termination of a MLE **23** with a "touch safe" connector (not shown) that would in itself be connected to the electrical connectors and allow manipulation and connection of the MLE to the power cable with minimal risk of electrical shock or sparking. The present invention further includes a removable terminating connector (not shown) for connecting with the touch safe connector and safely terminating MLE **23** thereby. It is within the scope of the present invention that the terminating connector includes the features and components of monitor **80** described herein above.

While the foregoing is directed to embodiments of the present invention for use in conventional tubing deployed ESP systems, other systems utilizing permanent magnet motors where a similar risk of shock hazard exists such as electric drilling, rigless completions, coiled tubing and the like are within the scope of the present invention.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. An apparatus for attachment to a plurality of power cables electrically coupled to a permanent magnet motor comprising:

a plurality of clamps selectively electrically coupled to a plurality of electrical conductors of the power cables, wherein the plurality of power cables are overwrapped by a metallic armor;

a plurality of shorting conductors electrically coupled to the clamps and extending therefrom;

the shorting conductors electrically coupled to a bus bar electrically shorting the shorting conductors; and

a conductor electrically coupled to the metallic armor and the bus bar.

2. The apparatus of claim **1**, further comprising a grounded conductor connected to the bus bar and extending therefrom and electrically grounding the shorting conductors to earth.

3. The apparatus of claim **1**, wherein at least one of the power cables or at least one of the shorting conductors includes an insulation wherein the shorting conductors are enclosed within the insulation, a plurality of teeth disposed within the clamps piercing the insulation and contacting the electrical conductors and thereby electrically coupling the power cables and the shorting conductors.

4. The apparatus of claim **1**, wherein electrically shorting the shorting conductors produces a braking torque in the permanent magnet motor.

5. An apparatus for attachment to a plurality of power cables electrically coupled to a permanent magnet motor comprising:

a plurality of clamps selectively electrically coupled to a plurality of electrical conductors of the power cables;

a plurality of shorting conductors electrically coupled to the clamps and extending therefrom;

the shorting conductors electrically coupled to a bus bar electrically shorting the shorting conductors; and

a module having the bus bar mounted therein, the module further comprising at least one monitoring device monitoring at least one condition of the permanent magnet motor.

6. The apparatus of claim **5**, wherein the at least one monitoring device measures a voltage, a current or an impedance.

7. The apparatus of claim **5**, wherein the module includes a display, an indicator or an annunciator coupled to the at least one monitoring device.

8. The apparatus of claim **5**, wherein the at least one condition includes a speed of the permanent magnet motor.

9. A method for safely working with a plurality of power cables, the method comprising:

coupling a first end of the plurality of power cables of a motor lead end to a permanent magnet motor;

providing a plurality of clamps;

selectively electrically coupling the clamps to a plurality of electrical conductors of a second end of the power cables;

electrically coupling the clamps to a plurality of shorting conductors;

electrically coupling the shorting conductors to a bus bar; and

monitoring at least one condition of the permanent magnet motor.

10. The method of claim **9**, further comprising electrically grounding the shorting conductors to earth.

11. The method of claim **9**, wherein at least one of the power cables and the conductors includes an insulation wherein the shorting conductors are enclosed within the insulation, the method further comprising the clamp piercing the insulation contacting the electrical conductors and thereby electrically coupling the power cables and the shorting conductors.

12. The method of claim **9**, wherein the at least one condition includes a current, a voltage, or an impedance.

13. The method of claim **9**, further including displaying, indicating or annunciating a condition related to the at least one condition.

14. The method of claim **9**, wherein the plurality of power cables are overwrapped by a metallic armor, the method further comprising electrically coupling the metallic armor to the shorting conductors shorting the metallic armor.

15. The method of claim **9**, further comprising producing a braking torque in the permanent magnet motor.

16. The method of claim **9** further comprising splicing the second end of the motor lead to a plurality of conductors of a power cable.

17. The method of claim **16** wherein the conductors of the power cable are comprised of an electrical conductor disposed within an insulation layer, the method further comprising:

terminating the second end of the motor lead and an end of the power cable;

exposing the insulated conductors of the second end of the motor lead and the power cable;

stripping a portion of the insulating jacket from the terminated ends of the insulated conductors exposing a portion of the electrical conductors;

electrically splicing the electrical conductors of the motor lead to the electrical conductors of the power cable; and

one-by-one decoupling one of the shorting conductors from one of the insulated electrical conductors and encapsulating the splice and a portion of the insulating jacket in an insulating material.

18. The method of claim **17**, wherein terminating comprises sawing.

19. The method of claim **9**, further comprising interrupting the method if a hazard is present.

20. The method of claim **19**, wherein the hazard comprises a shock, a sparking, or an earth fault.

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