(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 January 2016 (21.01.2016)

(10) International Publication Number
WO 2016/008013 A1

(51) International Patent Classification:
H02J 3/16 (2006.01) *H02J 3/18* (2006.01)

(21) International Application Number:
PCT/AU2015/050402

(22) International Filing Date:
17 July 2015 (17.07.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2014902785 18 July 2014 (18.07.2014) AU

(71) Applicant: **RECOV GLOBAL PTY LTD** [AU/AU]; C/- Cullens Patent and Trade Mark Attorneys, Level 32, 239 George Street, Brisbane, Queensland 4000 (AU).

(72) Inventor: **COOMER, Ron**; C-/- Cullens Patent and Trade Mark Attorneys, Level 32, 239 George Street, Brisbane, Queensland 4000 (AU).

(74) Agent: **CULLENS PATENT AND TRADE MARK ATTORNEYS**; Level 32, 239 George Street, Brisbane, Queensland 4000 (AU).

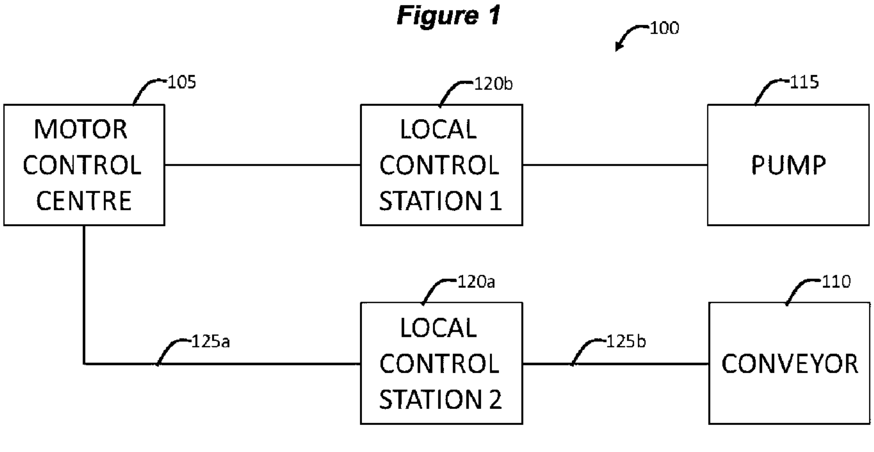
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: IMPROVED POWER SYSTEM

Figure 1



(57) **Abstract**: A power system and a local control station (LCS), for controlling a reactive load device is disclosed. The LCS includes a power input, for receiving power from a motor control centre (MCC); a power output, for powering the reactive load device using the power input; and a power factor correction module, intermediate to the power input and the power output, for at least partially compensating for a reactive load of the reactive load device.

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IMPROVED POWER SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to power systems. In particular, although not exclusively, the present invention relates to industrial power control systems, for use in, for example, mining.

BACKGROUND ART

[0002] The manufacturing and mining industries are generally reliant on a large number of electric motors, including conveyors and pumps. Electric motors are generally reliable, have a low cost and low maintenance requirements.

[0003] Motor Control Centres (MCCs) can be used to power and control motors in industrial and mining environments. MCCs typically contain a circuit breaker for each of the electric motors to provide overload protection and enable a site manager to isolate each of the motors in case of a fault.

[0004] MCCs generally also include functionality for automatic control of each of the motors. Such functionality can include contactors for direct on line starting, or soft starters to reduce surges during electrical start up, or variable speed drives to control the speed of the motors, as well as advanced monitoring, control, and diagnostics systems, for monitoring and automatically controlling the motors based upon the monitored data.

[0005] MCCs are generally modular, and are thus fast and easy to install. Also, MCCs often provide safety features, including prevention of arc flashes, locks for locking switches when the door is open or closed, safety devices to prevent certain operations when power is supplied to the MCC.

[0006] A problem with MCCs of the prior art, is that they are generally used to control motors that a dispersed over a wide area, and may thus be located far from the motors which they are controlling. In many cases, the MCC can be located 100m or more from the motors in which it controls. Furthermore, each motor is typically fed by its own cable from the Motor Control Centre (MCC). Accordingly, a significant amount of cabling is required, which is costly.

[0007] Furthermore, many AC motors have a power factor of between 0.80 and 0.85, and thus draw greater than 20% more current than if the load was at unity power factor. This increases losses in the system and requires larger cable sizes to be used.

[0008] Alternatively, several MCCs may be spread over a site, such that an MCC is located close to each motor. However, this causes an increase in cost and maintenance, as some functionality is duplicated across the site.

[0009] Accordingly, there is a need for an improved power system.

[0010] It will be clearly understood that, if a prior art publication is referred to herein, this reference does not constitute an admission that the publication forms part of the common general knowledge in the art in Australia or in any other country.

SUMMARY OF INVENTION

[0011] The present invention is directed to power systems and local control stations, which may at least partially overcome at least one of the abovementioned disadvantages or provide the consumer with a useful or commercial choice.

[0012] With the foregoing in view, the present invention in one form, resides broadly in a local control station (LCS) for controlling a reactive load device, the LCS including:

a power input, for receiving power from a motor control centre (MCC) that is located remotely to the reactive load device;

a power output, for powering the reactive load device using the power input; and

a power factor correction module, intermediate to the power input and the power output, for at least partially compensating for a reactive load of the reactive load device.

[0013] Preferably, the LCS is for controlling a reactive load device in close proximity to the LCS and the MCC is located remotely to the reactive load device.

[0014] An advantage of embodiments of the present invention is that power factor correction can take place close to the reactive load device, which in turn minimises the consequences of low power factors in much of the system.

[0015] As power factor decreases, current increases. As such, losses in the system can be reduced by performing power factor correction at the LCS. Furthermore, larger cabling is required where the power factor is low. As power factor correction is performed close to the reactive load device, much of the cabling can be smaller (and thus cheaper) than if the power factor correction was performed centrally, or not at all.

[0016] The reactive load device may comprise an inductive load device. The inductive load device may include an electric motor. Alternatively, the reactive load device may comprise a capacitive load device. Examples of reactive devices include conveyors and pumps including electric motors. The electric motors may be three phase motors or alternatively single phase motors.

[0017] The power factor correction module for an inductive load device may comprise a single capacitor or a plurality of capacitors. According to certain embodiments, the power factor correction module comprises at least two banks of capacitors. The banks of capacitors may be selectively coupled to the inductive load device according to the rating of the inductive load device. This enables the LCS to be simply adapted to suit different inductive load devices.

[0018] Preferably, where two banks of capacitors are used, one bank of capacitors is twice the rating of the second bank. This enables selective coupling of the banks to obtain a capacitance of C (smaller bank only) or 2C (larger bank only) or 3C (both smaller and larger bank) to the inductive load device.

[0019] Preferably, where capacitors are used to provide power factor correction, overload protection is provided for each capacitor or each bank of capacitors, either internally or externally to the capacitors, in order to prevent short circuits in case of failure of one or more capacitors.

[0020] The power factor correction module for a capacitive load device may comprise a single inductor or a plurality of inductors. According to certain embodiments, the power factor correction module comprises at least two banks of inductors. The banks of inductors may be selectively coupled to the capacitive load device according to the rating of the capacitive load device. This enables the LCS to be simply adapted to suit different capacitive load devices.

[0021] Preferably where two banks of inductors are used, one bank of inductors is twice the rating of the second bank. This enables selective coupling of the bans to obtain an inductance of L (smaller bank only), 2L (larger bank only) or 3L (both smaller and larger banks) to the capacitive load device.

[0022] Preferably a reference table is placed on an inside of the LCS, to provide information to an installer to determine which selection of capacitor and/or inductor banks is best suited to the installation. The table may include power factor correction values for various capacitive or inductive load devices connected to the LCS. The table may alleviate the need for an installer to perform complex calculations on site.

[0023] The power factor correction module for a reactive load device may comprise a single inductor and a single capacitor or a plurality of inductors and capacitors. According to certain embodiments, the power factor correction module comprises at least one bank of inductors and at least one bank of capacitors. The banks of inductors and capacitors may be selectively coupled to the reactive load device according to the rating of the reactive load device. This enables the LCS to be simply adapted to suit different reactive load devices.

[0024] Alternatively, the power factor correction module for motors may comprise a Variable Voltage Variable Frequency (VVVF) drive.

[0025] Preferably, the power factor correction module is configured to provide a compensated power factor of greater than 0.9. More preferably, the power factor correction module is configured to provide a compensated power factor of greater than 0.95. More preferably again, the power factor correction module is configured to provide a compensated power factor of greater than 0.99.

[0026] The LCS may include a local isolator, for isolating the reactive load device from the MCC. The local isolator may comprise a locking mechanism to prevent re-energisation of the reactive load device. This can provide an operator an ability to isolate the reactive load device in case of a fault or for maintenance.

[0027] The LCS may comprise one or more buttons or switches. This can provide an operator an ability to locally start or stop the reactive load device.

[0028] The LCS may comprise a signal device, for signalling that the reactive load device is being powered by the MCC. The signal device may comprise a lamp.

[0029] The LCS may include a signal module, for providing signal data to the MCC. The signal data may include, for example, temperature data, flow data, pressure data. The signal module may be wired to the MCC, or wirelessly coupled to the MCC.

[0030] The LCS may include a plurality of transducers, for providing the signal data. The plurality of transducers may include a flow transducer, for measuring a water flow of a pump, a suction pressure transducer, for measuring a suction pressure of the pump, a discharge pressure transducer, for measuring a discharge pressure of the pump, and a pump volute temperature transducer, for measuring a volute temperature of the pump.

[0031] The LCS may further include a Resistance Temperature Detectors (RTD) to monitor a temperature of the reactive load device. The RTD may comprise one or more of motor winding RTDs, for measuring temperatures at windings of a motor, a drive end bearing RTD, for measuring a temperature at the drive end bearing of the motor, and a non-drive end bearing RTD, for measuring a temperature at the non-drive end bearing of the motor.

[0032] The LCS may be shielded from weather. For example, the LCS may be enclosed in an enclosure. The enclosure may be rated according to an IP66 rating and may have a hood / sunshield to protect it from the weather and sun in outdoor applications. Preferably the hood / sunshield has a sloping top to prevent the buildup of dirt and grime on the LCS.

[0033] The LCS enclosure may include apertures, for receiving cables. The apertures may be located on an underside of the enclosure.

[0034] The LCS may include a local distribution board, to power one or more devices that are auxiliary to the reactive load device. This eliminates the need to provide additional cells in the MCC and run additional cables from the MCC to power the auxiliary devices.

[0035] In another form, the invention resides broadly in a power system including:

a reactive load device;

a motor control centre (MCC), located remotely to the reactive load device, for powering the reactive load device;

a local control station (LCS) in close proximity to the reactive load device, the LCS including:

a power input, coupled to the MCC, for receiving power from the MCC;

a power output, coupled to the reactive load device, for powering a reactive load device; and

a power factor correction module, intermediate to the power input and the power output, for at least partially compensating for a reactive load of reactive load device.

[0036] The system may include a plurality of reactive load devices and a plurality of LCS's, wherein the MCC is located remotely to a plurality of reactive load devices, with each LCS including:

a power input, coupled to the MCC, for receiving power from the MCC;

a power output, coupled to the respective reactive load device, for powering a reactive load device; and

a power factor correction module, intermediate to the power input and the power output, for at least partially compensating for a reactive load of further reactive load device.

[0037] The reactive load devices may be located remotely to each other.

[0038] Advantages of certain embodiments of the present invention include an ability to provide simple power factor correction. In particular, when power factor correction modules are provided for each of a plurality of reactive load devices, power factor correction can be performed statically. In clear contrast, if power factor correction is performed centrally for a plurality of reactive load devices, the power factor correction must dynamically adapt to take into account which of the reactive load devices are operational and which are not, which is more complex.

[0039] For dynamic power factor correction using capacitors, a bleed resistor arrangement may be employed to ensure the capacitors are discharged in a reasonable time to prevent electrical injury to personnel after the capacitors have been de-energised. These bleed resistors generally add losses to the system and when internal to each capacitor contribute to self heating which reduces the life of the capacitors. This is generally not required in static power factor correction because the inductive load provides a discharge path for each capacitor.

[0040] The power input may be coupled to the MCC by a first cable, and the power output may be coupled to the reactive load device by a second cable.

[0041] The first cable may have a smaller gauge than the second cable.

[0042] The first cable may be longer than the second cable. Preferably, the first cable is at least twice as long as the second cable. More preferably, the first cable is at least five times longer than the second cable. More preferably again, the first cable is at least ten times longer than the second cable.

[0043] As such, an advantage of certain embodiments of the present invention is that an amount of large gauge cabling can be reduced, which in turn can reduce costs.

[0044] An alternate advantage for existing installations is they may be upgraded to include larger reactive loads (up to 30% greater) without the need to run larger gauge cabling from the MCC to the LCS or increase the rating of the equipment in the MCC, which can provide significant cost savings for upgrade projects.

[0045] Any of the features described herein can be combined in any combination with any one or more of the other features described herein within the scope of the invention.

[0046] The reference to any prior art in this specification is not, and should not be taken as an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge.

BRIEF DESCRIPTION OF DRAWINGS

[0047] Various embodiments of the invention will be described with reference to the following drawings, in which:

[0048] FIG. 1 illustrates a schematic of a power system, according to an embodiment of the present invention;

[0049] FIG. 2 illustrates a schematic of a local control station (LCS), according to an embodiment of the present invention;

[0050] FIG. 3 illustrates a perspective view of first and second LCS's according to an embodiment of the present invention;

[0051] FIG. 4 is a graph illustrating current at a motor control centre (MCC) against tonnes per hour of material on a conveyor, comparing a prior art system with an embodiment of the present invention;

[0052] FIG. 5 is a graph illustrating reduction in upstream power loss against motor rating for various loads on the motor, when comparing a prior art system with an embodiment of the present invention;

[0053] FIG. 6 is a graph illustrating power factor against motor rating at various motor loads, both before and after an LCS according to an embodiment of the present invention has been installed;

[0054] FIG. 7 is a graph illustrating current supply against time in relation to a mine producing about 1000 tonnes of coal per hour;

[0055] FIG. 8 illustrates a front perspective view of an LCS, according to an embodiment of the present invention;

[0056] FIG. 9 illustrates a schematic of a local control station (LCS), according to an alternative embodiment of the present invention; and

[0057] FIG. 10 illustrates a schematic of a local control station (LCS), according to yet an alternative embodiment of the present invention.

[0058] Preferred features, embodiments and variations of the invention may be discerned from the following Detailed Description which provides sufficient information for those skilled in the art to perform the invention. The Detailed Description is not to be regarded as limiting the scope of the preceding Summary of the Invention in any way.

DESCRIPTION OF EMBODIMENTS

[0059] FIG. 1 illustrates a schematic of a power system 100, according to an embodiment of the present invention.

[0060] The power system 100 includes a motor control centre (MCC) 105, a conveyor 110, and a pump 115. The conveyor 110 and the pump 115 are examples of reactive load devices, and include one or more electric motors. The skilled addressee will, however, appreciate that any combination of electrical equipment may be coupled to the MCC 105, including a plurality of conveyors 110 and pumps 115, or other reactive load devices, including capacitive and inductive load devices.

[0061] The conveyor 110 is coupled to the conveyor by a first Local Control Station (LCS) 120a. In particular, a first cable 125a couples the MCC 105 to the first LCS 120a and a second cable 125b couples the first LCS 120a to the conveyor. Similarly, the pump 115 is coupled to the MCC 105 by a second LCS 120b.

[0062] The first and second LCS's 120a, 120b are located adjacent to the conveyor 110 and the pump 115 respectively. In contrast, the MCC 105 is located remotely to the conveyor 110 and the pump 115. As such, the first cable 125a is long, for example around 100m long, and the second cable is short, for example around 5m long.

[0063] The conveyor 110 and the pump 115 include AC motors (not illustrated). The AC motors may be three-phase motors. Such motors are inductive, and as such have a low power factor, i.e. a power factor substantially less than 1.

[0064] As described in further detail below, the first LCS 120a and the second LCS 120b include power factor correction modules, to correct the power factor associated with the motors, i.e. increase the power factor to be approximately 1.

[0065] As power factor correction is performed at the first and second LCS's 120a, 120b, less current is drawn from the MCC 105 to the first and second LCS's 120a, 120b than from the first and second LCS's 120a, 120b to the conveyor 110 and the pump 115 respectively. As such, the first cable 125a, which is long, can have a smaller gauge than the second cable 125b, which is relatively short.

[0066] In clear contrast, if power correction would alternatively be performed at the MCC 105, or not at all, the first cable 125a, which is long would need a larger gauge, which would result in a significant increase in cost.

[0067] The LCS's 120a, 120b may include overload protection, which can automatically disconnect power to the conveyor 110 and the pump 115 when overload is detected. When power factor correction is employed in the system 100, settings relating to the overload protection may need to be adjusted to take into account the power factor correction. In particular, as the power factor is increased, the overload setting for the motor will need to be reduced to compensate therefore.

[0068] As an illustrative example, in retrofit applications where the conveyor 110 and the pump 115 is not changed but power factor correction is installed, overload settings of the MCC 105 must generally also be adjusted to provide adequate protection for the conveyor 110 and the pump 115. For example, if the power factor is improved from about 0.8 to unity, the overload settings will need to be reduced by about 20%. Alternatively, the original protection settings could be used if the conveyor 110 and the pump 115 are upgraded in size by about 20%.

[0069] FIG. 2 illustrates a schematic of a local control station (LCS) 200, according to an embodiment of the present invention. The local control station 200 can be similar or identical to the first and second LCS's 120a, 120b of FIG. 1.

[0070] The LCS 200 is coupled to a motor control centre (not illustrated), such as the MCC 105 of FIG. 1, and a three-phase motor 205. The three-phase motor 205 may be a motor of a pump, such as the pump 110 of FIG. 1.

[0071] The LCS 200 includes an input cable 210 in the form of a 3C+E 25mm^2 cable from a motor control centre, such as the MCC 105 of FIG. 1. The input cable 205 provides power to the motor 205 from the MCC. The LCS 200 further includes an output cable 215, which is coupled to the three-phase motor 205 by a motor cable termination box 220. The motor cable termination box 220 includes a plurality of junctions to enable simple attachment of the motor 205 to the output cable 215.

[0072] The input cable 210 and the output cable 215 are joined by a local isolator 225 and at least one of a first and second bank of capacitors 230a, 230b. The local isolator 225 enables power to the motor 205 to be disconnected. The local isolator may include, for example, a button or a key to enable an operator to quickly isolate the motor.

[0073] The banks of capacitors 230a, 230b provide power correction to the motor 205. Each bank of capacitors 230a, 230b comprises a plurality of capacitors that are coupled in parallel to the motor 205, and thus provide compensation for the inductive power factor offset provide by the motor 205.

[0074] The banks of capacitors 230a, 230b may be selectively coupled to the LCS 200 and thus the motor 205, depending on a rating of the motor 205. In particular, the first bank of capacitors

230a may be configured to provide correction when the motor 205 has a first rating, and the second bank of capacitors 230b may be configured to provide correction when the motor 205 has a second rating. As such, the one or more of the banks of capacitors 230a, 230b may be coupled to the LCS 200 when installing the LCS, based upon the motor 205.

[0075] In particular, the banks of capacitors 230a, 230b may be selectable to suit one or more standard 3 phase IEC and/or NEMA motors and to provide an input power factor close to unity (1).

[0076] Examples of suitable low voltage (LV) capacitors include RS metallized polypropylene film (MPF) alternating current (AC) motor capacitors of RS Components Pty Ltd of Smithfield, Australia and MPF AC motor run capacitors of Cornell Dubilier Electronics, Inc of Massachusetts, United States.

[0077] Medium voltage (MV) and high voltage (HV) capacitors are available from suppliers such as ABB, Siemens and General Electric.

[0078] The LCS 200 further includes a control/signal cable 235 in the form of a 20 pair 1.5mm2 telecommunications cable. The control provides control signalling to the MCC, such as sensor data, as described below.

[0079] The LCS 200 includes a plurality of transducers 240, including a flow transducer 240a, for measuring a water flow of a pump, a suction pressure transducer 240b, for measuring a suction pressure of the pump, a discharge pressure transducer 240c, for measuring a discharge pressure of the pump, and a pump volute temperature transducer 240d, for measuring a volute temperature of the pump.

[0080] The LCS 200 further includes a plurality of temperature transmitters 245, for transmitting temperatures of the motor 205. In particular, a plurality of Resistance Temperature Detectors (RTD's) 250 are used to monitor temperatures of the motor, and provide the temperatures to the MCC using the temperature transmitters 245. The plurality of RTD's 250 includes motor winding RTDs 250a (two for each winding of the motor 205), for measuring temperatures at the windings, a drive end bearing RTD 250b, for measuring a temperature at the drive end bearing of the motor 205, and a non-drive end bearing RTD 250c, for measuring a temperature at the non-drive end bearing of the motor 205.

[0081] According to alternative embodiments, described below, an LCS may include serial communication capability via Ethernet, Modbus or Profibus, for providing control data to the MCC.

[0082] As discussed above, the LCS 200 includes a local isolator 225, for isolating the reactive load device from the MCC. The local isolator may comprise a button or switch. This can provide an operator an ability to isolate the reactive load device in case of an emergency, a fault or for maintenance.

[0083] The LCS 200 further includes a signal device in the form of a lamp, for signalling that the reactive load device is being powered by the MCC.

[0084] According to alternative embodiments, described further below, an LCS can include a local distribution board, for powering one or more devices that are auxiliary to the motor. Such local distribution of power can minimise the wiring required between the LCS 200 and the MCC.

[0085] FIG. 3 illustrates a perspective view of first and second local control stations (LCS's) 300a, 300b, according to an embodiment of the present invention.

[0086] The LCS's 300a, 300b are mounted to a frame and comprise enclosures in the form of stainless steel cabinets 305 with hinged stainless steel doors 310. The cabinets 305 and doors 310 are protected from the environment, for example according to IP66 (IEC standard 60529). This enables the LCS's 300a, 300b to be mounted outdoors.

[0087] An input cable 315 enters through an aperture in a lower portion of the enclosure, and an output cable 320 exits from an aperture in the lower portion of the enclosure. Furthermore, a signal cable 325 enters through an aperture in a lower portion of the enclosure

[0088] The LCS's 300a, 300b may include locks, for preventing unauthorised access to the LCS, as well as other safety features, for example to comply with statutory and/or mining regulations.

[0089] According to certain embodiments, not illustrated, power factor correction components, e.g. banks of capacitors 230a, 230b, are housed in a separate enclosure located adjacent to the stainless steel cabinets 305. This is particularly beneficial in upgrade scenarios where existing control station components are already housed in a suitable enclosure, and that enclosure is too small for the new power factor correction components.

[0090] FIG. 4 is a graph 400 illustrating current 405 at an MCC against tonnes per hour 410 of material on a conveyor, comparing a prior art system with an embodiment of the present invention.

[0091] A non-power factor correction (non-PFC) line 415 illustrates the current at the MCC without any power factor correction. A PFC line 420 illustrates the current at the MCC with power factor correction at a local control station (LCS) according to an embodiment of the present invention.

[0092] As can be seen by comparing the non-PFC line 415 with the PFC line 420, current at the MCC can be reduced by over 25% at certain loads in a typical mining application, by placing PFC at a LCS. As such, smaller (and thus cheaper) cabling can be used to couple the MCC to the LCS.

[0093] Figure 5 is a graph 50 illustrating reduction in upstream power loss 52 against motor rating 54 for various loads on the motor, when comparing a prior art system with an embodiment of the present invention. As illustrated, embodiments of the present invention comprise 100A, 250A and 400A local control stations.

[0094] The graph 50 includes a 50% load element 56, a 75% load element 58 and a 100% load element 60. Given that most motors in industry are loaded at between 50% and 75% load, the graph 50 illustrates that a reduction in upstream power system losses (and associated heating of components) of between about 40% and 50% are obtainable in such situations.

[0095] Figure 6 is a graph 60 illustrating power factor 62 against motor rating 64 for 100A, 250A and 400A LCSs at various motor loads both before and after installation of an LCS according to an embodiment of the present invention.

[0096] The graph 60 includes a non-PFC 50% load element 66, a non-PFC 75% load element 68 and a non-PFC 100% load element 70, and a PFC 50% load element 72, a PFC 75% load element 74 and a PFC 100% load element 76. The non-PFC load elements correspond to prior art systems without PFC (power factor correction) and the PFC load elements correspond to systems including a LCS providing PFC, according to embodiments of the present invention.

[0097] As can be seen from the graph, the power factor increases from around 0.75-0.9 without power factor correction, to close to unity (1) with power factor correction, for all loads, i.e. 50% load, 75% load and 100% load.

[0098] Figure 7 is a graph 70 illustrating current supply 72 against time 74 in relation to a mine producing about 1000 tonnes of coal per hour. The graph 70 initially illustrates no power factor correction, followed by power factor correction according an embodiment of the present invention applied to some of the reactive loads of the mine, and later power factor correction according an embodiment of the present invention is applied to the majority of the reactive loads of the mine.

[0099] As illustrated in the graph 70, the mine initially, i.e. before power factor correction, averages about 100 Amps of current is drawn. At first upgrade time 76, power factor correction according an embodiment of the present invention applied to some of the reactive loads of the mine.

As a result, the current drawn is reduced to about 90 Amps. At second upgrade time 78, power factor correction according an embodiment of the present invention applied to a majority of the reactive loads of the mine. As a result, the current drawn is reduced to about 80 Amps.

[00100] The graph 70 illustrates several dips to around 10 Amps of current or less. Such dips correspond to shut downs in the mine where much of the equipment is turned off, e.g. for maintenance, and is thus not relevant to the present invention.

[00101] Figure 8 illustrates a front perspective view of a local control station (LCS) 80, according to an embodiment of the present invention. The LCS 80 is similar to the LCS's 300a, 300b, but smaller in size.

[00102] The LCS 80 comprises a stainless steel cabinet 82, with a hinged stainless steel door 84. The stainless steel door 84 includes a viewing window 86, to enable the user to look inside the LCS without opening the door. Circuit breakers or fuses, for example, may be visible through the window 86, and as such, the user may be able to view the circuit breakers or fuses without having to open the LCS, which in turn may improve safety.

[00103] The cabinet includes an upper surface 88, which is sloping relative to the cabinet 82, to prevent the buildup of dirt and grime on the LCS 80. In the case of a coal mine, significant amounts of coal dust can be present in the air around the LCS 80, and as such, it is important to prevent the buildup of such dust on the LCS 80.

[00104] The LCS 80 comprises an emergency stop button 90 and a start button 92, as well as an on-off lever 94, to enable a user to isolate the system for maintenance or when there is an emergency.

[00105] Finally, the door 84 includes a lock 96, to prevent unauthorised access to an inside of the LCS 80.

[00106] FIG. 9 illustrates a schematic of a local control station (LCS) 500, according to an embodiment of the present invention. The LCS 500 is similar to the LCS 200 of FIG. 2.

[00107] The LCS 500 includes a 3-phase softstarter module 505, coupled between the input cable 210 and the output cable 215. The 3-phase softstarter module 505 limits the current when starting the motor, which may reduce current surge, and load and torque in the motor.

[00108] The LCS 500 also includes an RTD analogue remote IO device 510, in place of the temperature transmitters 245. In particular, the RTD analogue remote IO device 510 is coupled to

the plurality of RTD's 250, from which temperature signals are determined. The temperature signals are then provided to the MCC by serial communication, for example by MODBUS, PROFIBUS, DEVICENET or any other suitable serial communication method.

[00109] FIG. 10 illustrates a schematic of a local control station (LCS) 600, according to an embodiment of the present invention. The LCS 600 is similar to the LCS 500 of FIG. 5.

[00110] The LCS 600 includes a VVVF drive 605 in place of the first and second bank of capacitors 230a, 230b. The VVVF drive 605 is able to control a speed of the motor 205 to improve power factor. The VVVF drive may also be used to control the speed of the motor 205 to provide soft start functionality, to take into account variability in the operation of the motor (e.g. load on a conveyor), or the like.

[00111] In particular, the control/signal cable 235 is coupled to the VVVF drive 605 to enable the MCC to monitor and control the VVVF drive 605.

[00112] The LCS 600 is also coupled to a cooling fan 610, which is auxiliary to the motor 205. In particular, the LCS 600 includes a local distribution board including a breaker, to power the cooling fan 610. The cooling fan 610 is connected to the power output 215, which negates the need to obtain separate power from the MCC for the cooling fan 610.

[00113] The skilled addressee will readily appreciate that the local distribution board may power several devices that are auxiliary to the reactive load device.

[00114] The VVVF drive 605 generally requires cooling, which may, for example, be in the form of a heat sink extending through the enclosure, an air cooling system, or a water cooling system.

[00115] The Local Control Stations described herein can be adapted to suit various motor loads. For example, the following configurations may be provided:

16A - for motor loads from 4kW to 7.5kW (6kVar PFC);

100A - for motor loads from 11kW to 55kW (11kVar to 22kVar PFC in 11kVar steps);

250A - for motor loads from 70kW to 185kW (43kVar to 86kVar PFC in 43kVar steps); and

400A - for motor loads from 200kW to 280kW (130kVar PFC).

[00116] In the present specification and claims (if any), the word 'comprising' and its derivatives including 'comprises' and 'comprise' include each of the stated integers but does not exclude the inclusion of one or more further integers.

[00117] Reference throughout this specification to 'one embodiment' or 'an embodiment' means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases 'in one embodiment' or 'in an embodiment' in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more combinations.

[00118] In compliance with the statute, the invention has been described in language more or less specific to structural or methodical features. It is to be understood that the invention is not limited to specific features shown or described since the means herein described comprises preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims (if any) appropriately interpreted by those skilled in the art.

CLAIMS

1. A local control station (LCS), for controlling a reactive load device, the LCS including:
a power input, for receiving power from a motor control centre (MCC);
a power output, for powering the reactive load device using the power input; and
a power factor correction module, intermediate to the power input and the power output, for at least partially compensating for a reactive load of the reactive load device.

2. The LCS of claim 1, wherein the reactive load device in close proximity to the LCS and the MCC is located remotely to the reactive load device.

3. The LCS of claim 1, wherein the reactive load device includes an inductive load device and the power factor correction module includes a capacitor.

4. The LCS of claim 1, wherein the reactive load device may include a capacitive load device and the power factor correction module includes an inductor.

5. The LCS of claim 1, wherein the power factor correction module includes at least two banks of capacitors or inductors, wherein each of the banks is selectively coupleable to the reactive load device.

6. The LCS of claim 5, including a reference table on an inside of the LCS, to provide information to an installer to determine which selection of the at least two banks of capacitors or inductors is best suited to the reactive load device.

7. The LCS of claim 5, wherein the power factor correction module comprises at least one bank of capacitors and at least one bank of inductors.

8. The LCS of claim 1, wherein the load includes a motor, and the power factor correction module includes a Variable Voltage Variable Frequency (VVVF) drive for the motor.

9. The LCS of claim 1, wherein the power factor correction module is configured to provide a compensated power factor of at least 0.9.

10. The LCS of claim 1, further including a local isolator, for isolating the reactive load device from the MCC.

11. The LCS of claim 1, further including one or more buttons or switches to provide an operator an ability to locally start or stop the reactive load device.

12. The LCS of claim 1, further including a signal device, for signaling that the reactive load

device is being powered by the MCC.

13. The LCS of claim 1, further including a signal module, for providing signal data to the MCC.

14. The LCS of claim 1, further including a plurality of transducers, for providing the signal data, wherein the transducers include at least one of a flow transducer, for measuring a water flow of a pump, a suction pressure transducer, for measuring a suction pressure of the pump, a discharge pressure transducer, for measuring a discharge pressure of the pump, and a pump volute temperature transducer, for measuring a volute temperature of the pump.

15. The LCS of claim 1, further including a Resistance Temperature Detector (RTD) to monitor a temperature of the reactive load device.

16. The LCS of claim 1, further comprising a hood / sunshield to protect the LCS from the weather and sunlight.

17. The LCS of claim 16, wherein the hood / sunshield comprises a sloping top to prevent the buildup of dirt and grime on the LCS.

18. The LCS of claim 1, further comprising a local distribution board, for powering one or more devices that are auxiliary to the reactive load device.

19. A power system including:

a reactive load device;

a motor control centre (MCC), located remotely to the reactive load device, for powering the reactive load device;

a local control station (LCS) in close proximity to the reactive load device, the LCS including:

a power input, coupled to the MCC, for receiving power from the MCC;

a power output, coupled to the reactive load device, for powering a reactive load device; and

a power factor correction module, intermediate the power input and the power output, for at least partially compensating for a reactive load of reactive load device.

20. The power system of claim 19, further including a plurality of reactive load devices and a plurality of LCSs, wherein the MCC is located remotely to a plurality of the reactive load devices, and each of the plurality of LCSs is coupled to a reactive load device of the plurality of reactive load devices, and wherein each of the plurality of LCSs includes:

a power input, coupled to the MCC, for receiving power from the MCC;

a power output, coupled to the further reactive load device, for powering a further reactive load device; and

a power factor correction module, intermediate to the power input and the power output, for at least partially compensating for a reactive load of the respective reactive load device.

21. The power system of claim 19, wherein the power input may be coupled to the MCC by a first cable, and the power output may be coupled to the reactive load device by a second cable, wherein the first cable has a smaller gauge than the second cable.

22. The power system of claim 21, wherein the first cable is at least twice as long as the second cable.

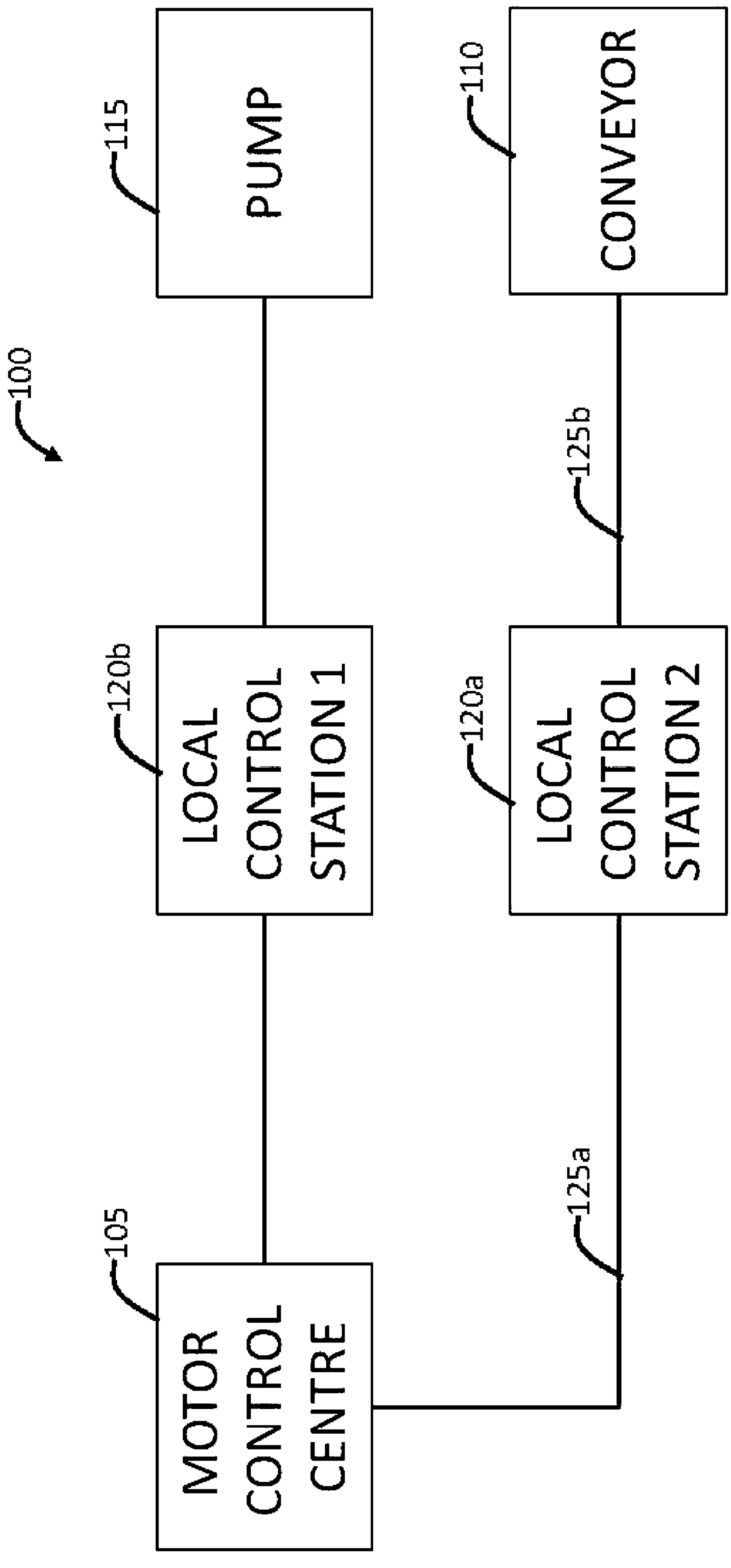
100
PUMP
115
CONVEYOR
110
LOCAL CONTROL STATION 1
120b
LOCAL CONTROL STATION 2
120a
125b
MOTOR CONTROL CENTRE
105
125a

Figure 1

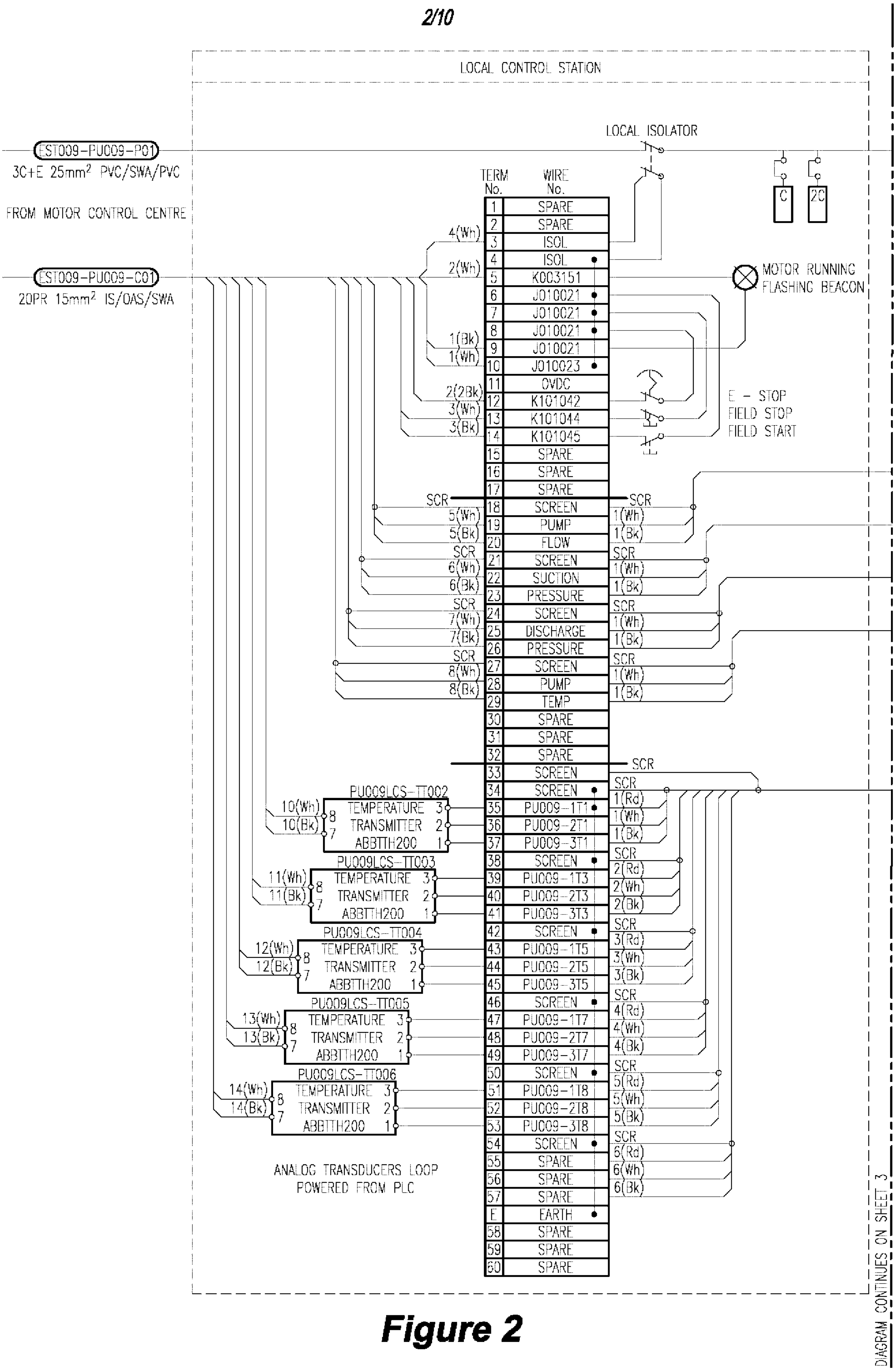
LOCAL CONTROL STATION
LOCAL ISOLATOR
EST009-PU009-P01
3C+E 25mm² PVC/SWA/PVC
FROM MOTOR CONTROL CENTRE
EST009-PU009-C01
20PR 15mm² IS/OAS/SWA
TERM No.
WIRE No.
SPARE
ISOL
K003151
J010021
J010023
0VDC
K101042
K101044
K101045
SCREEN
PUMP
FLOW
SUCTION
PRESSURE
DISCHARGE
TEMP
EARTH
PU009-1T1
PU009-2T1
PU009-3T1
MOTOR RUNNING FLASHING BEACON
E - STOP
FIELD STOP
FIELD START
PU009LCS-TT002
PU009LCS-TT003
PU009LCS-TT004
PU009LCS-TT005
PU009LCS-TT006
TEMPERATURE TRANSMITTER ABBTTH200
ANALOG TRANSDUCERS LOOP POWERED FROM PLC
DIAGRAM CONTINUES ON SHEET 3

Figure 2

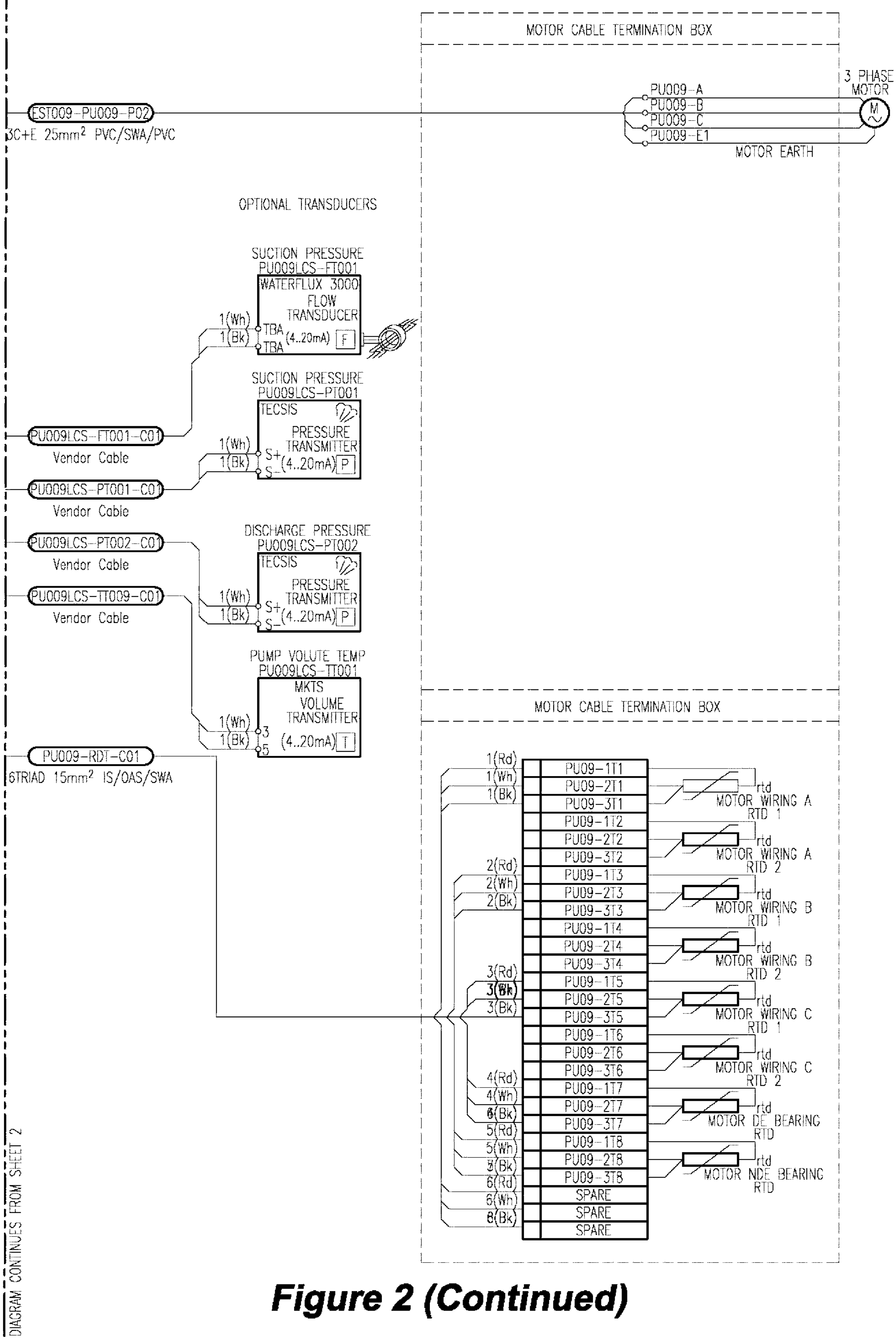

Figure 2 (Continued)

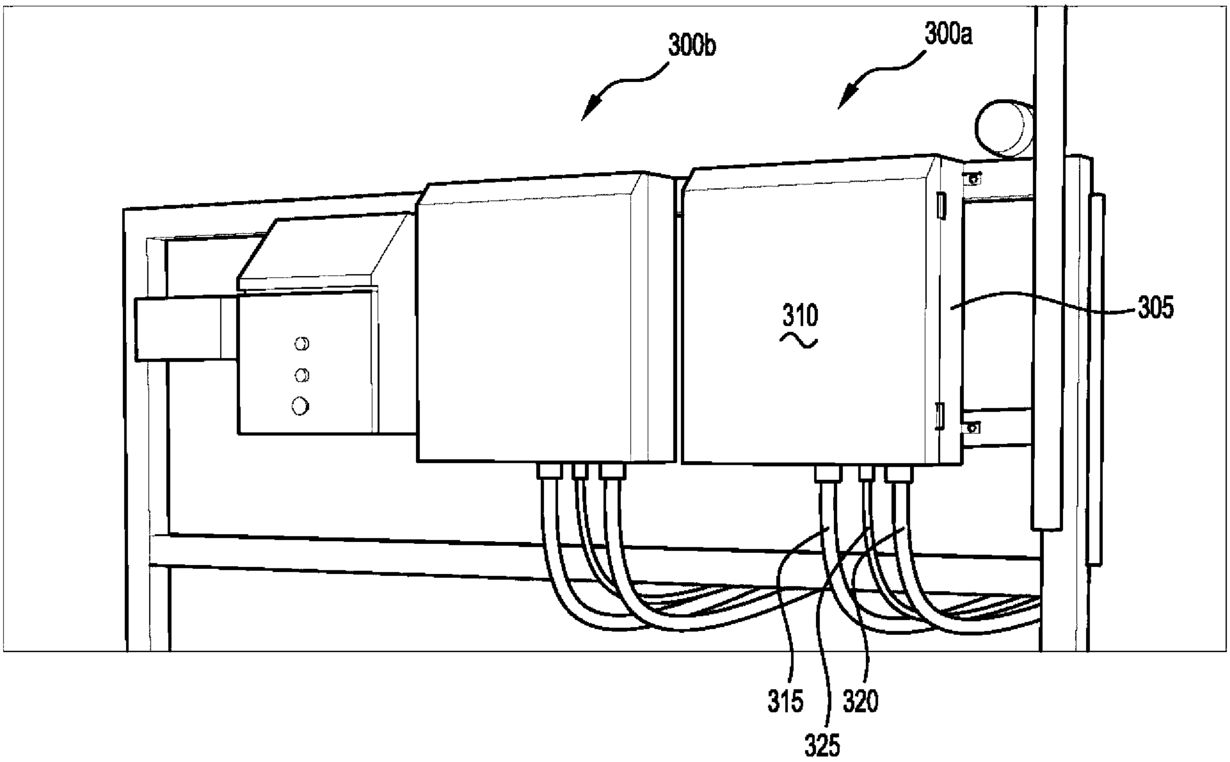

Figure 3

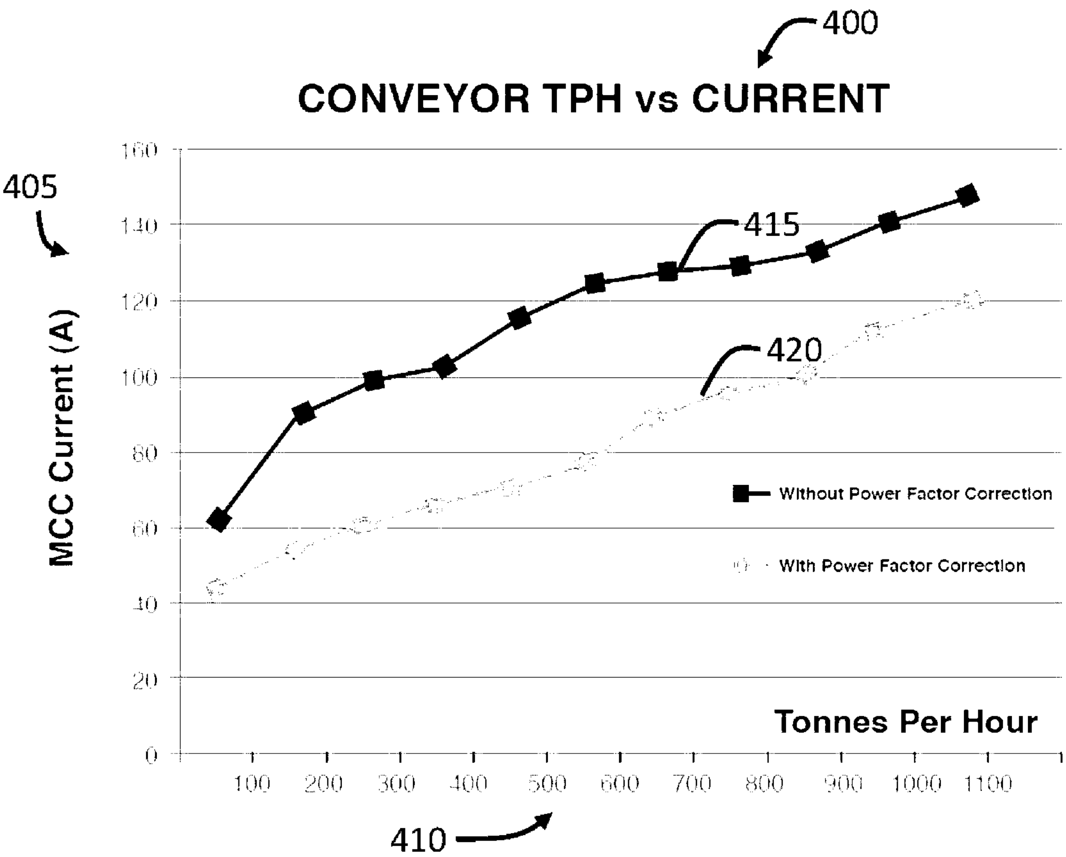

FIG. 4

Substitute

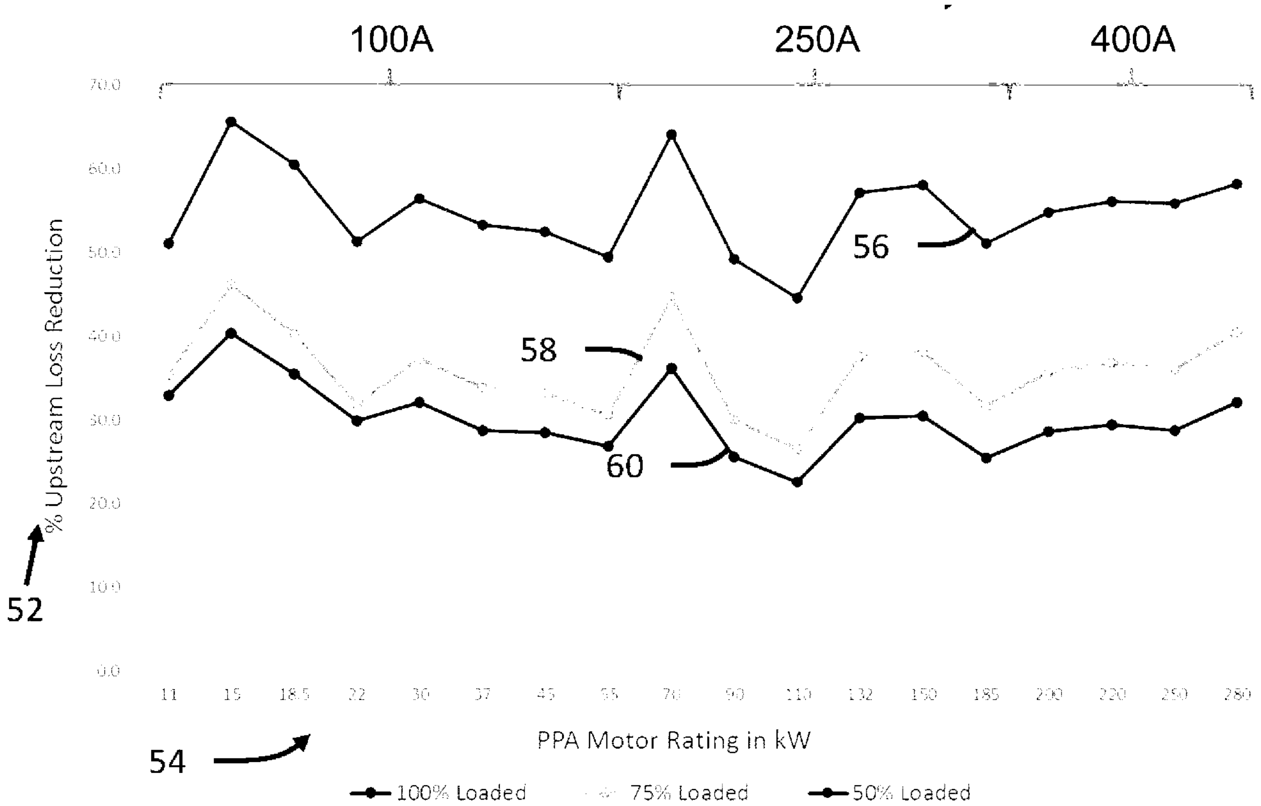

Figure 5

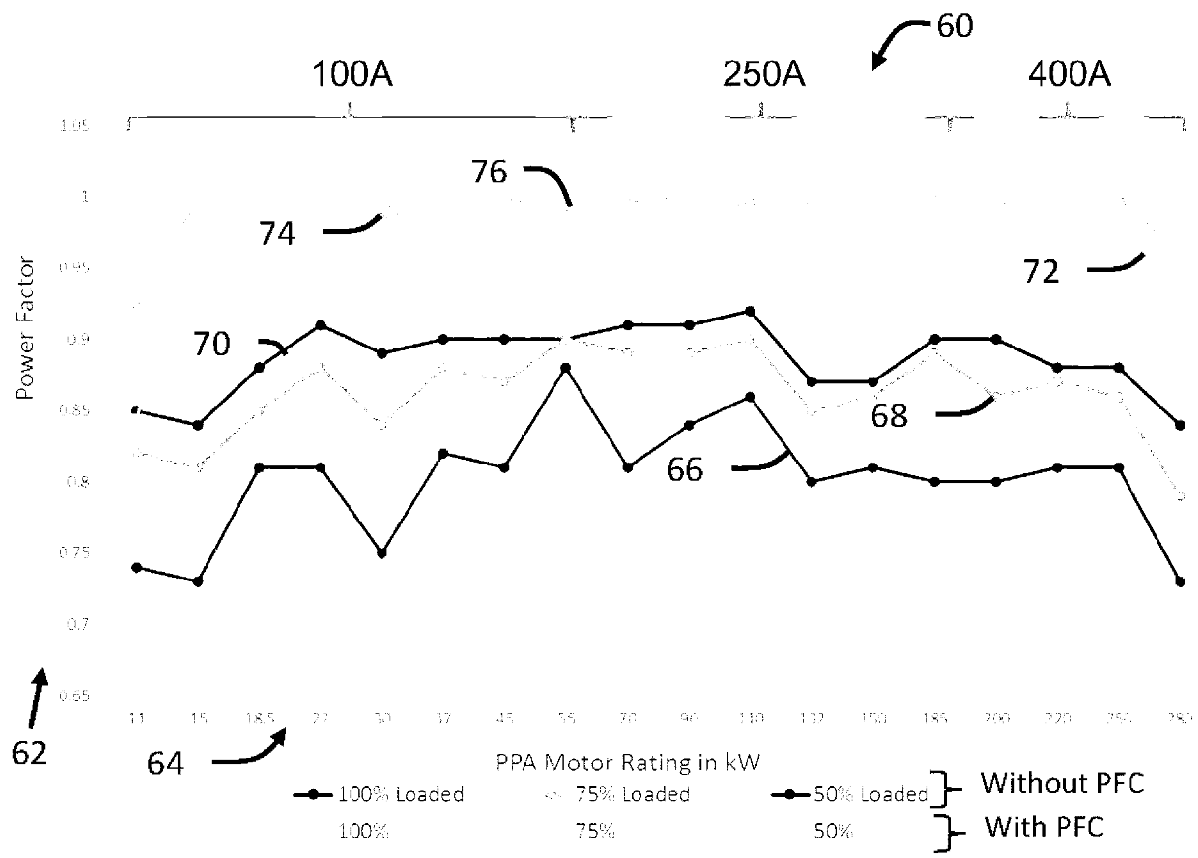

Figure 6

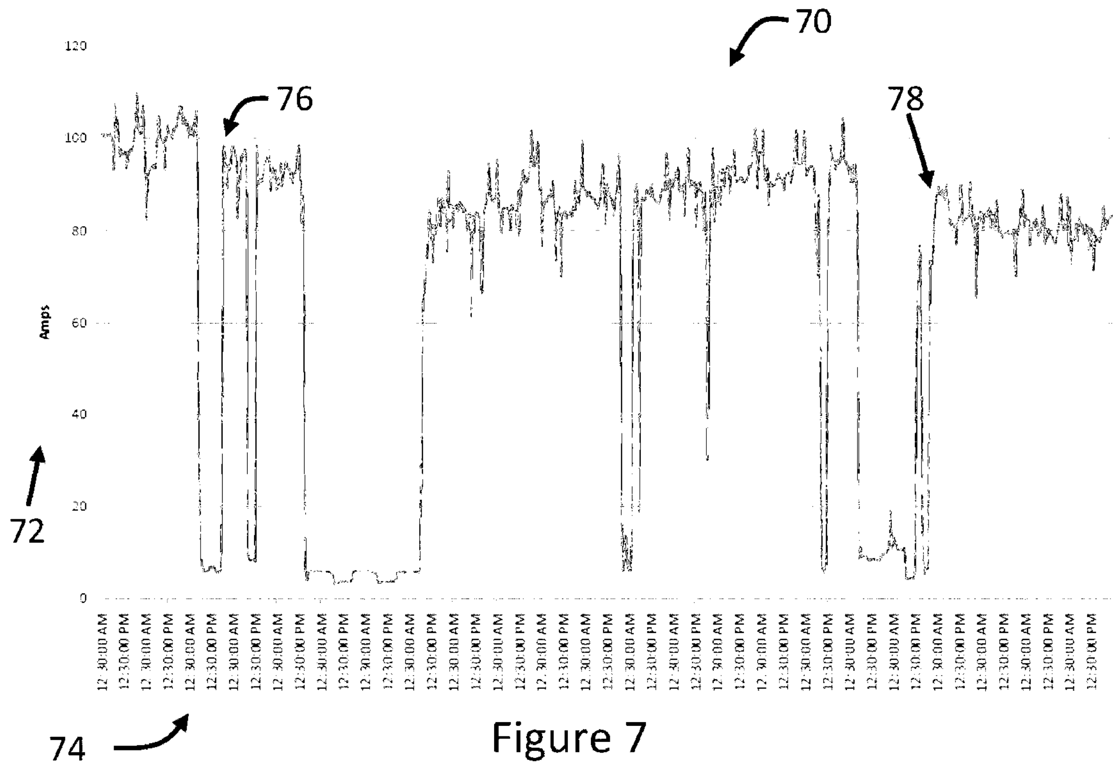

Figure 7

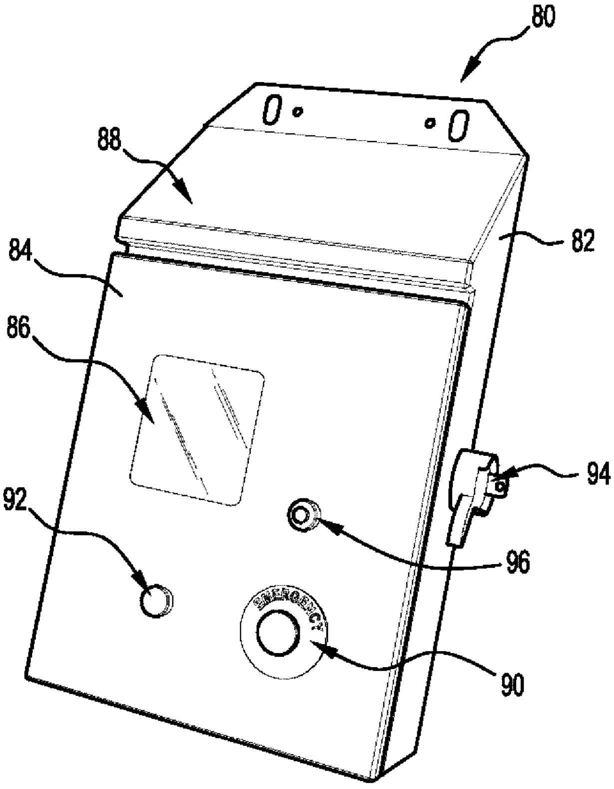

Figure 8

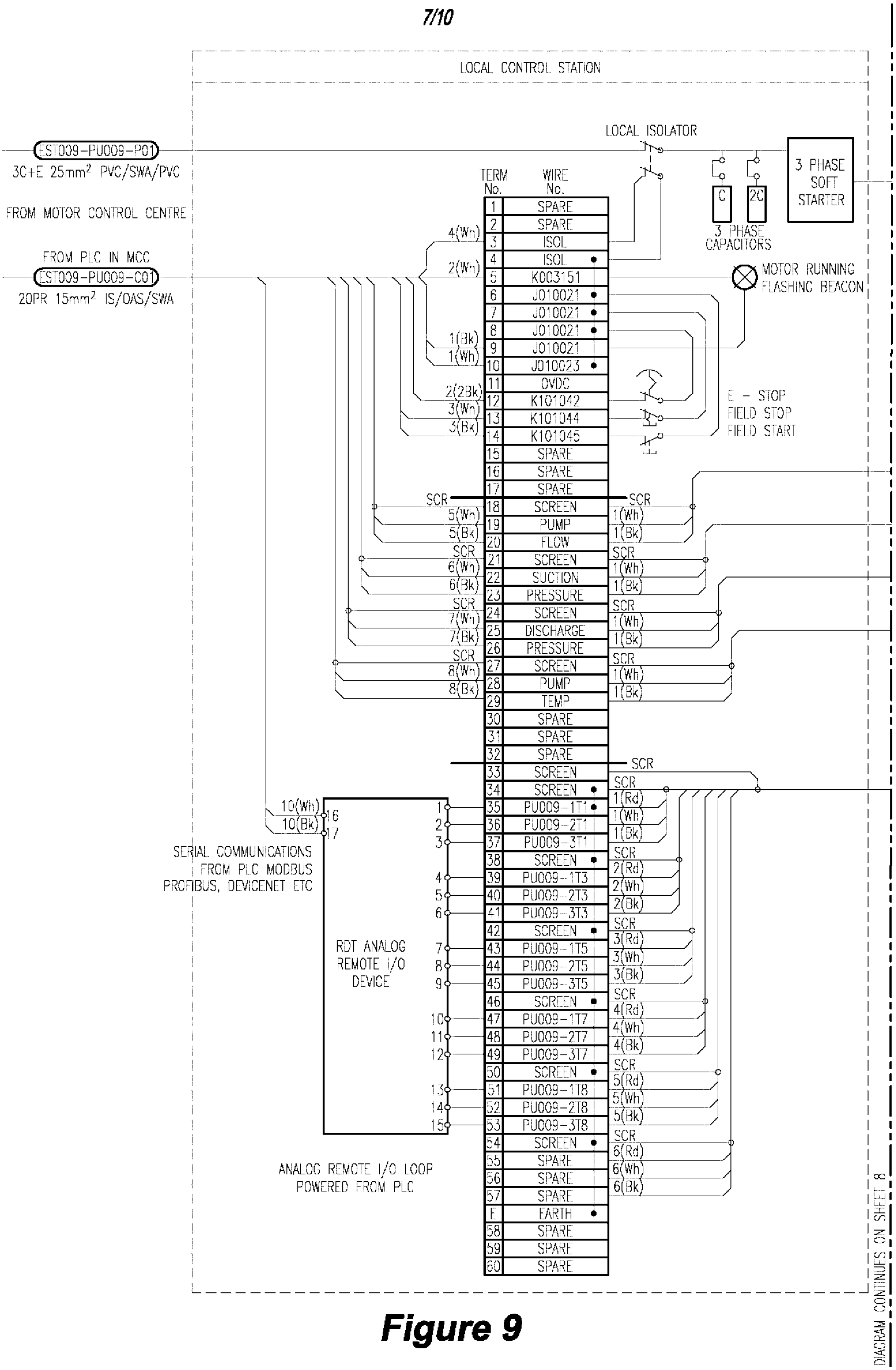
LOCAL CONTROL STATION
LOCAL ISOLATOR
EST009-PU009-P01
3C+E 25mm² PVC/SWA/PVC
FROM MOTOR CONTROL CENTRE
FROM PLC IN MCC
EST009-PU009-C01
20PR 15mm² IS/OAS/SWA
3 PHASE SOFT STARTER
3 PHASE CAPACITORS
MOTOR RUNNING FLASHING BEACON
E - STOP
FIELD STOP
FIELD START
TERM No.
WIRE No.
SPARE
ISOL
K003151
J010021
J010023
OVDC
K101042
K101044
K101045
SCREEN
PUMP
FLOW
SUCTION
PRESSURE
DISCHARGE
TEMP
PU009-1T1
PU009-2T1
PU009-3T1
PU009-1T3
PU009-2T3
PU009-3T3
PU009-1T5
PU009-2T5
PU009-3T5
PU009-1T7
PU009-2T7
PU009-3T7
PU009-1T8
PU009-2T8
PU009-3T8
EARTH
SCR
SERIAL COMMUNICATIONS FROM PLC MODBUS PROFIBUS, DEVICENET ETC
RDT ANALOG REMOTE I/O DEVICE
ANALOG REMOTE I/O LOOP POWERED FROM PLC
DIAGRAM CONTINUES ON SHEET 8

Figure 9

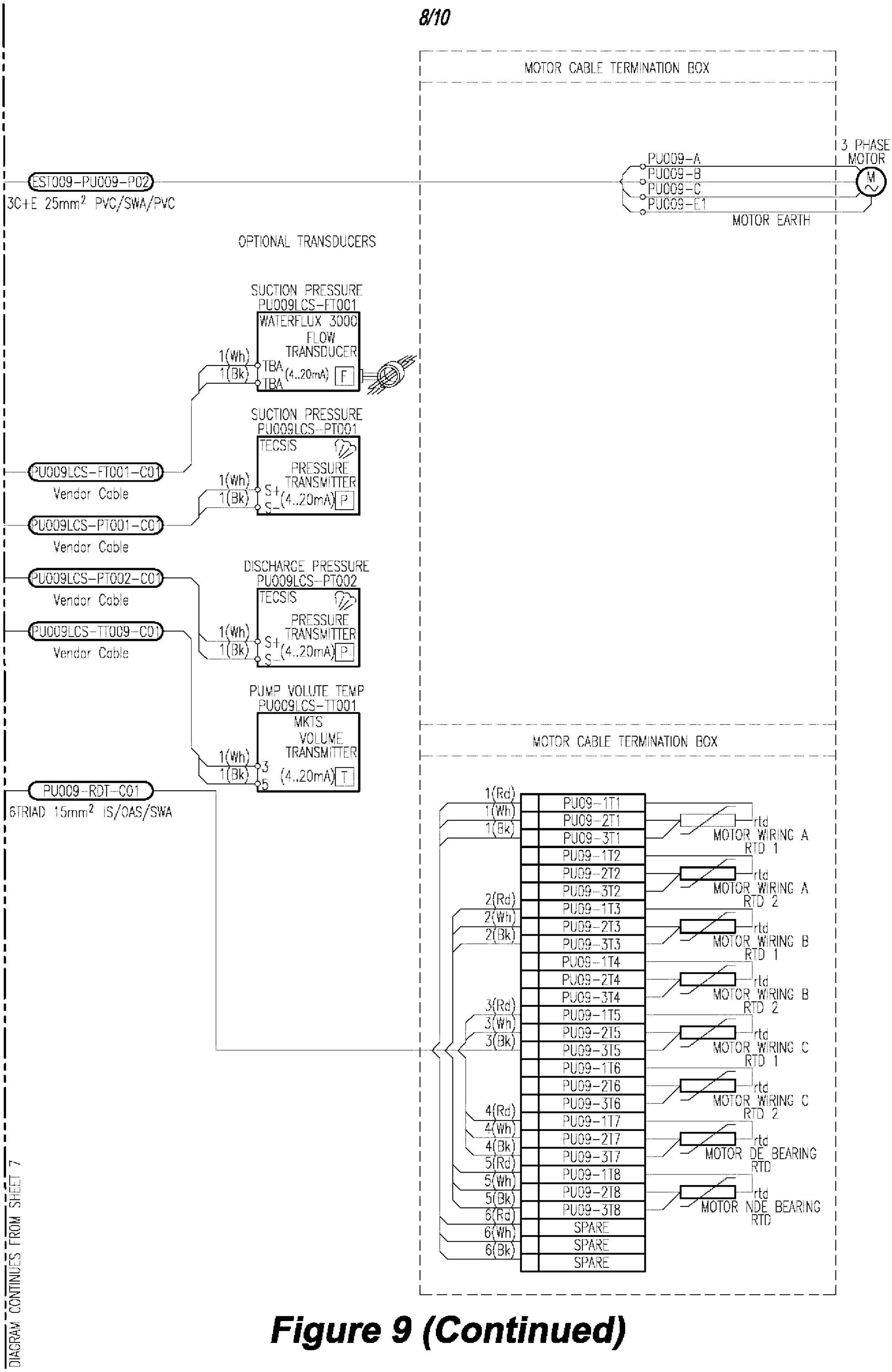

Figure 9 (Continued)

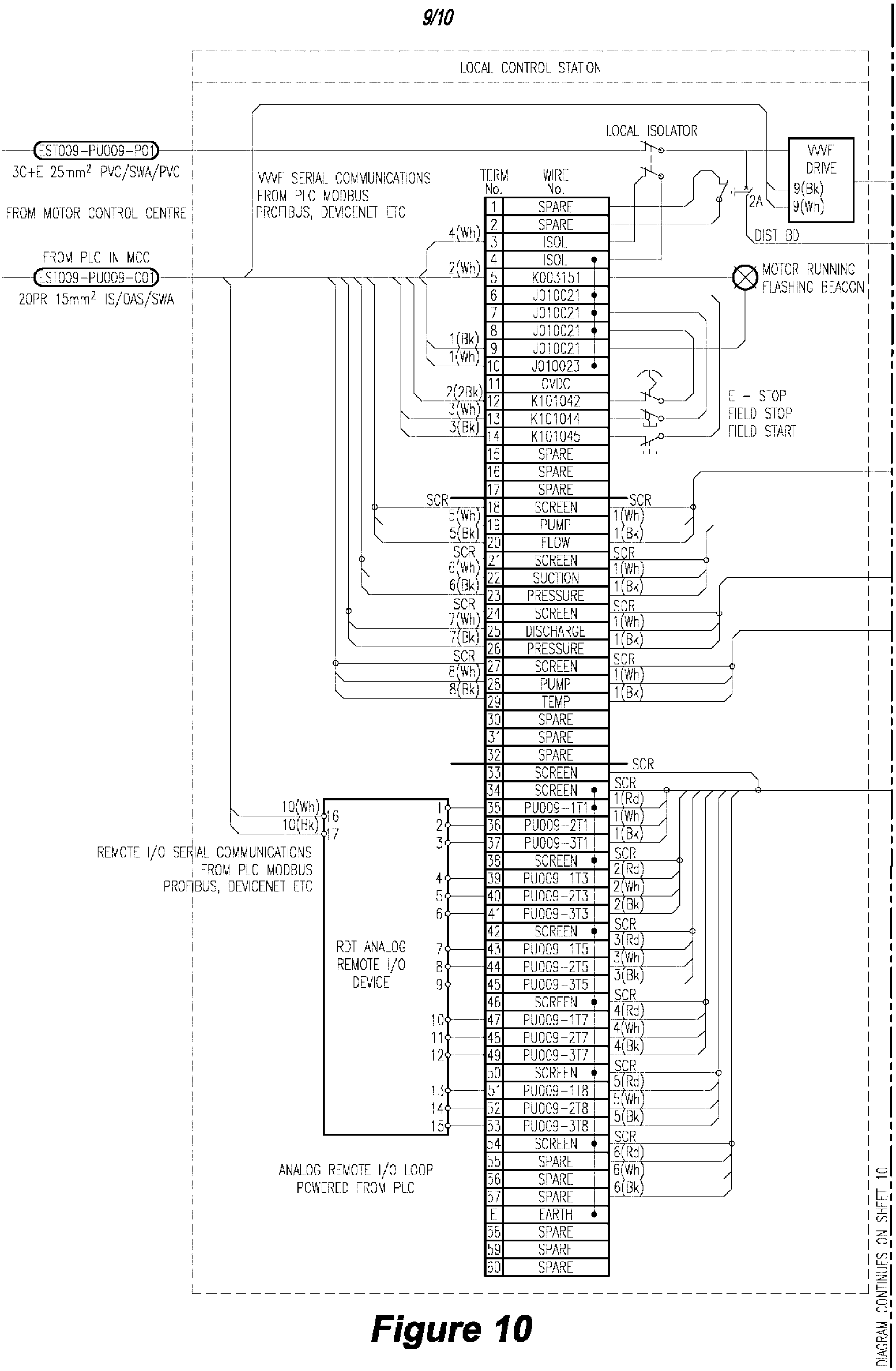

Figure 10

SUBSTITUTE SHEET (RULE 26) RO/AU

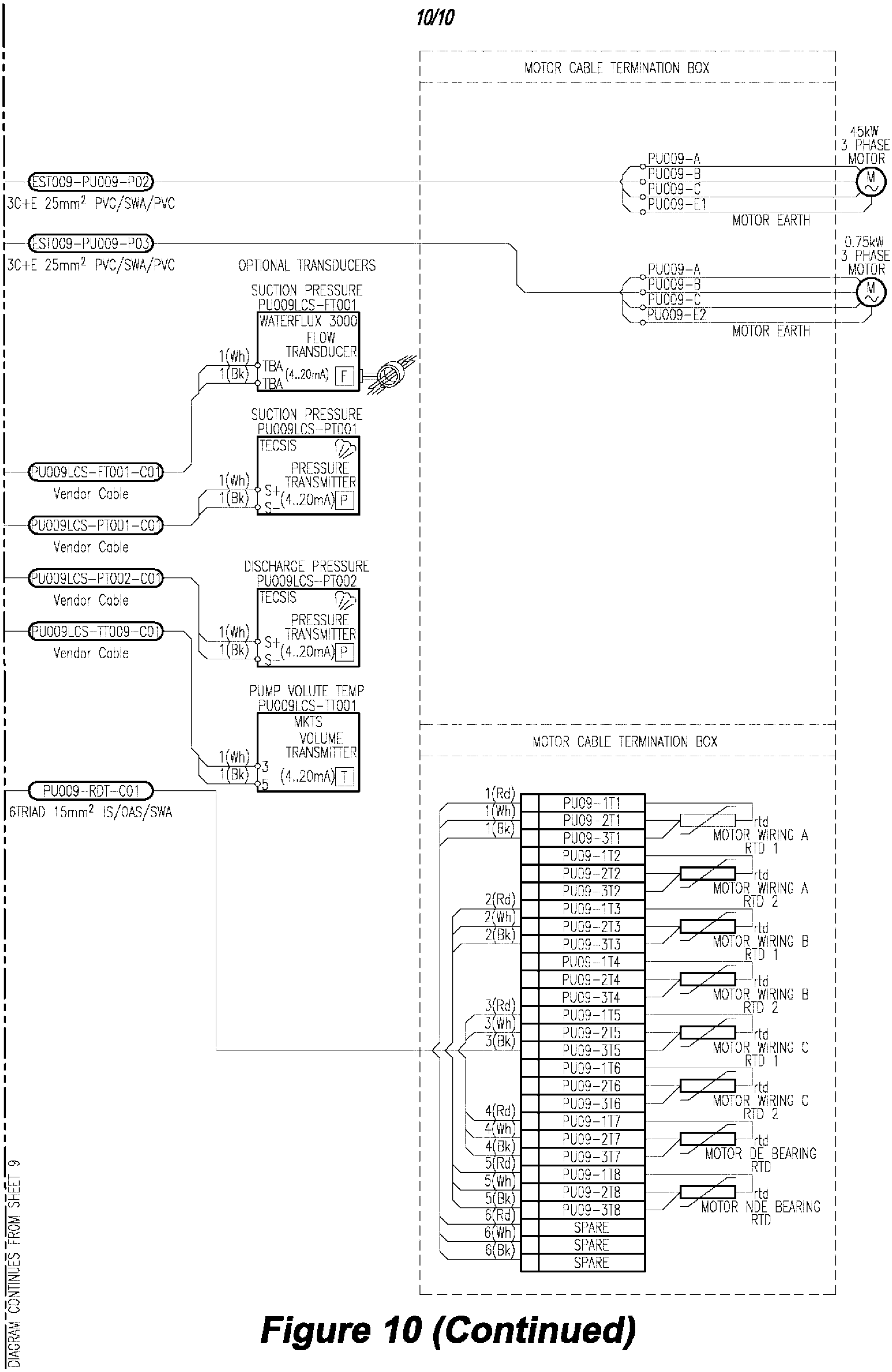

Figure 10 (Continued)

INTERNATIONAL SEARCH REPORT	International application No. **PCT/AU2015/050402**

A. CLASSIFICATION OF SUBJECT MATTER

H02J 3/16 (2006.01) H02J 3/18 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPIAP, EPODOC with keywords: power factor, correction, reactive load, motor control circuit, local, capacitor, variable voltage variable frequency and like terms.

Google/Google Patents search using keywords: local control station, reactive load device, power factor correction; mining; reactive load; motor control centre and like terms.

Abstract/Title/Applicant/Inventor search on Espacenet, Auspat and IP Australia's internal database with keywords: improved power system, local control station, Recov Global, Coomer Ron

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 October 2015	23 October 2015
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	**Authorised officer** Selvam Kalymuthu AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832467

INTERNATIONAL SEARCH REPORT

International application No. **PCT/AU2015/050402**

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 201243204 Y (XI AN BOMAY ELECTRIC INDUSTRY) 20 May 2009 Abstract, Fig 1 and Whole document	1-22
A	WO 2008/055084 A2 (CURRENT TECHNOLOGIES, LLC.) 08 May 2008 Whole document	1-22
A	US 4982147 A (LAUW) 01 January 1991 Whole document	1-22

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
CN 201243204 Y	20 May 2009		
WO 2008/055084 A2	08 May 2008	WO 2008055084 A2	08 May 2008
		US 2008106426 A1	08 May 2008
		US 7675427 B2	09 Mar 2010
		US 2008106425 A1	08 May 2008
		US 7701357 B2	20 Apr 2010
		US 2008122642 A1	29 May 2008
		US 7795877 B2	14 Sep 2010
		US 2008106241 A1	08 May 2008
		US 7804280 B2	28 Sep 2010
		US 2010156649 A1	24 Jun 2010
		US 7965193 B2	21 Jun 2011
		US 2008109387 A1	08 May 2008
		WO 2008057807 A2	15 May 2008
		WO 2008057808 A2	15 May 2008
		WO 2008057809 A2	15 May 2008
		WO 2008057810 A2	15 May 2008
US 4982147 A	01 January 1991	US 4982147 A	01 Jan 1991

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.