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TENSION STRINGING APPARATUS AND PROCESS

Abstract

The process and apparatus for tension stringing a conductor through above-ground supports uses a length of rope affixed to the conductor wound on the tensioning machine and pulled by the puller machine. Each of the first and second stringing apparatuses includes an onboard control system which controls each of the first and second stringing apparatuses in pulling mode or in tensioning mode. Each of the first and second stringing apparatuses includes a motor/regenerative brake or other means of inducing tension into the conductor. Each of the machines includes a wireless transceiver which is hardwired to said onboard control systems. A first operator resides on the puller machine and selects the machine as a puller machine operating in pulling mode using an onboard control system. An observer resides on the tensioner and selects the second machine to be the tensioner. Each of the wireless transceivers communicates with the other wireless transceiver enabling control of both the machines by the onboard control system of the puller machine.

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Background/Summary

[0001] The instant United States patent application is a continuation of U.S. patent application Ser. No. 16/814,897, filed Mar. 10, 2020. The instant patent application is assigned to TSE International, Inc., Shreveport, LA. [0002] The instant United States patent application claims the benefit of and the priority to U.S. patent application Ser. No. 16/814,897, filed Mar. 10, 2020, which is owned by TSE International, Inc., Shreveport, LA and is incorporated herein by reference. [0003] U.S. patent application Ser. No. 16/814,897 claims the benefit of and the priority to U.S. Provisional Patent Application Ser. No. 62/919,410 filed Mar. 12, 2019 which is owned by the Applicant hereof. U.S. Provisional Patent Application Ser. No. 62/919,410 filed Mar. 12, 2019 is incorporated herein in its entirety by reference hereto. U.S. Provisional Patent Application Ser. No. 62/919,410 filed Mar. 12, 2019 is assigned to TSE International, Inc., Shreveport, LA. [0004] U.S. Pat. No. 8,322,689 B2 issued Dec. 4, 2012 to Johnson et al. and assigned to TSE International, Inc., Shreveport, LA is incorporated herein in its entirety by reference hereto. United States Patent U.S. Pat. No. 9,178,340 B2 issued Nov. 3, 2015 to Johnson et al. and assigned to TSE International, Inc., Shreveport, LA is incorporated herein in its entirety by reference hereto.

BACKGROUND OF THE INVENTION

Field of the Invention

[0005] The present invention relates generally to the process used for the installation of electrical or fiber optic conductor. More specifically, the invention relates to a system utilizing wireless communication between a pulling machine (hereinafter sometimes referred to as the puller) and a tensioning machine (hereinafter sometimes referred to as the tensioner) in order to allow the puller to automatically adjust the operational state of the tensioner based on operational parameter values set in the puller by a single operator.

Description of the Related Art

[0006] Conventional practice for a tension stringing operation includes a puller, a tensioner, and one skilled operator located on each machine. These operators function to determine the state of operation of the various machines in order to conduct the tension stringing operation. The equipment is set up such that the puller is located at one end of a series of structures that are to have conductor installed upon them and the tensioner located at the other end of the series of structures. The puller machine is sometimes referred to herein as the first machine or the pulling machine and the tensioner machine is referred to as the second machine or tensioning machine. These structures can include wooden poles, metal poles, composite poles, and towers built with similar materials. The tension stringing operation can range from as little as a few hundred feet to approximately **5** miles in range, depending on the particular puller and tensioner setup and the operator's requirements.

[0007] The puller is equipped with a pulling rope which is attached to the conductor, located on the tensioner, which is to be installed on the structures. The puller will use the pulling rope to pull the

conductor off of the tensioner. The operator controlling the puller will adjust the puller to operate at a certain speed and maximum pulling force as required. The actual force that is required to be applied to the rope and/or conductor (hereinafter sometimes referred to as tension) is controlled by the tensioning machine and varies based on factors comprised of the weight of the conductor being installed, the number of structures, the distance between the two furthest separated structures (hereinafter sometimes referred to as the ruling span), and the desired height of the lowest point on the conductor relative to the surface below the conductor (hereinafter sometimes referred to as sag) as it is installed upon the structures. The tension applied to the rope and/or conductor must not exceed the maximum tension rating of the conductor as published by the conductor manufacturer.

[0008] The tensioner must be continuously monitored and its operating parameter values adjusted as necessary to properly execute the tension stringing operation. Conventionally, this adjustment is determined based upon the observations of the operation by the operators controlling the two machines and support personnel during the operation. This creates safety risks due to the response time required to make adjustments of the operating parameter values due to the need to relay information between the puller operator and the tensioner operator. This communication is often performed with the use of two-way radios or cellular telephones. Once the operator on the tensioner has received and interpreted the communication, he must make the adjustments to the tensioner. These adjustments are comprised of manual increases or decreases in brake force being applied to a brake disk style tensioner and adjustment to a higher or lower hydraulic pressure for hydraulic style tensioners. These adjustments take additional time to perform and must be confirmed by the support personnel through additional communications between the operators and the support personnel. These delays can lead to an increase in potential equipment or property damage.

SUMMARY OF THE INVENTION

[0009] The subject invention comprises a process and apparatus used for the installation of electrical or fiber optic conductor. The invention includes a wireless communication network operating between the puller and the tensioner in the tension stringing process. This wireless communication network is controlled by a single skilled operator located on the puller (once the machine is up and running) to conduct the tension stringing process without use of a skilled operator on the tensioner. The tensioner will only require an observer that can perform basic functions on the machine, such as power the machine on and off, select the machine as the tensioner, and request an emergency stop of the puller if necessary. The wireless communication system and control system employed on the puller and the tensioner allows the puller and the tensioner to communicate their operating parameter values in real time to each other. This information is in turn used by the puller. This information also allows the skilled operator on the puller to input operating parameter values on the puller. The control system on the puller calculates new values for the tensioner operating parameters and wirelessly communicates new, updated operating parameters to the tensioner. The tensioner then adjusts its operating parameter values automatically in response according to wireless commands from the puller. This provides an advantage over the prior art by changing operating parameter values of the tensioner immediately and accurately. The system increases safety due to the reduction of operator errors during the tension stringing process.

[0010] A process for tension stringing a conductor through above-ground supports is disclosed and claimed. Alternatively, the supports may be underground or in a tunnel, chamber or the like. The process includes affixing a length of rope to the conductor, positioning a first stringing apparatus near a first end of the above-ground supports, and positioning a second stringing apparatus near a second end of the above-ground supports. Each of the first and second stringing apparatuses are comprised of Green Machines powered by electric batteries, diesel operated hydraulic machines, or an electric-hydraulic hybrid. Each of the first and second stringing apparatuses includes an onboard control system which controls each of the first and second stringing apparatuses in pulling mode or in tensioning mode. Each of the first and second stringing apparatuses includes a method of

generating torque comprising of a motor/regenerative brake. Each of the machines includes a wireless transceiver which is hard-wired to the onboard control systems. A skilled operator is used on the machine which will be the puller or pulling machine. An observer is used on the machine that will be the tensioner or tensioning machine. The skilled operator selects one of the first and second stringing machines as a puller machine operating in pulling mode using the onboard control system of the machine designated as the puller machine. Once the selection of the puller machine is made, the observer on the tensioner machine has to select the machine he/she is on to be the tensioner machine. If the observer on the tensioning machine attempts to select his/her machine as the puller machine and the skilled operator of the puller machine has already selected his/her machine as the puller, the tensioner control system will not accept the selection of the machine as the puller.

[0011] Each of the wireless transceivers communicates with the other wireless transceiver enabling control of both of the machines by the onboard control system of the machine designated as the puller machine. Verifying that the wireless communications sent from the transceiver of the puller machine were received by the transceiver of the tensioning machine and the onboard control system of the tensioning machine is necessary to perform safe operation of the machine.

[0012] The puller machine in pulling mode is for pulling the conductor off of the tensioning machine and onto the structures. The tensioning machine being in the tensioning mode is for developing the required tension on the conductor while it is being pulled off of the tensioning machine. The process further includes performing a driveline brake check on the puller machine and if applicable, the tensioning machine. The process further includes providing that the driveline brake check on the puller machine and if applicable, the tensioning machine are satisfactory such that there is no rotation of the puller machine reel and the tensioning machine reel. The process further includes inputting a maximum pull value in pounds-force into the onboard puller control system and communicating the desired tension value wirelessly to the tensioning machine.

[0013] The process further provides the tensioning machine operating in tensioning mode returning and acknowledging the tension value from the puller machine operating in pulling mode. Note that all wireless signals in the system are verified. Every wireless command sent by the puller machine to the tensioning machine is verified. Next, the process includes setting the tensioning machine motor speed to zero (0.00) and releasing the driveline brakes on the puller machine and the tensioning machine. Next, the process includes selecting the puller machine desired drum speed until the conductor is completely pulled through the supports.

[0014] If the conductor is completely pulled through the supports, the process includes simultaneously applying the driveline brakes on the puller machine and the tensioning machine as commanded by the puller machine control system on the puller machine.

[0015] The process further includes that the wireless transceiver is a 1 W radio transceiver and that the antenna is a Yagi-Uda type or omnidirectional type. The process further includes use of a Yagi-Uda type or omnidirectional type antenna having a gain of 6 dBm.

[0016] The process includes a driveline brake that is an electro-mechanical brake which prevents rotation of the puller machine reel and the tensioner machine reel. Upon loss or intentional discontinuation of power to the driveline brake, the brake fails in the on position, that is, with the brake applied. The process further requires interposing a bidirectional repeater between the puller machine and the tensioner machine. The bidirectional repeater is comprised of a radio transceiver, an omni-directional radio antenna, and a power supply.

[0017] And additionally, the process includes, during application of the driveline brakes, that each-motor controller outputs the maximum programmed amount of motor torque, and, that each motor controller outputs the maximum programmed motor rotations per minute.

[0018] The driveline brake is a safety brake while the tensioning motor/regenerative brake holds the tensioning reel and or bullwheels back to create controlled tension in the conductor.

[0019] It is an object of the present invention to provide a tension stringing process and apparatus

requiring a single skilled operator residing on a puller machine to operate the puller machine and the tensioner machine wherein communication between the machines is performed wirelessly.
[0020] It is an object of the present invention to provide a wireless tension stringing process and apparatus wherein a repeater is used to facilitate transmission of signals in rough terrain and/or where there is a line of sight problem.
[0021] The conductor stringing apparatus includes a puller machine which pulls a rope affixed to a conductor. The rope has been at least partially guided through the above-ground supports. The rope is secured to a reel on the puller machine and is wound therearound as the conductor is pulled through the supports while it traverses the spans between the supports.
[0022] The puller machine comprises: a frame; an onboard control system; a wireless transceiver hardwired to the onboard control system; a reel about which the pulling rope is wound; an electric motor affixed to the frame and coupled to the reel; a safety brake; and the electric motor expending electrical energy when pulling the conductor in a pulling mode. The conductor stringing apparatus also includes a tensioner machine which tensions out the conductor from a reel on the tensioning apparatus. Tension in the rope and the conductor is created by the puller reel rotation having the rope wound therearound in combination with the application of the regenerative brake (or hydraulic disk brake) to the drive train of the reel of the tensioner machine. Simply put, the puller machine pulls the rope/conductor while the tensioner machine holds-back or resists the paying out of the conductor from the reel of the tensioner machine.
[0023] The tensioner machine comprises: a frame; an onboard control system; a wireless transceiver hard-wired to said onboard control system; a reel about which the conductor is wound; an electric motor affixed to the frame and coupled to the reel; said electric motor is a regenerative brake generating electrical energy when tensioning the conductor in a tensioning mode.
[0024] The wireless transceiver of the puller machine communicates with the wireless transceiver of the tensioner machine; and, the onboard control system of the puller machine controls the onboard control system of the tensioner machine.
[0025] The puller machine includes an electro-mechanical driveline brake which is a safety brake which prevents rotation of the reel of the puller machine when engaged. The tensioner machine includes an electro-mechanical driveline brake which is a safety brake which prevents rotation of the reel of the tensioner machine when engaged.
[0026] The process includes an optional feature wherein the safety brake check is not performed and once the prerequisites for establishing the operation of the machine are satisfied the machine can operate the tension stringing process directly. The prerequisites are the setup of the puller machine and the tensioner machine by the respective operators.
[0027] The wireless transceiver of the tensioner machine repeats all communications from the wireless transceiver of the puller machine for verification of the communications and their accuracy. One of the important features is that a single skilled operator interfaces with the onboard control system of the puller machine. An observer interfaces with the onboard control system of the tensioner machine.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0028] The various exemplary embodiments of the present invention, which will become more apparent as the description proceeds, are described in the following detailed description in conjunction with the accompanying drawings, in which:
[0029] FIG. **1** illustrates a tension stringing operation and the common elements which may be included in such an operation, such as the puller, tensioner, structures, pulling rope, conductor, and two skilled operators.

[0030] FIG. **2** illustrates a schematic view of the tension stringing process including a puller, tensioner, and the wireless communication network according to the present invention with just one skilled operator.
[0031] FIG. **3** illustrates an example of the present invention illustrating one skilled operator on the puller machine.
[0032] FIG. **4** illustrates a typical onboard control panel arrangement of the present invention.
[0033] FIG. **4**A illustrates a front view of the display.
[0034] FIG. **4**B is a diagram of the repeater interposed between the puller machine and the tensioner machine.
[0035] FIG. **5**A schematically illustrates a portion of the process flow diagram wherein: selection of one of the machines as the puller machine is made on the puller machine; selection of the other of the machines as the tensioner machine is made on the tensioner machine; and, communication is established and verified through radio checks between the stringing apparatuses (puller and tensioning machines).
[0036] FIG. **5**B schematically illustrates a portion of the process flow diagram wherein: the safety brake check (driveline brake check) on both the puller machine and the safety brake check (driveline brake check) of the tensioner machine is made. FIG. **5**B schematically illustrates setting an initial value for the maximum pull force of the puller machine and wirelessly sending the tension value to the tensioner machine.
[0037] FIG. **5**C schematically illustrates that the desired tension value was received by the tensioner. FIG. **5**C is a continuation of FIG. **5**B and schematically illustrates that the driveline brake release on the puller machine and the tensioner machine is made.
[0038] FIG. **5**D illustrates a portion of the process flow diagram which establishes the line pull operation until the process is complete or stopped.
[0039] FIG. **5**E illustrates a portion of the process flow diagram which establishes a portion of the driveline brake check for the tensioner which relates to the driveline brake check in FIGS. **5**B and **5**C. FIG. **5**E also illustrates repeatedly receiving the command message from the puller and establishing verified wireless communications therebetween. FIG. **5**E also schematically illustrates the radio check between the radio (transceiver) and onboard controller of the tensioning machine and the radio (transceiver) and onboard controller of the pulling machine.
[0040] FIG. **5**F is a continuation of FIG. **5**E and illustrates the receipt by the tensioning machine of the required tension force as commanded by the puller machine.

DETAILED DESCRIPTION OF THE INVENTION

Apparatus and Initial Process Steps

[0041] When referring to the drawings, like numerals indicate like or corresponding parts throughout the views, an exemplary puller is shown at **1** and an exemplary tensioner is shown at **2**. In FIGS. **5**A-**5**F, the diamonds are for queries, the parallelograms are for decisions made by the operator, and the rectangles are for functional statements. FIG. **1** illustrates the tension stringing operation and the common elements which may be included in such an operation, such as the puller machine **1**, tensioner machine **2**, structures **5**, pulling rope **7**, conductor **6**, and two operators **3**.
[0042] FIG. **2** illustrates a schematic view of the tension stringing process including a puller machine **1**, tensioner machine **2**, a single operator **3**, and the wireless communication network **4** for communication between the machines. The wireless transceiver is hard-wired to an onboard control system on the puller machine and the onboard control system of the tensioner machine.
[0043] FIG. **3** illustrates an example of the present invention. Referring to FIG. **3**, the puller machine **1** is equipped with an onboard control system and an onboard wireless communication system **4**, **8**. The onboard control system includes an onboard programmable logic controller, for example, a Danfoss MC050 (hereinafter sometimes referred to as the microcontroller) and a LCD display **9**, for example, a Danfoss DP700 (hereinafter sometimes referred to as the display) which function to operate the puller **1** based on desired operating parameter values input by the operator

3, including desired speed (hereinafter sometimes referred to as the line speed) and maximum linepull on the pulling rope **7**. These values are input by the operator **3** on the puller **1** using a plurality of controls located on a typical control panel, shown in FIG. **4**, comprised of a single axis directional control **14**, for example, a PQ Controls M115 (hereinafter sometimes referred to as the joystick) equipped with two rocker buttons on the handle, soft buttons on the display **9** which function to adjust parameters shown on the display **9**, a single axis joystick **10** for operation of the level wind system, a two position system power switch **13**, a battery charge level display **11**, and an emergency stop button **12**. In addition to a typical control panel, the puller **1** and tensioner **2** are each equipped with an apparatus which when paired with the microcontrollers located on the puller **1** and the tensioner **2** respectively allows for the formation of a wireless communication network **4** between the two machines. Each onboard controller is hard-wired to the antenna. The onboard control system may be operated manually from each machine (puller or tensioner) if so desired.

Wireless Communication

[0044] FIG. **5**A schematically illustrates a portion of the process flow diagram wherein: selection of one of the machines as the puller machine **1** is made; selection of the other of the machines as the tensioner machine **2** is made after selection of the puller machine is made; and, communication is established and verified through radio checks between the stringing apparatuses (puller and tensioning machines). FIG. **5**E also schematically illustrates the radio check between the radio (transceiver **4**) and onboard controller of the tensioning machine **2** and the radio (transceiver **4**) and onboard controller of the pulling machine **1**.

[0045] FIG. **5**B schematically illustrates a portion of the process flow diagram wherein: the safety brake check (driveline brake check) on both the puller machine **1** and the safety brake check (driveline brake check) of the tensioner machine **2** is made. FIG. **5**B schematically illustrates setting an initial value for the line pull force **72** of the puller machine **1** and wirelessly sending the value to the tensioner machine **2**. FIG. **5**C schematically illustrates that the desired line pull value was received by the tensioner. FIG. **5**C is a continuation of FIG. **5**B and schematically illustrates that the driveline brake release on the puller machine **1** and the tensioner machine **2** is made.

[0046] FIG. **5**D illustrates a portion of the process flow diagram which establishes the line pull operation **130** until the process is complete or stopped **98**.

[0047] FIG. **5**E illustrates a portion of the process flow diagram which establishes a portion of the driveline brake check for the tensioner which relates to the driveline brake check in FIGS. **5**B and **5**C. FIG. **5**E also illustrates receiving the command **31** instructing the machine to operate as the tensioner **1** and establishing verified **26** wireless communications therebetween (FIG. **5**A).

[0048] FIG. **5**F is a continuation of FIG. **5**E and illustrates the receipt **70** by the tensioning machine of the required line pull force as commanded **131** by the puller machine (FIG. **5**B).

[0049] Referring to FIGS. **2**, **5**A, **5**B, **5**C, **5**D, **5**E, and **5**F, the apparatus which forms the wireless communication network **4** is comprised of a 1 W radio transceiver on both the puller **1** and the tensioner **2**, and a radio antenna **8**, for example, a Yagi-Uda type or omnidirectional type antenna on both the puller **1** and the tensioner **2**. The radio used in the wireless communication network **4** operates without the requirement of a license in accordance with the rules and regulations set forth under Title 47 of the Code of Federal Regulations (CFR) in the Federal Communications Commission (FCC) part 15 (hereinafter sometimes referred to as 47 CFR part 15). The radio used is direct FM controlled operating on an unlicensed ISM (Industrial, Scientific and Medical) band with a frequency in the range of 902-928 MHz. In order to achieve the maximum range and obstacle penetration capability while operating in this ISM band, a 1-watt (30 dBm) (decibels milliwatts) transmission is paired with a 6 dBm gain radio antenna. Provided that small losses to gain due to equipment comprised of the radio antenna cable and fittings are present, the total effective isotropic radiated power (hereinafter sometimes referred to as EIRP) is less than or equal to 36 dBm in accordance with 47 CFR part 15 rules.

[0050] Both the puller and the tensioner are identically equipped and include an onboard control

system (a programmable logic controller), a wireless communication system, a frame and supporting wheels and tires, a reel, an electric motor controller, an electric motor/regenerative brake, and an electro-mechanical driveline brake. The electro-mechanical driveline brake is a safety feature and prevents rotation of the reel when it is applied.

[0051] Whichever machine is selected to be the puller is the dominant machine and the control system of the dominant machine controls the other machine (tensioner) and interacts with the onboard control system of the tensioner. Either machine can be selected as the puller machine as the machines are identical. Only one skilled operator is required on the puller machine after the puller machine acquires jurisdiction and control with respect to the tensioner machine. The tensioner requires an observer to designate/select it as the tensioner machine following selection of the other machine as the puller machine. The tensioner requires an observer to energize and deenergize the tensioner machine.

[0052] All operator actions are on the puller except designation/selection of the tensioning machine as the tensioning machine.

[0053] The transceiver will encode data sent to it from the microcontroller over a controller area network (hereinafter sometimes referred to as the CAN) on the transmitting machine (puller **1** or tensioner **2**) and then broadcast the message to the transceiver on the receiving machine. The transceiver will decode the message into a message of the same CAN format before the transceiver of the sending machine encoded the data. This message is then sent across the CAN bus to the microcontroller on the receiving machine (puller **1** or tensioner **2**). The control system and the transceiver are powered by the onboard 12-volt DC electrical power supply of the puller **1** and the tensioner **2**.

[0054] The tensioner **2** is also equipped with a typical control panel, an onboard control system, and an onboard wireless communication system **4**. This enables a member of the operational crew to manually operate the tensioner **2** if desired. This also allows the tensioner **2** to be powered up and prepared for remote control via the wireless communication network **4** with the puller **1**. This control panel includes an emergency stop button **12** that can be pressed in the event of an emergency situation to request the halt of operation of both the puller **1** and the tensioner **2**. The puller **1** will activate this emergency halt state automatically if the wireless communication network **4** fails and the puller **1** is no longer in communication with the tensioner **2** for a prescribed duration of time.

[0055] All wireless communications between the machines are verified to ensure safe operation of the system.

[0056] The wireless communication network **4** functions to transmit data gathered from a plurality of sensors located on both the puller **1** and tensioner **2** to the microcontrollers located on each machine. These various sensors include speed sensors, electrical current sensors, and voltage sensors. The speed is used to determine the speed of an electric motor that is used for propelling the drivetrain of the puller **1** and the tensioner **2**. The current and voltage sensors are used to determine the torque at which the electric motor is operating. A rotary pulse generator is located such that the pulling rope **7** on the puller **1** or conductor **6** on the tensioner **2** respectively will rotate the pulse generator as the pulling rope **7** or conductor **6** are pulled onto or paid off of the respective machine. This rotation provides a frequency signal which is used with data from the driveline speed sensor to calculate the radius of the outer most layer of pulling rope **7** or conductor **6** on the respective reel.

[0057] This data is used by the microcontroller, in conjunction with a desired operational parameter value input by the operator **3** located on the puller **1**, to compute a required corresponding operational parameter value for the tensioner **2**. This value is transmitted across the wireless communication network **4** from the puller **1** to the tensioner **2**. The tensioner **2** will then adjust its current state of operation based on this transmitted information and its own array of sensors that are similar to the sensors on the puller **1**, until the desired operational parameter values are met on the tensioner **2**.

[0058] In order for a single skilled operator **3** to control both the puller **1** and tensioner **2** from the puller **1** control panel, the wireless communication network **4** must be used, as indicated by the query at **16** (FIG. **5**A). To use this wireless communication network **4** (activate In-Command system), the puller **1** will be located at one end of a series of structures **5** that are to have conductor **6** installed upon them, and the tensioner **2** will be located at the opposite end of the series of structures **5**. The pulling rope **7** on the puller **1** will be attached **7**A to the conductor **6**. See FIGS. **1**, **3**A. The operator **3** will begin the tension stringing operation by enabling the wireless communication network **4** in order for the puller **1** to gain control over the tensioner **2**. See FIG. **2**. To enable the wireless communication network **4**, the operator **3** must select the option to activate **17** (FIG. **5**A) the In-Command wireless communication network **4** by pressing the associated button on the display **9** of the puller **1**.

Repeater

[0059] Referring to FIG. **4**B, If the tension stringing operation is to extend beyond the range of the wireless communication network **4**, or if there is some obstruction between the puller **1** and tensioner **2** that inhibits the wireless communication, for example, a large building, hill, or forested area, the operator **3** may choose to deploy a bidirectional radio signal repeater **1**A (hereinafter sometimes referred to as a repeater). The bidirectional repeater **1**A is a self-contained unit comprised of a radio transceiver, an omni-directional radio antenna, and a power supply. The bidirectional repeater **1**A is placed between the puller machine **1** and the tensioner machine **2** and functions to receive incoming signals from the transmitting system (either the puller or the tensioner) and relay them to the receiving system in order to extend overall range and to allow communications around obstacles which may otherwise prohibit communications. The quantity of repeaters deployed is not limited to a single unit. Each additional repeater **1**A will extend the system range by relaying messages between repeaters until the messages are delivered to the receiving unit.

[0060] After the operator **3** activates the wireless communication network **4** (activate In-Command system), the program will display a prompt to the operator **3** with a menu to select whether the machine the operator **3** is on is to be the puller **1** or the tensioner **2**, shown at queries **19** and **20**, respectively (FIG. **5**A). Both queries “is this machine the puller?” and “is this machine the tensioner?” will appear on the display **9** of each machine. Either machine can be selected as the puller or the tensioner. The operators, of course, know which machine is which, that is, the tensioner has the conductor wound around the reel and the puller just has the rope wound around the reel of the puller.

[0061] A skilled operator is used on the machine which is the puller or pulling machine. An observer is used on the machine that is the tensioner or tensioning machine. The skilled operator selects **21** one of the first and second stringing machines as a puller machine operating in pulling mode using the onboard control system of the machine designated as the puller machine. Once the selection of the puller machine is made the observer on the tensioner machine has to select **23** the machine he/she is on to be the tensioner machine. If the observer on the tensioning machine attempts to select his/her machine as the puller machine and the skilled operator of the puller machine has already selected his/her machine as the puller, the tensioner control system will not accept the selection of the machine as the puller. Each of the wireless transceivers are communicating with the other wireless transceiver enabling control of both of the machines by the onboard control system of the machine designated as the puller machine. Verifying that the wireless communications sent from the transceiver of the puller machine were received by the transceiver of the tensioning machine and the onboard control system of the tensioning machine is necessary to perform safe operation of the machine. Verification of wireless communications between the machines is verified continuously throughout the operation of the system.

[0062] The puller machine in pulling mode is for pulling the conductor off of the tensioning machine and onto the structures. The tensioning machine being in the tensioning mode is for

developing the required tension on the conductor while it is being pulled off of the tensioning machine.

[0063] If the machine is to be the puller **1** during the tension stringing process, the operator **3** uses the buttons on the display **9** to select the puller option, shown at **21**. If the machine is to be the tensioner **2** during the tension stringing process, shown at query **20**, the observer will use the buttons on the display **9** to select the tensioner option, shown at **23** (FIG. **5**A).

[0064] If neither puller nor tensioner options are selected, the machine will not enable the wireless communication network **4** and will continue to function with standard operating procedures requiring one skilled operator **3** located on each machine for controlling the machines independently, shown at **18** (FIG. **5**A).

[0065] Referring to FIGS. **5**A and **5**E, once the puller **1** and the tensioner **2** have been identified by the respective operators **3**, the operator **3** on the puller machine prepares for the beginning of the tension stringing operation. Referring to FIG. **5**A, the puller **1** will begin by generating a radio check signal as a CAN message. This message is sent to the wireless communication network **4** and transmitted to the tensioner **2**, shown at **22**. The tensioner **2** will receive this message, shown at **25**, and relay it back to the puller **1**, shown at **28** (FIG. **5**E). The puller **1** will then receive this relayed message from the tensioner **2** and compare the value to the original CAN message, shown at **26** (FIG. **5**A). If this message is not received correctly, the operator **3** will be required to choose between ending the process, shown at **30** (FIG. **5**A), or selecting to continue attempting to transmit and correctly receive the radio check message, shown at **24** (FIG. **5**A). This functions as a handshake to verify that the wireless communication network **4** is functioning properly and is sending and receiving data with the proper encryption. Messages will be continuously transmitted and verified in this manner during use of the apparatus and performance of the process. If the message is verified as correct once it is relayed back from the tensioner **2**, the puller **1** will assume command over the functionality of the tensioner **2**, shown at **29**, and will transmit a command message over the wireless communication network **4** to the tensioner **2** indicating such. See FIG. **5**A.

[0066] Still referring to FIG. **5**A, once the puller **1** has transmitted the command message **29** to the tensioner **2** indicating that the puller **1** is in command of the tensioner **2**, the tensioner **2** will relay this message back to the puller **1** using the wireless communication network **4**, shown at **35** (FIG. **5**E). The puller **1** will receive this relayed message and verify that the tensioner **2** has received the correct message by comparing it to the original message that the puller **1** produced, shown at **32** (FIG. **5**A). Once this message has been verified as correct, the puller **1** and the tensioner **2** will display “In-Command Active” on their displays **9**, shown at **41** (FIG. **5**A) and **36** (FIG. **5**E) respectively.

Safety Brake Check

[0067] Referring to FIGS. **5**B and **5**C and others, the operator **3** begins the tension stringing operation by performing a safety check on both the puller **1** and the tensioner **2** in a process called a brake check, shown at **44** (FIG. **5**A). The operator **3** selects to activate the brake check process on either the puller **1**, the tensioner **2**, or both the puller and the tensioner by using the buttons located on the puller **1** display **9**, shown at **46**, **47**, and **48** respectively.

[0068] If the tensioner option is selected in FIG. **5**B, **48**, or if both the puller and the tensioner are selected FIG. **5**B, **47**, the tensioner **2** will automatically engage its driveline brake, adjust its motor controller to output the programmed amount of motor torque, and adjust its motor controller to output the programmed motor rpm, shown at **45** (FIG. **5**E).

[0069] When the puller **1** option **46** is selected, or if both the puller and the tensioner are selected FIG. **5**B, **47**, the puller **1** will simultaneously perform the same routine with its own driveline brake and motor controller, shown at **51** (FIG. **5**B). By same routine it is meant that the puller will adjusts its motor controller to output the programmed amount of motor torque, and adjust its motor controller to output the programmed motor rpm, shown at **51** (FIG. **5**B). This simulates a maximum

line tension situation where the driveline brake would be required to prevent drum rotation should the operator **3** choose to engage the driveline brake for safety reasons or for operational reasons (ie, shutdown for the day, a storm, lunch, and/or a repair).

[0070] Both the puller **1** and the tensioner **2** will utilize their onboard plurality of sensors to determine whether their driveline brake was capable of preventing rotation of their respective reels, indicated at query **55** (FIG. **5**B, puller) and **49** (FIG. **5**E, tensioner) respectively. If the puller **1** detects any rotation of its reel a warning will be displayed on the puller **1** display **9**, shown at **55** (FIG. **5**B). If the tensioner **2** detects any rotation of its reel, a status message will be generated and transmitted via the wireless communication network **4** to the puller **1** indicating that tensioner **2** reel rotation was detected during the tensioner **2** brake check routine, shown at **54**A (FIG. **5**E). If no rotation was detected during the tensioner **2** brake check routine, a different status message will be generated and transmitted via the wireless communication network **4** to the puller **1** indicating that no tensioner **2** reel rotation was detected during the tensioner **2** brake check routine, shown at **54** (FIG. **5**E). The puller **1** will receive the message from the tensioner **2**, shown at **62** (FIG. **5**B). If this message indicates the tensioner **2** detected drum rotation, a warning will be displayed on the puller **1** display **9** (FIG. **4**A). The operator **3** will have the option to retry the brake check on either machine, or end the operation without the successful completion of the brake check routine, shown at **69** (FIG. **5**B).

[0071] Once the brake check routine is complete, the puller **1** and tensioner **2** will then return their driveline brake and motor controller settings for motor torque and rpm to normal values (brake engaged, motor torque setting prior to the brake check, and 0.00 motor rpm), shown at **59** (FIG. **5**E). Once the puller **1** and tensioner **2** have returned to normal settings, their display **9** will produce a message indicating that the brake check routine has been passed, shown at **56**A (FIG. **5**B) and **73** (FIG. **5**B) respectively.

Not Performing the Safety Brake Check

[0072] If the safety brake check is not desired, it may be bypassed **170** as indicated in FIG. **5**A which directs an Alternate Start **160** (FIG. **5**B). All of the setup operations on FIG. **5**A regarding the designation of the puller and the tensioner are performed, the desired tension **72** (FIG. **5**B) can be inputted and the line pull operation can progress according to FIGS. **5**D and **5**E.

Preparation for the Pull

[0073] Referring to FIG. **4**, using the rocker buttons on the joystick **14**, the operator **3** will select the desired tension (lbs-force) for the operation, shown at **72** (FIG. **5**B). The microcontroller program on the puller **1** will turn this desired value into a command signal in the form of a CAN message. This message is sent to the wireless communication network **4** and transmitted to the tensioner **2**, shown at **131** (FIG. **5**B). The tensioner **2** will receive the command message as a desired tension (lbs-force) for operation, shown at **70** (FIG. **5**F). The tensioner **2** will relay this information back to the puller **1** as a status message via the wireless communication network **4**, shown at **35** (FIG. **5**E). The puller **1** will receive this message and verify that the tensioner **2** received the correct value by comparing it to the original command message for desired tension (lbs.-force), shown at **81** (FIG. **5**C).

[0074] The operator **3** must set the maximum line pull (lbs.-force) setting on the puller **1**. This value must be slightly higher than the desired tension setting that is transmitted to the tensioner **2**. The puller **1** will convert the maximum line pull setting within its microcontroller program to a value that is sent to the puller **1** motor controller for a desired amount of motor torque (Nm), shown at **78** (FIG. **5**C). This is accomplished by using the calculated value for the radius of the outermost layer of pulling rope **7** on the reel and computing a required motor torque value that will meet the maximum line pull on the pulling rope **7**.

[0075] The tensioner **2** will convert the desired tension input from the command message within its microcontroller program to a value that is sent to the tensioner **2** motor controller for a desired amount of motor torque (Nm), shown at **75** (FIG. **5**F). This is accomplished by using the calculated

value for the radius of the outermost layer of conductor **6** on the reel and computing a required motor torque value that will meet the desired line tension on the conductor **6**. The tensioner **2** will then send its actual motor torque value in a status message to the puller **1** via the wireless communication network **4**, shown at **35** (FIG. **5**E). The puller **1** will receive this message for diagnostics purposes, shown at **39** (FIG. **5**A). The puller **1** will verify that the value returned in the tensioner **2** status message is correct, shown at **81** (FIG. **5**C). If the value is correct, the operator **3** may move forward with the process. If the value is not correct, the operator **3** must choose to retry the message transmission, shown at **79** (FIG. **5**C), or end the operation, shown at **84** (FIG. **5**C).

Releasing the Safety Brake (Driveline Brake) and Preparing to Begin the Line Pull

[0076] Referring to FIGS. **5**B and **5**C, when the operator **3** is prepared to begin pulling in the pulling rope **7** and conductor **6**, the operator **3** will select to release the driveline brake on either the puller **1**, tensioner **2**, or both by using the buttons on the display **9** of the puller **1**, shown at **86** (FIG. **5**C) and **88** (FIG. **5**C) respectively.

[0077] If the operator **3** chooses to release the brake for the tensioner **2**, the puller **1** will generate a command signal to instruct the tensioner **2** to release its driveline brake and then send this signal to the tensioner **2** via the wireless communication network **4**, shown at **90** (FIG. **5**C). The tensioner **2** will receive this command message and relay it back to the puller **1** via the wireless communication network **4**, shown at **35** (FIG. **5**E). The puller **1** will receive this relayed message and verify that the tensioner **2** received the correct command by comparing it to the original command, shown at **92** (FIG. **5**C). If this message verifies that the tensioner **2** received the correct command, the tensioner **2** will release its driveline brake, shown at **76** (FIG. **5**F). If the message is not correct, the operator **3** must choose to end operation of the present invention, shown at **95** (FIG. **5**C), or continue attempting to transmit the brake release command and receive the correct response, shown at **90**, **91** (FIG. **5**C).

[0078] Once the tensioner **2** has released its brake, it will send a status signal to the puller **1** via the wireless communication network **4** to tell the puller **1** that the tensioner **2** brake is released, shown at **35** (FIG. **5**E). The puller **1** receives this status message, shown at **39** (FIG. **5**A), and displays to the operator **3** on the puller **1** display **9** that the tensioner **2** driveline brake has been released, shown at **94** (FIG. **5**D).

[0079] If the operator **3** chooses to release the driveline brake on the puller **1**, shown at **86** (FIG. **5**C), the puller **1** will release its brake, shown at **89** (FIG. **5**C), and display the released status to the operator **3** on the display **9**.

Beginning the Pull

[0080] Once both the tensioner **2** and puller **1** driveline brakes are confirmed to be released, the operator **3** will use the joystick **14** located on the puller **1** to set a desired drum speed (rpm), shown at **96** (FIG. **5**D). The center position of the joystick **14** indicates 0 rpm and moving the joystick **14** further away from center increases the desired speed from 0 rpm at center position to maximum rpm at maximum joystick **14** stroke. The tensioner **2** motor rpm will always be set to a desired 0 rpm. Once the puller **1** begins operation, the tensioner **2** will then send its actual motor speed as a status message to the puller **1** via the wireless communication network **4**, shown at **35** (FIG. **5**E). The puller **1** will receive this status message and display the tensioner **2** motor speed to the operator **3** for diagnostics purposes, shown at **39** (FIG. **5**A).

[0081] Referring to FIG. **5**D, at this point, the pulling rope **7** and conductor **6** begin to move through the structures **5** toward the puller **1**. During this operation, the tensioner **2** will regularly send real-time data to the puller **1** as a status message, shown at **35** (FIG. **5**E). This is done via the wireless communication network **4**. The puller **1** will then receive these status messages and display the data to the operator **3** for diagnostics purposes, shown at **39** (FIG. **5**A).

[0082] The operator **3** can then determine whether the operation is to continue, shown at query **98** (FIG. **5**D) as to the puller machine. If the operation is not complete, the operator **3** will continue operating the present invention as to the puller machine. If the operation is determined to be

complete, the operator **3** will set the desired reel speed to 0 rpm by moving the joystick **14** on the puller **1** to the center position, shown at **99** (FIG. **5**D). The puller **1** will then set its motor rpm to 0.00 rpm, as shown in **100** (FIG. **5**D).

[0083] Once the operator **3** has determined that the puller **1** and the tensioner **2** reels have come to a speed of 0 rpm by reviewing diagnostics data on the display **9**, the operator **3** will select to engage the driveline brake for each machine, shown at **101** (FIG. **5**D) and **103** (FIG. **5**D) respectively. The puller **1** will then send a command message to the tensioner **2** via the wireless communication network **4** instructing it to engage its driveline brake, shown at **104** (FIG. **5**D). The tensioner **2** will receive this message, shown at **77** (FIG. **5**F), and relay it back to the puller **1** via the wireless communication network **4**, shown at **35** (FIG. **5**E). The puller **1** will verify that the tensioner **2** sent the correct signal by comparing it to the original command, shown at **106** (FIG. **5**D). If the signal was not sent back correctly, the operator **3** must choose to end the process, shown at **109**, or continue attempting to transmit the brake engage command to the tensioner **2**, shown at **105** (FIG. **5**D). If the signal is returned correctly, the puller **1** and the tensioner **2** will engage their driveline brakes, shown at **102** (FIG. **5**D) and **80** (FIG. **5**F) respectively.

[0084] The operator **3** will monitor diagnostics information to verify that the driveline brakes for both machines have been engaged. Once verified, the operator **3** will disable the “In-Command System” by pressing the corresponding button on the display **9** of the puller **1**, shown at **108** (FIG. **5**D). This action will end the transmission of the radio check message that the puller **1** and tensioner **2** continuously relay to each other via the wireless communication network **4**, shown at **109** (FIG. **5**D). When the tensioner **2** no longer receives this message, it will exit the “In-Command System” mode and will revert to standard operation mode, shown at **27**, **30** (FIG. **5**A).

[0085] The operator **3** will then use the system power switch **13** located on the puller **1** to turn off the system power to the puller **1**, shown at **110** (FIG. **5**D). The puller **1** system will then power down, shown at **111** (FIG. **5**D). The observer will then use the system power switch **13** located on the tensioner **2** to turn off the power to the tensioner **2**, shown at **83** (FIG. **5**F). The tensioner **2** system will then power down, shown at **85** (FIG. **5**F).

[0086] The conductor stringing apparatus includes a puller machine **1** which pulls a rope **7** affixed **7**A to a conductor **6**. The rope **6** has been at least partially guided through the above-ground supports **7**B. The rope is secured to a reel on the puller machine and is wound therearound as the conductor is pulled through the supports **7**B as it traverses the spans between the supports **7**B.

[0087] The puller machine comprises: a frame; an onboard control system; a wireless transceiver **4** hard-wired to said onboard control system; a reel about which said rope is wound; an electric motor affixed to said frame and coupled to the reel; a safety brake; the electric motor expending electrical energy when pulling the conductor in a pulling mode. The conductor stringing apparatus also includes a tensioner machine **2** which tensions out the conductor from a reel on the tensioning machine. Tension in the rope and the conductor is created by the puller reel rotation having the rope wound therearound in combination with the application of the regenerative brake to the drivetrain of the tensioner machine. Simply put the puller machine pulls the rope/conductor while the tensioner machine holds-back or resists the paying out of the conductor from the reel of the tensioner machine. In this way, the rope and the conductor remain taut enough so as to prevent the rope and the conductor from sagging too near the ground. Keeping the rope and the conductor taut prevents interference with the ground, buildings, trees etc.

[0088] The tensioner machine comprises: a frame; an onboard control system; a wireless transceiver **4** hard-wired to said onboard control system; a reel about which the conductor is wound; an electric motor affixed to the frame and coupled to the reel; said electric motor is a regenerative brake generating electrical energy when tensioning the conductor in a tensioning mode.

[0089] The wireless transceiver of the puller machine communicates with the wireless transceiver of the tensioner machine; and, the onboard control system of the puller machine controls the

onboard control system of the tensioner machine.
[0090] The puller machine includes an electro-mechanical driveline brake which is a safety brake which prevents rotation of the reel of the puller machine when engaged. The tensioner machine includes an electro-mechanical driveline brake which is a safety brake which prevents rotation of the reel of the tensioner machine when engaged.
[0091] The wireless transceiver of the tensioner machine repeats all communications from the wireless transceiver of the puller machine for verification of the communications and their accuracy. One of the important features is that a single skilled operator interfaces with the onboard control system of the puller machine. An observer interfaces with the onboard control system of the tensioner machine.
[0092] There can be multiple combinations of different types of pullers and tensioners utilized with the subject invention. A bullwheel puller, comprises: a frame; a plurality of bullwheels about which a rope is wound; having a motor selected from a group comprising of a hydraulic motor, an electric motor, or a pneumatic motor; affixed to said frame and coupled to said plurality of bullwheels; and, said motor expending energy when pulling said rope affixed to said conductor. A bullwheel tensioner, comprises: a frame; a plurality of bullwheels about which a conductor is wound; having a motor selected from a group comprising of a hydraulic motor, an electric motor, or an pneumatic motor; affixed to said frame and coupled to said plurality of bullwheels; and, said motor generating energy when tensioning out said conductor. A bullwheel tensioner, comprises: a frame; a plurality of bullwheels about which a conductor is wound; having a brake selected from a group comprising of a hydraulically operated, a pneumatically operated, or an electrically operated brake; affixed to said frame and coupled to said plurality of bullwheels; and, said brake generating energy when tensioning out said conductor. A v-groove puller, comprises: a frame; one or more v-grooves about which a rope is wound; having a motor selected from a group comprising of a hydraulic motor, an electric motor, or a pneumatic motor; affixed to said frame and coupled to said v-groove; and, said motor expending energy when pulling said rope affixed to said conductor. A v-groove tensioner, comprises: a frame; one or more v-grooves about which a conductor is wound; having a motor selected from a group comprising of a hydraulic motor, an electric motor, or an pneumatic motor; affixed to said frame and coupled to said v-grooves; and, said motor generating energy when tensioning out said conductor. A v-grooves tensioner, comprises: a frame; one or more v-grooves about which a conductor is wound; having a brake selected from a group comprising of a hydraulically operated, a pneumatically operated, or an electrically operated brake; affixed to said frame and coupled to said v-grooves; and, said brake generating energy when tensioning out said conductor.
REFERENCE NUMERALS
[0093] **1** puller [0094] **1**A bidirectional wireless repeater [0095] **2** tensioner [0096] **3** operator [0097] **4** radio communication network (wireless communication network) [0098] **5** structure [0099] **6** conductor [0100] **7** pulling rope [0101] **7**A connection of the pulling rope **7** and the conductor **6** [0102] **8** directional radio antenna [0103] **9** display [0104] **10** single axis joystick [0105] **11** battery charge level display [0106] **12** emergency stop button [0107] **13** 2 position switch [0108] **14** single axis joystick [0109] **15** tension stringing process is required [0110] **16** determine whether to operate with a single operator or two operators? [0111] **17** operator activates In-Command system [0112] **18** operate with standard procedure with two operators [0113] **19** Query: is machine the puller? [0114] **20** Query: is machine the tensioner? [0115] **21** Operator selects puller option [0116] **22** Puller repeatedly transmits a radio check message [0117] **23** Operator accepts tensioner mode on puller machine menu [0118] **24** Operator selects to continue operating [0119] **25** Query: did tensioner receive radio check message? [0120] **26** Query: is radio check message returned to puller correctly? [0121] **27** Query: continue with In-Command system? [0122] **28** Tensioner sends radio check message reply [0123] **29** Puller sends message to tensioner for verification [0124] **30** End use of In-Command system [0125] **31** Tensioner receives the tensioner

command [0126] **32** Query: did tensioner command message return correctly? [0127] **33** Query: continue with In-Command system? [0128] **34** Tensioner repeatedly receives command messages [0129] **35** Tensioner repeatedly sends status messages [0130] **36** Tensioner displays “In-Command Active” on display [0131] **37** Tensioner receives brake check command [0132] **38** End use of In-Command system [0133] **39** Puller repeatedly receives tensioner status messages [0134] **40** Puller repeatedly sends command message [0135] **41** Puller displays “In-Command Active” on display [0136] **42** Query: perform tensioner brake check? [0137] **43** End use of In-Command system [0138] **44** Query: perform brake check? [0139] **45** Perform tensioner brake check [0140] **46** Operator selects “Puller Brake Check” [0141] **47** Operator selects “Puller and Tensioner Brake Check” [0142] **48** Operator selects “Tensioner Brake Check” [0143] **49** Query: did tensioner reel rotate? [0144] **50** Set tensioner drum speed to 0 rpm [0145] **51** Perform Puller Brake Check [0146] **52** Puller sends message to Tensioner commanding it to perform a Brake Check [0147] **53** Operator selects to continue on Puller Display [0148] **54** Tensioner sends signal to Puller indicating it passed its Brake Check [0149] **54**A Tensioner sends signal to Puller indicating it failed its Brake Check [0150] **55** Query did the Puller Reel rotate [0151] **56**A Display “Puller Brake Check Passed” [0152] **57** Query: is tensioner Brake Check status correct? [0153] **58** Query: continue with In-Command system? [0154] **59** End Tensioner Brake Check routine [0155] **60** Query: check for Brake Check command [0156] **61** Puller set drum speed to 0 and engage brake [0157] **62** Puller receives Tensioner Brake Check results [0158] **63** End use of In-Command system [0159] **64** Display “Tensioner Brake Check Passed” [0160] **65** Tensioner sets drum speed to 0 rpm [0161] **66** Warning displayed on Puller display when Puller drum rotation detected during Brake Check routine [0162] **67** Query: perform Puller Brake Check again? [0163] **68** Query: did tensioner pass Brake Check? [0164] **69** Query: perform Tensioner Brake Check again? [0165] **70** Tensioner receive desired tension value **131** [0166] **71** End use of In-Command system [0167] **72** Operator input of desired tension {ibs} on Puller [0168] **72**A Operator input of maximum line pull {ibs} on Puller [0169] **73** Display “Tensioner Brake Check Passed” [0170] **74** Tensioner receives command **90** to release brake [0171] **75** Tensioner adjusts required motor torque if needed [0172] **76** Tensioner releases driveline brake [0173] **77** Tensioner receives command **103** to engage brake [0174] **78** Puller adjusts required motor torque if needed [0175] **79** Operator selects to continue on Puller Display [0176] **80** Tensioner engages driveline brake [0177] **81** Query: is Tensioner returning correct desired line pull? [0178] **82** Query: continue with In-Command system? [0179] **83** Operator switches off Tensioner power [0180] **84** End use of In-Command system [0181] **85** Tensioner powers down [0182] **86** Operator selects to release Puller driveline brake [0183] **87** End use of In-Command System [0184] **88** Operator selects to release Tensioner driveline brake [0185] **89** Puller releases driveline brake [0186] **90** Puller commands Tensioner to release Tensioner brake [0187] **91** Operator selects to continue on Puller Display [0188] **92** Query: is Tensioner brake status correct? [0189] **93** Query: continue with In-Command system? [0190] **94** Display “Tensioner Brake Released” on Puller Display [0191] **95** End use of In-Command system [0192] **96** Operator selects desired reel speed [0193] **97** Puller adjusts motor speed [0194] **98** Query: is operation complete? [0195] **99** Operator set desired reel speed to 0.00 rpm [0196] **100** Puller adjusts motor speed to 0.00 rpm [0197] **101** Operator selects to engage Puller driveline brake [0198] **102** Puller engages driveline brake [0199] **103** Operator selects to engage Tensioner driveline brake [0200] **104** Puller send command to Tensioner to engage brake [0201] **105** Operator selects to continue on Puller Display [0202] **106** Query: is the Tensioner brake status returned correctly? [0203] **107** Query: continue use of the In-Command system? [0204] **108** Operator disables the In-Command system [0205] **109** Puller ends transmission of radio messages [0206] **110** Operator switches off Puller power [0207] **111** Puller powers down [0208] **112** End of operation [0209] **113** line to FIG. **5**B, options **46**, **47** and **48** [0210] **115** line to FIG. **5**E, receive radio check message **25** [0211] **116** line to FIG. **5**C, adjust puller motor torque if required **78** [0212] **117** line to FIG. **5**D, display tensioner brake release on puller **94** [0213] **118** line to FIG. **5**F, engage tensioner driveline brake **80**

[0214] **119** line to FIG. **5**F, receive desired tension value **70** [0215] **130** operate puller [0216] **130**A operate tensioner [0217] **131** send desired tension message to tensioner [0218] **160** Alternate Start [0219] **170** Bypass brake check, go to alternate start **160**

[0220] While this invention has been described in conjunction with the specific embodiments outlined above, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the examples of the invention as set forth above are intended to be illustrative, and not limiting. Various changes may be made without departing from the spirit and scope of the invention.

Claims

1. A process for tension stringing a conductor through above-ground supports, comprising the steps of: affixing a length of rope to said conductor; positioning a first stringing apparatus near a first end of said above-ground supports; positioning a second stringing apparatus near a second end of said above-ground supports; each of said first and second stringing apparatuses are Green Machines powered by electric batteries; each of said first and second stringing apparatuses includes an onboard control system which controls each of said first and second stringing apparatuses in pulling mode or in tensioning mode; each of said first and second stringing apparatuses includes a motor/regenerative brake; each of said machines includes a wireless transceiver which is hard-wired to said onboard control system; an operator selects one of said first and second stringing machines as a puller machine operating in pulling mode using said onboard control system of said machine designated as said puller machine; each of said wireless transceivers communicating with the other wireless transceiver enabling control of both said machines by said onboard control system of said puller machine; verifying said wireless communications sent from said transceiver of said puller machine were received by said transceiver of said tensioning machine and said onboard control system of said tensioning machine; an observer located on said tensioning machine selects and commands the other machine to operate as a tensioning machine operating in tensioning mode, said puller machine being, thereafter, in command of said tensioning machine wirelessly communicating with said transceiver of said tensioning machine and controlling said onboard control system of said tensioning machine; said puller machine in pulling mode for pulling in said conductor toward a puller machine reel and a tensioning machine being in said tensioning mode operating said regenerative brake of said tension machine for tensioning out said conductor from said tensioning machine reel; performing a driveline brake check on said puller machine and said tensioning machine; providing said driveline brake check on said puller machine and said tensioning machine are satisfactory such that there is no rotation of said puller machine reel and said tensioning machine reel, an input maximum line pull value in pounds-force is input into said onboard puller control system, an input tension value in pounds-force is input into said onboard puller control system and is communicated wirelessly to said tensioning machine; said tensioning machine operating in tensioning mode returning and acknowledging said input tension value from said puller machine operating in pulling mode; setting the tensioning machine motor speed to zero; releasing said driveline brakes on said puller machine and said tensioning machine; selecting the puller machine desired reel speed until said conductor is completely pulled through said supports; and, if said conductor is completely pulled through said supports, simultaneously applying said driveline brakes on said puller machine and said tensioning machine as commanded by said puller machine control system on said puller machine.

2. A process for tension stringing a conductor through above-ground supports as claimed in claim 1 wherein said wireless transceiver is a 1W radio transceiver and a Yagi-Uda type or omnidirectional type antenna.

3. A process for tension stringing a conductor through above-ground supports as claimed in claim 2 wherein said Yagi-Uda type antenna or omnidirectional type antenna has a gain of 6 dBm.

4. A process for tension stringing a conductor through above-ground supports as claimed in claim 1 wherein each of said driveline brakes is an electro-mechanical brake which prevents rotation of said puller machine reel and said tensioner machine reel.

5. A process for tension stringing a conductor through above-ground supports as claimed in claim 1, further comprising the step of: Interposing a bidirectional repeater between said puller machine and said tensioner machine; and, said bidirectional repeater is comprised of a radio transceiver, an omni-directional radio antenna, and a power supply.

6. A process for tension stringing a conductor through above-ground supports as claimed in claim 1, further comprising the step of: during application of said driveline brakes, each of: said motor controllers output the programmed amount of motor torque, and, said motor controllers output the programmed motor rotations per minute.

7. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine, comprising the steps of: attaching a rope to said conductor, said conductor initially wound on a reel of said tensioning machine; establishing and verifying wireless communication between a control system of said pulling machine and a control system of said tensioning machine during said tension stringing said conductor; applying a driveline brake on said pulling machine if wireless communication between said pulling machine and said tensioning machine is not verified; applying a driveline brake on said tensioning machine if wireless communication between said pulling machine and said tensioning machine is not verified; checking said driveline brakes by applying torque and speed commands to said motor controllers which drive the reels on said pulling machine and said tensioning machine; monitoring said pulling machine and said tensioning machine for movement of said reels during said checking of said driveline brakes; inputting a desired maximum line pull force on said pulling machine control system; inputting a desired tension force on said pulling machine control system; communicating said desired tension force on said pulling control system to said tensioning machine control system on said tensioning machine; said tensioning machine generating a tensioning force based on said desired tension force of said pulling machine using a regenerative brake of said tensioning machine; and, pulling said rope and said conductor through said supports with said pulling machine.

8. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine as claimed in claim **7**, further comprising the steps of: said tensioning force is calculated based on the weight of the rope and the conductor used, the friction load generated as the rope and the conductor are pulled through the supports, the terrain that the supports, rope and conductor traverse, a horizontal load, a vertical load, and the distance between said pulling machine and said tensioning machine.

9. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine as claimed in claim 7, wherein said puller machine and said tensioner machine includes a frame; a conductor; a rope; a reel about which said conductor or said rope is wound; an electric motor affixed to said frame and coupled to said reel; and, said electric motor expending electrical energy when in a pulling mode and pulling in said rope affixed to said conductor, alternatively, said electric motor generating electrical energy when tensioning said conductor out in tensioning mode.

10. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine as claimed in claim 9, wherein each of said puller machine and said tensioning machine includes: a motor controller in combination with said electric motor; an onboard control system switchable between a pulling mode and a tensioning mode; said onboard controller outputting commands to said motor controller for control of said electric motor; a plurality of batteries; said onboard controller applying electrical energy from said batteries to said electric motor when in said

pulling mode; said onboard control system applying electrical energy generated by said electric motor to said plurality of batteries when in said tensioning mode; said onboard control system controlling electric motor torque and speed and said onboard control system controlling torque in said pulling mode; and, said processor controlling electric motor torque in said tensioning mode.

11. A conductor stringing apparatus, comprising: a puller machine which pulls a rope affixed to a conductor, said rope having been at least partially guided through supports; said puller machine comprises: a frame; an onboard control system; a wireless transceiver hard-wired to said onboard control system; a reel about which said rope is wound; an electric motor affixed to said frame and coupled to said reel; a safety brake; and, said electric motor expending electrical energy when pulling said conductor in a pulling mode; a tensioner machine which tensions out said conductor; said tensioner machine comprises: a frame; an onboard control system; a wireless transceiver hard-wired to said onboard control system; a reel about which said conductor wound; an electric motor affixed to said frame and coupled to said reel; and, said electric motor is a regenerative brake generating electrical energy when tensioning said conductor in a tensioning mode; said wireless transceiver of said puller machine communicates with said wireless transceiver of said tensioner machine; and, said onboard control system of said puller machine controls said onboard control system of said tensioner machine.

12. A conductor stringing apparatus as claimed in claim 11, further comprising: said puller machine includes an electro-mechanical driveline brake which is a safety brake which prevents rotation of the reel of the puller machine when engaged; and, said tensioner machine includes an electro-mechanical driveline brake which is a safety brake which prevents rotation of the reel of the tensioner machine when engaged.

13. A conductor stringing apparatus as claimed in claim 11, further comprising: said wireless transceiver of said tensioner machine repeats all communications from said wireless transceiver of said puller machine for verification of said communications and their accuracy.

14. A conductor stringing apparatus as claimed in claim 11, further comprising: a single skilled operator interfaces with said onboard control system of said puller machine.

15. A conductor stringing apparatus as claimed in claim 13, further comprising: an observer interfaces with said onboard control system of said tensioner machine.

16. A process for tension stringing a conductor through above-ground supports as claimed in claim 1, further comprising the step of: wherein said brake force of said regenerative brake of said tension machine for tensioning out said conductor from said tensioning machine reel is a function of said tension pull force for said puller machine.

17. A process for tension stringing a conductor through supports, comprising the steps of: affixing a length of rope to said conductor; positioning a first stringing apparatus near a first end of said supports; positioning a second stringing apparatus near a second end of said supports; each of said first and second stringing apparatuses are selected from the group consisting of a Green Machine powered by electric batteries, diesel powered electric over hydraulic system, and electric over hydraulic system; each of said first and second stringing apparatuses includes an onboard control system which controls each of said first and second stringing apparatuses in pulling mode or in tensioning mode; each of said first and second stringing apparatuses includes a brake selected from the group consisting of a motor/regenerative brake, a hydraulic circuit, and a hydraulically applied brake; each of said machines includes a wireless transceiver which is hard-wired to said onboard control system; establishing and verifying wireless communication between said first and second stringing apparatuses; initiating operation of said onboard control systems of each machine, each of said machines includes a display for viewing by the respective operator or observer; creating queries on each of said displays to activate an “In-Command” operating system wherein said operator or observer of the respective machine exclusively selects to operate said machine as either the pulling machine or the tensioning machine; an operator selects one of said first and second stringing machines as a puller machine operating in pulling mode using said onboard control

system of said machine designated as said puller machine; each of said wireless transceivers communicating with the other wireless transceiver enabling control of both said machines by said onboard control system of said puller machine; verifying said wireless communications sent from said transceiver of said puller machine were received by said transceiver of said tensioning machine and said onboard control system of said tensioning machine; an observer located on said tensioning machine selects and commands the other machine to operate as a tensioning machine operating in tensioning mode, said puller machine being, thereafter, in command of said tensioning machine wirelessly communicating with said transceiver of said tensioning machine and controlling said onboard control system of said tensioning machine; said puller machine in pulling mode for pulling in said rope affixed to said conductor and a tensioning machine being in said tensioning mode operating said regenerative brake of said tension machine for tensioning out said conductor from said tensioning machine reel; performing a driveline brake check on said puller machine and said tensioning machine; providing said driveline brake check on said puller machine and said tensioning machine are satisfactory such that there is no rotation of said puller machine reel and said tensioning machine reel, an input maximum line pull value in pounds-force is input into said onboard puller control system, an desired tension value in pounds-force is input into said onboard puller control system and is communicated wirelessly to said tensioning machine; said tensioning machine operating in tensioning mode returning and acknowledging said input desired tension value from said puller machine operating in pulling mode; setting the tensioning machine motor speed to zero; releasing said driveline brakes on said puller machine and said tensioning machine; selecting the puller machine desired reel speed; pulling said rope and said conductor until said conductor is completely pulled through said supports; and, if said conductor is completely pulled through said supports, simultaneously applying said driveline brakes on said puller machine and said tensioning machine as commanded by said puller machine control system on said puller machine.

18. A process for tension stringing a conductor through supports as claimed in claim 17, further comprising the steps of: adjusting the tensioner motor torque of said tensioning machine creating a braking force on said reel of said tensioner while said rope and said conductor are being pulled through said supports when said motor/regenerative brake is selected; and, adjusting said hydraulic circuit creating a braking force on said reel of said tensioner while said rope and said conductor are being pulled through said supports when said hydraulic circuit is selected; and, adjusting said hydraulically applied brake creating a braking force on said reel of said tensioner while said rope and said conductor are being pulled through said supports when said hydraulically applied brake is selected.

19. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine as claimed in claim 7, further comprising the steps of: said supports are located underground.

20. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine, comprising the steps of: attaching a rope to said conductor, said conductor initially wound on a reel of said tensioning machine; establishing and verifying wireless communication between a control system of said pulling machine and a control system of said tensioning machine during said tension stringing said conductor; applying a driveline brake on said pulling machine if wireless communication between said pulling machine and said tensioning machine is not verified; applying a driveline brake on said tensioning machine if wireless communication between said pulling machine and said tensioning machine is not verified; checking said driveline brakes by applying torque and speed commands to said motor controllers which drive the reels on said pulling machine and said tensioning machine; monitoring said pulling machine and said tensioning machine for movement of said reels during said checking of said driveline brakes; inputting a desired maximum

line pull force on said pulling machine control system; inputting a desired tension force on said pulling machine control system; communicating said desired tension force on said pulling control system to said tensioning machine control system on said tensioning machine; said tensioning machine generating a tensioning force based on said desired tension force of said pulling machine using a brake selected from the group consisting of a regenerative brake, hydraulic circuit, and a hydraulic brake of said tensioning machine; and, pulling said rope and said conductor through said supports with said pulling machine.

21. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine as claimed in claim 20, further comprising the steps of: said supports are located underground.

22. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning machine, comprising the steps of: affixing a length of rope to said conductor; positioning a first stringing apparatus near a first end of said supports; positioning a second stringing apparatus near a second end of said supports; each of said first and second stringing apparatuses are selected from the group of Green Machines powered by electric batteries, diesel powered electric over hydraulic system, and electric over hydraulic system; each of said first and second stringing apparatuses includes an onboard control system which controls each of said first and second stringing apparatuses in pulling mode or in tensioning mode; each of said first and second stringing apparatuses includes a brake selected from the group of a regenerative brake, hydraulic circuit, and a hydraulically operated brake; each of said machines includes a wireless transceiver which is hard-wired to said onboard control system; said first stringing apparatus has an operator and said second stringing apparatus has an observer; establishing and verifying wireless communication between said first and second stringing apparatuses; initiating operation of said onboard control systems of each machine, each of said machines includes a display for viewing by the respective operator or observer; creating queries on each of said displays to activate an “In-Command” operating system wherein said operator or observer of the respective machine exclusively selects to operate said machine as either the pulling machine or the tensioning machine; an operator selects one of said first and second stringing machines as a puller machine operating in pulling mode using said onboard control system of said machine designated as said puller machine; each of said wireless transceivers communicating with the other wireless transceiver enabling control of both said machines by said onboard control system of said puller machine; verifying said wireless communications sent from said transceiver of said puller machine were received by said transceiver of said tensioning machine and said onboard control system of said tensioning machine; an observer located on said tensioning machine selects and commands the other machine to operate as a tensioning machine operating in tensioning mode, said puller machine being, thereafter, in command of said tensioning machine wirelessly communicating with said transceiver of said tensioning machine and controlling said onboard control system of said tensioning machine; said puller machine in pulling mode for pulling in said rope affixed to said conductor and a tensioning machine being in said tensioning mode operating said brake selected from the group of a regenerative brake, a hydraulic circuit, and a hydraulic brake of said tension machine for tensioning out said conductor from said tensioning machine reel; inputting a desired maximum line pull force on said pulling machine control system; inputting a desired tension force on said pulling machine control system; communicating said desired tension force on said pulling control system to said tensioning machine control system on said tensioning machine; said tensioning machine generating a tensioning force based on said desired tension force of said pulling machine using said brake; and, pulling said rope and said conductor through said supports with said pulling machine.

23. A process for tension stringing a conductor through supports using a pulling machine and a tensioning machine, said pulling machine controlling said pulling machine and said tensioning

machine as claimed in claim 22, further comprising the steps of: said supports are located underground.

24. A conductor stringing apparatus, comprising: a puller machine which pulls a rope affixed to a conductor, said rope having been at least partially guided through supports; said puller machine comprises: an onboard control system; a wireless transceiver hard-wired to said onboard control system; a means to pull in said rope; a tensioner machine which tensions out said conductor; said tensioner machine comprises: an onboard control system; a wireless transceiver hard-wired to said onboard control system; a means to develop tension in said conductor; said wireless transceiver of said puller machine communicates with said wireless transceiver of said tensioner machine; and, said onboard control system of said puller machine controls said onboard control system of said tensioner machine.