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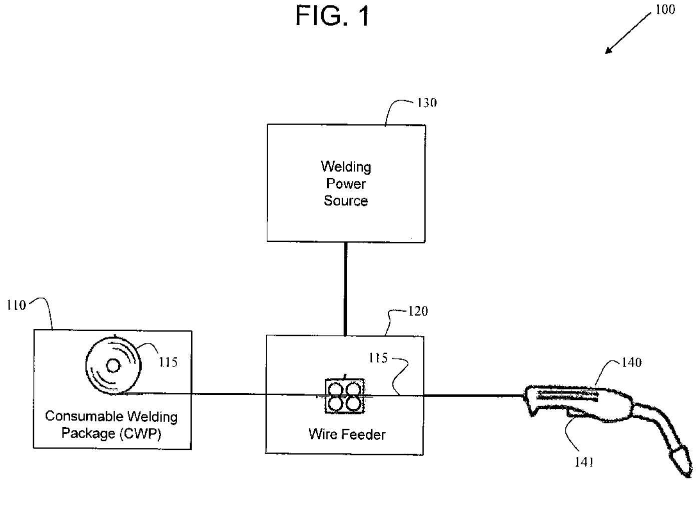
(54) **Title**: TWO-WAY COMMUNICATION BETWEEN A WIRE FEEDER AND A WELDING POWER SOURCE PROVIDING IMPROVED OPERATION

FIG. 1



(57) **Abstract**: Systems (100) and methods (500, 700) of communicating between a welding power source (130) and a welding wire (120) feeder to improve the operation of a welding system (100). Two-way communication between a welding power source (130) and a welding wire feeder (120) is provided either wirelessly or over the welding output cable (310). The communication between the welding power source (130) and the welding wire feeder (120) facilitates output voltage selection at the welding wire feeder (120) as well as the entering of a lower output power state of the welding power source (130) when not welding.

TWO-WAY COMMUNICATION BETWEEN A WIRE FEEDER AND A WELDING POWER SOURCE PROVIDING IMPROVED OPERATION

FIELD OF THE INVENTION

[0001] The invention is related to a method of communication between a welding power source and a welding wire feeder according to claims 1 and 4, to a method of controlling an electrical output of a welding power source according to claim 9, to a welding system according to claims 11 and 12 and to a welding power source according to claims 16 and 17. Certain embodiments of the present invention relate to welding. More particularly, certain embodiments of the present invention relate to systems and methods of communicating between a welding power source and a welding wire feeder to improve the operation of a welding system.

TECHNICAL BACKGROUND

[0002] In many prior art welding systems, the output voltage level of the welding power source switches between a higher open circuit voltage level (when not welding) and a lower welding output voltage level (when welding). The constant presence of such a higher open circuit voltage level when not welding can present a hazard to the operator or to the workpiece to be welded. Furthermore, welding wire feeders also often have electrical contactors which switch high power provided by a welding power source to a welding electrode. Contactors add cost and weight to the welding wire feeder and require frequent maintenance. Many prior art welding systems use welding wire feeders that rely on batteries or other energy storage devices in the welding wire feeder to provide electrical power for operation of the welding wire feeder. Such batteries or other energy storage devices are an added expense to the welding wire feeder and can be drained rather quickly, depending on the operation of the welding wire feeder. Also, many prior art welding systems rely on a dedicated control cable between the welding power source and the welding wire feeder which adds weight, can cause trip hazards, and frequently requires repair.

[0003] Further limitations and disadvantages of conventional, traditional, and proposed approaches will become apparent to one of skill in the art, through comparison of such systems and methods with embodiments of the present invention as set forth in the remainder of the present application with reference to the drawings.

DESCRIPTION OF THE INVENTION

[0004] It is an object to overcome the above mentioned limitations and disadvantages. This problem is solved by a method of communication between a welding power source and a welding wire feeder according to claims 1 and 4, by a method of controlling an electrical output of a welding power source according to claim 9, by a welding system according to claims 11 and 12 and by a welding power source according to claims 16 and 17. Further embodiments of the invention are subject of the subclaims. Embodiments of the present invention provide systems and methods of communicating between a welding power source and a welding wire feeder to improve the operation of a welding system. Two-way communication between a welding power source and a welding wire feeder is provided either wirelessly or over the welding output cable. The communication between the welding power source and the welding wire feeder facilitates output voltage selection at the welding wire feeder as well as the entering of a lower output power state of the welding power source when not welding.

[0005] One embodiment of the present invention is a method of communication between a welding power source and a welding wire feeder. The method includes communicating a welding power source identifier, corresponding to a welding power source type, from a welding power source being of the welding power source type to a welding wire feeder operatively connected to the welding power source. The method also includes automatically scaling an output range of an output control device of the welding wire feeder, in response to the welding power source identifier, to a range of welding output voltage values corresponding to a range of welding output potentials provided by the welding power source. The method may further include automatically displaying a welding output voltage value on a display of the welding wire feeder corresponding to a present setting of the output control device. The method may also include communicating a present setting of the output control device from the welding wire feeder to the welding power source. The communicating may be performed wirelessly or via encoded signals over a welding output cable operatively connecting the welding power source to the welding wire feeder. The method may further include the welding power source providing a welding output potential, corresponding to the welding output voltage value, to the welding wire feeder over a welding output cable operatively connecting the welding power source to the welding wire feeder.

[0006] One embodiment of the present invention is a method of communication between a welding power source and a welding wire feeder. The method includes communicating a welding power source identifier, corresponding to a welding power source type, from a welding power source being of the welding power source type to a welding wire feeder operatively connected to the welding power source. The method also includes communicating a present setting value from the welding wire feeder to the welding power source, wherein the present setting value is based on a present setting of an output control device of the welding wire feeder and the welding power source identifier. The method may further include the welding power source automatically converting the present setting value to a welding output voltage value, and communicating the welding output voltage value from the welding power source to the welding wire feeder. The communicating may be performed wirelessly or via encoded signals over a welding output cable operatively connecting the welding power source to the welding wire feeder. The method may also include displaying the welding output voltage value on a display of the welding wire feeder. The method may further include the welding power source providing a welding output potential, corresponding to the welding output voltage value, to the welding wire feeder over a welding output cable operatively connecting the welding power source to the welding wire feeder.

[0007] One embodiment of the present invention is a method of controlling an electrical output of a welding power source. The method includes regulating an electrical output of a welding power source to a low output voltage level of a low power state of the welding power source. The method also includes regulating the electrical output of the welding power source to an open circuit voltage level when a trigger signal is received at the welding power source from a welding wire feeder, wherein a magnitude of the open circuit voltage level is larger than a magnitude of the low output voltage level. The method further includes regulating the electrical output of the welding power source to a welding output voltage level when an electric arc exists between an electrode and a workpiece electrically connected to the electrical output of the welding power source, wherein a magnitude of the welding output voltage level is between the magnitudes of the low output voltage level and the open circuit voltage level. The method may also include regulating the electrical output of the welding power source to the low output voltage level of the low power state of the welding power source when the trigger signal is no longer received by the welding power source. The trigger signal may be wirelessly received by the welding power source from a welding wire feeder. The trigger signal may be received by the welding power source over a welding output cable operatively connected between the welding power source and a welding wire feeder.

[0008] One embodiment of the present invention is a welding system. The welding system includes a welding power source having a first wireless transceiver. The system also includes a welding wire feeder having a second wireless transceiver, wherein the first wireless transceiver and the second wireless transceiver are configured to provide two-way communication between the welding power source and the welding wire feeder. The system further includes a welding output cable operatively connecting the welding power source to the welding wire feeder for providing electrical power from the welding power source to the welding wire feeder, wherein the second wireless transceiver is configured to be powered by electrical power from the welding power source. The system may further include a plurality of calibration curves stored in a computer memory of the welding wire feeder. Each calibration curve of the plurality of calibration curves corresponds to a welding power source type and is configured to scale an output range of an output control device of the welding wire feeder to a range of welding output voltage values in response to the second wireless transceiver receiving a welding power source identifier, corresponding to a welding power source type, from the first wireless transceiver. The range of welding output voltage values may correspond to a range of welding output potentials that a welding power source of the corresponding welding power source type is configured to provide to the welding wire feeder over the welding output cable. In accordance with an embodiment, the welding wire feeder may be configured to be fully powered by electrical power from the welding power source.

[0009] One embodiment of the present invention is a welding system. The welding system includes a welding power source having a first transceiver, a welding wire feeder having a second transceiver, and a welding output cable operatively connecting the welding power source to the welding wire feeder for providing electrical power from the welding power source to the welding wire feeder. The second transceiver is configured to be powered by electrical power from the welding power source. The first transceiver and the second transceiver are configured to provide two-way communication between the welding power source and the welding wire feeder over the welding output cable. The system may further include a plurality of calibration curves stored in a computer memory of the welding wire feeder. Each calibration curve of the plurality of calibration curves corresponds to a welding power source type and is configured to scale an output range of an output control device of the welding wire feeder to a range of welding output voltage values in response to the second wireless transceiver receiving a welding power source identifier, corresponding to a welding power source type, from the first wireless transceiver. The range of welding output voltage values may correspond to a range of welding output potentials that a welding power source of the corresponding welding power source type is configured to provide to the welding wire feeder over the welding output cable. In accordance with an embodiment, the welding wire feeder may be configured to be fully powered by electrical power from the welding power source.

[0010] One embodiment of the present invention is a welding power source providing a low power state. The welding power source includes a transceiver configured to facilitate two-way communication with a welding wire feeder. The transceiver may be a wireless transceiver, or the transceiver may be configured to communicate with a welding wire feeder over a welding output cable operatively connected between the welding power source and the welding wire feeder. The welding power source also includes electrical output circuitry providing an electrical output. The welding power source further includes a controller configured to control the electrical output circuitry. The controller controls the electrical output circuitry by regulating the electrical output to a low output voltage level of a low power state of the welding power source when a trigger signal is not being received by the transceiver. The controller also controls the electrical output circuitry by regulating the electrical output to an open circuit voltage level when a trigger signal from a welding wire feeder is being received by the transceiver, and when an electric arc does not exist between an electrode and a workpiece electrically connected to the electrical output circuitry. A magnitude of the open circuit voltage level is larger than a magnitude of the low output voltage level. The controller further controls the electrical output circuitry by regulating the electrical output to a welding output voltage level when a trigger signal from a welding wire feeder is being received by the transceiver, and when an electric arc exists between an electrode and a workpiece electrically connected to the electrical output circuitry. A magnitude of the welding output voltage level is between the magnitudes of the low output voltage level and the open circuit voltage level. In accordance with an embodiment, the low power state of the welding power source is configured to provide electrical power to fully power a welding wire feeder operatively connected to the welding power source. According to a preferred embodiment of the welding power source the transceiver is a wireless transceiver. According to a further preferred embodiment the transceiver is configured to communicate with a welding wire feeder over a welding output cable operatively connected between the welding power source and the welding wire feeder. According to a further preferred embodiment the low power state is configured to provide electrical power to fully power a welding wire feeder operatively connected to the welding power source.

[0011] Details of illustrated embodiments of the present invention will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] *Fig. 1* illustrates a schematic block diagram of an exemplary embodiment of a welding system having a welding power source and a welding wire feeder;

[0013] *Fig. 2* is a functional block diagram illustrating a first exemplary embodiment of communication between the welding power source and the welding wire feeder of *Fig. 1*;

[0014] *Fig. 3* illustrates a schematic block diagram of a first exemplary embodiment of the welding power source and the welding wire feeder of *Fig. 1 and Fig. 2*;

[0015] *Fig. 4* illustrates a schematic block diagram of a second exemplary embodiment of the welding power source and the welding wire feeder of *Fig. 1 and Fig 2*;

[0016] *Fig. 5* is a flowchart of a first exemplary embodiment of a method of communication between the welding power source and the welding wire feeder of *Fig. 1*;

[0017] *Fig. 6* is a graph illustrating exemplary embodiments of two calibration curves of two welding power sources being of two different welding power source types;

[0018] *Fig. 7* is a flowchart of a second exemplary embodiment of a method of communication between the welding power source and the welding wire feeder of *Fig. 1*;

[0019] *Fig. 8* is a functional block diagram illustrating a second exemplary embodiment of communication between the welding power source and the welding wire feeder of *Fig. 1*;

[0020] *Fig. 9* illustrates a schematic block diagram of an exemplary embodiment of the welding power source of *Fig. 8*; and

[0021] *Fig. 10* is an exemplary embodiment of a timing diagram illustrating the operation of the welding power source of *Fig. 9*.

DETAILED DESCRIPTION OF THE DRAWINGS

[0022] The following are definitions of exemplary terms that may be used within the disclosure. Both singular and plural forms of all terms fall within each meaning:

[0023] "Software" or "computer program" as used herein includes, but is not limited to, one or more computer readable and/or executable instructions that cause a computer or other electronic device to perform functions, actions, and/or behave in a desired manner. The instructions may be embodied in various forms such as routines, algorithms, modules or programs including separate applications or code from dynamically linked libraries. Software may also be implemented in various forms such as a stand-alone program, a function call, a servlet, an applet, an application, instructions stored in a memory, part of an operating system or other type of executable instructions. It will be appreciated by one of ordinary skill in the art that the form of software is dependent on, for example, requirements of a desired application, the environment it runs on, and/or the desires of a designer/programmer or the like.

[0024] "Computer" or "processing element" or "computer device" as used herein includes, but is not limited to, any programmed or programmable electronic device that can store, retrieve, and process data. "Non-transitory computer-readable media" include, but are not limited to, a CD-ROM, a removable flash memory card, a hard disk drive, a magnetic tape, and a floppy disk.

[0025] "Consumable welding package", as used herein, refers to, but is not limited to, a drum of consumable welding wire, a box of consumable welding wire, a spool of consumable welding wire, a palette of consumable welding wire, or equivalents thereof.

[0026] "Welding tool", as used herein, refers to, but is not limited to, a welding gun, a welding torch, or any welding device that accepts a consumable welding wire for the purpose of applying electrical power to the consumable welding wire provided by a welding power source.

[0027] "Welding power source identifier", as used herein, refers to a code, a signal, information, or data indicating the type of a welding power source, and is used to allow a welding output voltage range of the welding power source to be known to a wire feeder.

[0028] "Output control device", as used herein, refers to a device in a welding wire feeder allowing an operator to select a desired welding output potential to be provided by a welding power source. The output control device may include, but is not limited to, a potentiometer and an encoder.

[0029] "Welding output potential", as used herein, refers to an actual welding output voltage provided by a welding power source.

[0030] "Present setting", as used herein, refers to the output state of an output control device of a welding wire feeder at a present time.

[0031] "Present setting value", as used herein, refers to the value of the output state of an output control device of a welding wire feeder at a present time.

[0032] "Welding output cable", as used herein, refers to the electrical cable that may be connected between a welding power source and a welding wire feeder to provide electrical power from the welding power source to the welding wire feeder. The welding output cable may also be used for communication between the welding power source and the welding wire feeder.

[0033] "Encoded signals", as used herein, refers to electrical signals having information encoded thereon.

[0034] "Electrical output", as used herein, may refer to the electrical output circuitry or output port of a welding power source, or to the electrical power, voltage, or current provided by the electrical output circuitry or output port of a welding power source.

[0035] "Open circuit voltage", as used herein, refers to the electrical potential provided by the electrical output of a welding power source when not welding and when not in a low power state.

[0036] "Trigger signal", as used herein, refers to the signal, data, or information provided from a welding wire feeder to a welding power source indicating that a trigger of a welding tool has been activated.

[0037] "Wireless transceiver", as used herein, refers to a transmitter and receiver configuration capable of providing two-way communication with another device via radio frequency means, infrared means, or other means not requiring a wired transmission path.

[0038] "Transceiver", as used herein, refers to a transmitter and receiver configuration capable of providing two-way communication with another device via a wired transmission path.

[0039] "Computer memory", as used herein, refers to a storage device configured to store digital data or information which can be retrieved by a computer or processing element.

[0040] "Calibration curve", as used herein, refers to a mapping, conversion, or scaling from a range of input values to a range of output values. The terms "mapping", "conversion", and "scaling", and derivative forms thereof, may be used interchangeably herein.

[0041] "Electrical output circuitry", as used herein, refers to the circuitry within a welding power source directly associated with providing electrical output power for welding.

[0042] "Controller", as used herein, refers to the logic circuitry and/or processing elements and associated software involved in controlling the electrical output of a welding power source in response to various input signals or data.

[0043] The terms "signal", "data", and "information" may be used interchangeably herein and may be in digital or analog form.

[0044] *Fig. 1* illustrates a schematic block diagram of an exemplary embodiment of a welding system **100** having a welding power source **130** and a welding wire feeder **120**. The system **100** also includes a welding tool **140** and a source of consumable welding wire **115** in the form of, for example, a consumable welding package **110.** The welding power source **130** is operatively connected to the welding wire feeder **120**, and the welding wire feeder is operatively connected to the welding tool **140**. The wire feeder **120** feeds consumable welding wire **115** from the consumable welding package **110** to the welding tool **140**. The welding power source **130** provides electrical power to the welding tool **140** via the welding wire feeder **120**, which can be applied to the welding wire **115** at the welding tool **140**, for example, for the purpose of welding a workpiece. In accordance with an embodiment of the present invention, the welding wire feeder **120** is configured to be fully powered by electrical power from said welding power source **130**. No batteries are other energy storage devices are used by the wire feeder **120** as a source of electrical power.

[0045] *Fig. 2* is a functional block diagram illustrating a first exemplary embodiment of communication between the welding power source **130** and the welding wire feeder **120** of *Fig. 1*. The welding wire feeder **120** includes a display **121** (e.g., a liquid crystal display), a user interface **122** (e.g., a keypad or DIP switches), an output control device **123** (e.g., a dial or knob operatively connected to a potentiometer or to a encoder device), and computer memory **125**. The output control device **123** is used by an operator to set or select the welding output voltage to be supplied by the welding power source **130** and applied to the welding wire **115** at the welding tool **140** via the welding wire feeder **120**. In accordance with an embodiment, the display **121** may be used to present a selected welding output voltage to an operator.

[0046] Referring to *Fig. 2*, two-way communication takes place between the welding power source **130** and the welding wire feeder **120**. For example, the welding power source **130** may communicate a welding power source identifier (ID) to the welding wire feeder **120**. The welding power source ID identifies to the wire feeder **120** the type of welding power source **130** to which the wire feeder **120** is operatively connected. The wire feeder **120** may use the welding power source ID as described later herein. In accordance with an alternative embodiment of the present invention, the welding power source ID or type may be manually entered by an operator via the user interface **122**.

[0047] Furthermore, the welding wire feeder **120** may communicate a present setting of the output control device (e.g., a voltage value from a potentiometer of the output control device, or an encoder value from an encoder of the output control device) to the welding power source **130.** The welding power source **130** may use the present setting as described later herein. Also, the welding power source **130** may communicate a welding output voltage value to the welding wire feeder **120.** The welding output voltage value may correspond to a present setting of the output control device **123**, as described later herein, and may be displayed on the display **121** of the wire feeder **120**.

[0048] *Fig. 3* illustrates a schematic block diagram of a first exemplary embodiment of the welding power source **130** and the welding wire feeder **120** of *Fig. 1 and Fig. 2*. The welding power source **130** includes a wireless transceiver **334** and the welding wire feeder includes a wireless transceiver **324**. The transceivers **324** and **334** are each configured to transmit and receive information between the welding power source **130** and the welding wire feeder **120** wirelessly. For example, referring again to Fig. 2, the welding power source ID, the present setting of the output control device, and the welding output voltage value may be communicated via the wireless transceivers **324** and **334**. The wireless transceivers **324** and **334** may be radio frequency (RF) transceivers, for example. Other types of wireless transceivers are possible as well such as, for example, infrared (IR) transceivers.

[0049] Electrical power is provided by the welding power source **130** to the welding wire feeder **120** via a welding output cable **310**. However, the welding output cable **310** is not used for communication between the welding power source **130** and the wire feeder **120** in the embodiment of *Fig. 3*. In accordance with an embodiment of the present invention, the wireless transceiver **324** in the wire feeder **120** is powered by electrical power provided by the welding power source **130** over the cable **310.** In accordance with another embodiment, the entire welding wire feeder **120** is configured to be fully powered by electrical power from the welding power source **130**. Furthermore, electrical power provided by the welding power source **130** over the welding output cable **310** to the wire feeder **120** is also used to provide a welding output potential to the welding wire **115** at the welding tool **140** for welding.

[0050] *Fig. 4* illustrates a schematic block diagram of a second exemplary embodiment of the welding power source **130** and the welding wire feeder **120** of *Fig. 1 and Fig 2.* The welding power source **130** includes a transceiver **434** and the welding wire feeder includes a transceiver **424.** The transceivers **424** and **434** are each configured to transmit and receive information between the welding power source **130** and the welding wire feeder **120** over the welding output cable **310**. For example, referring again to Fig. 2, the welding power source ID, the present setting of the output control device, and the welding output voltage value may each be communicated via the transceivers **424** and **434** as an electrical signal **410** over the welding output cable **310**.

[0051] Again, electrical power is provided by the welding power source **130** to the welding wire feeder **120** via the welding output cable **310**. However, the welding output cable **310** is also used for communication between the welding power source **130** and the wire feeder **120** in the embodiment of *Fig. 4.* In accordance with an embodiment of the present invention, the transceiver **424** in the wire feeder **120** is powered by electrical power provided by the welding power source **130** over the cable **310**. In accordance with another embodiment, the entire welding wire feeder **120** is configured to be fully powered by electrical power from the welding power source **130**. Furthermore, electrical power provided by the welding power source **130** over the welding output cable **310** to the wire feeder **120** is also used to provide a welding output potential to the welding wire **115** at the welding tool **140** for welding.

[0052] *Fig. 5* is a flowchart of a first exemplary embodiment of a method **500** of communication between the welding power source **130** and the welding wire feeder 120 of *Fig. 1.* In step **510** of the method **500**, a welding power source identifier (ID), corresponding to a welding power source type, is communicated from a welding power source, being of the welding power source type as identified by the ID, to a welding wire feeder operatively connected to the welding power source. In step **520** of the method **500**, an output range of an output control device of the welding wire feeder is automatically scaled, in response to the welding power source ID, to

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a range of welding output voltage values corresponding to a range of welding output potentials provided by the welding power source.

[0053] In step **530** of the method **500**, a welding output voltage value corresponding to a present setting of the output control device is automatically displayed on a display of the welding wire feeder. In step **540** of the method **500**, a present setting of the output control device is communicated from the welding wire feeder to the welding power source. In step **550** of the method **500**, a welding output potential, corresponding to the welding output voltage value, is provided by the welding power source to the welding wire feeder over a welding output cable connecting the welding power source to the welding wire feeder.

[0054] In accordance with one embodiment of the present invention, communication between the welding power source **130** and the welding wire feeder **120** is accomplished wirelessly in accordance with, for example, the embodiment of *Fig. 3*. In accordance with another embodiment of the present invention, communication between the welding power source **130** and the welding wire feeder **120** is accomplished over the welding output cable **310** in accordance with, for example, the embodiment of *Fig. 4*.

[0055] As an example of the method **500**, referring to *Fig. 2*, the welding power source **130** may communicate a welding power source ID to the welding wire feeder **120**. The welding wire feeder **120** receives and reads the ID and uses the ID to select a calibration curve stored in a computer memory **125** of the welding wire feeder **120**. The calibration curve effectively tells the welding wire feeder **120** how to scale, map, or convert the output range of the output control device **123** to a range of welding output voltage values corresponding to a range of welding output potentials provided by the welding power source **130** for welding. For example, the calibration curves may each be in the form of an addressable look-up table.

[0056] For example, if the output control device **123** includes a potentiometer having voltages of -5 VDC and +10 VDC applied across the potentiometer when powered by the welding power source **130**, the welding wire feeder **120** may scale the range of -5 VDC to +10 VDC to the range of values of +10 VDC to +80 VDC, based upon the calibration curve for the welding power source, which is equivalent to the range of welding output potentials provided by the welding power source **130**. Therefore, if the operator turns a dial or knob (or equivalent thereof) of the output control device **123** such that the potentiometer output reads +5 VDC for example, the welding wire feeder **120**, applying the calibration curve, may display a welding output voltage value of, for example, +50 VDC.

[0057] Furthermore, when the +5 VDC setting of the output control device **123** is communicated to the welding power source **130** as the present setting of the output control device, a controller in the welding power source **130** is configured to regulate the welding output potential to provide a welding output potential of +50 VDC to the welding wire feeder **120** over the welding output cable when welding.

[0058] *Fig. 6* is a graph illustrating exemplary embodiments of two calibration curves of two welding power sources (welding power source A and welding power source B) being of two different welding power source types. As can be seen from *Fig. 6*, a calibration curve may be linear (as for welding power source A) or non-linear (as for welding power source B), for example. Again, each welding power source type may have its own calibration curve which can be stored in a welding wire feeder for the purposes discussed herein. In accordance with an alternative embodiment of the present invention, the welding power source **130** may instead communicate its calibration curve to the welding wire feeder **120**. In such an alternative embodiment, the welding wire feeder does not have to store a plurality of calibration curves for various types of welding power sources. Instead, the welding power source **130** may store a single calibration curve in its computer memory **135**.

[0059] *Fig. 7* is a flowchart of a second exemplary embodiment of a method **700** of communication between the welding power source **130** and the welding wire feeder 120 of *Fig. 1*. In the method **500** of *Fig. 5*, the calibration curve is in the welding wire feeder **120**. In the method **700** of *Fig. 7*, the calibration curve is in the welding power source **130**.

[0060] In step **710** of the method **700**, a welding power source identifier (ID), corresponding to a welding power source type, is communicated from a welding power source, being of the welding power source type as identified by the ID, to a welding wire feeder operatively connected to the welding power source. In step **720** of the method **700**, a present setting value of an output control device of the welding wire feeder is communicated from the welding wire feeder to the welding power source, wherein the present setting value is based on a present setting of an output control device of the welding wire feeder and the welding power source ID. That is, the welding wire feeder is configured to scale or convert the output range of the output control device, based on the welding power source ID, to the range that the welding power source expects to see from the wire feeder.

[0061] In step **730** of the method **700**, the welding power source automatically converts the present setting value to a welding output voltage value. In accordance with an embodiment, the welding power source employs a calibration curve to accomplish the conversion. In step **740** of the method **700**, the welding output voltage value is communicated from the welding power source to the welding wire feeder. In step **750** of the method **700**, the welding output voltage value is displayed on a display of the welding wire feeder. In step **760** of the method **700**, the welding power source provides a welding output potential, corresponding to the welding output voltage value, to the welding wire feeder over a welding output cable operatively connecting the welding power source to the welding wire feeder. Again, a controller in the welding power source is configured to regulate the welding output potential to provide a welding output potential, based on the present setting value from the wire feeder, to the welding wire feeder over the welding output cable when welding.

[0062] In accordance with one embodiment of the present invention, communication between the welding power source **130** and the welding wire feeder **120** is accomplished wirelessly in accordance with, for example, the embodiment of *Fig. 3*. In accordance with another embodiment of the present invention, communication between the welding power source **130** and the welding wire feeder **120** is accomplished over the welding output cable **310** in accordance with, for example, the embodiment of *Fig. 4*.

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[0063] As an example of the method **700**, referring again to *Fig. 2*, the welding power source **130** may communicate a welding power source ID to the welding wire feeder **120**. The welding wire feeder **120** receives and reads the ID and uses the ID and the present setting of the output control device **123** to convert an encoder output of the output control device **123** to a present setting value (e.g., 3 VDC). Again, the welding wire feeder **120** is configured to scale or convert the output range of the output control device **123**, based on the welding power source ID, to the range (e.g., 0 to 5 VDC) that the welding power source **130** expects to see from the wire feeder **120**. The present setting value (e.g., 3 VDC) is then communicated from the welding wire feeder **120** to the welding power source **130** where the welding power source **130**, using a calibration curve, converts the present value setting to a welding output voltage value (e.g., 50 VDC).

[0064] In general, the welding power source ID tells the welding wire feeder **120** how to convert or scale the encoder output of the output control device **123**, and a controller in the welding power source **130** is configured to regulate the welding output potential to provide a welding output potential, based on the present setting value from the wire feeder **120**, to the welding wire feeder over the welding output cable **310** when welding. Again, in the method **700** of *Fig. 7*, the calibration curve is in the welding power source **130**. In the method **500** of *Fig. 5*, the calibration curve is in the welding wire feeder **120**. Communication between the welding power source **130** and the welding wire feeder **120** is performed wirelessly (e.g., see *Fig. 3*) or over the welding output cable **310** (see *Fig. 4*). No separate control or communication cable is needed between the welding power source **130** and the welding wire feeder **120.**

[0065] *Fig. 8* is a functional block diagram illustrating a second exemplary embodiment of communication between the welding power source **130** and the welding wire feeder **120** of *Fig. 1*. When an operator of the welding system desires to weld, the operator may press the trigger **141** on the welding tool **140**. Upon pressing the trigger **141**, a trigger signal is communicated from the welding wire feeder **120** to the welding power source **130**, either wirelessly or over the welding output cable as previously described herein with respect to *Figs. 3 and 4*.

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[0066] *Fig. 9* illustrates a schematic block diagram of an exemplary embodiment of the welding power source **130** of *Fig. 8*. The welding power source **130** includes a wireless transceiver **334** configured to wirelessly facilitate two-way communication with the welding wire feeder **120**. Alternatively, the welding power source **130** may instead include a transceiver **434** configured to facilitate two-way communication with the welding wire feeder **120** over the welding output cable **310** (see *Fig. 4*). The welding power source **130** also includes a controller **910** operatively connected to the transceiver **334** and electrical output circuitry **920** operatively connected to the controller **910** and providing an electrical output **930**. In accordance with an embodiment of the present invention, the electrical output **930** is configured to operatively connect to the welding output cable **310**.

[0067] In accordance with an embodiment, the controller **910** and the electrical output circuitry **920** includes a waveform generator, a pulse-width modulator, inverter circuitry and/or chopper circuitry, logic circuitry and/or a processing element and associated software, and computer memory, as is well known in the art. However, the controller **910** and the electrical output circuitry , are configured to provide a low power state, in accordance with an embodiment, as described with respect to *Fig. 10*.

[0068] *Fig. 10* is an exemplary embodiment of a timing diagram **1000** illustrating the operation of the welding power source **130** of *Fig. 9*. The timing diagram **1000** shows the welding output in relation to the trigger signal **1010**. Before the trigger **141** of the welding tool **140** is activated and the trigger signal **1010** is received at the welding power source **130**, the welding power source **130** is in a low power state, where the electrical output is regulated to a low output voltage level **1020** (e.g., 15 VDC). In the low power state, the welding power source **130** is able to provide sufficient electrical power (e.g., 15 VDC at 4 amps) to power the entire welding wire feeder **120**, in accordance with an embodiment.

[0069] When the trigger **141** is activated and the trigger signal **1010** is received by the power source **130**, but before the consumable electrode is positioned proximate a workpiece to strike an arc, the welding power source **130** is in an open circuit voltage (OCV) state, where the electrical output is regulated to an open circuit voltage

(OCV) level **1030** (e.g., 80 VDC). A magnitude of the OCV level **1030** is larger than a magnitude of the low output voltage level **1020**. In accordance with an embodiment, the OCV level **1030** is sufficient to start an arc between the consumable electrode and the workpiece but the low output voltage level **1020** is not. Furthermore, the OCV level **1030** is further sufficient to power the wire feeder **120**.

[0070] When an arc is struck between the consumable electrode and the workpiece and the trigger signal **1010** is still present, the welding power source **130** is in a welding state, where the electrical output is regulated to a selected welding output voltage level **1040** (e.g., 50 VDC). A magnitude of the welding output voltage level **1040** is between the magnitudes of the low output voltage level **1020** and the open circuit voltage level **1030**. When the trigger **141** of the welding tool **140** is released and the trigger signal **1010** goes away, the welding power source **130** again goes to the low power state, where the electrical output is again regulated to the low output voltage level **1020** (e.g., 15 VDC).

[0071] As shown in Fig. 10, if an electrical short occurs between the welding electrode and the workpiece, the welding output goes to a short voltage **1050** of 0 VDC during the time of the short. When the short is cleared, the welding output goes back to the low output voltage level **1020**. By providing a low power state, the welding power source can reduce or eliminate an electrical hazard presented to the operator or to the workpiece to be welded by minimizing the presence of the open circuit voltage at the electrical output of the welding power source. By communicating the trigger signal from the wire feeder to the welding power source either wirelessly or over the welding output cable, a separate cable for the trigger signal is not needed. Furthermore, by providing a low power state as described herein, electrical contactors for switching the high power provided by the welding power source may not be needed in the welding wire feeder.

[0072] As a safety feature, if the welding power source loses communication with the welding wire feeder (e.g., loses the trigger signal), the welding power source may be configured to automatically return to the low power state. In accordance with an alternative embodiment of the present invention, the trigger signal is complemented by an OFF signal. That is, the welding power source may initially re-

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ceive a trigger signal to command entry into the OCV state or the welding state, and then receive a separate OFF signal to command return to the low power state.

[0073] In summary, systems and methods of communicating between a welding power source and a welding wire feeder to improve the operation of a welding system are disclosed. Two-way communication between a welding power source and a welding wire feeder is provided either wirelessly or over the welding output cable. The communication between the welding power source and the welding wire feeder facilitates output voltage selection at the welding wire feeder as well as the entering of a lower output power state of the welding power source when not welding. Furthermore, the welding power source may provide electrical power to operate the welding wire feeder, eliminating the need for batteries or some other energy storage device in the wire feeder and allowing for robust, two-way communication between the welding power source and the wire feeder, even when the power source and wire feeder are separated by a significant distance.

[0074] In appended claims, the terms "including" and "having" are used as the plain language equivalents of the term "comprising"; the term "in which" is equivalent to "wherein." Moreover, in appended claims, the terms "first," "second," "third," "upper," "lower," "bottom," "top," etc. are used merely as labels, and are not intended to impose numerical or positional requirements on their objects. Further, the limitations of the appended claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure. As used herein, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to "one embodiment" of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments "comprising," "including," or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property. Moreover, certain embodiments may be shown as having like or similar elements, however, this is merely for illustration purposes, and such embodiments need not necessarily have the same elements unless specified in the claims.

[0075] As used herein, the terms "may" and "may be" indicate a possibility of an occurrence within a set of circumstances; a possession of a specified property, characteristic or function; and/or qualify another verb by expressing one or more of an ability, capability, or possibility associated with the qualified verb. Accordingly, usage of "may" and "may be" indicates that a modified term is apparently appropriate, capable, or suitable for an indicated capacity, function, or usage, while taking into account that in some circumstances the modified term may sometimes not be appropriate, capable, or suitable. For example, in some circumstances an event or capacity can be expected, while in other circumstances the event or capacity cannot occur – this distinction is captured by the terms "may" and "may be."

[0076] This written description uses examples to disclose the invention, including the best mode, and also to enable one of ordinary skill in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to one of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differentiate from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

[0077] While the claimed subject matter of the present application has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the claimed subject matter. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the claimed subject matter without departing from its scope. Therefore, it is intended that the claimed subject matter not be limited to the particular embodiments disclosed, but that the claimed subject matter will include all embodiments falling within the scope of the appended claims.

REFERENCE NUMBERS

100	welding system
110	welding package
115	welding wire
120	welding wire feeder
121	display
122	user interface
123	output control device
125	computer memory
130	power source
135	computer memory
140	welding tool
141	trigger
310	output cable
324	wireless transceiver
334	wireless transceiver
410	electric signal
424	transceiver
434	transceiver
500	method
510	step
520	step
530	step
540	step
550	step
700	method
710	step
720	step
730	step
740	step
750	step
760	step
910	controller
920	output circuitry
930	electrical output
1000	timing diagram
1010	trigger signal
1020	output voltage level
1030	open circuit voltage (OCV) level
1040	output voltage level
1050	short voltage

CLAIMS

What is claimed is:

1. A method of communication between a welding power source and a welding wire feeder, said method comprising:

   communicating a welding power source identifier, corresponding to a welding power source type, from a welding power source being of the welding power source type to a welding wire feeder operatively connected to the welding power source; and

   automatically scaling an output range of an output control device of the welding wire feeder, in response to the welding power source identifier, to a range of welding output voltage values corresponding to a range of welding output potentials provided by the welding power source.

2. The method of claim 1, further comprising automatically displaying a welding output voltage value on a display of the welding wire feeder corresponding to a present setting of the output control device.

3. The method of claim 1 or 2, further comprising communicating a present setting of the output control device from the welding wire feeder to the welding power source.

4. A method of communication between a welding power source and a welding wire feeder, said method comprising:

   communicating a welding power source identifier, corresponding to a welding power source type, from a welding power source being of the welding power source type to a welding wire feeder operatively connected to the welding power source; and

   communicating a present setting value from the welding wire feeder to the welding power source, wherein the present setting value is based on a present setting of an output control device of the welding wire feeder and the welding power source identifier.

5. The method of claim 4, further comprising:

said welding power source automatically converting said present setting value to a welding output voltage value; and

communicating said welding output voltage value from said welding power source to said welding wire feeder.

6. The method of any of the claims 1 to 5, further comprising said welding power source providing a welding output potential, corresponding to said welding output voltage value, to said welding wire feeder over a welding output cable operatively connecting said welding power source to said welding wire feeder.

7. The method of any of the claims 1 to 6, wherein said communicating is performed wirelessly.

8. The method of any of the claims 1 to 7, wherein said communicating is performed via encoded signals over a welding output cable operatively connecting said welding power source to said welding wire feeder.

9. A method of controlling an electrical output of a welding power source, said method comprising:

regulating an electrical output of a welding power source to a low output voltage level of a low power state of the welding power source;

regulating the electrical output of the welding power source to an open circuit voltage level when a trigger signal is received at the welding power source from a welding wire feeder, wherein a magnitude of the open circuit voltage level is larger than a magnitude of the low output voltage level; and regulating the electrical output of the welding power source to a welding output voltage level when an electric arc exists between an electrode and a workpiece electrically connected to the electrical output of the welding power source, wherein a magnitude of the welding output voltage level is between the magnitudes of the low output voltage level and the open circuit voltage level.

10. The method of claim 9, further comprising regulating the electrical output of the welding power source to the low output voltage level of the low power state of the welding power source when the trigger signal is no longer received by the welding power source.

11. A welding system (100), said welding system (100) comprising:

a welding power source (130) having a first wireless transceiver (324, 334);

a welding wire feeder (120) having a second wireless transceiver, wherein said first wireless transceiver (324, 334) and said second wireless transceiver (324, 334) are configured to provide two-way communication between said welding power source (130) and said welding wire feeder (120); and

a welding output cable (310) operatively connecting said welding power source (130) to said welding wire feeder (120) for providing electrical power from said welding power source (130) to said welding wire feeder (120), wherein said second wireless transceiver (324, 334) is configured to be powered by electrical power from said welding power source (130).

12. A welding system (100), said welding system (100) comprising:

a welding power source (130) having a first transceiver (424, 434);

a welding wire feeder having a second transceiver (424, 434); and a welding output cable (310) operatively connecting said welding power source (130) to said welding wire feeder (120) for providing electrical power from said welding power source (130) to said welding wire feeder (120), wherein said second transceiver (424, 434) is configured to be powered by electrical power from said welding power source (130), and wherein said first transceiver (424, 434) and said second transceiver (424, 434) are configured to provide two-way communication between said welding power source (130) and said welding wire feeder (120) over said welding output cable (310).

13. The welding system of claim 11 or 12, further comprising a plurality of calibration curves stored in a computer memory (135) of said welding wire feeder (120), wherein each calibration curve of said plurality of calibration curves corresponds to a welding power source type and is configured to scale an output range of an output control device of the welding wire feeder (120) to a range of welding output voltage values in response to the second transceiver (424, 434) or second wireless transceiver (324, 334) receiving a welding power source identifier, corresponding to a welding power source type, from the first transceiver (424, 434) a first wireless transceiver (324, 334).

14. The welding system of any of the claims 11 to 13, wherein said range of welding output voltage values corresponds to a range of welding output potentials that a welding power source (130) of the corresponding welding power source type is configured to provide to the welding wire feeder (120) over the welding output cable (310).

15. The welding system (100) of any of the claims 11 to 14, wherein said welding wire feeder (120) is configured to be fully powered by electrical power from said welding power source (130).

16. A welding power source (100) providing a low power state, said welding power source (130) comprising:

a transceiver (324, 334, 424, 434) configured to facilitate two-way communication with a welding wire feeder (120);

electrical output circuitry (920) providing an electrical output (930); and

a controller (910) configured to control the electrical output circuitry (920) by:

regulating the electrical output to a low output voltage level of a low power state of the welding power source when a trigger signal is not being received by the transceiver (324, 334, 424, 434),

regulating the electrical output to an open circuit voltage level (1030) when a trigger signal from a welding wire feeder (120) is being received by the transceiver (324, 334, 424, 434) and when an electric arc does not exist between an electrode and a workpiece electrically connected to the electrical output circuitry (920), wherein a magnitude of the open circuit voltage level (1030) is larger than a magnitude of the low output voltage level, and

regulating the electrical output to a welding output voltage level when a trigger signal from a welding wire feeder (120) is being received by the transceiver (324, 334, 424, 434) and when an electric arc exists between an electrode and a workpiece electrically connected to the electrical output circuitry (920), wherein a magnitude of the welding output voltage level is between the magnitudes of the low output voltage level and the open circuit voltage level (1030).

17. A welding power source (130) configured to output a low power level when not welding, and further configured to not produce an open circuit voltage (1030) or a welding output voltage until receiving a trigger signal.

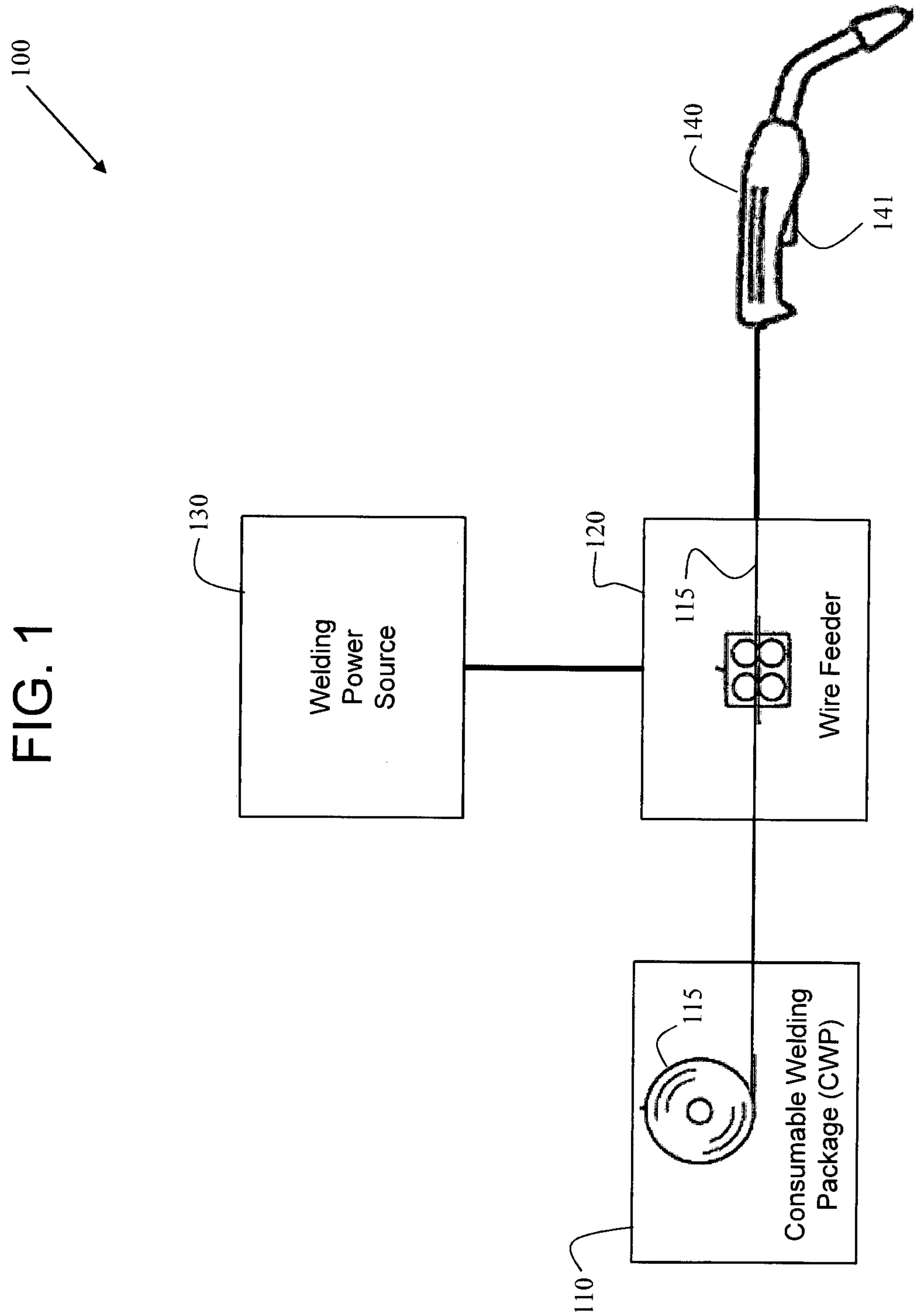

100
130
Welding
Power
Source
120
115
Wire Feeder
140
141
110
115
Consumable Welding
Package (CWP)

FIG. 1

FIG. 2

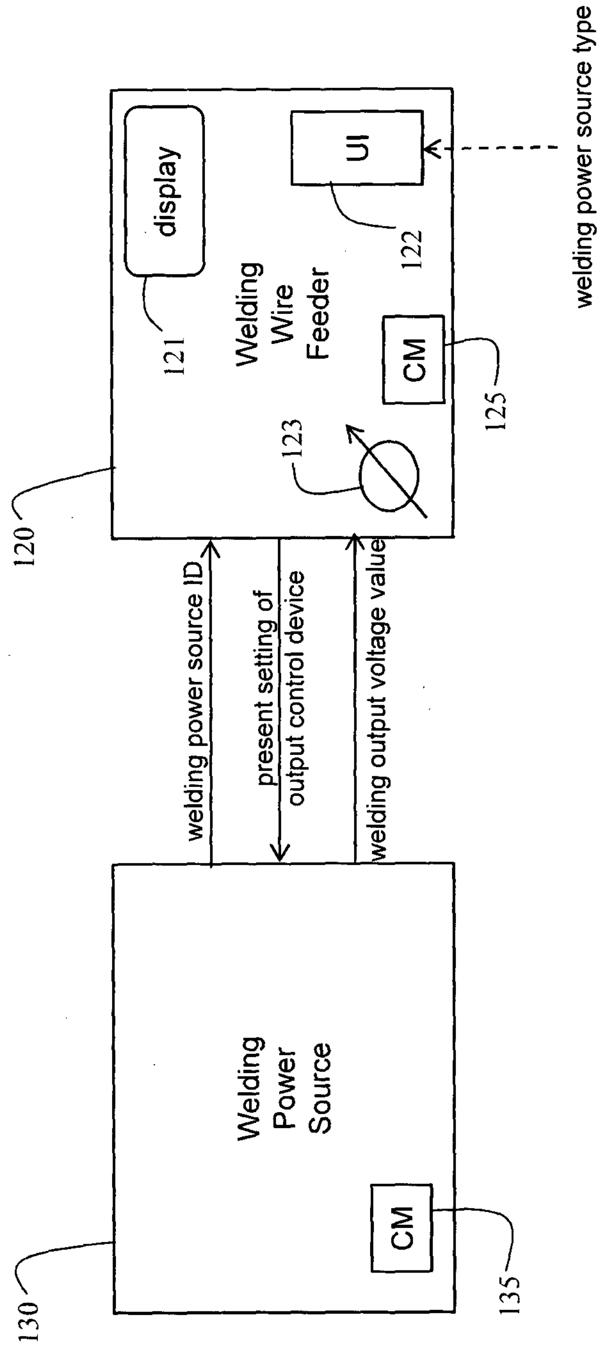

120
display
121
Welding Wire Feeder
UI
122
123
CM
125
welding power source type
welding power source ID
present setting of output control device
welding output voltage value
Welding Power Source
CM
130
135

FIG. 3

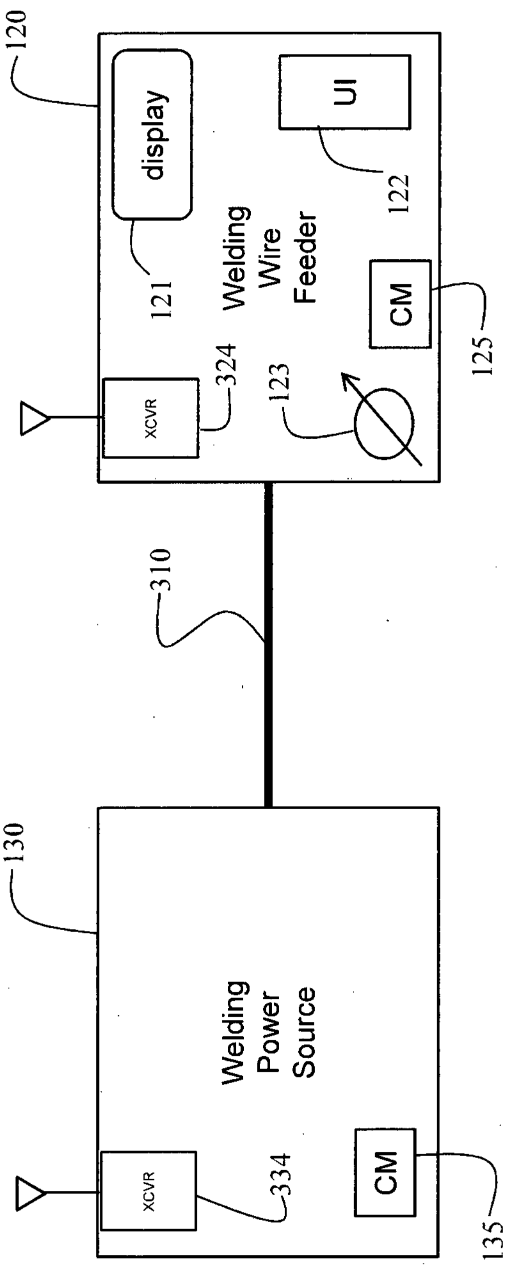
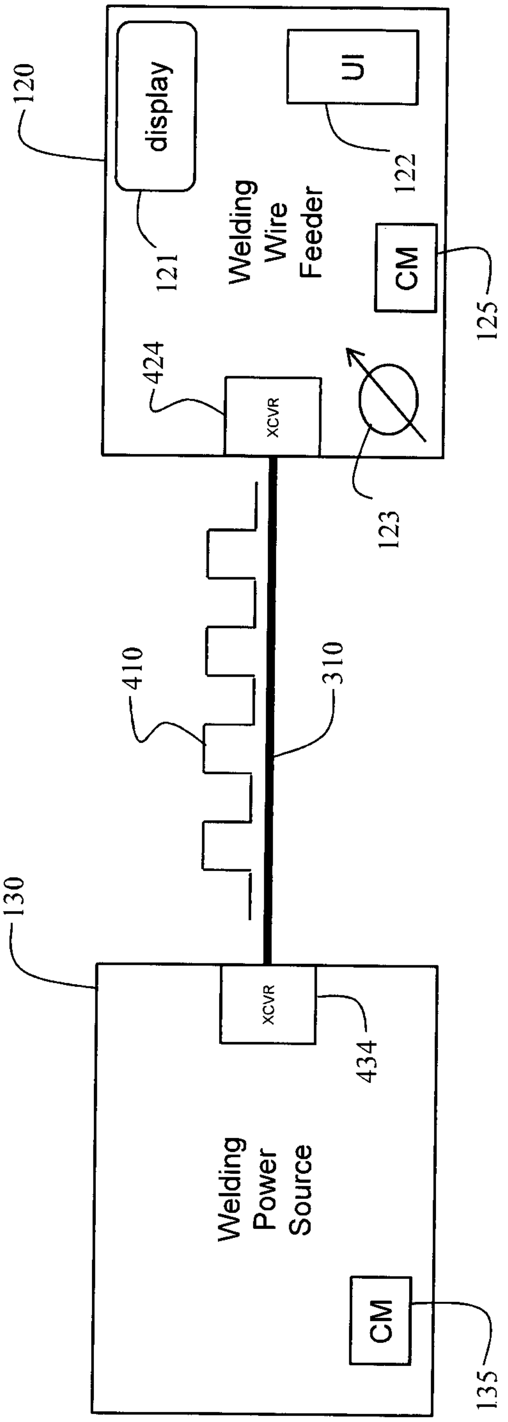

120
display
121
UI
122
Welding Wire Feeder
CM
125
XCVR
324
123
310
130
Welding Power Source
XCVR
334
CM
135

FIG. 4


120
display
121
Welding
Wire
Feeder
UI
122
CM
125
424
XCVR
123
410
310
130
XCVR
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Welding
Power
Source
CM
135

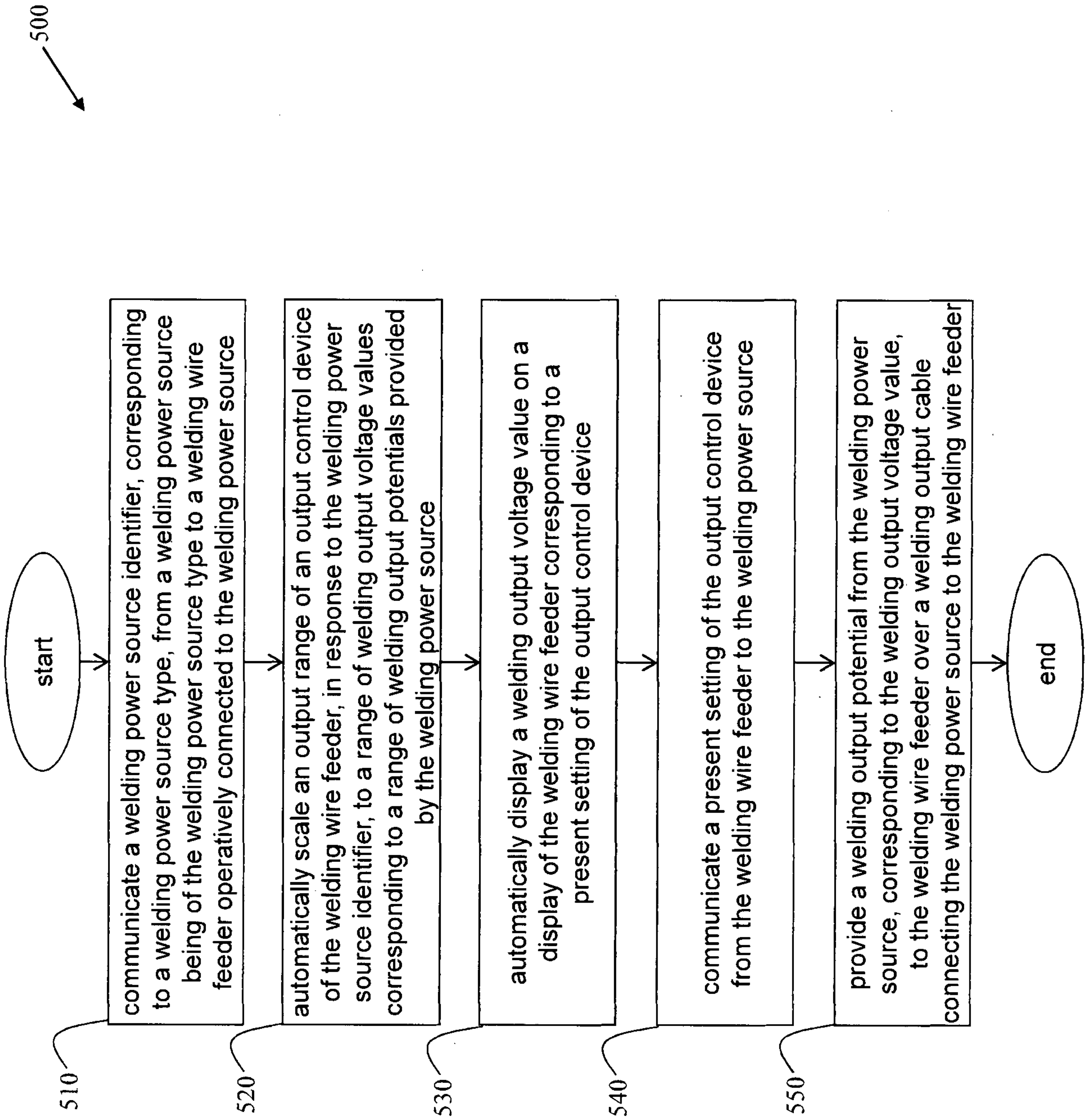

FIG. 5

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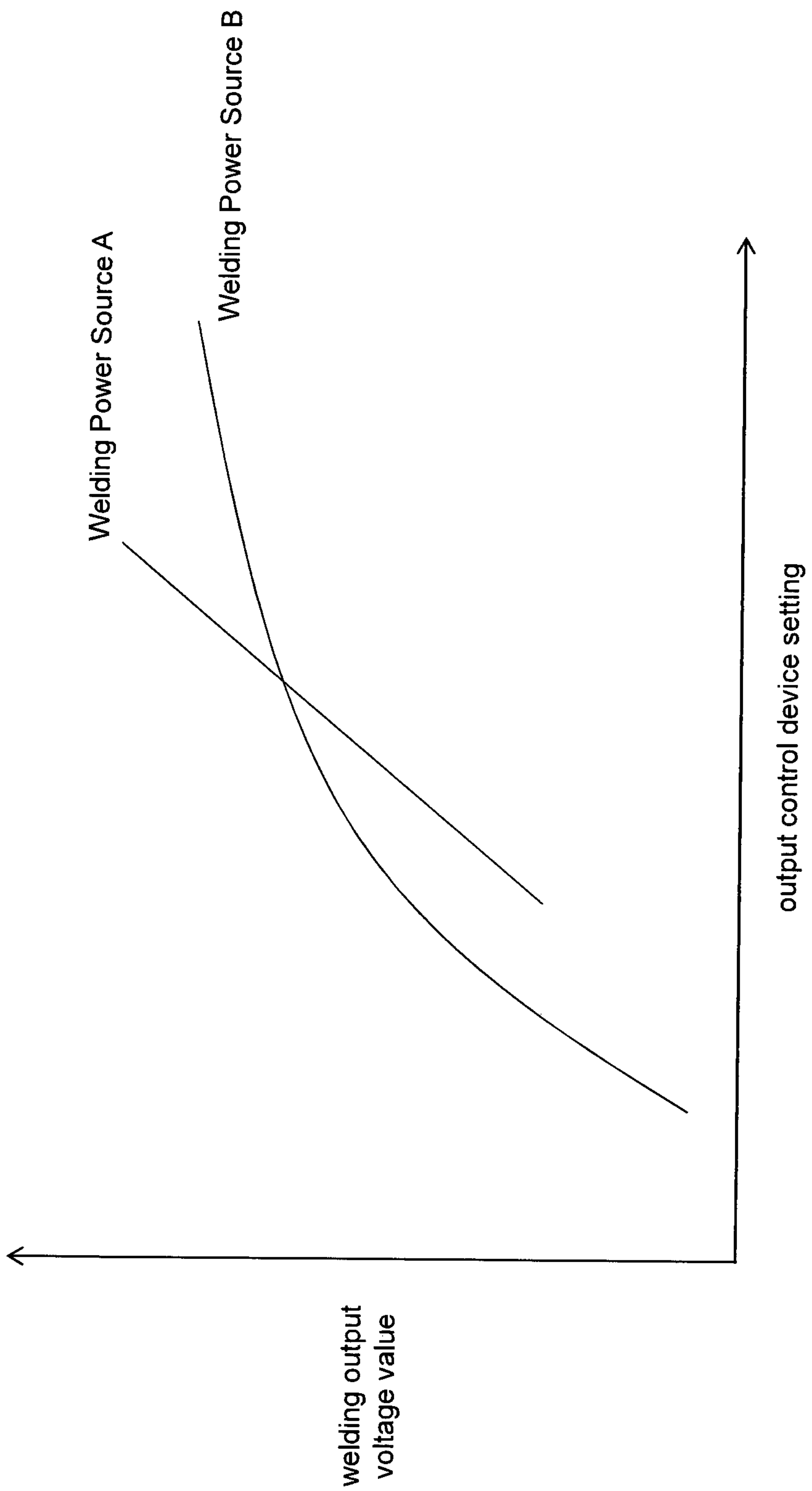
FIG. 6



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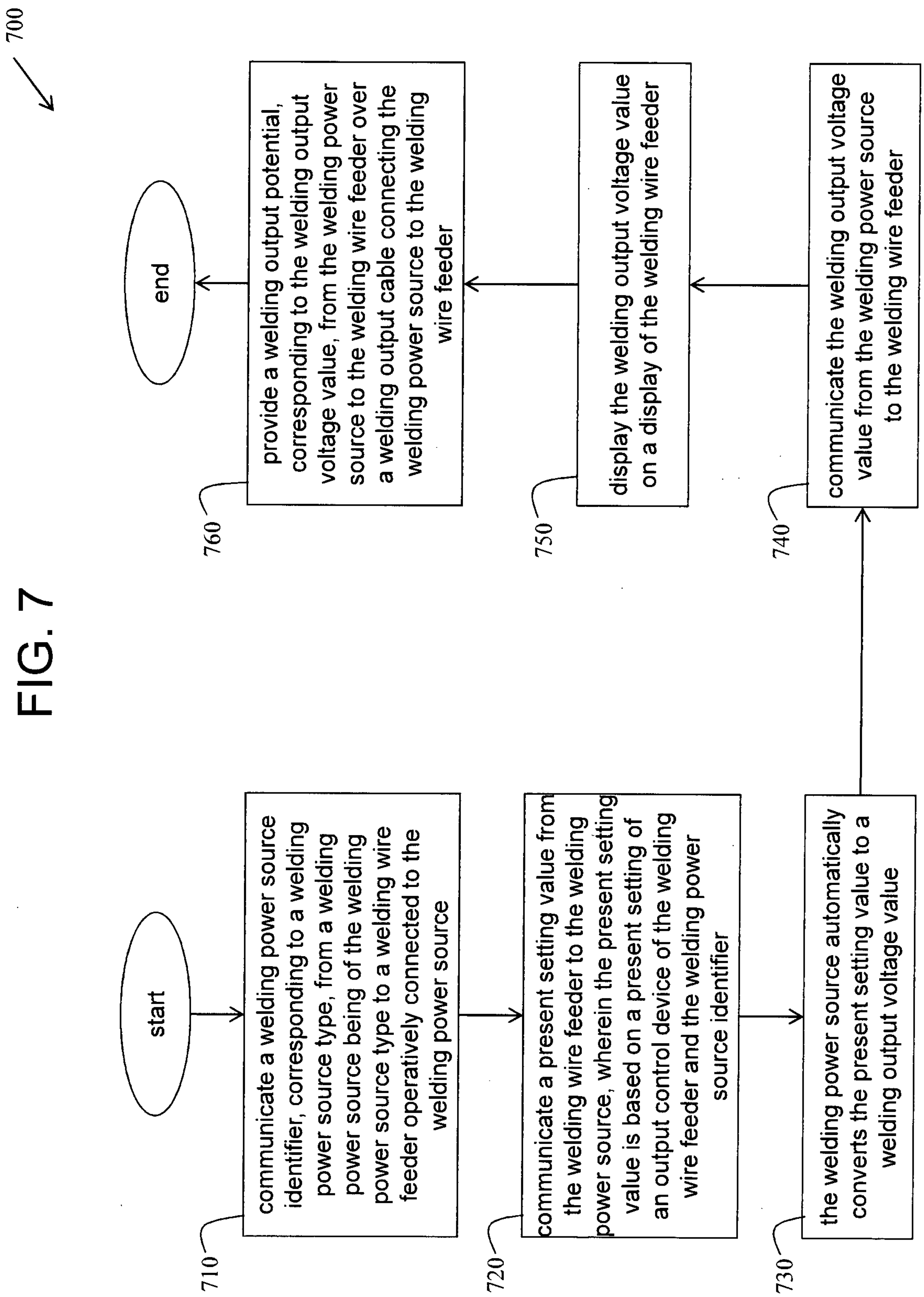

700
start
710
communicate a welding power source identifier, corresponding to a welding power source type, from a welding power source being of the welding power source type to a welding wire feeder operatively connected to the welding power source
720
communicate a present setting value from the welding wire feeder to the welding power source, wherein the present setting value is based on a present setting of an output control device of the welding wire feeder and the welding power source identifier
730
the welding power source automatically converts the present setting value to a welding output voltage value
740
communicate the welding output voltage value from the welding power source to the welding wire feeder
750
display the welding output voltage value on a display of the welding wire feeder
760
provide a welding output potential, corresponding to the welding output voltage value, from the welding power source to the welding wire feeder over a welding output cable connecting the welding power source to the welding wire feeder
end

FIG. 7

FIG. 8

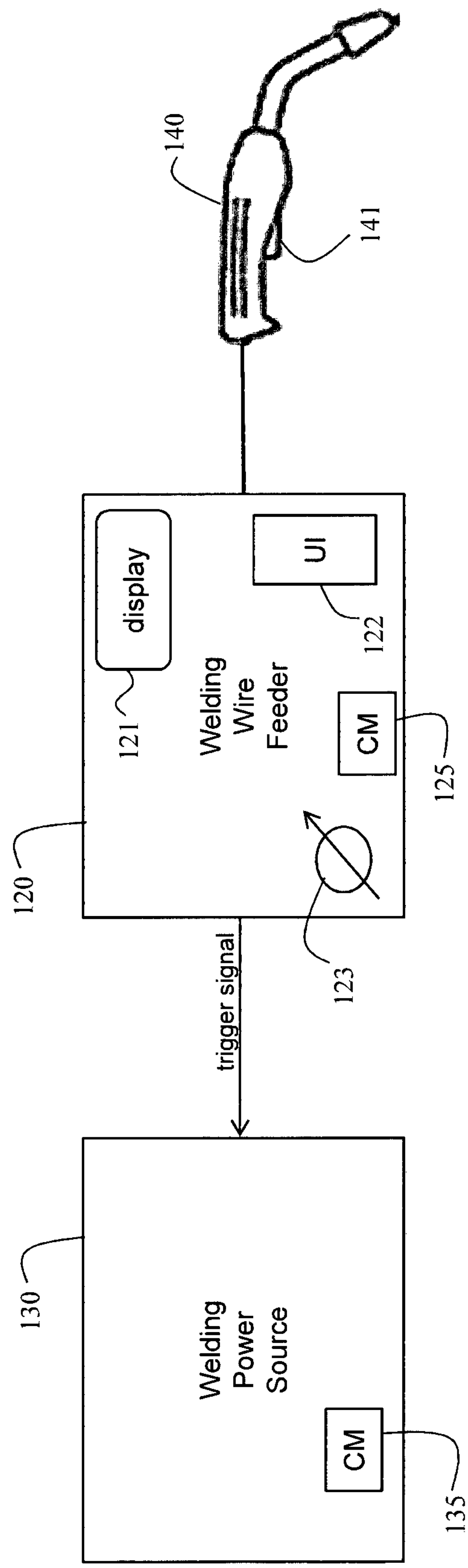

140
141
display
121
UI
122
Welding
Wire
Feeder
CM
125
120
123
trigger signal
130
Welding
Power
Source
CM
135

FIG. 9

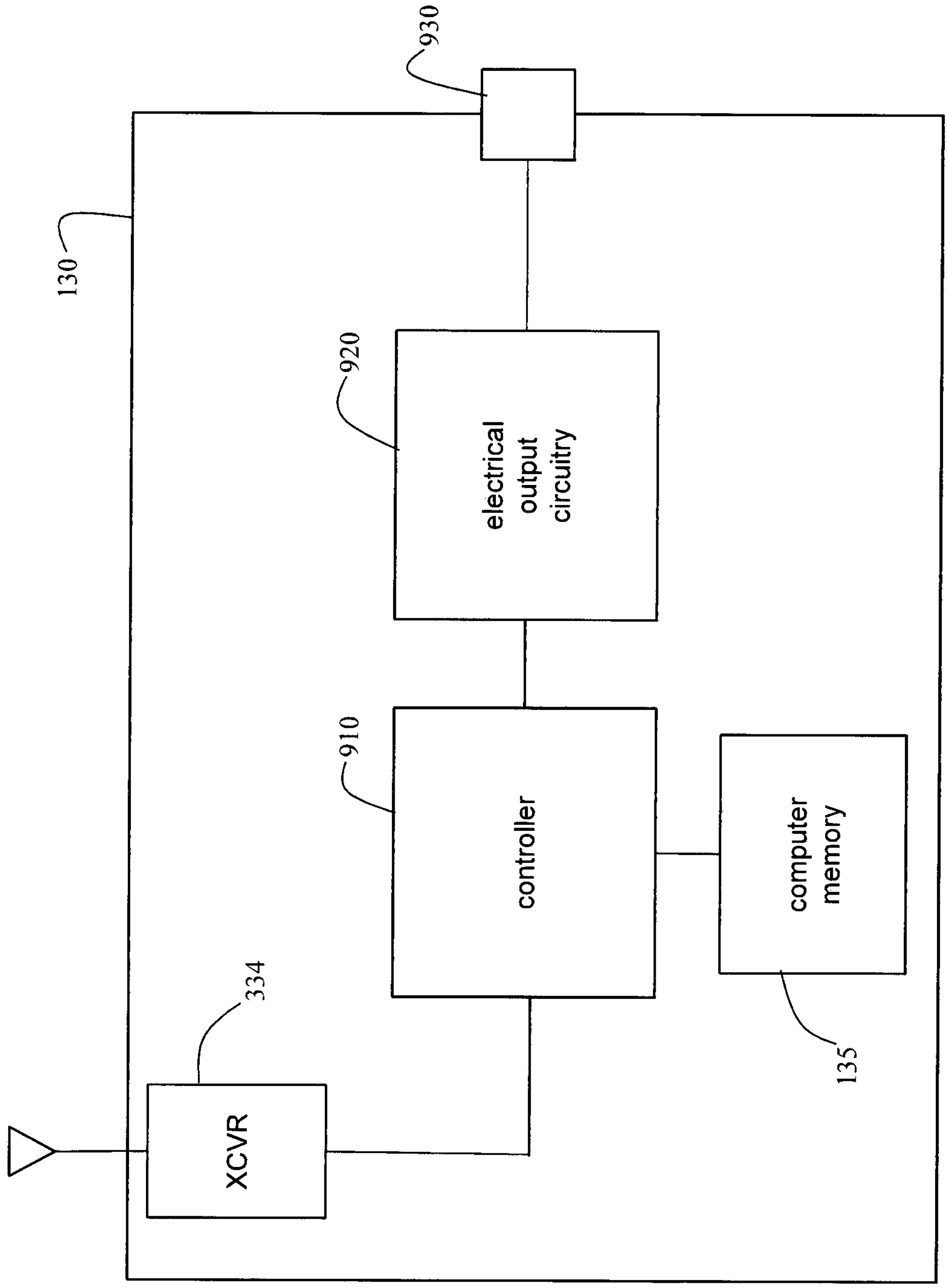
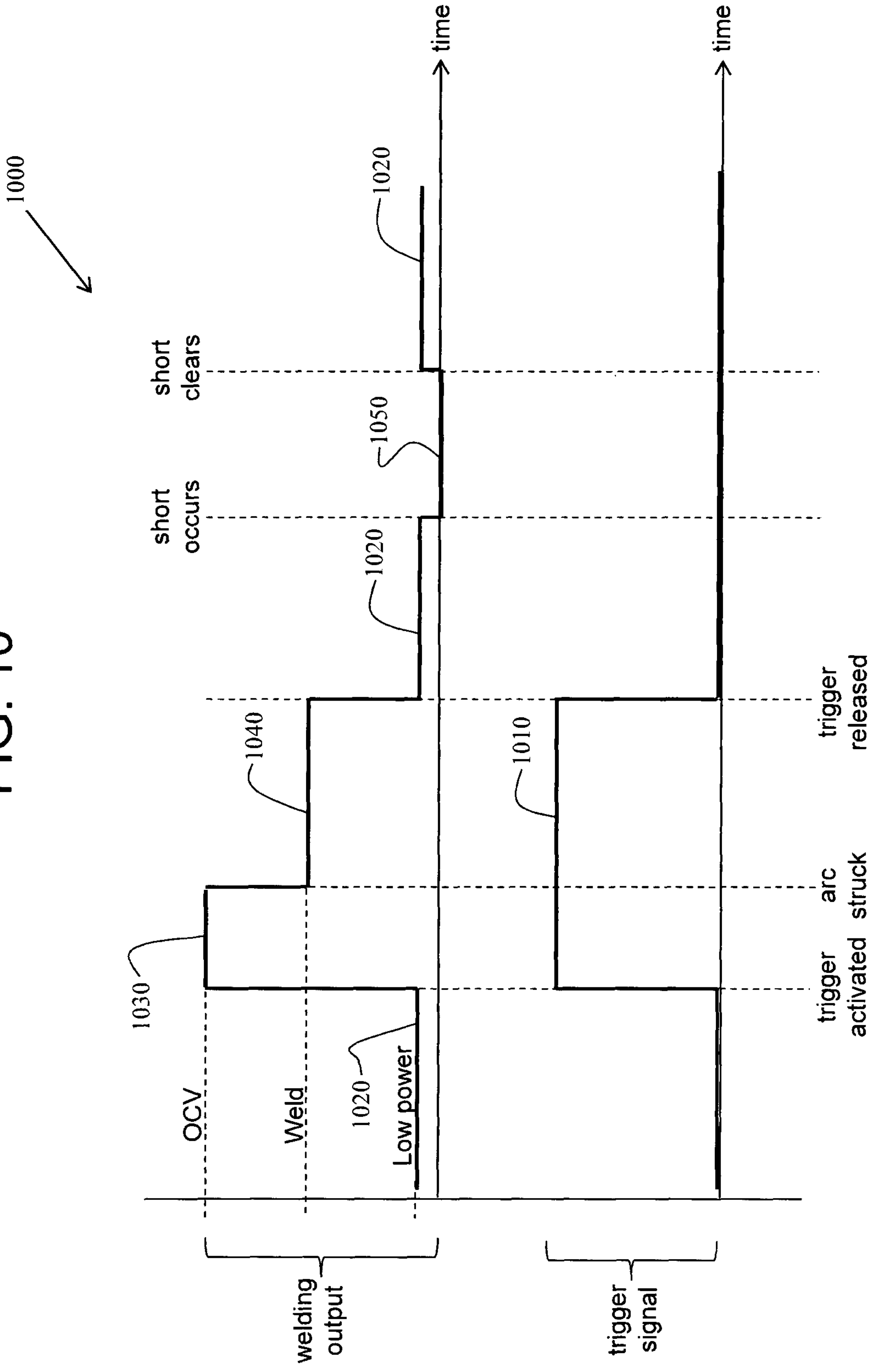

930
130
920
electrical output circuitry
910
controller
computer memory
334
XCVR
135

FIG. 10



1000
time
time
short clears
short occurs
1020
1050
1020
1040
1010
1030
1020
OCV
Weld
Low power
trigger released
arc struck
trigger activated
welding output
trigger signal