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IMMOBILIZATION OF ELECTROHYDRAULIC POWER MACHINE

Abstract

Power machines having an electric power source and a controller configured to provide improved immobilization of power machine functions when an operator is not present or properly positioned within an operator station or compartment of the power machine.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation application of U.S. application Ser. No. 17/442,902, filed on Sep. 24, 2021, which published as U.S. publication number 2022/0195700 A 1, on Jun. 23, 2022, which is a National Stage application of PCT application number PCT/US2020/024665, filed on Mar. 25, 2020, which published as WO 2020/198330, on Oct. 1, 2020, which claims the benefit of U.S. provisional application No. 62/823,098, filed on Mar. 25, 2019, the contents of which are hereby incorporated by reference in their entireties.

BACKGROUND

[0002] This disclosure is directed toward power machines. More particularly, this disclosure is directed to power machines having systems that enable one or more functions of the power machine after an operator performs an initialization routine.

[0003] Power machines, for the purposes of this disclosure, include any type of machine that generates power for the purpose of accomplishing a particular task or a variety of tasks. One type of power machine is a work vehicle. Work vehicles are generally self-propelled vehicles that have a work device, such as a lift arm (although some work vehicles can have other work devices) that can be manipulated to perform a work function. Work vehicles include excavators, loaders, utility vehicles, tractors, and trenchers, to name a few examples.

[0004] Power machines sometimes include control systems that require an operator perform an initialization routine before some functions of the machine are activated. For example, some power machines with hydraulic systems that power travel functions and work functions include sensors that detect the presence of the operator in a seat of a cab, detect whether a safety bar or other restraint is in a lowered or protective position, and/or detect a seatbelt or restraint engagement status. In addition, some power machines can also include or alternatively include one or more operator inputs such as switches that an operator can manipulate as part of an initialization routine. While an engine drives one or more hydraulic pumps, hydraulic fluid from the pumps may be prevented by a valve from being provided to travel motors or other actuators until the operator has performed an initialization routine that can include activating some or all of the sensors and operator inputs discussed above.

[0005] The discussion above is merely provided for general background information and is not intended to be used as an aid in determining the scope of the claimed subject matter.

SUMMARY

[0006] Disclosed embodiments provide improved immobilization of power machine functions when an operator has not performed an initialization routine required by systems on the power machine. The disclosed embodiments include power machines having an electric power source. In exemplary embodiments, the electric power source can be used to power hydraulic actuators using an electro-hydraulic system. In disclosed power machines, power machine function enablement can be achieved while also reducing power consumption, reducing or eliminating hydraulic components required to prevent enablement of these machine functions until the operator has performed an initialization routine required by systems.

[0007] One general aspect of a disclosed embodiment includes a power machine (**100**; **200**; **400**; **500**; **600**) including: a frame (**110**; **210**) including an operator station (**150**; **250**) configured to provide an operating position for an operator of the work machine; at least one actuator (**440**) configured to perform a machine work function; an operator input (**256**; **406**) configured to be manipulated by the operator and to responsively provide an operator command signal (**408**) to command usage of the at least one actuator to perform the work function; at least one operator engagement sequence input (**402**) configured to provide an enablement signal (**404**) indicative of whether the operator is engaged or positioned such that machine work function can be activated or enabled; an electric power source (**420**) supported by the frame and configured to provide a power source output; a power conversion system (**430**) coupled to the power source and configured to receive the power source output and to utilize the power source output to provide power signals (**432**) to the at least one actuator (**440**) to cause the at least one actuator to perform the machine work function; and a controller (**410**) configured to receive the operator command signal and the engagement sequence output and to responsively provide control signals (**412**; **512**; **514**) to the electric power source to control the power source output, where the controller is further configured such that if the engagement sequence output is indicative of a proper operator enablement action, the controller generates, responsive to the operator command signal commanding usage of the at least one actuator, the control signals to control the electric power source to provide power to the power conversion system to provide the power signals to the at least one actuator and perform the commanded usage of the at least one actuator, where the controller is further configured such that if the engagement sequence output is not indicative of the proper operator enablement action, the controller generates the control signals to control the electric power source to not provide power to the power conversion system regardless of the commanded usage indicated by the operator command output.

[0008] Implementations may include one or more of the following features. The power machine where power source output of the electric power source includes a rotating shaft of an electric motor (**528**), and where the power conversion system is coupled to the rotating shaft and configured to provide the power signals (**432**) in the form of pressurized hydraulic fluid. The power machine where the power conversion system includes: a hydraulic pump (**630**) coupled to the rotating shaft of the electric motor and configured to provide the pressurized hydraulic fluid; and a hydraulic valve (**634**) coupled to the hydraulic pump and configured to control the application of the power signals to the at least one actuator responsive to the operator command output.

[0009] The power machine where the electric power source further includes battery components (**524**) coupled to the electric motor, and where the control signals include battery control signals (**512**) to control the battery components and generating control signals (**514**) to control the electric motor.

[0010] The power machine where the at least one operator engagement sequence input includes at least one of an operator seat or position sensor, a safety bar position sensor, and a seat belt engagement sensor. The power machine where the at least one operator engagement sequence input includes a sensor or input device positioned in the operator station and configured to provide the engagement sequence output as an indication of the operator's presence in the operator station. The power machine where the operator input is positioned in the operator station.

[0011] The power machine where the at least one actuator includes at least one of a travel motor, a lift cylinder and a tilt cylinder.

[0012] One general aspect of another embodiment includes a power machine (**100**; **200**; **400**; **500**; **600**) including: at least one hydraulic actuator (**440**) configured to perform a machine work function; an operator input (**256**; **406**) configured to be manipulated by an operator and to responsively provide an operator command signal (**408**) to command usage of the at least one actuator to perform the work function; an operator engagement sequence input (**402**) configured to provide an enablement signal (**404**) indicative of whether the operator is engaged or positioned such that machine work function can be activated or enabled; an electric power source (**420**) including an electric motor and configured to provide a power source output in the form of a rotating shaft; a power conversion system (**430**) coupled to the rotating shaft and configured to provide power signals (**432**) in the form of pressurized hydraulic fluid to the at least one hydraulic actuator (**440**) to cause the at least one actuator to perform the machine work function; and a controller (**410**) configured to receive the operator command signal and the engagement sequence output and to responsively provide control signals (**412**; **512**; **514**) to the electric power source to control the power source output, where the controller is further configured such that if the engagement sequence output is indicative of a proper operator enablement action, the controller generates, responsive to the operator command signal commanding usage of the at least one actuator, the control signals to control the electric power source to provide power to the power conversion system to provide the power signals to the at least one actuator and perform the commanded usage of the at least one actuator, where the controller is further configured such that if the engagement sequence output is not indicative of the proper operator enablement action, the controller generates the control signals to control the electric power source to not provide power to the power conversion system regardless of the commanded usage indicated by the operator command output.

[0013] Implementations may include one or more of the following features. The power machine where the power conversion system includes a hydraulic pump (**630**) coupled to the rotating shaft of the electric motor and configured to provide the pressurized hydraulic fluid. The power machine where the power conversion system further includes a hydraulic valve (**634**) coupled to the hydraulic pump and configured to control the application of the power signals to the at least one hydraulic actuator responsive to the operator command output.

[0014] The power machine where the electric power source further includes battery components (**524**) coupled to the electric motor and configured to provide electric power to the electric motor, and where the control signals include battery control signals (**512**) to control the battery components and generating control signals (**514**) to control the electric motor.

[0015] The power machine and further including a frame (**110**; **210**) including an operator station (**150**; **250**) configured to provide an operating position for an operator of the work machine, where the operator input is positioned in the operator station. The power machine where the at least one operator engagement sequence input is configured to provide the engagement sequence output as an indication of the operator's presence in the operator station. The power machine where the at least one operator engagement sequence input includes at least one of an operator seat or position sensor, a safety bar position sensor, and a seat belt engagement sensor. The power machine where the at least one operator engagement sequence input includes a push button.

[0016] The power machine where the at least one hydraulic actuator includes at least one of a travel motor, a lift cylinder and a tilt cylinder.

[0017] One general aspect of another embodiment includes a power machine (**100**; **200**; **400**; **500**; **600**) including: a frame (**110**; **210**) including an operator station (**150**; **250**) configured to provide an operating position for an operator of the work machine; at least one actuator (**440**) configured to perform a machine work function; an operator input (**256**; **406**) configured to be manipulated by the operator and to responsively provide an operator command signal (**408**) to command usage of the at least one actuator to perform the work function; an electric power source (**420**) supported by the frame and operably coupled to the actuator and configured to selectively provide a power source output to the actuator; a controller (**410**) configured to receive the operator command signal and at least one enablement signal (**404**) and determine whether an operator has performed a proper enablement action, and to responsively provide control signals (**412**; **512**; **514**) to the electric power source to control the power source output, where the controller is further configured such that if the enablement signal is indicative of a proper operator enablement action, the controller generates, responsive to the operator command signal commanding usage of the at least one actuator, the control signals to control the electric power source to provide power signals to the at least one actuator and perform the commanded usage of the at least one actuator, where the controller is further configured such that if the enablement signal is not indicative of the proper operator enablement action, the controller generates the control signals to control the electric power source to not provide power signals to the at least one actuator regardless of the commanded usage indicated by the operator command output.

[0018] Implementations may include one or more of the following features. The power machine where power source output of the electric power source includes a rotating shaft of an electric motor (**528**), and further including a power conversion system that is coupled to the rotating shaft and configured to provide power signals (**432**) in the form of pressurized hydraulic fluid to the at least one actuator.

[0019] The power machine where the power conversion system includes: a hydraulic pump (**630**) coupled to the rotating shaft of the electric motor and configured to provide the pressurized hydraulic fluid; and a hydraulic valve (**634**) coupled to the hydraulic pump and configured to control the application of the power signals to the at least one actuator responsive to the operator command output.

[0020] The power machine where the controller is further configured such that if the operator command signal is indicative of no manipulation by the operator, the controller generates the control signals to control the electric power source to not provide power regardless of the enablement signal.

[0021] The power machine where the electric power source further includes battery components (**524**) coupled to the electric motor, and including control signals (**514**) to control the electric motor.

[0022] The power machine where the at least one operator engagement sequence input includes at least one of an operator seat or position sensor, a safety bar position sensor, and a seat belt engagement sensor. The power machine where the at least one operator engagement sequence input includes a sensor or input device positioned in the operator station and configured to provide the engagement sequence output as an indication of the operator's presence in the operator station. The power machine and further including an operator interface configured to alert the operator of a status of the enablement signal.

[0023] One general aspect in accordance with another embodiment includes a power machine (**100**; **200**; **400**; **500**; **600**) including: at least one hydraulic actuator (**440**) configured to perform a machine work function; an operator input (**256**; **406**) configured to be manipulated by an operator and to responsively provide an operator command signal (**408**) to command usage of the at least one actuator to perform the work function; an operator engagement sequence input (**402**) configured to provide an enablement signal (**404**) indicative of whether the operator is engaged or positioned such that machine work function can be activated or enabled; an electric power source (**420**) including an electric motor and configured to provide a power source output in the form of a rotating shaft; a power conversion system (**430**) coupled to the rotating shaft and configured to selectively provide power signals (**432**) in the form of pressurized hydraulic fluid to the at least one hydraulic actuator (**440**) to cause the at least one actuator to perform the machine work function; and a controller (**410**) configured to receive the operator command signal and the engagement sequence signal and to responsively provide control signals (**412**; **512**; **514**) to the electric power source to control the power source output, where the controller is further configured such that if the engagement sequence signal is indicative of a proper operator enablement action, the controller generates the control signals, responsive to the operator command signal commanding usage of the at least one actuator, to control the electric power source to provide power to the power conversion system to provide the power signals to the at least one actuator and perform the commanded usage of the at least one actuator, and where the controller is further configured such that if the engagement sequence signal is not indicative of the proper operator enablement action, the controller generates the control signals to control the electric power source to not provide power to the power conversion system regardless of the commanded usage indicated by the operator signal.

[0024] Implementations may include one or more of the following features. The power machine where the power conversion system includes a hydraulic pump (**630**) coupled to the rotating shaft of the electric motor and configured to provide the pressurized hydraulic fluid. The power machine where the power conversion system further includes a hydraulic valve (**634**) coupled to the hydraulic pump and configured to control the application of the power signals to the at least one

hydraulic actuator responsive to the operator signal.
[0025] The power machine where the electric power source further includes battery components (**524**) coupled to the electric motor and configured to provide electric power to the electric motor, and where the control signals include control signals (**514**) to control the electric motor.
[0026] The power machine and further including a frame (**110**; **210**) including an operator station (**150**; **250**) configured to provide an operating position for an operator of the work machine, where the operator input is positioned in the operator station. The power machine where the at least one operator engagement sequence input is configured to provide the engagement sequence output as an indication of the operator's presence in the operator station. The power machine where the at least one operator engagement sequence input includes at least one of an operator seat or position sensor, a safety bar position sensor, and a seat belt engagement sensor.
[0027] This Summary and the Abstract are provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0028] FIG. **1** is a block diagram illustrating functional systems of a representative power machine on which embodiments of the present disclosure can be practiced.
[0029] FIG. **2** is a front left perspective view of a representative power machine in the form of an excavator on which the disclosed embodiments can be practiced.
[0030] FIG. **3** is a rear right perspective view of the excavator of FIG. **2**.
[0031] FIG. **4** is a block diagram illustrating certain functional systems, of a representative power machine utilizing an electric power source that enable powering of travel or other functions once an operator has performed an initialization routine according to one illustrative embodiment.
[0032] FIG. **5** is a block diagram illustrating one more particular embodiment of the power machine shown in FIG. **4**.
[0033] FIG. **6** is a block diagram illustrating another more particular embodiment of the power machine shown in FIG. **4**.
DETAILED DESCRIPTION
[0034] The concepts disclosed in this discussion are described and illustrated with reference to exemplary embodiments. These concepts, however, are not limited in their application to the details of construction and the arrangement of components in the illustrative embodiments and are capable of being practiced or being carried out in various other ways. The terminology in this document is used for the purpose of description and should not be regarded as limiting. Words such as “including,” “comprising,” and “having” and variations thereof as used herein are meant to encompass the items listed thereafter, equivalents thereof, as well as additional items.
[0035] Disclosed embodiments provide improved immobilization of power machine functions, such as travel, swing, blade, lift and tilt functions until an operator has performed an initialization routine required by systems on the power machine. The disclosed embodiments are particularly directed to electric, hybrid-electric, and electro-hydraulic powered machines. Using disclosed concepts, for example in electro-hydraulic powered machines, selective machine function enablement can be achieved while also reducing power consumption, reducing or eliminating hydraulic components required to provide enablement of these machine functions.
[0036] These concepts can be practiced on various power machines, as will be described below. A representative power machine on which the embodiments can be practiced is illustrated in diagram form in FIG. **1** and one example of such a power machine is illustrated in FIGS. **2-3** and described

below before any embodiments are disclosed. For the sake of brevity, only one power machine is discussed. However, as mentioned above, the embodiments below can be practiced on any of a number of power machines, including power machines of different types from the representative power machine shown in FIGS. **2-3**. Power machines, for the purposes of this discussion, include a frame, at least one work element, and a power source that is capable of providing power to the work element to accomplish a work task. One type of power machine is a self-propelled work vehicle. Self-propelled work vehicles are a class of power machines that include a frame, work element, and a power source that is capable of providing power to the work element. At least one of the work elements is a motive system for moving the power machine under power. Disclosed embodiments can be utilized in power machines, such as excavators and loaders that utilize an electric or hybrid electric power source to power machine functions, for example through an electrically powered hydraulic system.

[0037] Referring now to FIG. **1**, a block diagram illustrates the basic systems of a power machine **100** upon which the embodiments discussed below can be advantageously incorporated and can be any of a number of different types of power machines. The block diagram of FIG. **1** identifies various systems on power machine **100** and the relationship between various components and systems. As mentioned above, at the most basic level, power machines for the purposes of this discussion include a frame, a power source, and a work element. The power machine **100** has a frame **110**, a power source **120**, and a work element **130**. Because power machine **100** shown in FIG. **1** is a self-propelled work vehicle, it also has tractive elements **140**, which are themselves work elements provided to move the power machine over a support surface and an operator station **150** that provides an operating position for controlling the work elements of the power machine. A control system **160** is provided to interact with the other systems to perform various work tasks at least in part in response to control signals provided by an operator.

[0038] Certain work vehicles have work elements that are capable of performing a dedicated task. For example, some work vehicles have a lift arm to which an implement such as a bucket is attached such as by a pinning arrangement. The work element, i.e., the lift arm can be manipulated to position the implement for the purpose of performing the task. The implement, in some instances can be positioned relative to the work element, such as by rotating a bucket relative to a lift arm, to further position the implement. Under normal operation of such a work vehicle, the bucket is intended to be attached and under use. Such work vehicles may be able to accept other implements by disassembling the implement/work element combination and reassembling another implement in place of the original bucket. Other work vehicles, however, are intended to be used with a wide variety of implements and have an implement interface such as implement interface **170** shown in FIG. **1**. At its most basic, implement interface **170** is a connection mechanism between the frame **110** or a work element **130** and an implement, which can be as simple as a connection point for attaching an implement directly to the frame **110** or a work element **130** or more complex, as discussed below.

[0039] On some power machines, implement interface **170** can include an implement carrier, which is a physical structure movably attached to a work element. The implement carrier has engagement features and locking features to accept and secure any of a number of implements to the work element. One characteristic of such an implement carrier is that once an implement is attached to it, it is fixed to the implement (i.e. not movable with respect to the implement) and when the implement carrier is moved with respect to the work element, the implement moves with the implement carrier. The term implement carrier is not merely a pivotal connection point, but rather a dedicated device specifically intended to accept and be secured to various different implements. The implement carrier itself is mountable to a work element **130** such as a lift arm or the frame **110**. Implement interface **170** can also include one or more power sources for providing power to one or more work elements on an implement. Some power machines can have a plurality of work element with implement interfaces, each of which may, but need not, have an implement carrier for receiving implements. Some other power machines can have a work element with a plurality of implement interfaces so that a single work element can accept a plurality of implements simultaneously. Each of these implement interfaces can, but need not, have an implement carrier.

[0040] Frame **110** includes a physical structure that can support various other components that are attached thereto or positioned thereon. The frame **110** can include any number of individual components. Some power machines have frames that are rigid. That is, no part of the frame is movable with respect to another part of the frame. Other power machines have at least one portion that is capable of moving with respect to another portion of the frame. For example, excavators can have an upper frame portion that rotates with respect to a lower frame portion. Other work vehicles have articulated frames such that one portion of the frame pivots with respect to another portion for accomplishing steering functions.

[0041] Frame **110** supports the power source **120**, which is capable of providing power to one or more work elements **130** including the one or more tractive elements **140**, as well as, in some instances, providing power for use by an attached implement via implement interface **170**. Power from the power source **120** can be provided directly to any of the work elements **130**, tractive elements **140**, and implement interfaces **170**. Alternatively, power from the power source **120** can be provided to a control system **160**, which in turn selectively provides power to the elements that capable of using it to perform a work function. Power sources for power machines typically include an engine such as an internal combustion engine and a power conversion system such as a mechanical transmission or a hydraulic system that is capable of converting the output from an engine into a form of power that is usable by a work element. Other types of power sources can be incorporated into power machines, including electrical sources or a combination of power sources, known generally as hybrid power sources. In particular, exemplary embodiments utilize power sources **120** that include an electrical power source, such as one or more batteries.

[0042] FIG. **1** shows a single work element designated as work element **130**, but various power machines can have any number of work elements. Work elements are typically attached to the frame of the power machine and movable with respect to the frame when performing a work task. In addition, tractive elements **140** are a special case of work element in that their work function is generally to move the power machine **100** over a support surface. Tractive elements **140** are shown separate from the work element **130** because many power machines have additional work elements besides tractive elements, although that is not always the case. Power machines can have any number of tractive elements, some or all of which can receive power from the power source **120** to propel the power machine **100**. Tractive elements can be, for example, wheels attached to an axle, track assemblies, and the like. Tractive elements can be rigidly mounted to the frame such that movement of the tractive element is limited to rotation about an axle or steerably mounted to the frame to accomplish steering by pivoting the tractive element with respect to the frame.

[0043] Power machine **100** includes an operator station **150**, which provides a position from which an operator can control operation of the power machine. In some power machines, the operator station **150** is defined by an enclosed or partially enclosed cab. Some power machines on which the disclosed embodiments may be practiced may not have a cab or an operator compartment of the type described above. For example, a walk behind loader may not have a cab or an operator compartment, but rather an operating position that serves as an operator station from which the power machine is properly operated. More broadly, power machines other than work vehicles may have operator stations that are not necessarily similar to the operating positions and operator compartments referenced above. Further, some power machines such as power machine **100** and others, whether or not they have operator compartments or operator positions, may be capable of being operated remotely (i.e. from a remotely located operator station) instead of or in addition to an operator station adjacent or on the power machine. This can include applications where at least some of the operator controlled functions of the power machine can be operated from a operating position associated with an implement that is coupled to the power machine. Alternatively, with some power machines, a remote control device can be provided (i.e. remote from both of the power machine and any implement to which is it coupled) that is capable of controlling at least some of the operator controlled functions on the power machine.

[0044] FIGS. **2-3** illustrate an excavator **200**, which is one particular example of a power machine of the type illustrated in FIG. **1**, on which the disclosed embodiments can be employed. Unless specifically noted otherwise, embodiments disclosed below can be practiced on a variety of power machines, with the excavator **200** being only one of those power machines. Excavator **200** is described below for illustrative purposes. Not every excavator or power machine on which the illustrative embodiments can be practiced need have all of the features or be limited to the features that excavator **200** has. Excavator **200** has a frame **210** that supports and encloses a power system **220** (represented in FIGS. **2-3** as a block, as the actual power system is enclosed within the frame **210**). The power system **220** can include an engine that aids in providing a power output to a hydraulic system, but generally includes an electric, or hybrid electric power source for providing the output to the hydraulic system. The hydraulic system acts as a power conversion system that includes one or more hydraulic pumps for selectively providing pressurized hydraulic fluid to actuators that are operably coupled to work elements in response to signals provided by operator input devices. The hydraulic system also includes a control valve system that selectively provides pressurized hydraulic fluid to actuators in response to signals provided by operator input devices. The excavator **200** includes a plurality of work elements in the form of a first lift arm structure **230** and a second lift arm structure **330** (not all excavators have a second lift arm structure). In addition, excavator **200**, being a work vehicle, includes a pair of tractive elements in the form of left and right track assemblies **240**A and **240**B, which are disposed on opposing sides of the frame **210**.

[0045] An operator compartment **250** is defined in part by a cab **252**, which is mounted on the frame **210**. The cab **252** shown on excavator **200** is an enclosed structure, but other operator compartments need not be enclosed. For example, some excavators have a canopy that provides a roof but is not enclosed A control system, shown as block **260** is provided for controlling the various work elements. Control system **260** includes operator input devices, which interact with the power system **220** to selectively provide power signals to actuators to control work functions on the excavator **200**.

[0046] Frame **210** includes an upper frame portion or house **211** that is pivotally mounted on a lower frame portion or undercarriage **212** via a swivel joint. The swivel joint includes a bearing, a ring gear, and a slew motor with a pinion gear (not pictured) that engages the ring gear to swivel the machine. The slew motor receives a power signal from the control system **260** to rotate the house **211** with respect to the undercarriage **212**. House **211** is capable of unlimited rotation about a swivel axis **214** under power with respect to the undercarriage **212** in response to manipulation of an input device by an operator. Hydraulic conduits are fed through the swivel joint via a hydraulic swivel to provide pressurized hydraulic fluid to the tractive elements and one or more work elements such as lift arm **330** that are operably coupled to the undercarriage **212**.

[0047] The first lift arm structure **230** is mounted to the house **211** via a swing mount **215**. (Some excavators do not have a swing mount of the type described here.) The first lift arm structure **230** is a boom-arm lift arm of the type that is generally employed on excavators although certain features of this lift arm structure may be unique to the lift arm illustrated in FIGS. **2-3**. The swing mount **215** includes a frame portion **215**A and a lift arm portion **215**B that is rotationally mounted to the frame portion **215**A at a mounting frame pivot **231**A. A swing actuator **233**A is coupled to the house **211** and the lift arm portion **215**B of the mount. Actuation of the swing actuator **233**A causes the lift arm structure **230** to pivot or swing about an axis that extends longitudinally through the mounting frame pivot **231**A.

[0048] The first lift arm structure **230** includes a first portion, known generally as a boom **232** and a second portion known as an arm or a dipper **234**. The boom **232** is pivotally attached on a first end **232**A to mount **215** at boom pivot mount **231**B. A boom actuator **233**B is attached to the mount

215 and the boom **232**. Actuation of the boom actuator **233**B causes the boom **232** to pivot about the boom pivot mount **231**B, which effectively causes a second end **232**B of the boom to be raised and lowered with respect to the house **211**. A first end **234**A of the arm **234** is pivotally attached to the second end **232**B of the boom **232** at an arm mount pivot **231**C. An arm actuator **233**C is attached to the boom **232** and the arm **234**. Actuation of the arm actuator **233**C causes the arm to pivot about the arm mount pivot **231**C. Each of the swing actuator **233**A, the boom actuator **233**B, and the arm actuator **233**C can be independently controlled in response to control signals from operator input devices.

[0049] An exemplary implement interface **270** is provided at a second end **234**B of the arm **234**. The implement interface **270** includes an implement carrier **272** that is capable of accepting and securing a variety of different implements to the lift arm **230**. Such implements have a machine interface that is configured to be engaged with the implement carrier **272**. The implement carrier **272** is pivotally mounted to the second end **234**B of the arm **234**. An implement carrier actuator **233**D is operably coupled to the arm **234** and a linkage assembly **276**. The linkage assembly includes a first link **276**A and a second link **276**B. The first link **276**A is pivotally mounted to the arm **234** and the implement carrier actuator **233**D. The second link **276**B is pivotally mounted to the implement carrier **272** and the first link **276**A. The linkage assembly **276** is provided to allow the implement carrier **272** to pivot about the arm **234** when the implement carrier actuator **233**D is actuated.

[0050] The implement interface **270** also includes an implement power source (not shown in FIGS. **2-3**) available for connection to an implement on the lift arm structure **230**. The implement power source includes pressurized hydraulic fluid port to which an implement can be coupled. The pressurized hydraulic fluid port selectively provides pressurized hydraulic fluid for powering one or more functions or actuators on an implement. The implement power source can also include an electrical power source for powering electrical actuators and/or an electronic controller on an implement. The electrical power source can also include electrical conduits that are in communication with a data bus on the excavator **200** to allow communication between a controller on an implement and electronic devices on the excavator **200**. It should be noted that the specific implement power source on excavator **200** does not include an electrical power source.

[0051] The lower frame **212** supports and has attached to it a pair of tractive elements **240**, identified in FIGS. **2-3** as left track drive assembly **240**A and right track drive assembly **240**B. Each of the tractive elements **240** has a track frame **242** that is coupled to the lower frame **212**. The track frame **242** supports and is surrounded by an endless track **244**, which rotates under power to propel the excavator **200** over a support surface. Various elements are coupled to or otherwise supported by the track **242** for engaging and supporting the track **244** and cause it to rotate about the track frame. For example, a sprocket **246** is supported by the track frame **242** and engages the endless track **244** to cause the endless track to rotate about the track frame. An idler **245** is held against the track **244** by a tensioner (not shown) to maintain proper tension on the track. The track frame **242** also supports a plurality of rollers **248**, which engage the track and, through the track, the support surface to support and distribute the weight of the excavator **200**. An upper track guide **249** is provided for providing tension on track **244** and prevent the track from rubbing on track frame **242**.

[0052] A second, or lower lift arm **330** is pivotally attached to the lower frame **212**. A lower lift arm actuator **332** is pivotally coupled to the lower frame **212** at a first end **332**A and to the lower lift arm **330** at a second end **332**B. The lower lift arm **330** is configured to carry a lower implement **334**. The lower implement **334** can be rigidly fixed to the lower lift arm **330** such that it is integral to the lift arm. Alternatively, the lower implement can be pivotally attached to the lower lift arm via an implement interface, which in some embodiments can include an implement carrier of the type described above. Lower lift arms with implement interfaces can accept and secure various different types of implements thereto. Actuation of the lower lift arm actuator **332**, in response to operator input, causes the lower lift arm **330** to pivot with respect to the lower frame **212**, thereby raising and lowering the lower implement **334**.

[0053] Upper frame portion **211** supports cab **252**, which defines, at least in part, operator compartment or station **250**. A seat **254** is provided within cab **252** in which an operator can be seated while operating the excavator. While sitting in the seat **254**, an operator will have access to a plurality of operator input devices **256** that the operator can manipulate to control various work functions, such as manipulating the lift arm **230**, the lower lift arm **330**, the traction system **240**, pivoting the house **211**, the tractive elements **240**, and so forth.

[0054] Excavator **200** provides a variety of different operator input devices **256** to control various functions. For example, in some embodiments, hydraulic joysticks are provided to control the lift arm **230** and swiveling of the house **211** of the excavator. Such hydraulic joysticks are typically in hydraulic communication with valves to control the flow of pressurized fluid to hydraulic actuators in response to activation of the joysticks in certain conditions. In other embodiments, electric joysticks can be used to provide signals indicative of an operator's request to control various actuators. Foot pedals with attached levers are provided for controlling travel and lift arm swing. Electrical switches are located on the joysticks for controlling the providing of power to an implement attached to the implement carrier **272**. Other types of operator inputs that can be used in excavator **200** and other excavators and power machines include, but are not limited to, switches, buttons, knobs, levers, variable sliders and the like. The specific control examples provided above are exemplary in nature and not intended to describe the input devices for all excavators and what they control.

[0055] Display devices are provided in the cab to give indications of information relatable to the operation of the power machines in a form that can be sensed by an operator, such as, for example audible and/or visual indications. Audible indications can be made in the form of buzzers, bells, and the like or via verbal communication. Visual indications can be made in the form of graphs, lights, icons, gauges, alphanumeric characters, and the like. Displays can be dedicated to provide dedicated indications, such as warning lights or gauges, or dynamic to provide programmable information, including programmable display devices such as monitors of various sizes and capabilities. Display devices can provide diagnostic information, troubleshooting information, instructional information, and various other types of information that assists an operator with operation of the power machine or an implement coupled to the power machine. Other information that may be useful for an operator can also be provided.

[0056] The description of power machine **100** and excavator **200** above is provided for illustrative purposes, to provide illustrative environments on which the embodiments discussed below can be practiced. While the embodiments discussed can be practiced on a power machine such as is generally described by the power machine **100** shown in the block diagram of FIG. **1** and more particularly on an excavator such as excavator **200**, unless otherwise noted, the concepts discussed below are not intended to be limited in their application to the environments specifically described above.

[0057] Referring now to FIG. **4**, a block diagram illustrates portions of a power machine **400** that can be similar to one or both of the power machines **100** and **200** discussed above. Power machine **400** can be, for example, an electro-hydraulic power machine in which a hydraulic system is driven by an electric or hybrid electric powertrain. As is mentioned above and in the discussion of some embodiments below, power machines such as power machine **400** can include one or more batteries as an electric power source. Alternatively, the power machine **400** and rely on an external power source and an electrical cord (neither shown) that is coupled to both the external power source and the power machine to provide electrical power to the power machine. In some instances, the power cord provides power to a power machine that does not have a battery or other storage device located on the machine. In other instances, the power cord can be provided to charge an electrical storage device on the machine while the machine is being operated.

[0058] As discussed below, power machine **400** and other disclosed embodiments provide immobilization of certain power machine functions, particularly electro-hydraulically powered machine functions, in certain defined states or conditions and enablement of these certain power machine functions in other defined states or conditions. For example, in an excavator, functions such as boom and arm operation, blade operation, swing motion of the boom, rotation of the house, and/or travel can be disabled or immobilized under certain conditions where the operator leaves the operator station or is otherwise out of a required position or has not performed an initialization routine to enable the functions. Such disabling of certain functions is achieved in a manner that potentially allows the hydraulic system to be simplified as compared to conventional hydraulic systems that have included hydraulic enablement functionality. This potentially lowers the cost of the hydraulic system by eliminating components, lowers a required number of hydraulic connections which reduces the potential for leakages, and reduces the space requirement of the hydraulic system.
[0059] To accomplish these or other advantages, disclosed embodiments utilize an electric powertrain energy cut-off instead of utilizing a hydraulic enablement valve such is conventionally used in power machines with an internal combustion engine that drives a pump continuously during machine operation. Because it is possible to easily start and stop an electric motor, as opposed to an engine in an engine-based powertrain, which typically would run continuously during potential operation of the power machine, energy for the electric powertrain can be selectively supplied through a controller when the operator has not performed the initialization routine or has performed an action that would require that the initialization routine be performed again to enable certain machine functions.
[0060] As shown in FIG. **4**, power machine **400** includes a controller **410** configured to generate control signals **412** that control an electric power source **420**, which can be one of the types of electric power sources or arrangements discussed above. As such, electric power source **420** can include one or more batteries providing electric power. Electric power source **420** provides an output **422** to power conversion system **430** that is configured to utilize power from the power source to provide power signals **432** to actuators **440** (such as travel motors, lift or tilt cylinders, etc.). In exemplary embodiments, power conversion system **430** is configured to convert the power from power source **420** into signals in the form of pressurized hydraulic fluid for powering hydraulic actuators. As such, power conversion system **430** can include one or more hydraulic motors driven by an electric motor of electric power source **420**. Power conversion system **430** can also include valves and other components used to control the application of hydraulic power to actuators **440**.
[0061] As also shown in FIG. **4**, power machine **400** includes one or more operator engagement sequence inputs **402** configured to provide enablement signals **404** indicative of whether the operator is engaged or positioned such that machine functions can be activated or enabled, or whether the operator is not properly engaged such that machine functions must be immobilized, prevented from activation, or unpowered. For instance, operator engagement sequence inputs **402** can include an operator seat or position sensor that detects whether the operator is seated properly within the operator cab or station. Inputs **402** can also or alternatively include other types of inputs, such as safety bar position inputs for loaders or other types of machines, seat belt engagement sensors, push button or other inputs that require the operator to complete a sequence of actions from a particular position, for example. This sequence of actions can be an initialization sequence of the type discussed above. Enablement signals **404** are provided to and received by controller **410**, as are outputs **408** from operator inputs **406**, which can be used to command machine functions through actuators **440** such as boom and arm operation, blade operation, swing motion of the boom, rotation of the house, and/or travel. Controller **410** is configured such that, unless enablement signals **404** are indicative of a proper operator enablement action (e.g., operator properly seated, seat belt engaged, etc.), controller **410** does not allow power to be provided to

some or all power machine actuators **440**, even when operator inputs **406** are manipulated to command usage of the actuators. If enablement signals **404** are indicative of a proper operator enablement action, controller **410** controls the electric power source **420** to provide power to the actuators through power conversion system **430**. In some embodiments, the enablement signals may be required to be received in a particular order (for instance, an operator may be required to fasten a seat belt and then engage an operator input. For the purposes of this discussion, reception of the one or more signals are collectively referred to as reception of the enablement signals **404**. Reception of the proper signals and (if necessary) in the proper order or subject to some other constraint is considered to be a proper operator engagement operation. In addition, actuation of a keyswitch, button, or other input to start a controller may be considered an enablement signal in some embodiments and may also be important to determine a proper order. However, a proper operator enablement action, for the purposes of this discussion, cannot include only a keyswitch or similar input. In some embodiments, the controller **410** can provide status information to a display or other operator interface to inform an operator of the status of the power machine vis-à-vis the enablement action. In other words, the display can provide an indication to the operator (in the form of visual and/or audible indicators, for example) that the operator has, or has not provided a proper operator enablement action. This can be useful to inform the operator as to whether the machine is functional but in need of a proper operator enablement action if the machine is not responding to other operator inputs.

[0062] By configuring controller **410** to control application of power from electric power source **420** based upon whether the operator performs the proper engagement or initialization sequence, actuators **440** can be prevented from receiving hydraulic or other power, without requiring the use of engagement valves to divert or block hydraulic flow from the actuators when the proper engagement sequence has not been performed. This allows for a simplified hydraulic system as described above, potentially reducing costs, space requirements and leakage. At the same time, in contrast to conventional systems in which an engine is powering the hydraulic system even when flow of hydraulic fluid is diverted from powering actuators **440**, in system **400** the controller controls the electrical power source such that battery power is not utilized to power the hydraulic system when the proper engagement sequence has not been performed.

[0063] Referring now to FIG. **5**, shown is a power machine **500** that is one more particular embodiment of power machine **400** discussed above. In this embodiment, electric power source **420** is shown to include battery components **524** and an electric motor **528** powered by energy from the battery components. Electric motor **528** provides an output (e.g., in the form of a rotating shaft) which power conversion system **430** uses to provide power to actuators **440**. The battery components **524** can include, for example, one or more batteries or battery packs and switching or control circuitry for selectively providing power from the batteries to electric motor **528**. Electric motor **528** can similarly include switches and other control circuitry for selectively allowing power from the batteries to be provided to the motor. In various exemplary embodiments, controller **410** can therefore generate the control signals **412** (shown in FIG. **4**) to control electric power source **420** by generating control signals **512** to control the battery components **524** (e.g., control switches of the battery components) or by generating control signals **514** to control the electric motor **528**. In either instance, based upon control from controller **410**, when operator engagement sequence inputs **402** do not indicate that a proper engagement sequence has occurred, power from the batteries is not used to power the electric motor. This both accomplishes the lockout and enablement of certain machine functions as discussed and reduces power consumption during the lockout of those functions.

[0064] Referring now to FIG. **6**, shown is a power machine **600** which is one more particular embodiment of power machines **400** and **500** discussed above. In power machine **600**, power conversion system **430** is shown to include at least one hydraulic pump **630** that is powered by output **422** from electric motor **528** to provide a pressurized hydraulic fluid output **632**. Power

conversion system **430** can also include one or more valves **634** to control the application of the pressurized fluid to the actuators responsive to operator inputs **406**.
[0065] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the discussion.

Claims

1. A power machine comprising: a frame providing an operating position for an operator of the power machine; an actuator; an operator input configured to be manipulated by the operator and to responsively provide an operator command signal to command usage of the actuator; an electric power source supported by the frame and operably coupled to the actuator and configured to selectively provide a rotating shaft of an electric motor as a power source output a power conversion system that is coupled to the rotating shaft and configured to provide power signals in the form of pressurized hydraulic fluid to the at least one actuator; and a controller configured to receive the operator command signal and an enablement signal indicative of an enablement action, and to responsively provide control signals to the electric power source to control the rotating shaft such that if the enablement signal is indicative of the enablement action, the controller generates the control signals responsive to the operator command signal to control the rotating shaft to cause the power conversion system to provide power signals to the actuator.
2. The power machine of claim 1, wherein the controller is further configured to receive the operator command signal and the enablement signal indicative of the enablement action and such that if the enablement signal is not indicative of the enablement action, the controller generates the control signals to control the rotating shaft to cause the power conversion system to not provide power signals to the actuator.
3. The power machine of claim 1, wherein the power conversion system includes: a hydraulic pump coupled to the rotating shaft of the electric motor and configured to provide the pressurized hydraulic fluid; and a hydraulic valve coupled to the hydraulic pump and configured to control the application of the power signals to the actuator responsive to the operator command signal.
4. The power machine of claim 3, wherein the controller is further configured such that if the operator command signal is indicative of no manipulation by the operator, the controller generates the control signals to control the electric power source to not provide power regardless of the enablement signal.
5. The power machine of claim 1, wherein the electric power source further comprises battery components coupled to the electric motor, and including control signals to control the electric motor.
6. The power machine of claim 1, wherein the enablement signal is provided by at least one of an operator seat or position sensor, a safety bar position sensor, and a seat belt engagement sensor.
7. The power machine of claim 1, wherein the enablement signal is provided by a sensor or input device configured to provide the enablement signal as an indication of the operator's presence at the operating position.
8. The power machine of claim 1 and further comprising an operator interface configured to alert the operator of a status of the enablement signal.
9. A power machine comprising: at least one hydraulic actuator configured to perform a machine work function; an operator input configured to be manipulated by an operator and to responsively provide an operator command signal to command usage of the at least one actuator to perform the work function; an operator engagement sequence input configured to provide an enablement signal indicative of whether the operator has performed a proper enablement action such that the machine work function can be activated or enabled; an electric power source including an electric motor and configured to provide a power source output in the form of a rotating shaft; a power conversion

system coupled to the rotating shaft and configured to selectively provide power signals in the form of pressurized hydraulic fluid to the at least one hydraulic actuator to cause the at least one actuator to perform the machine work function; and a controller configured to receive the operator command signal and the enablement signal and to responsively provide control signals to the electric power source to control the power source output, wherein the controller is further configured such that if the enablement signal is indicative of the proper enablement action, the controller generates the control signals, responsive to the operator command signal commanding usage of the at least one actuator, to control the electric power source to provide power to the power conversion system to provide the power signals to the at least one actuator.

10. The power machine of claim 9, wherein the controller is further configured such that if the enablement signal is not indicative of the proper enablement action, the controller generates the control signals to control the electric power source to not provide power to the power conversion system regardless of the commanded usage indicated by the operator command signal.

11. The power machine of claim 9, wherein the power conversion system comprises a hydraulic pump coupled to the rotating shaft of the electric motor and configured to provide the pressurized hydraulic fluid.

12. The power machine of claim 11, wherein the power conversion system further comprises a hydraulic valve coupled to the hydraulic pump and configured to control the application of the power signals to the at least one hydraulic actuator responsive to the operator command signal.

13. The power machine of claim 11, wherein the electric power source further comprises battery components coupled to the electric motor and configured to provide electric power to the electric motor, and wherein the control signals include control signals to control the electric motor.

14. The power machine of claim 9, further comprising a frame including an operator station configured to provide an operating position for an operator of the power machine, wherein the operator input is positioned in the operator station; wherein the operator engagement sequence input is configured to provide the enablement signal as an indication of the operator's presence in the operator station.

15. The power machine of claim 14, wherein the operator engagement sequence input comprises at least one of an operator seat or position sensor, a safety bar position sensor, and a seat belt engagement sensor.

16. The power machine of claim 9, wherein the controller is further configured such that if the operator command signal is indicative of no manipulation by the operator, the controller generates the control signals to control the electric power source to not provide power regardless of the enablement signal.

17. The power machine of claim 9, wherein the operator engagement sequence input providing the enablement signal is a sensor or input device configured to provide the enablement signal as an indication of the operator's presence at an operating position of the power machine.

18. The power machine of claim 9, and further comprising an operator interface configured to alert the operator of a status of the enablement signal.