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(54) SYSTEM AND METHOD FOR CONTROLLING A MACHINE

(57) A control system for a work machine having an upper frame rotatably mounted to a lower frame is provided. The upper frame includes an arm assembly. The system includes a controller. The controller is responsive to a first user command to lock or substantially restrict movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

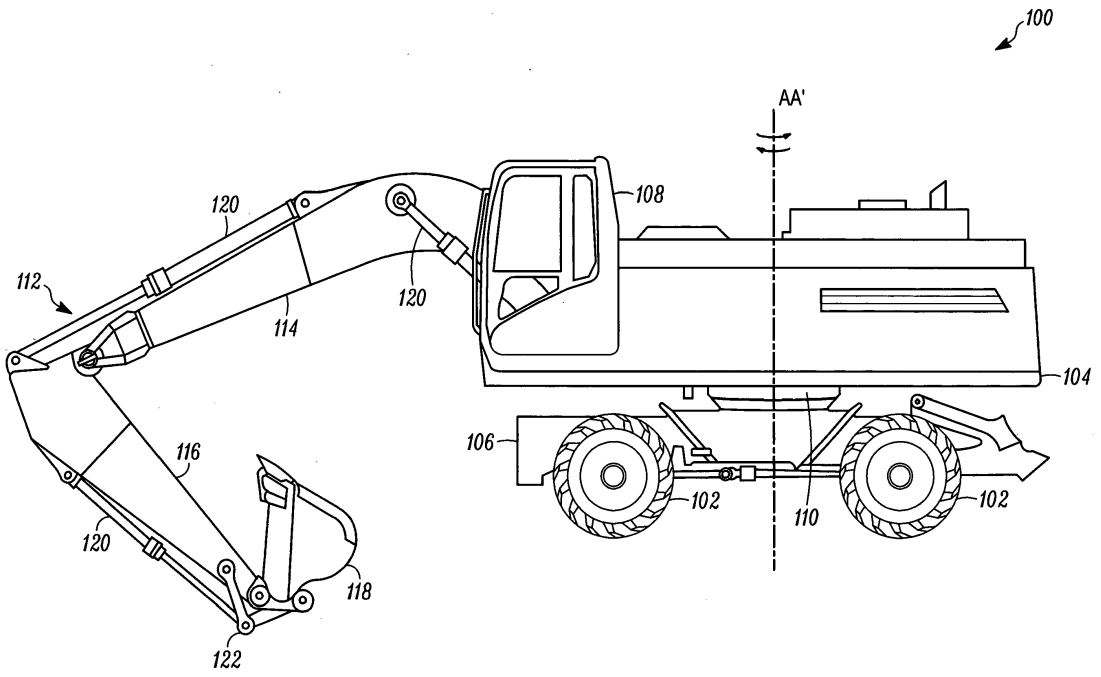

FIG. 1

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Description

Technical Field

[0001] The present disclosure relates to a system and method for controlling movement in a machine. More particularly, the present disclosure relates to controlling movement of an arm assembly and upper frame in a machine.

Background

[0002] Machines, such as wheeled excavators or backhoe loaders, include an upper frame, also called a swivel body, rotatably mounted on a lower frame. The lower frame includes wheels, tracks or the like for locomotion of the machine. Such machines are also provided with an arm assembly pivotally mounted on the upper frame. The arm assembly includes a work implement which may be for example, a bucket. The upper frame being rotatable relative to the lower frame allows more efficient operation the machine.

[0003] U.S. Patent Number 7,730,646 (hereinafter referred to as the "'646 patent") describes a swivel work machine having a swivel body pivotally mounted on a travel frame. A boom, to which a bucket is attached, is provided on the swivel body. Movement of the boom and bucket is controlled using a control lever located within the vehicle's operator station. The '646 patent describes a locking system for the swivel work machine wherein movement of the swivel body relative to the travel frame is constrained together with movement of the boom and bucket.

[0004] Locking systems such as that described in the '646 patent are typically used during transportation of the machine to prevent accidental movement of the swivel body, boom or work tool. In some situations, such as when loading the machine onto a truck, there may be a need to move the work tool and/or boom after the machine has been put in a position for transportation,. Hence, there is a need for an improved system for controlling movement of the swivel body and arm assembly.

Summary of the Disclosure

[0005] In an aspect of the present disclosure, a control system for a work machine having an upper frame rotatably mounted to a lower frame is provided. The upper frame includes an arm assembly. The system includes a controller responsive to a first user command to send appropriate control signals to lock or substantially restrict movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

[0006] In another aspect of the present disclosure, a work machine is provided. The work machine includes an upper frame rotatably mounted to a lower frame. Further, the work machine includes an arm assembly provided on the upper frame. The work machine includes a controller operable to lock or substantially restrict movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

[0007] In yet another aspect of the present disclosure, a method for controlling a work machine is provided. The work machine has an upper frame rotatably mounted to a lower frame. The upper frame includes an arm assembly. The method includes locking or substantially restricting movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

[0008] In some aspects of the present disclosure, a method for controlling a work machine is provided. The work machine has an upper frame rotatably mounted to a lower frame. The method includes detecting a rotational position of the upper frame relative to the lower frame. The method includes locking or substantially restricting movement of the upper frame relative to the lower frame when the upper frame is in a predetermined position relative to the lower frame. The method includes limiting the rate of rotational movement of the upper frame as it approaches the predetermined position.

[0009] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0010]

FIG. 1 is a side view of an exemplary work machine, in accordance with an embodiment of the present disclosure;

FIG. 2 is a block diagram of a control system associated with the work machine, in accordance with an embodiment of the present disclosure;

FIG. 3 is an exemplary low-level implementation of the control system of FIG. 2;

FIG. 4 is a flowchart of a method for controlling the exemplary work machine of FIG. 1, in accordance with an embodiment of the present disclosure; and

FIG. 5 is a top perspective view of the exemplary work machine of FIG. 1.

Detailed Description

[0011] Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or the like parts. FIG. 1 illustrates an exemplary work machine 100 (herein after referred to as "machine 100"). The machine 100 may be moved over a ground surface using wheels 102 provided on a lower frame 106 of the machine 100. The machine 100 also includes an upper frame 104 on which an operator cab 108 and an engine (not shown) are supported. The upper frame 104 is coupled to the lower frame 106 via a swivel base 110 so that the upper frame 104 may be rotated, in use, with respect to the lower frame 106 about an axis AA'.

[0012] The machine 100 shown in FIG. 1 is an exca-

vator. Alternatively, the machine 100 may include other swivel machines, whether tracked or wheeled, in which an upper frame of the machine is capable of rotational motion with respect to a lower frame of the machine.

[0013] The machine 100 also includes an arm assembly 112 provided on the upper frame 104. The arm assembly 112 includes a boom 114, a stick 116 and an implement 118. As shown, the boom 114 is pivotally connected at one end to the upper frame 104 of the machine 100 and is pivotally connected at another end thereof to the stick 116. The implement 118 is connected to the stick 116 via a coupling mechanism 122. The arm assembly 112 is actuated by a pair of hydraulic cylinders 120. The arrangement of the arm assembly 112 described herein is exemplary in nature and does not limit the scope of the present disclosure.

[0014] Referring to FIG. 1, the implement 118 is a work tool in the form of a bucket. Other forms of implement 118 may also be used according to the task to be performed. For example, the implement 118 may be a grappler, a hammer, a fork, a lifting hook, a saw, a rotary broom, a shear, or any other appropriate work tool known in the art.

[0015] The operator cab 108 includes a number of input devices (not shown) including, but not limited to, a control panel, joysticks, and levers for the operator to control one or more operations of the machine 100 and the implement 118. During operation, the engine may drive a hydraulic pump (not shown) to supply high pressure hydraulic fluid to a hydraulic system. The hydraulic system may be used to actuate the hydraulic cylinders 120 provided in association with the boom 114, the stick 116, and the implement 118.

[0016] Referring to FIG. 2, a control system 200 of the machine 100 is illustrated. The control system 200 includes a controller 204 configured to receive a signal from a sensor 202. The sensor 202 is configured to generate a signal indicative of a rotational position of the upper frame 104 relative to the lower frame 106 of the machine 100.

[0017] The controller 204 is configured to selectively control the locking of the upper frame 104 with respect to the lower frame 106 so as to substantially prevent or restrict rotational movement therebetween, while either permitting movement of the arm assembly 112 with respect to the upper frame 104, or locking the arm assembly 112 so as to substantially prevent or restrict movement of the arm assembly 112 with respect to the upper frame 104, as described in more detail below.

[0018] The controller 204 is communicably coupled to a swing lock button 206 that could be conveniently located within the operator cab 108 for use by an operator of the machine 100. The controller 204 is also communicably coupled to a hydraulic swing lock 208 associated with the swivel base 110 for controlling rotational movement of the upper frame 104 relative to the lower frame 106.

[0019] The swing lock button 206 may be operable by the operator from the operator cab 108 of the machine 100. In one embodiment, activation or depression of the swing lock button 206 momentarily by the operator is indicative of a first user command. Pressing of the swing lock button 206 may be considered as momentary if the operator presses the swing lock button 206 for less than a pre-determined time interval, for example, two seconds.

[0020] In response to the first user command, the controller 204 may determine from the signal received from the sensor 202 whether or not the upper frame 104 is disposed in a predetermined position, for example, when a longitudinal axis of the upper frame 104 is in alignment with a longitudinal plane BB' of the lower frame 106. In an example, the operator of the machine 100 may command rotation of the upper frame 104 to bring the upper frame 104 into alignment with the longitudinal plane BB' (shown in FIG. 5) of the lower frame 106, whereupon the controller 204 will determine the upper frame 104 is in the predetermined position. Once the controller 204 determines the upper frame 104 is in the predetermined position, the controller 204 is configured to send appropriate control signals to the hydraulic swing lock 208 associated with the swivel base 110 in order to cause the locking or restriction of the movement of the upper frame 104 relative to the lower frame 106.

[0021] In another example, if the controller 204 determines that the upper frame 104 is not at the predetermined position, the controller 204 may be configured to limit the rate of rotation *i.e.,* speed of rotation, of the upper frame 104 relative to the lower frame 106 as the upper frame 104 approaches the predetermined position. Thereafter, the controller 204 can command a locking or restriction of the movement of the upper frame 104 by activating the hydraulic swing lock 208 associated with the swivel base 110 as described above.

[0022] The controller 204 includes a memory 210, which may be any suitable data storage and retrieval device. In one embodiment, the controller 204 may retrieve the predetermined position of the upper frame 104 from the memory 210. As disclosed in an example herein, the predetermined position stored at the memory 210 may advantageously correspond to the alignment of the upper frame 104 with respect to the lower frame 106 such that once aligned, the controller 204 can command a locking or restriction of the movement of the upper frame 104 by activating the hydraulic swing lock 208 associated with the swivel base 110 as described above. In one example, the memory 210 may be integral with the controller 204. Further, the controller 204 may store in the memory 210 the current status *i.e.,* locked or unlocked state, of the upper frame 104 and arm assembly 112. In one embodiment the memory 210 is any suitable form of non-volatile memory such that the controller 204 remembers the locked or unlocked state of the upper frame 104 and arm assembly 112 when the machine is powered off.

[0023] In one embodiment, pressing of the swing lock button 206 for a longer duration is indicative of a second user command. In one example, pressing of the swing

lock button 206 for a duration of two seconds or more is interpreted by the controller 204 as a second user command. In other embodiments, the first and second user commands may be provided using other input arrangements, such as single vs multiple presses of the button 206, shorter or longer durations than two seconds, or alternatively separate buttons may be used to provide the first and second user commands. References to 'button' herein will be understood to include a physical press-button and a button input control on a touch-screen input device.

[0024] In response to the second user command, the controller 204 is configured to command a locking or restriction of the movement of the upper frame 104 relative to the lower frame 106 by activating the hydraulic swing lock 208 when the upper frame 104 is at the predetermined position as described above, and to then also command a locking or restriction of the movement of the arm assembly 112. The controller 204 may be configured to send appropriate control signals to cause restriction of a flow of hydraulic fluid to and from the hydraulic cylinders 120 associated with the arm assembly 112, resulting in a locking or restriction of the movement of the arm assembly 112.

[0025] Once the upper frame 104, or upper frame 104 and the arm assembly 112 according to the first or second user command, are in the locked state, movement of the upper frame 104 and the arm assembly 112 may be enabled/unlocked by providing one or more user commands via suitable input devices, for example, by pressing the swing lock button 206.

[0026] As shown in FIG. 2, the control system 200 may also include a lock status indicator 212 communicably coupled to the controller 204. Based on the current status of the upper frame 104 stored by the controller 204 in the memory 210, the controller 204 may also send appropriate control signals to cause the lock status indicator 212 to indicate whether movement of the upper frame 104 is locked or unlocked. The lock status indicator 212 may be embodied in the form of any known indication device including, but not limited to, a light device such as an LED, a graphical user interface (GUI), or a sound emitting device such as a loudspeaker or piezoelectric device configured to indicate the current status of the upper frame 104 to the operator of the machine 100.

[0027] Likewise, a status *i.e.*, locked state or unlocked state, of the arm assembly 112 may also be stored by the controller 204 in the memory 210 and such status may also be used by the controller 204 to send appropriate control signals to the lock status indicator 212 for indicating the updated status of the arm assembly 112 to the operator. Therefore, it will be appreciated that based on the locked status of the upper frame 104 and/or the arm assembly 112, the controller 204 may send appropriate control signals to the lock status indicator 212 for notifying or indicating to the operator the locked or unlocked status of each of the upper frame 104 and the arm assembly 112, as the case may be.

[0028] The controller 204 may be an electronic controller that operates in a logical fashion to perform operations, execute control algorithms, store and retrieve data and other desired operations. The controller 204 may include or access memory, secondary storage devices, processors, and any other components for running an application. The memory and secondary storage devices may be in the form of read-only memory (ROM) or random access memory (RAM) or integrated circuitry that is accessible by the controller. Various other circuits may be associated with the controller 204 such as power supply circuitry, signal conditioning circuitry, driver circuitry, and other types of circuitry. The controller 204 may be a single controller or may include more than one controller configured to control various functions and/or features of the machine 100. The term "controller" is meant to be used in its broadest sense to include one or more programmable logic controllers, embedded controllers, microcontrollers and/or microprocessors that may be associated with the machine 100 and that may cooperate in controlling various functions and operations of the machine 100 disclosed herein.

[0029] FIG. 3 is an exemplary low-level implementation of the control system 200 from FIG. 2 for controlling operation of the exemplary machine 100 of FIG. 1 in accordance with embodiments of the present disclosure. For the sake of simplicity in this document, the low-level implementation of the control system 200 will hereinafter be referred to as 'a computer system' and designated with similar reference numeral increased by 100 *i.e.,* reference numeral '300').

[0030] The present disclosure has been described herein in terms of functional block components, modules, and various processing steps. It should be appreciated that such functional blocks may be realized by any number of hardware and/or software components configured to perform the specified functions. For example, the controller 204 of the control system 200 may employ various integrated circuit components, *e.g.*, memory elements, processing elements, logic elements and the like which may carry out a variety of functions under the control of one or more microprocessors or other control devices. Similarly, the software elements of the system 300 may be implemented with any programming or scripting language such as C, C++, Java, COBOL, assembler, PERL, Visual Basic, SQL Stored Procedures, extensible markup language (XML), with the various algorithms being implemented with any combination of data structures, objects, processes, routines or other programming elements. Further, it should be noted that the system 300 may employ any number of conventional techniques for data transmission, signaling, data processing, network control, and/or the like. Still further, the system 300 could be configured to detect or prevent security issues with a user-side scripting language, such as JavaScript, VBScript or the like. In an embodiment of the present disclosure, the networking architecture between components of the system 300 may be implemented by way of

a client-server architecture. In an additional embodiment of this disclosure, the client-server architecture may be built on a customizable .Net (dot-Net) platform. However, it may be apparent to a person ordinarily skilled in the art that various other software frameworks may be utilized to build the client-server architecture between components of the control system 200 without departing from the spirit and scope of the disclosure.

[0031] These software elements may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions that execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks. These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce instructions which implement the function specified in the flowchart block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

[0032] The present disclosure (*i.e.,* the control system 200, the method 400, and any part(s) or function(s) thereof) may be implemented using hardware, software or a combination thereof, and may be implemented in one or more computer systems or other processing systems. However, the manipulations performed by the present disclosure were often referred to in terms such as detecting, determining, and the like, which are commonly associated with mental operations performed by a human operator. No such capability of a human operator is necessary, or desirable in most cases, in any of the operations described herein, which form a part of the present disclosure. Rather, the operations are machine operations. Useful machines for performing the operations in the present disclosure may include general-purpose digital computers or similar devices. As such, the functions of the controller 204 can also be applied for execution in the machine 100 regardless of the machine's level of automation, such levels of automation including, but not limited to, an operator assisted mode, a remotely operated mode, a supervised mode, or a fully autonomous mode.

[0033] In accordance with an embodiment of the present disclosure, the present disclosure is directed towards one or more computer systems capable of carrying out the functionality described herein. An example of the computer based system includes the computer system 300, which is shown by way of a block diagram in FIG. 3.

[0034] The computer system 300 includes at least one processor, such as a processor 302. The processor 302 may be connected to a communication infrastructure 304, for example, a communications bus, a cross-over bar, a network, and the like. Various software embodiments are described in terms of this exemplary computer system 300. Upon perusal of the present description, it will become apparent to a person skilled in the relevant art(s) how to implement the present disclosure using other computer systems and/or architectures.

[0035] The computer system 300 includes a display interface 306 that forwards graphics, text, and other data from the communication infrastructure 304 for display on a display unit 308. In an embodiment, the display interface and/or unit 306, 308 could be beneficially embodied in the form of a Graphical User Interface (GUI) or other equivalent devices capable of receiving user commands. Such display interface and/or unit 306, 308 could also be located at a remote operator station (not shown) for facilitating a remotely located operator to perform functions such as, but not limited to, locking the movement of the implement 118 relative to the upper frame 104 and/or locking he movement of the upper frame 104 relative to the lower frame 106.

[0036] The Computer system 300 further includes a main memory 310, such as random access memory (RAM), and may also include a secondary memory 312. The secondary memory 312 may further include, for example, a hard disk drive 314 and/or a removable storage drive 316, representing a floppy disk drive, a magnetic tape drive, an optical disk drive, *etc.* The removable storage drive 316 reads from and/or writes to a removable storage unit 318 in a well-known manner. The removable storage unit 318 may represent a floppy disk, magnetic tape or an optical disk, and may be read by and written to by the removable storage drive 316. As will be appreciated, the removable storage unit 318 includes a computer usable storage medium having stored therein, computer software and/or data.

[0037] In accordance with various embodiments of the present disclosure, the secondary memory 312 may include other similar devices for allowing computer programs or other instructions to be loaded into the computer system 300. Such devices may include, for example, a removable storage unit 320, and an interface 322. Examples of such may include a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an erasable programmable read only memory (EPROM), or programmable read only memory (PROM)) and associated socket, and other removable storage units 320 and interfaces 322, which allow software and data to be transferred from the removable storage unit 320 to the computer system 300.

[0038] The computer system 300 may further include a communication interface 324. The communication interface 324 allows software and data to be transferred between the computer system 300 and one or more ex-

ternal devices 330. Examples of the communication interface 324 include, but may not be limited to a modem, a network interface (such as an Ethernet card), a communications port, a Personal Computer Memory Card International Association (PCMCIA) slot and card, and the like. Software and data transferred via the communication interface 324 may be in the form of a plurality of signals, hereinafter referred to as signals 326, which may be electronic, electromagnetic, optical or other signals capable of being received by the communication interface 324. The signals 326 may be provided to the communication interface 324 via a communication path (*e.g.,* channel) 328. The communication path 328 carries signal 326 and may be implemented using wire or cable, fiber optics, a telephone line, a cellular link, a radio frequency (RF) link and other communication channels.

[0039] In this document, the terms "computer program medium" and "computer usable medium" are used to generally refer to media such as removable storage drive 316, a hard disk installed in hard disk drive 314, signals 326, and the like. These computer program products provide software to the computer system 300. The present disclosure is also directed to such computer program products.

[0040] Computer programs (also referred to as computer control logic) may be stored in the main memory 310 and/or the secondary memory 312. Computer programs may also be received via the communication interface 304. Such computer programs, when executed, enable the computer system 300 to perform the functions consistent with the present disclosure, as discussed herein. In particular, the computer programs, when executed, enable the processor 302 to perform the features of the present disclosure. Accordingly, such computer programs may represent controllers of the computer system 300.

[0041] In accordance with an embodiment of the present disclosure, where the disclosure is implemented using a software, the software may be stored in a computer program product and loaded into the computer system 300 using the removable storage drive 316, the hard disk drive 314 or the communication interface 324. The control logic (software), when executed by the processor 302, causes the processor 302 to perform the functions of the present disclosure as described herein.

[0042] In another embodiment, the control system 200 is implemented primarily in hardware using, for example, hardware components such as application specific integrated circuits (ASIC). Implementation of the hardware state machine so as to perform the functions described herein will be apparent to persons skilled in the relevant art(s). In yet another embodiment, the control system 200 is implemented using a combination of both the hardware and the software.

[0043] FIG. 4 illustrates a method 400 of operation of the control system 200. At step 402, in response to either a first or second user command the controller 204 detects the rotational position of the upper frame 104 relative to the lower frame 106. At step 404, the controller 204 limits the rate of rotational movement of the upper frame 104 as the upper frame 104 approaches a predetermined position relative to the lower frame 106. At step 406, the controller 204 sends appropriate control signals to lock or substantially restrict movement of the upper frame 104 relative to the lower frame 106 when the upper frame 104 is in the predetermined position. If the user command was a first user command, then at step 410, the controller 204 allows operator control of the arm assembly 112. Alternatively, if the user command was a second user command, then at step 408, the controller 204 send appropriate control signals to lock or substantially restrict movement of the arm assembly 112.

[0044] Various embodiments disclosed herein are to be taken in the illustrative and explanatory sense, and should in no way be construed as limiting of the present disclosure. All numerical terms, such as, but not limited to, "first", "second", "third", or any other ordinary and/or numerical terms, should also be taken only as identifiers, to assist the reader's understanding of the various embodiments, variations, components, and/or modifications of the present disclosure, and may not create any limitations, particularly as to the order, or preference, of any embodiment, variation, component and/or modification relative to, or over, another embodiment, variation, component and/or modification.

[0045] It is to be understood that individual features shown or described for one embodiment may be combined with individual features shown or described for another embodiment. The above described implementation does not in any way limit the scope of the present disclosure. Therefore, it is to be understood although some features are shown or described to illustrate the use of the present disclosure in the context of functional segments, such features may be omitted from the scope of the present disclosure without departing from the spirit of the present disclosure as defined in the appended claims.

Industrial Applicability

[0046] The present disclosure provides the control system 200 and the method 400 by which a movement of the upper frame 104 and the arm assembly 112 may be controlled independently of one another. Based on a type of user command received at the swing control button 206 from the operator, the controller 204 may continue to allow movement of the arm assembly 112 while the upper frame 104 of the machine 100 is locked or may send appropriate control signals to prevent or substantially restrict the movement of the arm assembly 112 while the upper frame 104 of the machine 100 is locked. Further, the controller 204 sends appropriate control signals to limit the rate of rotation of the upper frame 104 as the upper frame 104 approaches the predetermined position in order to allow the hydraulic swing lock 208 to engage successfully and also to reduce any vibrations that may

otherwise occur if the hydraulic swing lock 208 had been engaged to arrest the movement of the upper frame 104 at higher rotation speeds when the upper frame 104 reaches its predetermined position. The control system and method disclosed herein is applicable to work machines such as those described herein to provide superior operator control of the machine.

[0047] While aspects of the present disclosure have been particularly shown and described with reference to the embodiments above, it will be understood by those skilled in the art that various additional embodiments may be contemplated by the modification of the disclosed machines, systems and methods without departing from the spirit and scope of the disclosure. Such embodiments should be understood to fall within the scope of the present disclosure as determined based upon the claims and any equivalents thereof.

Claims

1. A control system for a work machine having an upper frame rotatably mounted to a lower frame, the upper frame including an arm assembly, the control system comprising:

a controller responsive to a first user command to send appropriate control signals to lock or substantially restrict movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

2. The control system of claim 1 further comprising:

a sensor that detects the rotational position of the upper frame relative to the lower frame;
the controller configured to send appropriate control signals to lock or substantially restrict movement of the upper frame relative to the lower frame when the sensor detects the upper frame is in a predetermined position relative to the lower frame.

3. The control system of claim 2, wherein:

the controller sends appropriate control signals to limit the rate of rotational movement of the upper frame as it approaches the predetermined position.

4. The control system of any preceding claim, wherein:

the controller is responsive to a second user command to send appropriate control signals to lock or substantially restrict movement of the upper frame relative to the lower frame and to send appropriate control signals to lock or substantially restrict movement of the arm assembly.

5. The control system of any preceding claim, further comprising:

a lock status indicator;
the controller configured to send appropriate control signals to said lock status indicator to indicate whether movement of the upper frame is locked.

6. The control system of any preceding claim, wherein:

the controller stores in non-volatile memory a status of whether movement of the upper frame or arm assembly is locked.

7. A work machine, comprising:

an upper frame rotatably mounted to a lower frame;
an arm assembly provided on the upper frame;
a controller operable to lock or substantially restrict movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

8. A method for controlling a work machine having an upper frame rotatably mounted to a lower frame, the upper frame including an arm assembly, the method comprising:

locking or substantially restricting movement of the upper frame relative to the lower frame while allowing user control of the arm assembly.

9. The method of claim 8, further comprising:

detecting a rotational position of the upper frame relative to the lower frame; and
locking or substantially restricting movement of the upper frame relative to the lower frame when the upper frame is in a predetermined position relative to the lower frame.

10. The method of claim 9, further comprising:

limiting the rate of rotational movement of the upper frame as it approaches the predetermined position.

11. A method for controlling a work machine having an upper frame rotatably mounted to a lower frame, the method comprising:

detecting a rotational position of the upper frame relative to the lower frame;
locking or substantially restricting movement of the upper frame relative to the lower frame when the upper frame is in a predetermined position

relative to the lower frame; and
limiting the rate of rotational movement of the upper frame as it approaches the predetermined position.

12. A non-transient computer readable medium containing program instructions for causing a computer to perform the method of claim 8.

13. A non-transient computer readable medium containing program instructions for causing a computer to perform the method of claim 11.

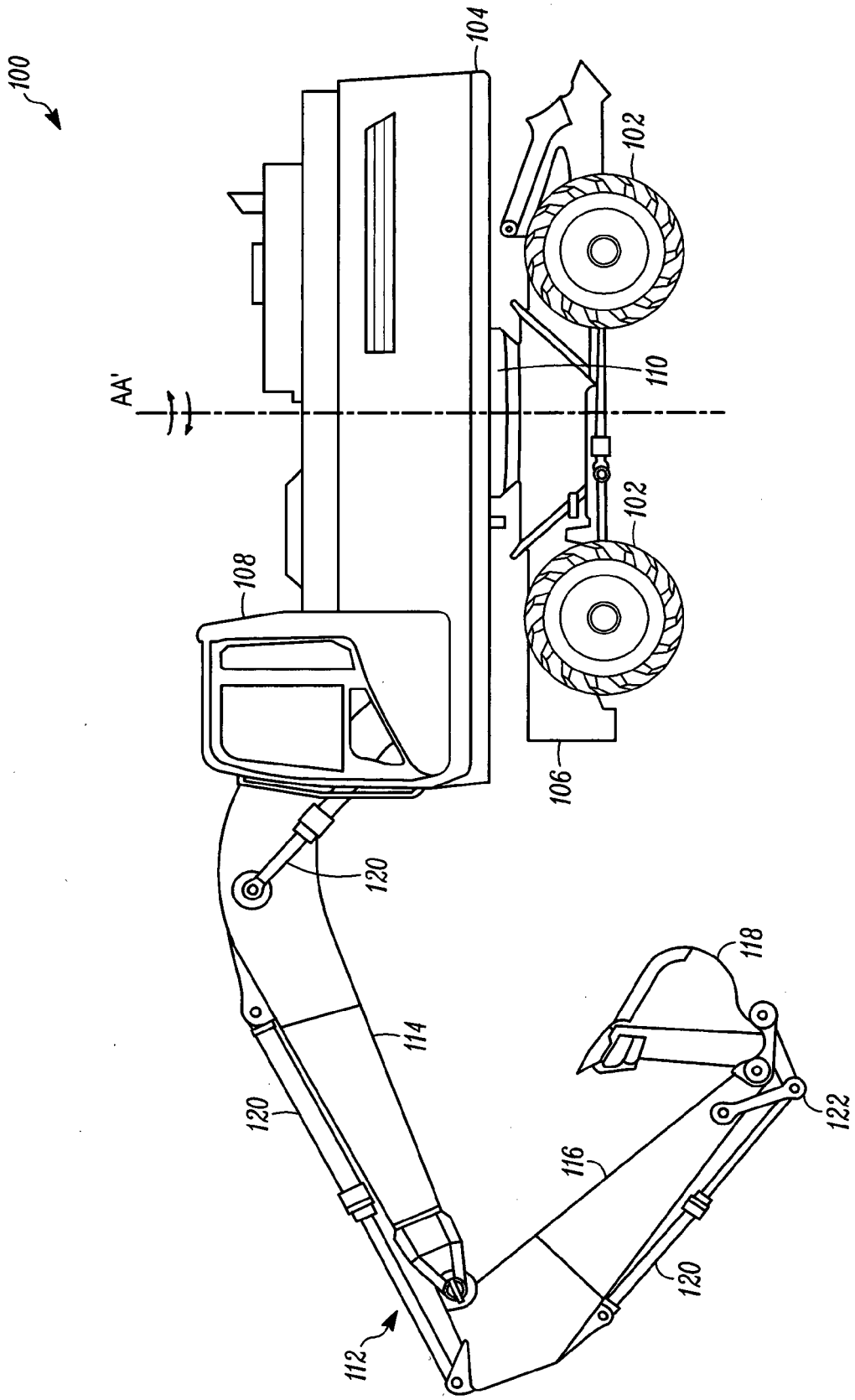

FIG. 1

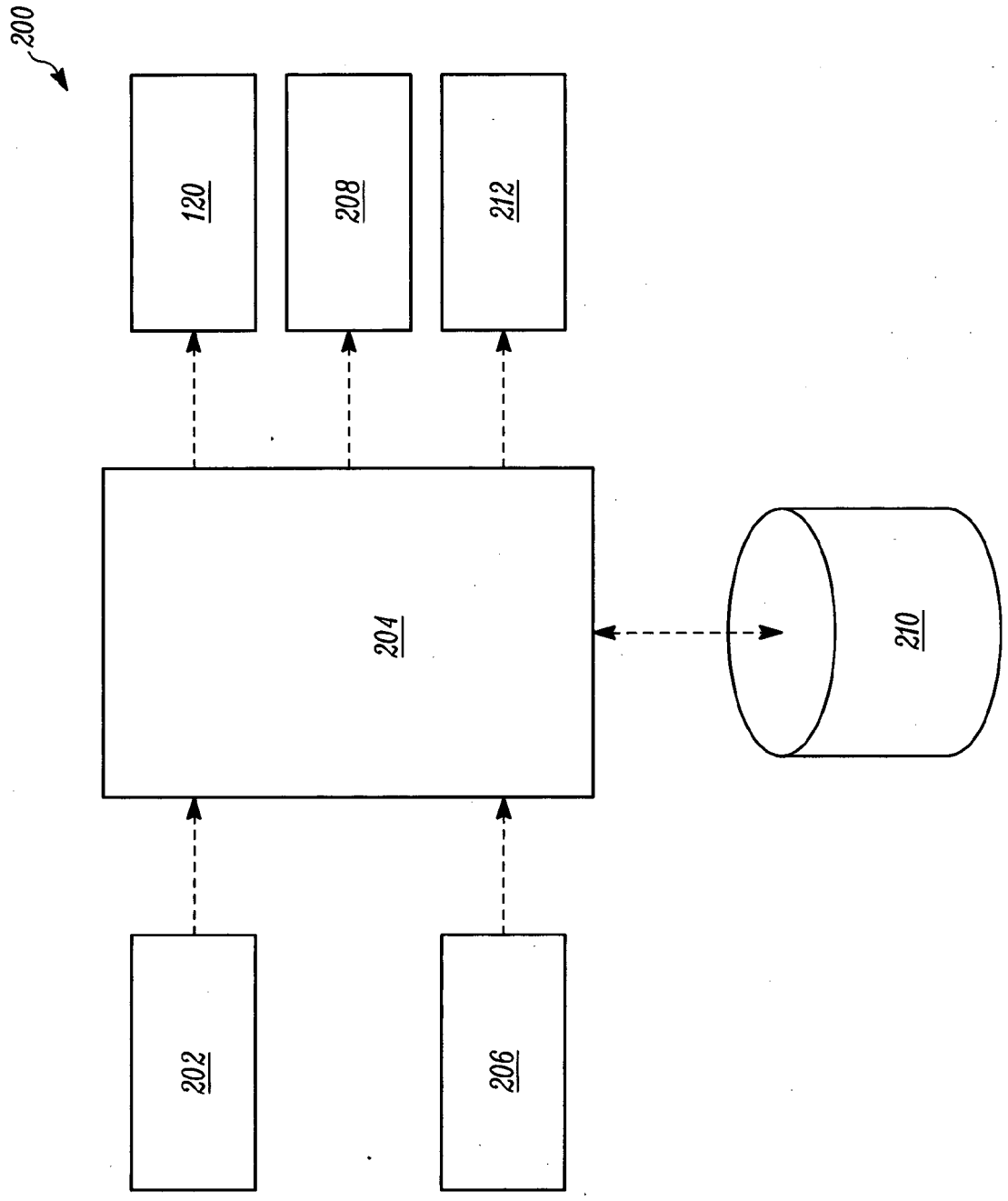

FIG. 2

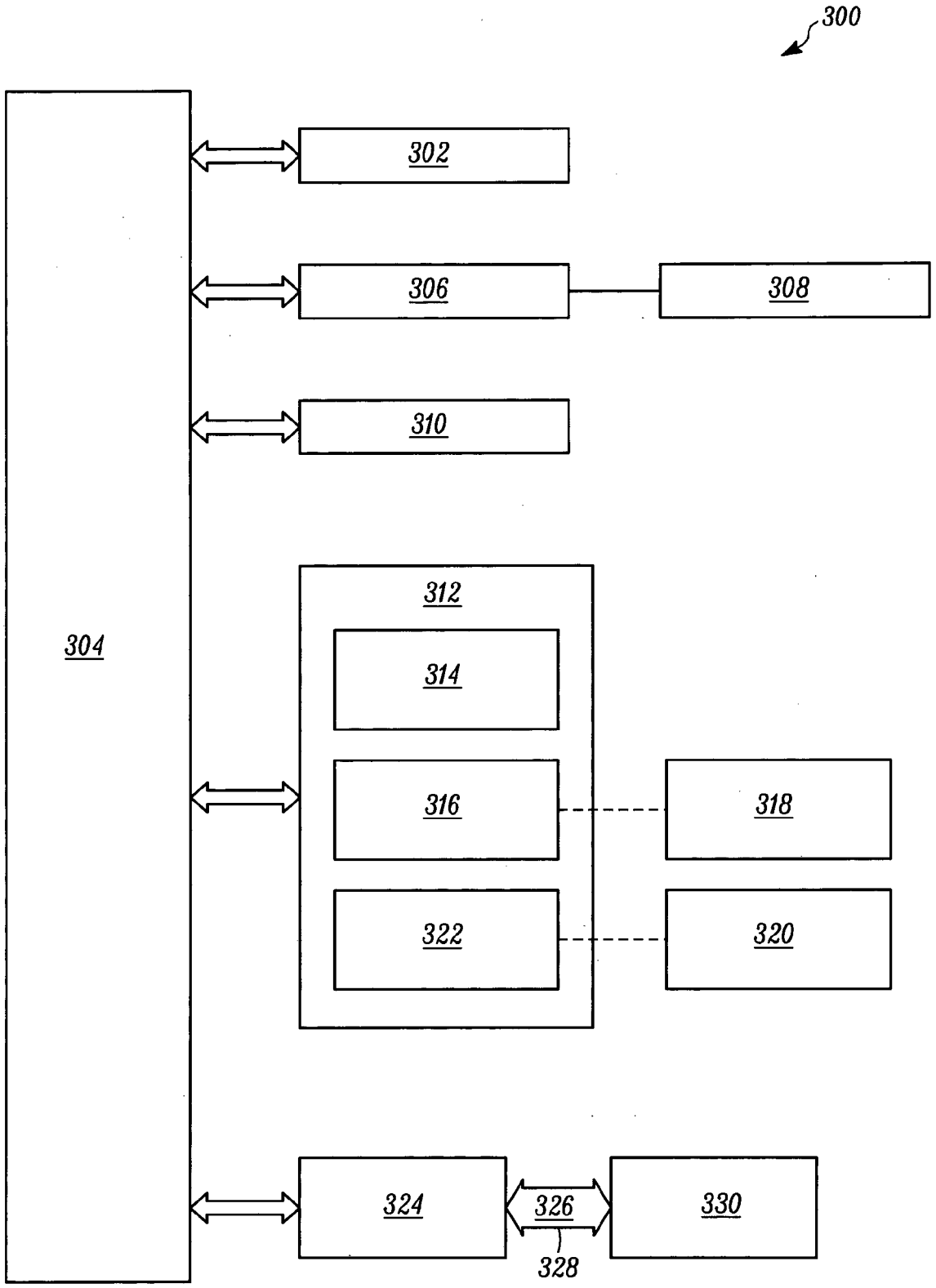

FIG. 3

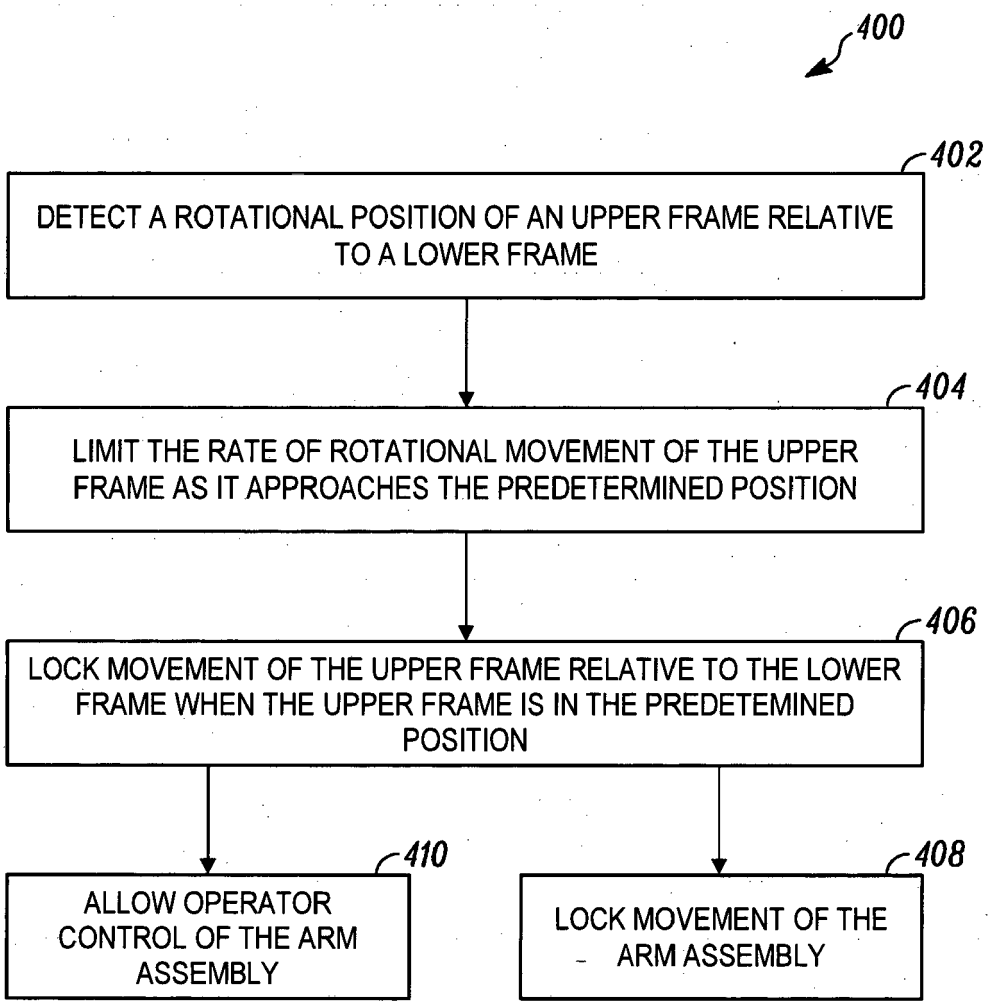
400
402
DETECT A ROTATIONAL POSITION OF AN UPPER FRAME RELATIVE TO A LOWER FRAME
404
LIMIT THE RATE OF ROTATIONAL MOVEMENT OF THE UPPER FRAME AS IT APPROACHES THE PREDETERMINED POSITION
406
LOCK MOVEMENT OF THE UPPER FRAME RELATIVE TO THE LOWER FRAME WHEN THE UPPER FRAME IS IN THE PREDETEMINED POSITION
410
ALLOW OPERATOR CONTROL OF THE ARM ASSEMBLY
408
LOCK MOVEMENT OF THE ARM ASSEMBLY

FIG. 4

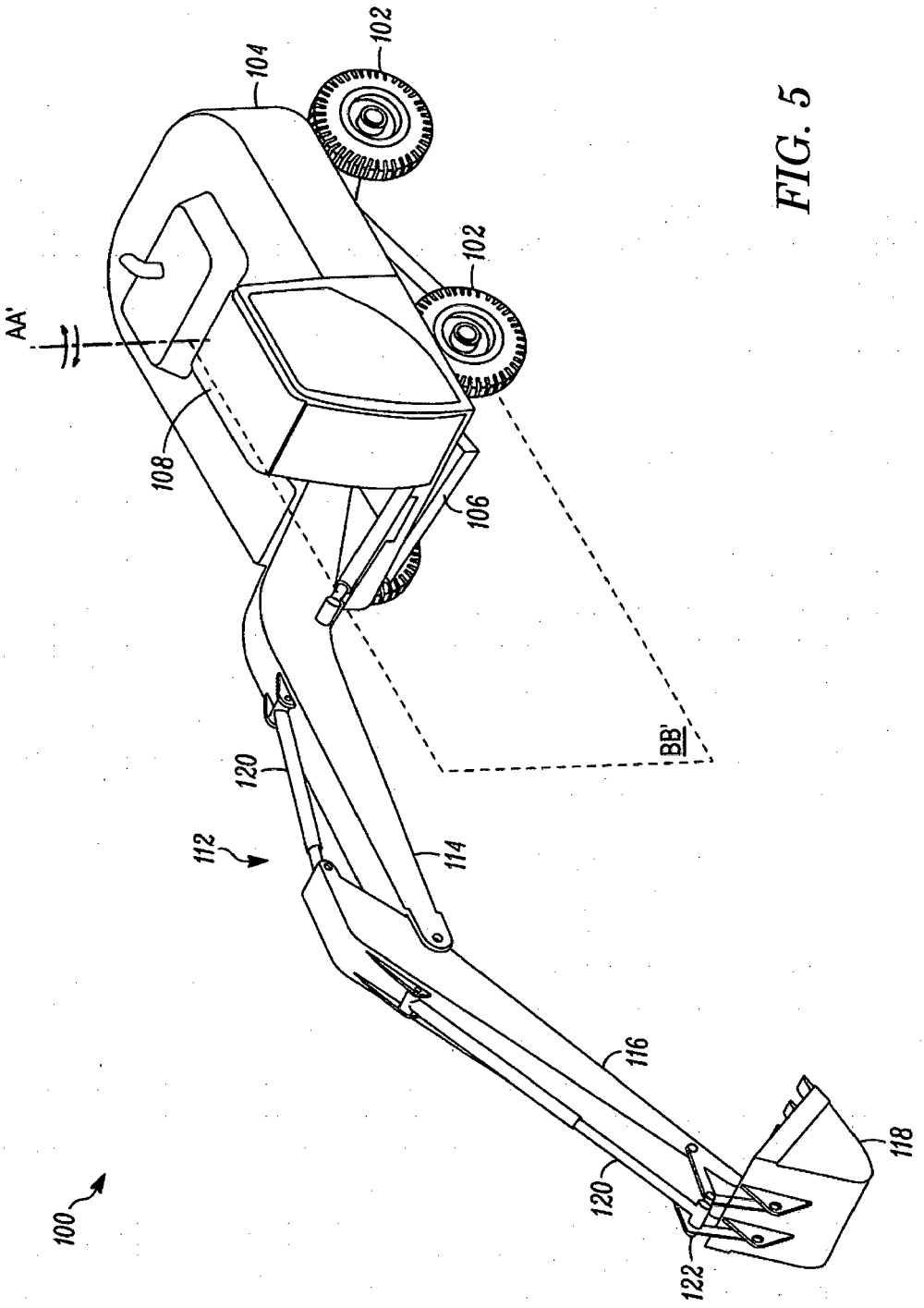

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7730646 B **[0003]**