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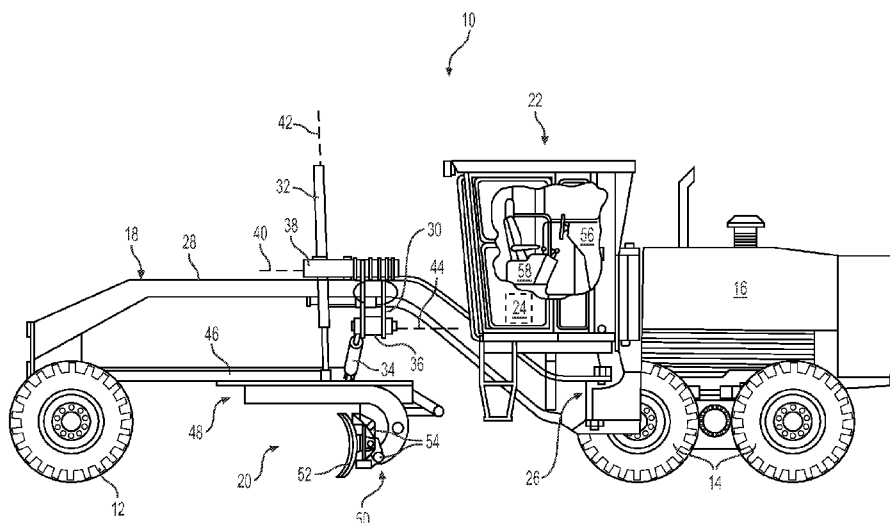


FIG. 1

(57) Abstract: A diagnostic system for a motor grader (10) with a blade (52), a drawbar member (46), and a center shift mounting member (30) associated with a drawbar-circle-moldboard (DCM) (20) includes actuators connecting the blade to the DCM and inter-connecting other components of the motor grader. The actuators affect movement of the blade relative to the DCM and affect movement of the other interconnected components relative to each other. Sensors generate signals indicative of a current position of the blade and positions of the other components of the motor grader. An input device receives an operator input indicative of a selection of predefined, diagnostic positions that can be checked visually by the operator for confirmation of proper operation. A controller (66, 74) selectively actuates the actuators based on the selection of a diagnostic position and a signal indicative of the current position of the blade to move the blade and other components of the motor grader into the selected diagnostic position.

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Description

BLADE POSITIONING DIAGNOSTIC SYSTEM FOR MOTOR GRADER

Technical Field

5 The present disclosure is directed to a blade positioning diagnostic system, and more particularly, to a blade positioning diagnostic system for a motor grader.

Background

10 Motor graders are used primarily as finishing tools to sculpt a surface of a construction site to a final shape and contour. Typically, motor graders include many hand-operated controls to steer the wheels of the grader, position a blade, and articulate the front frame of the grader. The blade is adjustably mounted to the front frame to move relatively small quantities of earth from side to side. In addition, the articulation of the front frame is adjusted by rotating the front frame of the grader relative to the rear frame of the grader.

15 To produce a final surface contour, the blade and the frame may be adjusted to many different positions. Positioning the blade of a motor grader can be a complex and time-consuming task. In particular, operations such as, for example, controlling surface elevations, angles, and cut depths may require a significant portion of the operator's attention. Such demands placed on the operator may cause other tasks necessary for the operation of the motor grader to be neglected. Frequently, an operator will desire one or more unique blade positions. However, due to the geometry of the motor grader, some adjustments of the blade position may lead to collisions of the blade with parts of the motor grader or unwanted contact with the ground. Such collisions may damage the blade, motor grader, or both. Furthermore, any unwanted contact with the ground may produce unwanted surface shapes and contours that may need to be corrected.

U.S. Patent No. 6,028,524 issued to Hartman et al. (Hartman) on February 22, 2000 discloses a motor grader, which includes a system for

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preventing the blade from contacting the front frame and/or the tires of the motor grader. The system in Hartman includes an electronic controller, blade controls having position sensors, and frame controls having position sensors. The controller monitors the output of the position sensors to ascertain the position of the blade and frame controls. When the blade and frame controls receive input signals requesting a repositioning of the blade or frame, the controller determines the present positions of the blade and frame. The controller then calculates future blade and frame positions based on the repositioning request. After calculating the future blade and frame positions, the controller predicts whether an intersection of the future blade position and future frame position will occur. If an intersection of positions is imminent, the controller will either produce a warning signal to the operator or cancel the repositioning request.

Although the system in Hartman may prevent the blade from colliding with the front frame and/or tires of the motor grader, the operator is still left to determine an alternate path for the blade to reach the desired position. Due to the complex geometry of the terrain and motor grader, safely repositioning the blade may be a prohibitively difficult and time-consuming task for an operator to perform. Furthermore, planning a new blade path may place such a demand on the operator, that other tasks necessary for the operation of the motor grader may be neglected. Additionally, the system in Hartman does not provide any means for an operator to readily perform diagnostics to compare whether the operator inputs are resulting in the blade of the motor grader or other components of the motor grader being moved to the expected positions, confirming that all of the various sensors, actuators, and linkages are working properly.

The disclosed system of the present disclosure solves one or more of the problems set forth above and/or other problems in the art.

Summary

In one aspect, the present disclosure is directed to a motor grader diagnostic mode and automatic positioning control system for a blade and other components of the motor grader. The diagnostic mode and automatic positioning

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control system includes one or more actuators connecting the blade to a drawbar-circle-moldboard and interconnecting other components of the motor grader. The one or more actuators are configured to affect movement of the blade relative to the drawbar-circle-moldboard, or affect movement of the other interconnected

5 components relative to each other, and one or more sensors are configured to generate signals indicative of a current position of the blade. The diagnostic mode and automatic positioning control system may include an input device configured to receive an operator input indicative of a selection of one of a plurality of predefined, diagnostic blade positions that can be checked visually by

10 the operator for confirmation of proper operation of the motor grader. The diagnostic mode and automatic positioning control system may further include a controller configured to selectively actuate the one or more actuators based on the selection and the signals to move one or more of the blade and other components of the motor grader into the selected diagnostic position.

15 In another aspect, the present disclosure is directed to a motor grader. The motor grader may include a power source, at least one traction device, a frame, a drawbar-circle-moldboard supported by the frame, and a blade pivotally connectable to the drawbar-circle-moldboard. The motor grader may also include one or more actuators connecting the blade to the drawbar-circle-

20 moldboard and configured to affect movement of the blade relative to the drawbar-circle-moldboard, and interconnecting other components of the motor grader, and one or more sensors configured to generate signals indicative of a current position of the blade and relative positions of the other components of the motor grader. The motor grader may still further include a motor grader

25 diagnostic mode and automatic positioning control system for the blade and the other components of the motor grader. The diagnostic mode and automatic positioning control system may include an input device configured to receive an operator input indicative of a selection of one of a plurality of predefined, diagnostic blade positions that can be checked visually by the operator for

30 confirmation of proper operation of the motor grader. The diagnostic mode and automatic positioning control system may further include a controller configured

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to selectively actuate the one or more actuators based on the selection and the signals to move one or more of the blade and other components of the motor grader into the selected diagnostic position.

5 In another aspect, the present disclosure is directed to a method for positioning a blade associated with a drawbar-circle-moldboard of a motor grader according to a selected diagnostic mode. The method may include sensing a current position of the blade using signals generated by one or more sensors. The method may also include receiving a first operator input at a user interface display operatively associated with a diagnostic mode and automatic positioning
10 control system, the input being indicative of a desire to diagnose any issues with the sensors or the control system via one or more of a visual comparison of a plurality of predefined blade positions to referenced points, or a comparison of measured distances between motor grader components and expected distances between the motor grader components.

15 Brief Description of the Drawings

Fig. 1 is a pictorial illustration of an exemplary disclosed motor grader;

Fig. 2 is a schematic illustration of an exemplary disclosed blade positioning system that may be used in conjunction with the motor grader of Fig. 1; and
20

Fig. 3 is a table depicting exemplary motor grader blade preset positions that may be performed by the blade positioning system of Fig. 2.

Detailed Description

Fig. 1 illustrates an exemplary machine 10. In the disclosed
25 embodiment, machine 10 may embody a motor grader. However, in other embodiments, machine 10 may embody an excavator, a backhoe loader, an agricultural tractor, a wheel loader, a skid-steer loader, or any other type of machine known in the art. Machine 10 may include a steerable traction device 12, a driven traction device 14, a power source 16 supported by driven traction

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device 14, and a frame 18 connecting steerable traction device 12 to driven traction device 14. Machine 10 may also include a work implement such as, for example, a drawbar-circle-moldboard assembly (DCM) 20, an operator station 22, and a blade positioning system 24.

5 Both steerable and driven traction devices 12, 14 may include one or more wheels located on each side of machine 10 (only one side shown). The wheels may be rotatable and/or tiltable for use during steering and leveling of a work surface. Alternatively, steerable and/or driven traction devices 12, 14 may include tracks, belts, or other traction devices known in the art. It is
10 contemplated that, in some embodiments, steerable traction devices 12 may also be driven, while driven traction device 14 may also be steerable. Frame 18 may connect steerable traction device 12 to driven traction device 14 by way of, for example, an articulation joint 26. Furthermore, machine 10 may be caused to articulate steerable traction device 12 relative to driven traction device 14 via
15 articulation joint 26.

Power source 16 may include an engine connected to a transmission. The engine may be, for example, a diesel engine, a gasoline engine, a natural gas engine, or any other engine known in the art. Power source
16 may also be a non-combustion source of power such as a fuel cell, a power
20 storage device, or another source of power known in the art. The transmission may be an electric transmission, a hydraulic transmission, a mechanical transmission, or any other transmission known in the art. The transmission may be operable to produce multiple output speed ratios and may be configured to transfer power from power source 16 to driven traction device 14 at a range of
25 output speeds.

Frame 18 may include an articulation joint 26 that connects driven traction device 14 to frame 18. Machine 10 may be caused to articulate steerable traction device 12 relative to driven traction device 14 via articulation joint 26. Machine 10 may also include a neutral articulation feature that, when activated,
30 causes automatic realignment of steerable traction device 12 relative to driven

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traction device 14 to cause articulation joint 26 to return to a neutral articulation position.

Frame 18 may also include a beam member 28 that supports a fixedly connected center shift mounting member 30. Beam member 28 may be, for example, a single formed or assembled beam having a substantially hollow square cross-section. The substantially hollow square cross-section may provide frame 18 with a substantially high moment of inertia required to adequately support DCM 20 and center shift mounting member 30. The cross-section of beam member 28 may alternatively be rectangular, round, triangular, or any other appropriate shape.

Center shift mounting member 30 may support a pair of double acting hydraulic rams 32 (only one shown) for affecting vertical movement of DCM 20, a center shift cylinder 34 for affecting horizontal movement of DCM 20, and a link bar 36 adjustable between a plurality of positions. Center shift mounting member 30 may be welded or otherwise fixedly connected to beam member 28 to indirectly support hydraulic rams 32 by way of a pair of bell cranks 38, also known as lift arms. That is, bell cranks 38 may be pivotally connected to center shift mounting member 30 along a horizontal axis 40, while hydraulic rams 32 may be pivotally connected to bell cranks 38 along a vertical axis 42. Each bell crank 38 may further be pivotally connected to link bar 36 along a horizontal axis 44. Center shift cylinder 34 may be similarly pivotally connected to link bar 36.

DCM 20 may include a drawbar member 46 supported by beam member 28 and a ball and socket joint (not shown) located proximal steerable traction device 12. As hydraulic rams 32 and/or center shift cylinder 34 are actuated, DCM 20 may pivot about the ball and socket joint. A circle assembly 48 may be connected to drawbar member 46 via a motor (not shown) to drivingly support a moldboard assembly 50 having a blade 52 and blade positioning cylinders 54. In addition to DCM 20 being both vertically and horizontally positioned relative to beam member 28, DCM 20 may also be controlled to rotate circle and moldboard assemblies 48, 50 relative to drawbar member 46. Blade 52

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may be moveable both horizontally and vertically, and oriented relative to circle assembly 48 via blade positioning cylinders 54.

Operator station 22 may embody an area of machine 10 configured to house an operator. Operator station 22 may include a dashboard 56
5 and an instrument panel 58 containing dials and/or controls for conveying information and for operating machine 10 and its various components.

As shown in Fig. 2, dashboard 56 may include a display system 60, and instrumental panel 58 may include a user interface 62. Display system 60 and user interface 62 may be in communication with blade positioning system 24.
10 Display system 60 may include a computer monitor with an audio speaker, video screen, and/or any other suitable visual display device that conveys information to the operator. For example, in one embodiment, display system 60 may be configured to display a plurality of predefined blade position preset modes and illustrate a selection of one of the plurality of predefined blade positions and
15 other machine configuration characteristics. User interface 62 may include a keyboard, a touch screen, a number pad, a joystick, or any other suitable input device. In one exemplary embodiment, user interface 62 embodies a joystick. Fig. 3 illustrates 5 exemplary blade position preset modes with factory default descriptions that may be displayed to an operator by display system 60. User
20 interface 62 may include touch screen capabilities, such as touch-activated drop-down menus with additional command choices or information, at some or all of the locations in the rows and columns having the various descriptions and illustrations included on display system 60.

In one exemplary embodiment, such as shown in Fig. 3, the
25 default blade position preset modes may include a “DIAGNOSTIC” mode (shown at the far right of display system 60 – but may be located at other positions on the display), in which an operator may command the automatic blade positioning system to automatically move blade 52 and/or other components of machine 10 to one or more predetermined positions relative to other components
30 of machine 10. The positions may be predetermined to correspond to locations or configurations of the blade or other components of machine 10 at which the

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operator, who may be located in operator station 22, or at other positions – such as standing near the machine when operating the machine semi-autonomously, can verify through a visual comparison to one or more reference points that sensors and controls used in operating machine 10 are performing properly or as expected. For example, a selection of a first diagnostic position on user interface 62 of display system 60, such as by touching one of a number of selections that appear in a drop-down menu in one of the rows in the column labeled “DIAGNOSTIC” in Fig. 3, may result in drawbar member 46 moving to a centered position relative to one or more reference points easily observable by the operator from a seat in operator station 22. As a result, an operator may simply select the desired diagnostic mode by touching a desired selection from a drop-down menu on user interface 62, and the blade positioning system 24 may be configured to then automatically move drawbar member 46, center shift mounting member 30, and blade 52 to a centered position that can be verified visually by the operator relative to one or more reference points. Additionally, blade positioning system 24 may be configured such that a selected diagnostic position may result in a number of other observable parameters being met, including, but not limited to: DCM 20 assuming a zero (0) degree orientation relative to frame 18, a pitch of machine 10 being set such that a neutral top of blade 52 is even with a cutting edge of blade 52, articulation of machine 10 being straight with steerable traction device 12 being automatically realigned relative to driven traction device 14 to cause articulation joint 26 to be set to a neutral articulation position, wheel lean being set such that wheels of steerable and driven traction devices 12, 14 are oriented vertically, and/or other configurations of blade 52 and other machine components.

Blade positioning system 24 may be configured to move blade 52 to a predetermined position in response to input signals received from user interface 62 of display system 60. Blade positioning system 24 may include one or more sensors 64 and a controller 66, 74. Sensors 64 may include, for example, cylinder position sensors, an articulation sensor, a link bar sensor, and/or a grade detector. It is contemplated that blade positioning system 24 may include other

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sensors known in the art, if desired. The cylinder position sensors may sense the extension and retraction of hydraulic rams 32, center shift cylinder 34, and/or blade positioning cylinders 54. The articulation sensor may sense the movement and relative position of articulation joint 26 and may be operatively coupled with articulation joint 26. The link bar sensor may sense the rotational angle of bell cranks 38 about horizontal axis 40. The grade detector may be a dual axis inclinometer associated with machine 10 and may continuously detect an inclination of machine 10 with respect to true horizontal. The extension and retraction of the cylinders and/or the movement of articulation joint 26 may be compared with reference look-up maps and/or tables stored in the memory of controller 66, 74 to determine the position and orientation of blade 52 and/or the articulation of joint 26. Additionally, when in a diagnostic mode, as discussed above, an operator may be able to verify proper operation of the various sensors and actuators, including hydraulic cylinders, by visual comparisons to predetermined reference points and/or by a simple comparison of a measured length of a cylinder in the diagnostic mode to an expected length.

In one embodiment, sensors 64 may provide signals indicative of a cross-slope inclination of blade 52. The cross-slope inclination of blade 52 may be defined as an inclination in a direction transverse to a path (“cross-slope”) along which machine 10 travels. In some embodiments, the cross-slope inclination of blade 52 may be represented as a percentage, while, in other embodiments, the cross-slope inclination of blade 52 may be represented as an angle. Blade positioning system 24 may be configured to receive signals from various sensors associated with blade 52 and other components of machine 10, and automatically initiate operation of various actuators to change positions, orientations, and/or operative configurations of blade 52, linkages, and other components of machine 10, including, but not limited to, blade pitch, blade rotation, blade sideshift, circle sideshift, blade lift, blade tilt, wheel lean, chassis articulation, and linkbar positions. The operations performed by blade positioning system 24 support any of the desired work modes or diagnostic mode. Regardless of any current linkage position, blade positioning system 24 may be

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configured to ensure that blade 52 and other components of machine 10 will move to and between various desired orientations and configurations while preventing any collisions between blade 52 and other machine components.

Articulation sensor 70 may sense the movement and relative
5 position of articulation joint 26 and may be operatively coupled with articulation joint 26. Some examples of suitable articulation sensors 70 include, among others, length potentiometers, radio frequency resonance sensors, rotary potentiometers, machine articulation angle sensors and the like. The movement of articulation joint 26 may be compared with reference look-up maps and/or
10 tables stored in the memory of controller 66, 74 to determine the articulation of machine 10.

Proximity sensor 72 may detect the distance between the ground and blade 52. Proximity sensor 72 may be located anywhere along the bottom edge of blade 52. Alternatively, proximity sensor 72 may be located anywhere
15 on frame 18, which may allow detection of the distance between the ground and blade 52. In addition, proximity sensor 72 may be an ultrasonic sensor, a radar sensor, an optical sensor, or any other type of sensor capable of detecting the location of the surface of the ground in relation to the bottom edge of blade 52.

Controller 66, 74 may actuate hydraulic rams 32, 34 and blade
20 positioning cylinders 54 to move blade 52 to a desired position and may embody a single microprocessor or multiple microprocessors that include a means for positioning blade 52. Numerous commercially available microprocessors can be configured to perform the functions of controller 66, 74. It should be appreciated that controller 66, 74 could readily embody a general machine microprocessor
25 capable of controlling numerous machine functions. Controller 66, 74 may include a memory, a secondary storage device, a processor, and any other components for running an application. Various other circuits may be associated with controller 66, 74 such as power supply circuitry, signal conditioning circuitry, solenoid driver circuitry, and other types of circuitry.

30 Controller 66, 74 may operate in a manual mode, semi-autonomous mode, or fully automatic mode, and may actuate hydraulic rams 32,

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34, and blade positioning cylinders 54 in response to signals received from user interface 62 and/or 66. Such signals may be generated when an operator interacts with user interfaces 62 and/or 66 to move blade 52 to a desired position. When moving blade 52 to a desired position in the manual mode, the operator may
5 choose to store the final position and orientation of blade 52 in the memory of controller 66, 74. The position and orientation may be stored by actuating a device associated with user interface 62 such as, for example, a button or keypad to generate signals, which may cause controller 66, 74 to store the position and orientation.

10 Controller 66, 74 may also be configured to operate in an automatic mode when the operator actuates a device associated with user interface 62 such as, for example, a button or keypad instructing controller 66, 74 to move blade 52 to the stored position and orientation. The stored position and orientation may be utilized by controller 66, 74 together with a current position
15 and orientation when operating in the automatic mode to create a travel path for moving blade 52. While operating in the automatic mode, controller 66, 74 may move blade 52 by actuating hydraulic rams 32, 34, and blade positioning cylinders 54 in response to signals received from cylinder position sensors 68, articulation sensor 70, and proximity sensor 72. The diagnostic mode discussed
20 above may include display of one or more operator selectable buttons in a drop-down menu that result in controller 66, 74 moving blade 52 to a centered and neutral position that can be verified by the operator through a visual comparison of the position of the blade with one or more reference points or through a comparison of a measured length or extension of one or more hydraulic cylinders
25 to a reference length or lengths.

Controller 66, 74 may monitor the movement of blade 52 in both the manual and automatic modes to determine whether a collision between blade 52 and a component of machine 10 or another obstacle is imminent. If an imminent collision with an obstacle is detected while controller 66, 74 is
30 operating in the manual mode, controller 66, 74 may override the set of input signals from user interface 62 and/or 66 that direct blade 52 in the direction of the

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obstacle, preventing the operator from directing blade 52 further toward the obstacle. If an imminent collision with the obstacle is detected while controller 66, 74 is operating in the automatic mode, controller 66, 74 may modify the blade travel path and redirect blade 52 away from the obstacle.

5 The monitoring of the blade movement and imminent collision detection may be performed by first creating a real-time mathematical model of machine 10, such as, for example, a wire-frame model. A wire-frame model may include a stationary element having mathematical representations of various components of machine 10 such as, for example, steerable traction devices 12,
10 driven traction devices 14, DCM 20, and a rear frame portion 80. Controller 66, 74 may create the component representations from data stored in the memory of controller 66, 74. Such stored data may include the location of various data points defining a geometry, location, and orientation of each component relative to an origin of a three-dimensional global coordinate system. It is contemplated
15 that data received from articulation sensor 70 may be used in conjunction with the stored data to create the component representations, if desired. The three-dimensional global coordinate system may originate at a location adjacent to the ground and equidistant from the center of all driven traction devices 14. The X and Z axes may generally be transverse and aligned with a forward traveling
20 direction of machine 10, respectively. A plane defined by the X and Z axes may generally be parallel to the surface of the ground. Furthermore, the Y axis may generally be normal to the ground.

 Controller 66, 74 may be configured to define safety zones around blade 52 or other machine components to detect imminent collisions between
25 blade 52 and other portions of machine 10 or other potential obstacles. Controller 66, 74 may also be configured to determine that a collision is imminent when an obstacle, such as another portion of machine 10, enters the volume defined by the safety zone around blade 52. In an exemplary embodiment, controller 66, 74 may be configured to define unit vectors that
30 indicate the orientation of blade 52 relative to a global coordinate system. Controller 66, 74, while operating in an automatic mode, may be configured to

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use the position and orientation data of a current position and a previously stored target position of blade 52 as expressed in the global coordinate system to create a travel path for blade 52. The travel path may be constructed in such a way that any point at a starting position of blade 52 may be connected by a straight line, or
5 other more complicated travel paths, to a corresponding point at a target position. Controller 66, 74 may be still further configured to reference signals received from cylinder position sensors 68 and update the position and orientation data of blade 52 in the wire-frame model. The updates may occur at regularly space intervals of time.

10 As shown in Fig. 2, user interface 62 may include one or more buttons (not shown) configured to receive operator input indicative of one or more desired blade operations. For example, user interface 62 may include a first button, a second button, and a third button. The first button may be configured to receive operator input indicative of a desire to store a target position of blade 52
15 as one of a plurality of predefined blade positions stored in a memory of controller 66, 74. In addition, the first button may also be configured to receive operator input indicative of a selection of one of the plurality of predefined blade positions. The second button may be configured to receive operator input indicative of a desire to cause the extension and retraction of hydraulic rams 32,
20 center shift cylinder 34, and/or blade positioning cylinders 54 to move blade 52 to a corresponding selected blade position. It should be noted that hydraulic rams 32, center shift cylinder 34, and/or blade positioning cylinders 54 may not be actuated to move blade 52 to a desired position and orientation, until the second button has been engaged (i.e., engaging the first button alone will not cause
25 movement of blade 52). The third button may be configured to receive operator input indicative of a predetermined incremental adjustment of the position of blade 52. For example, the predetermined incremental adjustment of the position of blade 52 may be an increase or a decrease in a predetermined percentage or angle of cross-slope inclination of blade 52.

30 In an exemplary disclosed embodiment, the first, second, and third buttons may be positioned on user interface 62 in a manner to facilitate the

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operator's access to each button. In particular, all three buttons may be grouped together, such that a single finger of the operator can reach each button without requiring significant movement of the operator's hand. The close proximity of all three buttons on user interface 62 may improve ergonomics and operator
5 comfortability as well as reduce a response time by the operator.

Controller 66, 74 may embody a single microprocessor or multiple microprocessors configured to actuate hydraulic rams 32, center shift cylinder 34, and/or blade positioning cylinders 54 to move blade 52 to a desired position and orientation based on received operator input. Numerous commercially available
10 microprocessors can be configured to perform the functions of controller 66, 74. It should be appreciated that controller 66, 74 could readily embody a general machine microprocessor capable of controlling numerous machine functions. Controller 66, 74 may include a memory, a secondary storage device, a processor, and any other components for running an application. In the disclosed
15 embodiment, the memory may store the plurality of predefined blade positions. Various other circuits may be associated with controller 66, 74 such as power supply circuitry, signal conditioning circuitry, solenoid driver circuitry, and other types of circuitry.

In some embodiments, controller 66, 74 may be configured to
20 store or select a target position of blade 52 in response to a predetermined threshold associated with the operator's interaction with user interface 62. For example, if the first button on user interface 62, referenced above, is engaged by the operator for a predetermined period of time, controller 66, 74 may store the target position of blade 52 as one of the plurality of predefined blade positions.
25 However, if the first button is engaged by the operator for less than the predetermined period of time, controller 66, 74 may instead select one of the plurality of predefined blade positions.

Industrial Applicability

The disclosed system may be implemented into any machine
30 operation requiring automated control of a work implement. The disclosed

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system may simplify operator control by allowing the operator to select and store a plurality of predefined blade positions in a memory. In addition, the disclosed system may implement multiple functions into a single button, thereby further simplifying operator control. Furthermore, the disclosed system may delay
5 movement of the blade until the operator indicates a desired to move the blade to a selected position.

Referring to Figs. 2 and 3, a diagnostic method according to an embodiment of this disclosure may begin by receiving one or more operator inputs via user interface 62 (e.g., touchscreen activations). For example, the
10 operator may engage one or more of the buttons included on user interface 62, causing signals to be transmitted to controller 66, 74. Controller 66, 74 may receive and process the signals to determine a blade operation based on the received operator input.

Controller 66, 74 may determine whether the first button on user
15 interface 62 is engaged based on the received operator input. If the first button is engaged, then controller 66, 74 may determine whether a predetermined threshold associated with the first button has been exceeded. For example, controller 66, 74 may determine whether the first button has been engaged for greater than a predetermined period of time (e.g., two seconds). If an operator
20 engages the first button for greater than two seconds, then controller 66, 74 may store a target position of blade 52. Otherwise, controller 66, 74 may continue to monitor actions undertaken by an operator through various command entries on user interface 62.

In one example, if the first button on user interface 62 is engaged
25 for greater than two seconds, and the target position of blade 52 is 25% cross-slope inclination, then, 25% cross-slope inclination may be stored as a predefined blade position. It should be noted that, in some instances, the target position of blade 52 may be different from a current position of blade 52. In one example, the current position of blade 52 may be 15% cross-slope inclination. The
30 operator may then engage the third button on user interface 62, for example, to manually adjust the target position of blade 52 to 25% cross-slope inclination,

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while the current position of blade 52 remains at 15% cross-slope inclination. Thereafter, the operator may engage the first button again for greater than two seconds to store the target position of blade 52 (25% cross-slope inclination), again while the current position of blade 52 remains at 15% cross-slope inclination.

After the first button has been engaged for less than two seconds, controller 66, 74 may select one of the predefined blade positions stored in the memory of controller 66, 74. The process allows the operator to recall and scroll through the predefined blade positions until the desired predefined blade position is selected. For instance, first, second, and third predefined blade position of 8%, 25%, and 12%, respectively, may be stored in the memory of controller 66, 74. By engaging the first button of user interface 62 for less than two seconds one time, the first predefined blade position of 8% cross-slope inclination may be selected. Then, by engaging the first button for less than two seconds a second time, the second predefined blade position of 25% cross-slope inclination may be selected. By engaging the first button for less than two seconds a third time, the third predefined blade position of 12% cross-slope inclination may be selected. Finally, by engaging the first button for less than two seconds a fourth time, the selection may return to the first predefined blade position of 8% cross-slope inclination. It is contemplated that any number of predefined blade positions may be stored in the memory of controller 66, 74, as desired.

Controller 66, 74 may send signals to actuate hydraulic rams 32, center shift cylinder 34, and/or blade positioning cylinders 54 to move blade 52 to a corresponding selected blade position. For example, controller 66, 74 may receive signals from sensors 64 to determine the current position of blade 52 and, then, move blade 52 to a corresponding selected blade position based on the current position of blade 52. In some exemplary embodiments, as discussed above, until the second button of user interface 62 is engaged, controller 66, 74 may not cause movement of blade 52. This may provide a safety feature, such that blade 52 does not move to an undesired position. For example, using the above example, if the first, second, and third predefined blade position are 8%,

25%, and 12% cross-slope inclination, respectively, the operator must switch from 8% cross-slope inclination to 25% cross-slope inclination, and then to 12% cross-slope inclination. If engaging the first button of user interface 62 alone was enough to cause movement of blade 52, then, blade 52 would start moving to

5 25% cross-slope inclination before the operator selected 12% cross-slope inclination. This can lead to undesirable consequences, such as, the blade removing more of a work surface than desired. The use of the second button of user interface 62 may delay movement of blade 52 until the operator indicates a desire to move the blade, thereby preventing undesirable movements of blade 52.

10 By implementing the disclosed method, operator control may be simplified. Specifically, providing a single button with multiple functions may reduce complexity. In addition, storing a plurality of predefined blade positions may provide more autonomous control to assist the operator. Finally, delaying the movement of the blade to a selected blade position until the operator indicates

15 a desire to move the blade can reduce errors associated with undesired movements of the blade.

During the above-described “DIAGNOSTIC” mode (selection of which may occur by touching an icon or icons such as shown at the far right of the display in Fig. 3) an operator may command the automatic blade positioning

20 system to automatically move blade 52 and/or other components of machine 10 to one or more predetermined positions relative to other components of machine 10. The positions may be predetermined to correspond to locations or configurations of the blade or other components of machine 10 at which the operator, who may be located in operator station 22, or at other positions – such

25 as standing near the machine when operating the machine semi-autonomously, can verify through a visual comparison to one or more reference points that sensors, actuators, linkages, and controls used in operating machine 10 are performing properly or as expected. For example, a selection of a first diagnostic position on user interface 62 of display system 60, such as by touching one of a

30 number of selections that appear in a drop-down menu in one of the rows in the column labeled “DIAGNOSTIC” in Fig. 3, may result in drawbar member 46

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moving to a centered position relative to one or more reference points easily observable by the operator from a seat in operator station 22. As a result, an operator may simply select the desired diagnostic mode by touching a desired selection from a drop-down menu on user interface 62, and the blade positioning system 24 may be configured to then automatically move drawbar member 46, center shift mounting member 30, and blade 52 to a centered position that can be verified visually by the operator relative to one or more reference points. Additionally, selection of a desired diagnostic mode may result in a number of other observable parameters being met, including, but not limited to: DCM 20 assuming a zero (0) degree orientation relative to frame 18, a pitch of machine 10 being set such that a neutral top of blade 52 is even with a cutting edge of blade 52, articulation of machine 10 being straight with steerable traction device 12 being automatically realigned relative to driven traction device 14 to cause articulation joint 26 to be set to a neutral articulation position, wheel lean being set such that wheels of steerable and driven traction devices 12, 14 are oriented vertically, and/or other configurations of blade 52 and other machine components.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed system without departing from the scope of the disclosure. Other embodiments will be apparent to those skilled in the art from consideration of the specification disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

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Claims

1. A motor grader diagnostic positioning system (24) for one or more of a blade (52), a drawbar member (46), and a center shift mounting member (30) associated with a drawbar-circle-moldboard (20) of a motor grader (10), the diagnostic positioning system (24) comprising:

one or more actuators connecting the blade (52) to the drawbar-circle-moldboard (20) and interconnecting other components of the motor grader (10), wherein the one or more actuators are configured to one or more of affect movement of the blade (52) relative to the drawbar-circle-moldboard (20) and affect movement of the other interconnected components relative to each other;

one or more sensors configured to generate signals indicative of a current position of the blade and positions of the other components of the motor grader;

an input device configured to receive an operator input indicative of a selection of one of a plurality of predefined, diagnostic positions, wherein the diagnostic positions can be checked visually by the operator for confirmation of proper operation of the motor grader; and

a controller (66, 74) configured to selectively actuate the one or more actuators based on the selection of one of the plurality of diagnostic positions and the signals indicative of the current position of the blade to move one or more of the blade and other components of the motor grader into the selected diagnostic position.

2. The diagnostic positioning system of claim 1, further including a display (60) configured to display representations of the plurality of predefined diagnostic positions and illustrate the selection of one of the plurality of predefined diagnostic positions.

3. The diagnostic positioning system of claim 1, wherein the diagnostic positions can be checked visually by the operator while the operator is

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either sitting in an operator station located on the motor grader or standing in the vicinity of the motor grader while operating the motor grader semi-autonomously using a remote control device.

5 4. The diagnostic positioning system of claim 1, wherein the diagnostic positions include a drawbar member (46) of the motor grader (10) being disposed in a centered position relative to a frame (18) of the motor grader (10).

10 5. The diagnostic positioning system of claim 1, wherein the diagnostic positions include a center shift mounting member (30) of the motor grader (10) being disposed in a centered position relative to a frame (18) the motor grader (10).

15 6. The diagnostic positioning system of claim 1, wherein the diagnostic positions include the blade (52) of the motor grader (10) being disposed in a centered position relative to a frame (18) of the motor grader (10).

20 7. The diagnostic positioning system of claim 1, wherein the diagnostic positions include the drawbar-circle-moldboard (20) being disposed at a zero degree orientation relative to a frame (18) of the motor grader (10).

25 8. The diagnostic positioning system of claim 1, wherein the diagnostic positions include a pitch of the motor grader (10) being set such that a neutral top of the blade (52) is even with a bottom cutting edge of the blade.

30 9. The diagnostic positioning system of claim 1, wherein the diagnostic positions include an articulation of the motor grader being straight with steerable traction devices of the motor grader being aligned with driven traction devices, and with all of the steerable and driven traction devices being vertically oriented.

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10. A motor grader (10), comprising:
- a power source (16);
 - at least one traction device (12, 14);
 - a frame (18);
 - 5 a drawbar-circle-moldboard (20) supported by the frame (18);
 - a blade (52) pivotally connectable to the drawbar-circle-moldboard (20);
 - one or more actuators connecting the blade (52) to the drawbar-circle-moldboard (20) and configured to affect movement of the blade (52)
 - 10 relative to the drawbar-circle-moldboard (20), and interconnecting other components of the motor grader;
 - one or more sensors configured to generate signals indicative of a current position of the blade and relative positions of the other components of the motor grader; and
 - 15 a diagnostic mode and automatic positioning control system (24) for the blade (52) and the other components of the motor grader, wherein the control system includes:
 - an input device configured to receive an operator input indicative of a selection of one of a plurality of predefined, diagnostic positions, wherein the
 - 20 diagnostic positions can be checked visually by the operator for confirmation of proper operation of the motor grader; and
 - a controller (66, 74) configured to selectively actuate the one or more actuators based on the selection of one of the plurality of predefined, diagnostic positions and the signals indicative of the current position of the blade
 - 25 to move one or more of the blade and the other components of the motor grader into the selected diagnostic position.

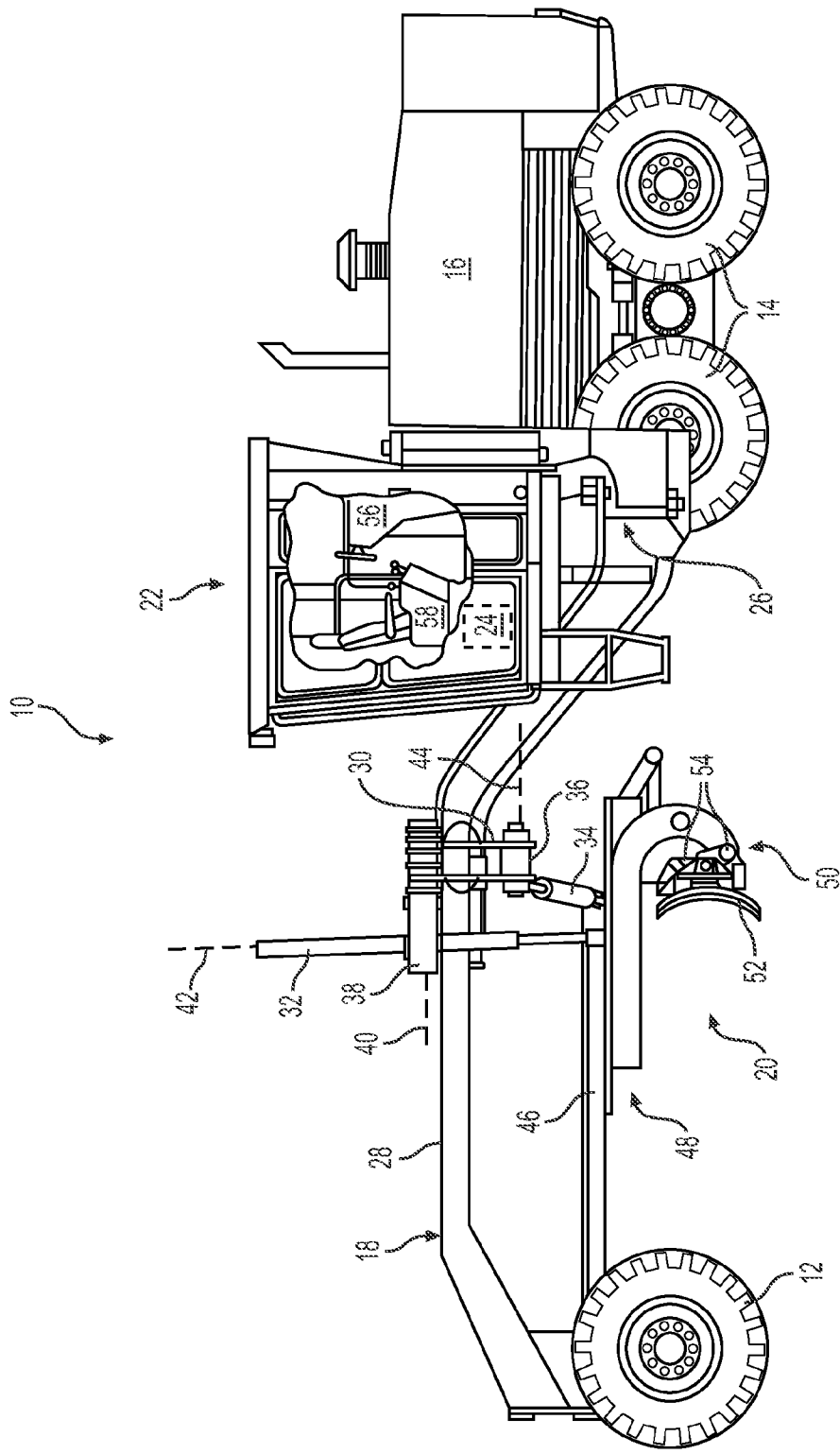


FIG. 1

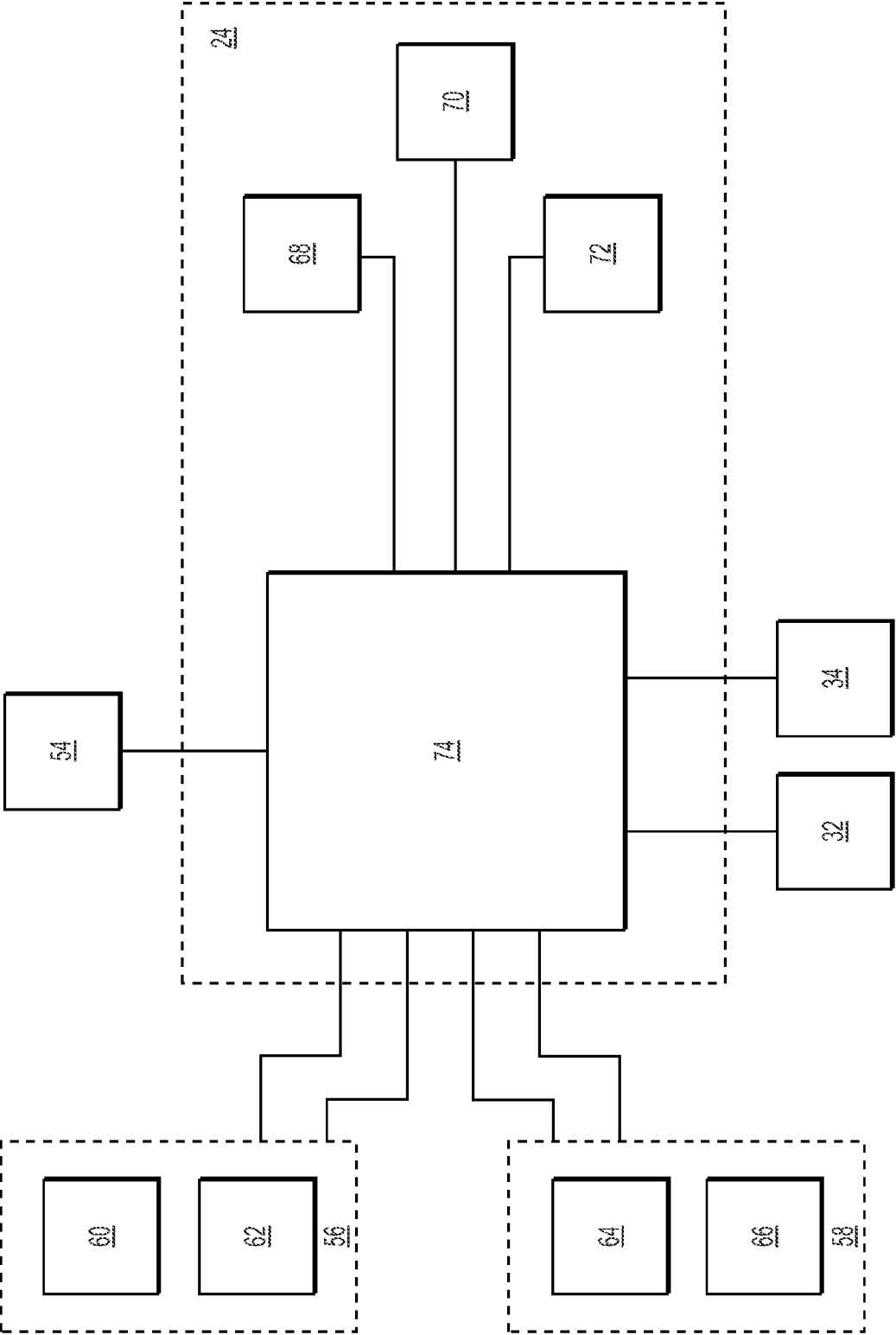


FIG. 2

BLADE POSITION PRESETS FACTORY DEFAULT DESCRIPTIONS

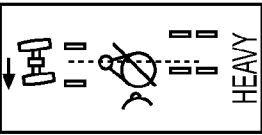
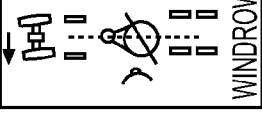
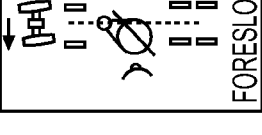
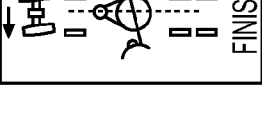
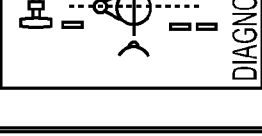
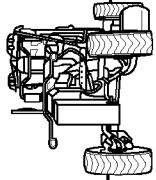
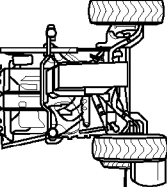
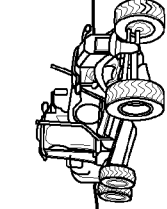
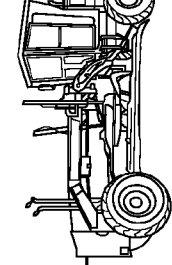
	HEAVY	WINDROW	FORESLOPE	FINISH	DIAGNOSTIC
DRAWBAR CENTERSHIFT	TOWARD HEEL HEEL LIFT CVL VERTICAL	TOWARD HEEL HEEL LIFT CVL VERTICAL	TOWARD HEEL, AWAY FROM DITCH	SLIGHTLY TOWARD HEEL HEEL LIFT CVL VERTICAL	CENTERED
CIRCLE	45 DEG	30 DEG	45 DEG	10 DEG	0 DEG
PITCH	NEUTRAL TOP 2" AHEAD OF CUT EDGE	NEUTRAL TOP 2" AHEAD OF CUT EDGE	NEUTRAL TOP 2" AHEAD OF CUT EDGE	FORWARD TOP 4-5" AHEAD OF CUT EDGE	NEUTRAL TOP EVEN WITH CUT EDGE
ARTICULATION	REAR 10 DEG TOWARD TOE	REAR 5 DEG TOWARD TOE	STRAIGHT REAR 2-3 DEG TOWARD TOE	STRAIGHT	STRAIGHT
WHEEL LEAN	TOWARD HEEL	TOWARD HEEL	TOWARD HEEL	TOWARD HEEL	STRAIGHT
DISPLAY IMAGE FOR FORESLOPE AND BACKSLOPE, DITCH IS ON RH SIDE					
EXEMPLARY MACHINE OPERATIONAL CONFIGURATIONS					

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/038286

A. CLASSIFICATION OF SUBJECT MATTER

INV. E02F3/76 E02F3/84 E02F9/26
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E02F

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	paragraphs [0032], [0099], [0103]; figures 3, 18, 19	5, 9
Y	US 2009/056961 A1 (GHARSALLI IMED [US] ET AL) 5 March 2009 (2009-03-05) paragraph [0021]; figure 1	5
Y	AU 2019 200 370 A1 (BARMINCO LTD [AU]) 31 October 2019 (2019-10-31) page 10, line 20 - line 25; figure 5	9
A	US 2020/362542 A1 (VEASY DAVID A [US] ET AL) 19 November 2020 (2020-11-19) paragraphs [0072], [0102]	1, 10
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

2 November 2022

Date of mailing of the international search report

10/11/2022

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/038286

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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