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(12) (19) (CA) **Demande-Application**

(21) (A1) **2,320,247**
(86) 1999/12/17
(87) 2000/06/22

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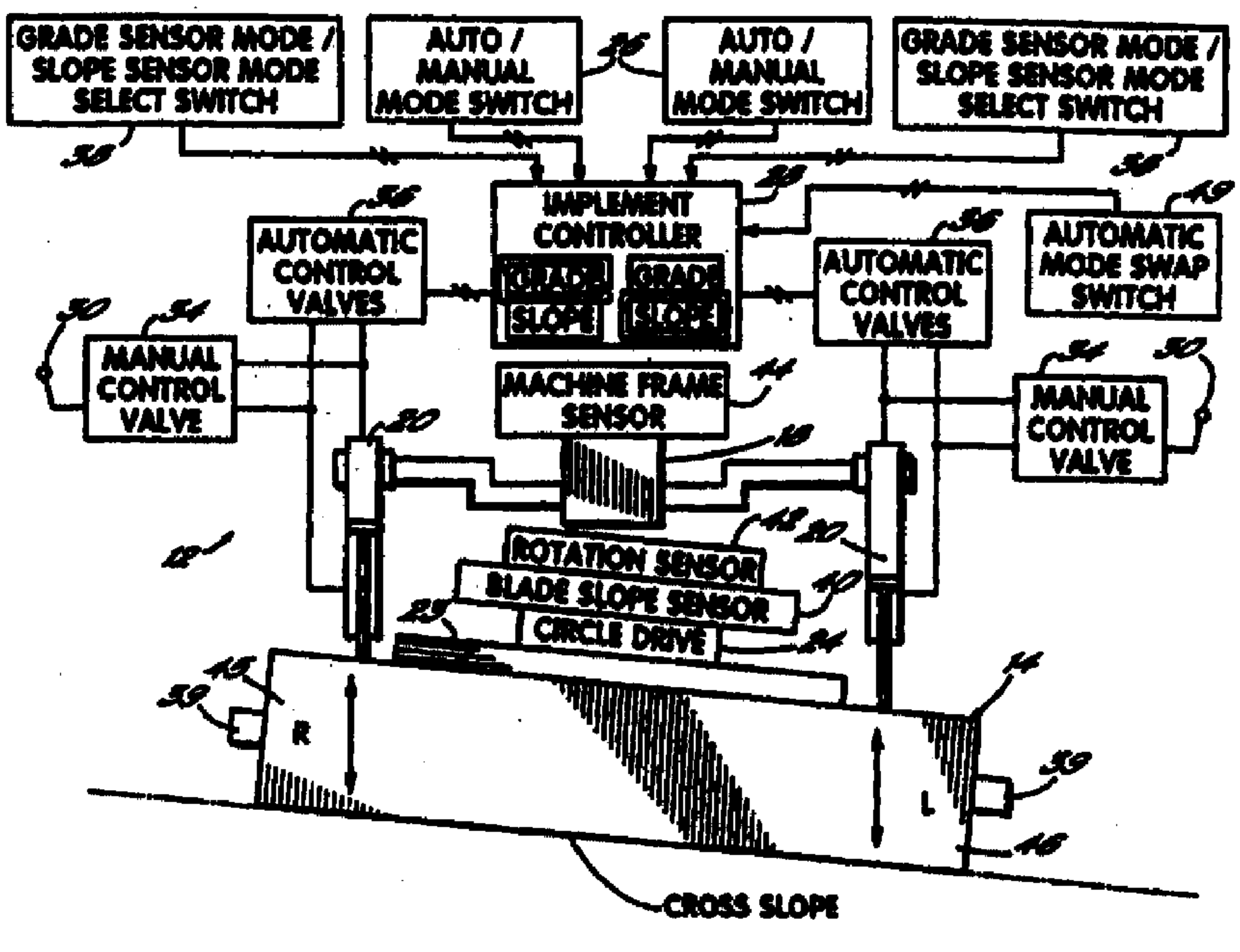
(51) Int.Cl.[7] E02F 3/84
(30) 1998/12/18 (60/112,959) US
(30) 1998/12/18 (09/216,180) US
(30) 1999/08/09 (09/370,868) US

(54) **PROCEDE ET APPAREIL SERVANT A COMMANDER UN INSTRUMENT DE TRAVAIL**

(54) **METHOD AND APPARATUS FOR CONTROLLING A WORK IMPLEMENT**



(57) L'invention concerne un procédé et un appareil servant à commander un instrument (14) de travail relié de façon mobile à un engin (10) de terrassement. Un dispositif de commande (28) d'instrument commande

(57) A method and apparatus for controlling a work implement (14) movably connected to a work machine (10). An implement controller (28) automatically controls simultaneous first and second control modes of

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automatiquement des premier et second modes de commande simultanés de fonctionnement, lesdits modes étant assignés à l'instrument (14) de travail. Un capteur (42) envoie un signal au dispositif de commande (28) d'instrument pour indiquer la position de l'instrument (14) de travail. Le dispositif de commande (28) d'instrument inverse les premier et second modes simultanés de commande assignés à l'instrument (14) de travail après détection d'un mouvement de travail prédéterminé. En outre, le dispositif de commande (28) d'instrument déplace automatiquement l'instrument (14) de travail d'une première position rotative à une seconde position rotative symétrique à la première, suite à la manoeuvre effectuée par un opérateur d'un dispositif (49) à actionnement manuel. On peut également modifier les assignations des premier et second modes simultanés de commande en actionnant le dispositif (49) à actionnement manuel.

operation assigned to the work implement (14). A sensor (42) applies a signal to the implement controller (28) indicating position of the work implement (14). The implement controller (28) reverses the simultaneous first and second control modes assigned to the work implement (14) upon detecting a predetermined movement of the work movement. The implement controller (28) also automatically moves the work implement (14) from a first rotation position to a second, mirror image rotational position upon operator actuation of a manually actuatable device (49). The simultaneous first and second control mode assignments may also be changed by actuation of the manually actuatable device (49).

CA 02320247 2000-08-11

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : E02F 3/84

A1

(11) International Publication Number: WO 00/36231

(43) International Publication Date: 22 June 2000 (22.06.00)

(21) International Application Number: PCT/US99/30278

(22) International Filing Date: 17 December 1999 (17.12.99)

(30) Priority Data:

09/216,180	18 December 1998 (18.12.98)	US
60/112,959	18 December 1998 (18.12.98)	US
09/370,868	9 August 1999 (09.08.99)	US

(81) Designated States: CA, DE, JP.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

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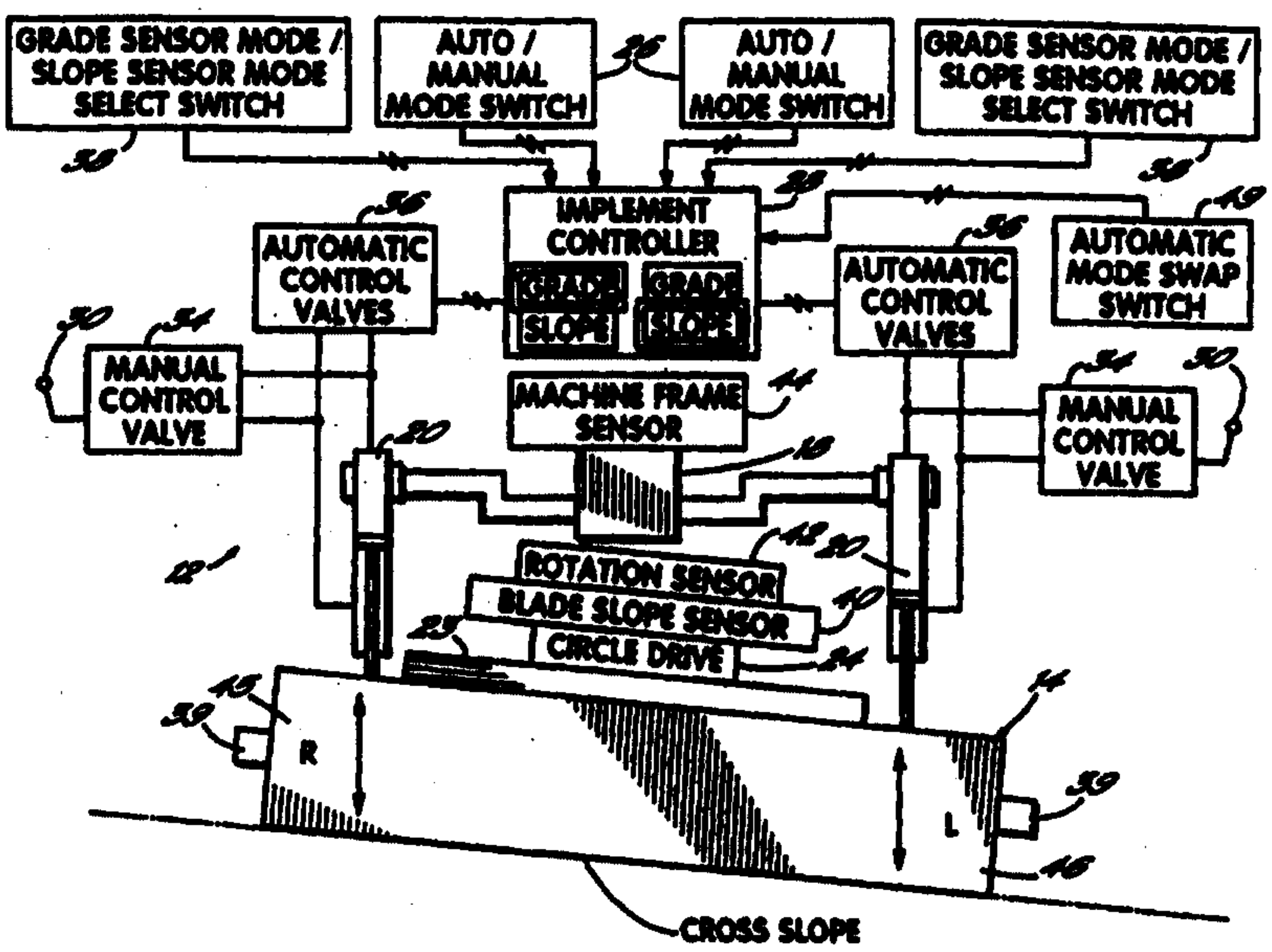
(54) Title: METHOD AND APPARATUS FOR CONTROLLING A WORK IMPLEMENT



(57) Abstract

A method and apparatus for controlling a work implement (14) movably connected to a work machine (10). An implement controller (28) automatically controls simultaneous first and second control modes of operation assigned to the work implement (14). A sensor (42) applies a signal to the implement controller (28) indicating position of the work implement (14). The implement controller (28) reverses the simultaneous first and second control modes assigned to the work implement (14) upon detecting a predetermined movement of the work movement. The implement controller (28) also automatically moves the work implement (14) from a first rotation position to a second, mirror image rotational position upon operator actuation of a manually actuatable device (49). The simultaneous first and second control mode assignments may also be changed by actuation of the manually actuatable device (49).

Description

METHOD AND APPARATUS FOR CONTROLLING A WORK IMPLEMENT

Technical Field

The present invention relates generally to manual and automatic positioning of a work implement and, more particularly, to a method and apparatus for controlling modes of operation of a work implement of a work machine.

Background Art

Work machines, such as motor graders, dozers, compactors, pavers, profilers and scrapers, are used for geographic surface altering operations. The machines include a work implement, such as a surface altering blade, that is movably connected to a frame of the machine by one or more hydraulic motors or cylinders, or the work implement may be fixed to the machine frame. The position of the blade relative to the work surface must be accurately controlled to achieve the desired surface altering cut.

In motor graders, for example, the surface altering blade is movably connected to the grader frame by a pair of independently actuatable hydraulic lift cylinders that are mounted on either side of the machine frame. The hydraulic lift cylinders are independently extensible and retractable to move corresponding sides of the blade relative to the machine frame. Each side of the blade may be set by the operator to operate in either a "manual" or "automatic" mode of operation. In either mode, each side of blade is also assignable by the operator to operate in a "grade sensor", "slope sensor" or "down force" mode of operation. Control for each side of the blade is independently assignable to one of the "grade sensor", "slope sensor" and "down force" modes of operation such that both sides may be assigned to "grade sensor" or "down force" modes, or one side assigned to "grade sensor" or "down force" mode while the other side is assigned to the "slope sensor" mode.

When "grade sensor" (or "down force") and "slope sensor" modes are assigned simultaneously to the opposite sides of the blade, the leading end or toe of the blade is generally assigned to the "grade sensor" mode, and the trailing or heel of the blade is assigned to the "slope sensor" mode. In "automatic" mode, a grade sensor maintains the grade sensor controlled side of the blade at a preselected position relative to a grade reference point. The elevation of the slope controlled side of the blade is controlled by a programmed cross slope value selected by the operator and stored in an implement controller that controls the "grade sensor", "down force" and "slope sensor" modes of operation.

During a grading operation in one direction, the operator rotates the blade to a desired grading angle relative to the machine frame and may assign the "grade sensor" (or "down force") and "slope sensor" control modes to the opposite sides of the blade. On a return grading pass in the opposite direction, the operator must rotate the blade to a mirror angle, and manually switch the "grade sensor" (or "down force") and "slope sensor" modes assigned to the opposite sides of the blade. To achieve the switch of the control modes, the operator must manually actuate control switches that are located in the cab.

During the motor grader reconfiguration process for the return grading pass, the operator may improperly reassign the control modes of operation to the blade which may result in the wrong cross slope cut. Moreover, the manual reconfiguration process required for grading in opposite directions reduces the operator's accuracy and efficiency.

The present invention is directed to overcoming one or more of the problems as set forth above.

Disclosure of the Invention

The present invention overcomes the foregoing and other shortcomings and drawbacks of work implement positioning and methods heretofore known. While the invention will be described in connection with certain embodiments, it will be understood that the invention is not limited to these embodiments. On the contrary, the invention includes all alternatives, modifications and equivalents as may be included within the spirit and scope of the present invention.

In one aspect of the invention, an apparatus for controlling a work implement of a work machine in simultaneous first and second control modes of operation is provided. An implement controller is operable to assign the first and second control modes of operation to the work implement. Positioning mechanisms may be connected to each side of the work implement for altering the position of each side of the work implement.

One of the positioning mechanisms may be operable to move one side of the work implement to a first position, and the other positioning mechanism may be operable to move the other side of the work implement to a second position. A sensor is associated with the work implement and coupled to the implement controller for applying a signal to the implement controller indicating position of the work implement. The implement controller is operable to change the control mode assignments to the work implement upon determining a predetermined movement of the work implement as indicated by the sensor, such as a predetermined rotation of the work implement. Upon determining a predetermined movement of the work implement, the implement controller may be operable to reverse the first and second control mode assignments to the work implement, and may also be operable to reverse the first and second positions of the work implement as well.

In another aspect of the invention, a drive mechanism may be operatively connected to the work implement for moving the work implement between a first rotational position and a second rotational position under control of the implement controller. A manually actuatable device is electrically coupled to the implement controller. The implement controller is operable to reverse the control assignments to, and the rotational position of, the work implement upon actuation of the manually actuatable device.

In yet another aspect of the invention, a method for controlling a work implement of a work machine in simultaneous first and second control modes of operation is provided. First and second automatic control modes are assigned to the work implement. Movement of the work implement is sensed and, upon a predetermined movement of the work implement as detected during the sensing step, the first and second control modes assigned to the work implement are reversed.

Brief Description of the Drawings

For better understanding of the present invention, reference may be made to the accompanying drawings in which:

Fig. 1 is a partial perspective view of a motor grader including an implement control system for controlling control modes of a work implement;

Figs. 2A and 2B are diagrams, partly schematic and partly block, showing front views of the motor grader of Fig. 1 traveling in opposite grading directions, and an implement control system for controlling control modes of a work implement as applied to a grader blade of the motor grader shown in Fig. 1;

Fig. 3 is a top plan view of the motor grader shown in Fig. 1; and

Fig. 4 is a flow chart illustrating a method for automatically moving the grader blade from a present blade position to a mirror image position in accordance with the principles of the present invention.

Best Mode for Carrying Out the Invention

With reference to the figures, and to Fig. 1 in particular, a work machine 10, illustrated as a geographic surface altering motor grader, is shown including an implement control system 12 (Figs. 2A-2B) for controlling control modes of a work implement 14, illustrated as a conventional grader blade. The work implement 14 is part of a blade sub-assembly, indicated generally at 16, that is movably mounted to a frame 18 of the motor grader 10 through a pair of selectively actuatable hydraulic motors or lift cylinders 20 and a centershift cylinder 21 that are connected between the machine frame 18 and the blade sub-assembly 16. The blade sub-assembly 16 includes a circle draw bar, indicated generally at 22, a circle 23 (Figs. 2A and 2B) rotatably mounted to the circle draw bar 22, and grader blade 14 mounted to the circle 23. A selectively actuatable circle drive 24 (Figs. 2A and 2B) is mounted to the circle draw bar 22 for rotating the circle 23 and the blade 14 mounted thereto about an elevational axis 25 (Fig. 3) located at the center of the circle 23 in a known manner. The grader blade 14 is mounted to a sliding joint of a blade mounting bracket that allows the blade 14 to be shifted side-to-side relative to the mounting bracket or the circle 23. This side-to-side shift is commonly referred to as blade sideshift and is provided by a sideshift cylinder 25a (Fig. 3). While the implement control system 12 will be described in detail below as applied to a motor grader, it will be appreciated by those skilled in the art that other geographic surface altering machines, such as dozers, compactors, pavers, profilers, scrapers and the like, equipped with suitable surface altering implements, are equivalents and considered within the scope of the invention.

With reference to Figs. 2A and 2B, the implement control system 12 is shown applied to motor grader 10 and, in particular, to the grader blade 14. During operation of the motor grader 10, the grade and cross-slope positions of blade 14 may be controlled by manual and/or automatic extension and retraction of the hydraulic lift cylinders 20 connected to the blade sub-assembly 16. The pair of hydraulic lift cylinders 20 are extensibly movable to elevationally move corresponding sides of the blade 14 relative to the frame 18. The centershift cylinder 21 (Fig. 1) is used primarily to sideshift the circle drawbar 22, and all of the blade components mounted to the circle relative to the front frame 18. This sideshift is commonly referred to as drawbar sideshift or circle centershift.

Each side of the blade 14 may be manually set by the operator to operate in either "manual" or "automatic" control modes of operation through a pair of mode select switches 26 that are each dedicated to a corresponding side of blade 14. Control for each side of the blade 14 is independently assignable to one of the “manual” and “automatic” control modes of operation such that both sides may be assigned to "manual" mode, one side may be assigned to "manual" mode while the other side is assigned to "automatic" mode, or both sides may be assigned to "automatic" mode. The mode select switches 26 are electrically coupled to an implement controller 28 that is responsible for controlling the side of blade 14 that is assigned to the "automatic" mode of operation as described in greater detail below. Implement controller 28 includes a processor (not shown) of any suitable kind, such as a microprocessor having appropriate control software and memory (not shown) to store the selected "manual" and "automatic" control modes of operation for each side of blade 14.

In the "manual" control mode, the operator controls the elevational position of one or both sides of the blade 14 through a pair of implement positioning devices, such as a pair of manually actuatable control levers 30, that are located within a cab 32 (Fig. 1) of the motor grader 10. Each of the manually actuatable control levers 30 is connected to a manually actuatable or manual control valve 34. The pair of manual control valves 34 are each connected between a hydraulic fluid supply (not shown), and a corresponding one of the hydraulic lift cylinders 20 mounted on a respective side of machine frame 18. Movement of each control lever 30 in one direction allows hydraulic fluid to flow under pressure through the manual control valves 34 to actuate the hydraulic lift cylinders 20 to an extended or retracted position. Movement of each control lever 30 in the opposite direction causes a reverse directional movement of the hydraulic lift cylinders 20. In a neutral position of control levers 30, the manual control valves 34 assume a neutral or dead position that inhibits hydraulic fluid flow through the manual control valves 34.

Further referring to Figs. 2A and 2B, a pair of electrically actuatable or automatic control valves 36 are connected between the hydraulic fluid supply (not shown) and a corresponding one of the hydraulic lift cylinders 20 to control extension and retraction of the corresponding hydraulic lift cylinder 20 in the "automatic" control mode. The automatic control valves 36 are electrically coupled to the implement controller 28 for receiving command signals from the implement controller 28 to adjust the elevational position of a corresponding blade side through actuation of a respective hydraulic lift cylinder 20. The automatic control valves 36 are connected in parallel with the manual control valves 34, and are operable independently from the manual control valves 34 as described in detail below.

In the "automatic" control mode, for example, each side of blade 14 may be assigned by the operator to a "grade sensor" mode or a "slope sensor" mode through a pair of sensor select switches 38 that are each dedicated to a corresponding side of blade 14. Other sensor modes are possible as well. For example, while not shown, each side of blade 14 is assignable to a "down force" mode of operation. Control for each side of blade 14 is independently assignable to one of the "grade sensor", "down force" and "slope sensor" modes of operation such that both sides may be assigned to "grade sensor" mode, both sides may be assigned to "down force" mode, or one side may be assigned to "grade sensor" or "down force" mode while the other side is assigned to the "slope sensor" mode. The assigned sensor modes for each side of blade 14 are stored in memory (not shown) of the implement controller 28. For simplicity of discussion, only the "grade sensor" and "slope sensor" modes of operation will be described hereinafter in the automatic operation of motor grader 10. However, it will be appreciated that the "grade sensor", "down force" and "slope sensor" modes of operation may also be assigned to corresponding sides of blade 14 in the "manual" control mode as well.

In "grade sensor" mode, an ultrasonic sensor or a laser sensor, both indicated generally at 39, (Figs. 2A and 2B), may be used to control the elevational position of the respective blade side relative to a grade reference point, such as a finished surface, curb, gutter, stringline or laser reference beam. The ultrasonic sensors or laser sensors 39 are coupled to the implement controller 28, and provide signals to the implement controller 28 indicating the elevational position of the corresponding side of blade 14.

In "grade sensor" mode, the grade sensor controlled side of blade 14 is maintained generally at a preselected elevational position or grade by the implement controller 28 that continuously compares the actual elevational position as determined by the grade sensor (not shown) with a desired grade setting selected by the operator. The implement controller 28 makes compensating elevational adjustments of the grade controlled side of the blade 14 through actuation of the corresponding hydraulic lift cylinder 20 as required. The operator selected "grade sensor" mode elevational value (or pair of values if both blade sides are assigned to the "grade sensor" mode) is assigned to the implement controller 28 through a corresponding one (or both) of a pair of momentary rocker switches (not shown) that are electrically coupled to the implement controller 28.

A two-axis blade slope sensor, indicated generally at 40 (Figs. 2A and 2B) is mounted on the blade sub-assembly 16 to provide blade pitch and blade roll signals to the implement controller 28 through electrical leads (not shown). In the "automatic" control mode, each side of the blade 14 may alternatively be assigned to a "slope sensor" mode in which the grade sensor controlled side of the blade 14 is maintained at the preselected elevational position as described above, while the implement controller 28 controls the cross slope of the "slope sensor" controlled blade side according to a kinematic control algorithm performed by the implement controller 28. As used herein, "cross slope" is the slope of a cut made by the blade 14 perpendicular to the direction of machine travel. The implement controller 28 receives the blade pitch and blade roll signals from the two-axis blade slope sensor 40, as well as signals from a blade rotation sensor 42 indicating blade rotation, and machine frame pitch and machine frame roll from a two-axis machine frame sensor 44 mounted to machine frame 18. Each of these values is taken into account by the kinematic control algorithm to accurately control the cross slope of the slope controlled side of the blade 14.

In "slope sensor" mode, the slope sensor controlled side of the blade 14 is maintained generally at a preselected elevational position as defined by the elevational position of the grade controlled side of blade 14 and the operator selected cross slope value. The implement controller 28 continuously compares the actual cross slope value computed from the various sensor signals with the desired cross slope, and makes compensating elevational adjustments through actuation of the corresponding hydraulic lift cylinder 20 as required. The operator selected "slope sensor" mode elevational value, i.e, cross slope value, is assigned to the implement controller 28 through a touch pad set point capture button. The cross slope value can be modified by a corresponding one of the pair of momentary rocker switches (not shown) electrically coupled to the implement controller 28.

During a grading operation, as shown in Figs. 1 and 3, the operator rotates the blade 14 to a desired grading angle relative to machine frame 18 through actuation of circle drive 24. Typically, most grading operations are performed with the blade 14 rotated clockwise or counterclockwise at an angle "α" between about 10o and about 45o relative to an axis 43 transverse to machine frame 18. As the motor grader 10 grades in opposite passes (or directions) as shown in Figs. 2A and 2B, both sides of blade 14 may be assigned to the "automatic" control mode of operation, with one or both sides of blade 14 assigned to "grade sensor" (or "down force") mode, or one side assigned to "grade sensor" (or "down force") mode and the other side assigned to "slope sensor" mode. When "grade sensor" and "slope sensor" modes are assigned simultaneously to the opposite sides of blade 14 as shown in Figs. 2A and 2B, the leading end or toe 45 of blade 14 is typically assigned to the "grade sensor" mode, and the trailing end or heel 46 of blade 14 is assigned to the "slope sensor" mode. When the operator changes directions to grade in the opposite direction, the blade 14 is rotated to a mirror angular position, as indicated generally at 48.

In one aspect of the present invention, the rotational position of blade 14 relative to machine frame 18 is provided by blade rotation sensor 42 (Figs. 2A and 2B) to the implement controller 28 as a pulse width modulation (PWM) signal. The implement controller 28 converts the PWM signal from blade rotation sensor 42 to a rotational position value and determines if blade 14 has been rotated through a preselected angle "β", referred to hereafter as the "swap position". Blade rotation sensor 42 may include potentiometers (not shown), limit switches (not shown), electromechanical actuators (not shown), encoders (not shown), or equivalent sensors associated with circle 23 and blade 14 for providing signals to implement controller 28 that indicate the rotational position of blade 14 relative to a fixed reference point. Alternatively, the blade rotation signal applied to implement controller 28 may be generated by sensors (not shown) located in the environment of motor grader 10 that are operable to detect a rotated position of blade 14.

As shown in Fig. 2A, in one grading pass of motor grader 10, the right side or toe 45 of blade 14 (as viewed from within cab 32) is assigned to the "grade sensor" mode of operation, and is elevated in position relative to the left side or heel 46 of blade 14. The grade sensor 39 maintains the toe 45 of blade 14 at a preselected elevational position relative to a grade reference point through control of the corresponding hydraulic lift cylinder 20 by implement controller 28. The heel 46 is assigned to the "slope sensor" mode of operation, and its elevation is controlled by the programmed cross slope value selected and stored in the implement controller 28 that controls the corresponding hydraulic lift cylinder 20.

With reference to Figs. 2A, 2B and 3, as the operator rotates the blade 14 through the "swap position" as determined by implement controller 28, the implement controller 28 automatically changes the "grade sensor" and "slope sensor" assignments to the toe 45 and heel 46 of blade 14, and the cross slope of the blade 14. Preferably, implement controller 28 automatically reverses or "swaps" the "grade sensor" and "slope sensor" assignments to the toe 45 and heel 46 of blade 14, and the cross slope of the blade 14 to configure motor grader 10 to grade in the opposite direction as shown in Fig. 2B. During the "automatic" swap, the sides of blade 14 may each be assigned to the "manual" mode of operation to prevent any unexpected movement of blade 14 during the "swap".

Alternatively, an automatic mode swap switch 49 (Figs. 2A and 2B) may be provided in cab 32 to allow the operator to automatically rotate the blade 14 to the mirror angular position 48 (Fig. 3) by a single manual actuation of the switch 49. Depression of the automatic mode swap switch 49 also automatically changes the "grade sensor" and "slope sensor" assignments to the toe 45 and heel 46 of blade 14, and the cross slope of blade 14 as described in detail above. In this aspect of the invention, the automatic mode swap switch 49 is electrically coupled to the implement controller 28. The circle drive 24 is an electrohydraulic circle drive that operates under the control of implement controller 28. The set rotational position of blade 14 during a beginning grading pass is stored in memory of the implement controller 28, and is recalled by implement controller 28 to automatically move blade 14 to the mirror angular position 48 upon depression of switch 49 to reconfigure the motor grader 10 for a return grading pass in the opposite direction.

More particularly referring to the flow chart of Fig. 4, a flow chart illustrating a preferred method for automatically moving the motor grader blade 14 from a present blade position to a mirror image position is shown. As will be appreciated by one of ordinary skill in the art, although the flow chart illustrates sequential steps, the particular order of processing is not important to achieving the objects of the present invention. As will also be recognized, the method illustrated may be performed in software, hardware, or a combination of both as in a preferred embodiment of the present invention.

During operation of motor grader 10, an operator is provided with both automatic and manual or hand controls to adjust the position of the blade 14. Initially, it is determined whether the operator is using the hand controls, as represented by block 50. If the operator is using the hand controls, the automatic mirror image position control is turned off, as illustrated by block 52. The implement controller 28 produces and transmits a control signal to actuate the respective control, i.e. the circle drive 24, the sideshift cylinder 25a, and/or the centershift cylinder 21, in accordance with the action requested by the manual controls, as represented by 54. The program waits for the next synchronized control time, as illustrated by 56, and then interprets the next automatic or hand control input signal, as represented by block 58.

If the operator is not using the hand controls, it is determined if the operator has requested the automatic mirror image position control through actuation of switch 49, as illustrated by block 60. If the operator has requested the automatic mirror image position control, the automatic mirror image position control is turned on, as represented by block 62. Information regarding the actual position of the blade controls, i.e. the circle drive 24, the sideshift cylinder 25a, and the centershift cylinder 21, is obtained by the controller 28, as illustrated by block 64. The controller 28 calculates a mirror image position of the present blade position, as represented by block 66. Using this position information, the implement controller 28 produces and transmits a control signal designed to achieve the mirror image position requested by the automatic mirror image position control, as illustrated by block 68. The control signal actuates the blade controls, i.e. the circle drive 24, the sideshift cylinder 25a, and/or the centershift cylinder 21, to automatically move the blade 14 from its actual blade position to the mirror image of the actual blade position. The program waits for the next synchronized control time, as represented by 56, and then interprets the next automatic or hand control input signal, as illustrated by block 58.

If the operator has not requested automatic mirror image position control, the implement controller 28 produces and transmits a zero control signal, as represented by block 70. The program waits for the next synchronized control time, as illustrated by 56, and then interprets the next automatic or hand control input signal, as represented by block 58.

Industrial Applicability

With reference to the drawings and in operation, the operator of the work machine 10 selects "manual" or "automatic" modes of operation for each side of the blade 14 by actuating the mode select switches 26 corresponding to each side of the blade 14. In either mode, the operator also selects "grade sensor", “down force”, or "slope sensor" control for each side of the blade 14 by actuating sensor select switches 38 corresponding to each side of the blade 14.

Control of each side of blade 14 is independently assignable to one of the "manual" and automatic" modes of operation, and one of the "grade sensor", "down force" and "slope sensor" modes as well.

After a grading pass in one direction, the operator rotates blade 14 relative to frame 18 to configure the rotation of blade 14 for the return pass in the opposite direction. As the blade 14 rotates past the predetermined "swap position", the implement controller 28 preferably automatically reverses or "swaps" the "grade sensor" (or "down force") and "slope sensor" assignments to the toe 45 and heel 46 of blade 14, and the cross slope of the blade 14 to configure motor grader 10 to grade in the opposite direction.

Alternatively, the operator manually actuates the automatic mode swap switch 49 to automatically rotate blade 14 to the mirror angular position 48, and preferably reverse the "grade sensor" (or "down force") and "slope sensor" assignments to corresponding sides of the blade 14, and the cross slope of blade 14.

The automatic "swap" performed by implement controller 28 enhances operator accuracy and efficiency as the blade 14 is automatically configured for grading in the opposite direction.

Other aspects, objects and advantages of the present invention can be obtained from a study of the drawings, the disclosure and the appended claims.

Claims

1. An apparatus for controlling a work implement (14) of a work machine (10) in simultaneous first and second control modes of operation, comprising:

an implement controller (28) operable to assign the first and second control modes of operation to the work implement (14); and

a sensor (42) associated with the work implement (14) and coupled to the implement controller (28) for applying a signal to the implement controller (28) indicating position of the work implement (14), whereby the implement controller (28) is operable to change the control mode assignments to the work implement (14) upon determining a predetermined movement of the work implement (14) as indicated by the sensor (42).

2. An apparatus as recited in claim 1, wherein the implement controller (28) is operable to detect a predetermined rotation of the work implement (14).

3. An apparatus as recited in claim 1, wherein the implement controller (28) is operable to reverse the first and second control mode assignments to the work implement (14) upon receipt of the signal from the sensor (42).

4. An apparatus as recited in claim 1, including a manually actuatable device (38) coupled to the implement controller (28) for selecting the first and second control mode assignments to the work implement (14).

5. An apparatus as recited in claim 1, including a sensor (40) associated with the work implement (14) and coupled to the implement controller (28) for applying signals to the implement controller (28) indicating pitch and roll positions of the work implement (14).

6. An apparatus for controlling opposite sides of a work implement (14) of a work machine (10) in simultaneous first and second control modes of operation, comprising:

an implement controller (28) operable to assign the first and second control modes of operation to the opposites sides of the work implement (14), wherein one side of the work implement (14) is assigned to the first control mode and the other side of the work implement (14) is assigned to the second control mode; and

a sensor (42) associated with the work implement (14) and coupled to the implement controller (28) for applying a signal to the implement controller (28) indicating position of the work implement (14), whereby the implement controller (28) is operable to change the first and second control mode assignments to the opposite sides of the work implement (14) upon determining a predetermined movement of the work implement (14) as indicated by the sensor (42).

7. An apparatus as recited in claim 6, wherein the implement controller (28) is operable to detect a predetermined rotation of the work implement (14).

8. An apparatus as recited in claim 6, wherein the implement controller (28) is operable to reverse the first and second control mode assignments to the opposite sides of the work implement (14) upon receipt of the signal from the sensor (42).

9. An apparatus as recited in claim 6, including a manually actuatable device (38) coupled to the implement controller (28) for selecting the first and second control mode assignments to the opposite sides of the work implement (14).

10. An apparatus as recited in claim 6, including a sensor (39) associated with each side of the work implement (14) and coupled to the implement controller (28), wherein each sensor (39) is operable to apply a signal to the implement controller (28) indicating elevational position of the corresponding side of the work implement (14).

11. An apparatus as recited in claim 6, including a sensor (40) associated with the work implement (14) and coupled to the implement controller (28) for applying a signal to the implement controller (28) indicating slope of the work implement (14).

12. An apparatus for controlling opposite sides of a work implement (14) of a work machine (10) in simultaneous first and second modes of operation, comprising:

an implement controller (28) operable to assign the first and second control modes of operation to the opposites sides of the work implement (14), wherein one side of the work implement (14) is assigned to the first control mode and the other side of the work implement (14) is assigned to the second control mode;

positioning mechanisms (20) connected to each side of the work implement (14) for altering the position of each side of the work implement (14), wherein one of the positioning mechanisms (20) is operable to move one side of the work implement (14) to a first position and the other positioning mechanism (20) is operable to move the other side of the work implement (14) to a second position; and

a sensor (42) associated with the work implement (14) and coupled to the implement controller (28) for applying a signal to the implement controller (28) indicating position of the work implement (14), whereby the implement controller (28) is operable to change the control mode assignments to, and the first and second positions of, the opposite sides of the work implement (14) upon determining a predetermined movement of the work implement (14) as indicated by the sensor (42).

13. An apparatus as recited in claim 12, wherein the implement controller (28) is operable to reverse the first and second control mode assignments to the opposite sides of the work implement (14) upon receipt of the signal from the sensor (42).

14. An apparatus as recited in claim 12, wherein the implement controller (28) is operable to reverse the first and second positions of the opposite sides of the work implement (14) upon receipt of the signal from the sensor (42).

15. An apparatus as recited in claim 12, including a sensor (39) associated with each side of the work implement (14) and coupled to the implement controller (28), wherein each sensor (39) is operable to apply a signal to the implement controller (28) indicating elevational position of the corresponding side of the work implement (14).

16. An apparatus as recited in claim 12, including a sensor (40) associated with the work implement (14) and coupled to the implement controller (28) for applying a signal to the implement controller (28) indicating slope of the work implement (14).

17. An apparatus for automatically moving a work implement (14) of a work machine (10) from a first rotational position to a second, mirror image rotational position, comprising:

an implement controller (28);

a drive mechanism (24) operatively connected to the implement controller (28) and the work implement (14) for moving the work implement (14) between the first rotational position and the second, mirror image rotational position under control of the implement controller (28); and

a manually actuatable device (49) electrically coupled to the implement controller (28), whereby the implement controller (28) and drive mechanism (24) are operable to move the work implement (14) from the first rotational position to the second, mirror image rotational position upon actuation of the manually actuatable device (49).

18. An apparatus as recited in claim 17, including a sensor (42) associated with the work implement (14) and coupled to the implement controller (28) for applying a signal to the implement controller (28) indicating a rotational position of the work implement (14).

19. A method for controlling a work implement (14) of a work machine (10) in simultaneous first and second control modes of operation, comprising:

assigning a first control mode to the work implement (14);

assigning a second control mode to the work implement (14);

sensing movement of the work implement (14);

and reversing the first and second control modes assigned to the work implement (14) upon a predetermined movement of the work implement (14) as detected during the sensing step.

20. A method as recited in claim 19, wherein the sensing step includes sensing rotational movement of the work implement (14).

21. A method for controlling a work implement (14) of a work machine (10) in simultaneous first and second control modes of operation, comprising:

assigning a first control mode to the work implement (14);

assigning a second control mode to the work implement (14);

detecting actuation of a manually actuatable device (49); and

reversing the first and second control modes assigned to the work implement (14) upon actuation of the manually actuatable device (49) as detected during the detecting step.

22. A method for controlling opposite sides of a work implement (14) of a work machine (10) in simultaneous first and second control modes of operation, comprising:

assigning a first control mode to one side of the work implement (14);

assigning a second control mode to the other side of the work implement (14);

sensing movement of the work implement (14);

and reversing the first and second control modes assigned to the work implement (14) upon a predetermined movement of the work implement (14) as detected during the sensing step.

23. A method as recited in claim 22, wherein the sensing step includes sensing rotational movement of the work implement (14).

24. A method as recited in claim 22, including the steps of:

positioning one of the sides of the work implement (14) at a first position;

positioning the other side of the work implement (14) at a second position; and

reversing the first and second positions of the work implement (14) upon a predetermined movement of the work implement (14) as detected during the sensing step.

25. A method for automatically moving a blade (14) of a motor grader (10) from a first rotational position to a second, mirror image rotational position, comprising:

determining a first rotational position of the blade (14);

processing an operator initiated command requesting movement of the blade (14) to a second, mirror image rotational position;

determining the second, mirror image rotational position of the blade (14); and

moving the blade (14) to the second, mirror image rotational position upon processing of the operator initiated command.

26. A method as set forth in claim 25 wherein the step of determining the first rotational position of the blade (14) further includes the step of determining the present blade sideshift.

27. A method as set forth in claim 26 wherein the step of determining the second, mirror image rotational position of the blade (14) further includes the step of determining the mirror image position of the present blade sideshift.

28. A method as set forth in claim 25 wherein the step of determining the first rotational position of the blade (14) further includes the step of determining the present drawbar sideshift.

29. A method as set forth in claim 28 wherein the step of determining the second, mirror image rotational position of the blade (14) further includes the step of determining the mirror image position of the present drawbar sideshift.

30. A geographic surface altering work machine (10), comprising:

a moveable machine frame (18);

a work implement (14) moveably connected to the machine frame (18); and

an apparatus for controlling the work implement (14) in simultaneous first and second control modes of operation according to claim 1.

31. A geographic surface altering work machine (10), comprising:

a moveable machine frame (18);

a work implement (14) moveably connected to the machine frame (18); and

an apparatus for automatically moving the work implement (14) from a first rotational position to a second, mirror image rotational position according to claim 17.

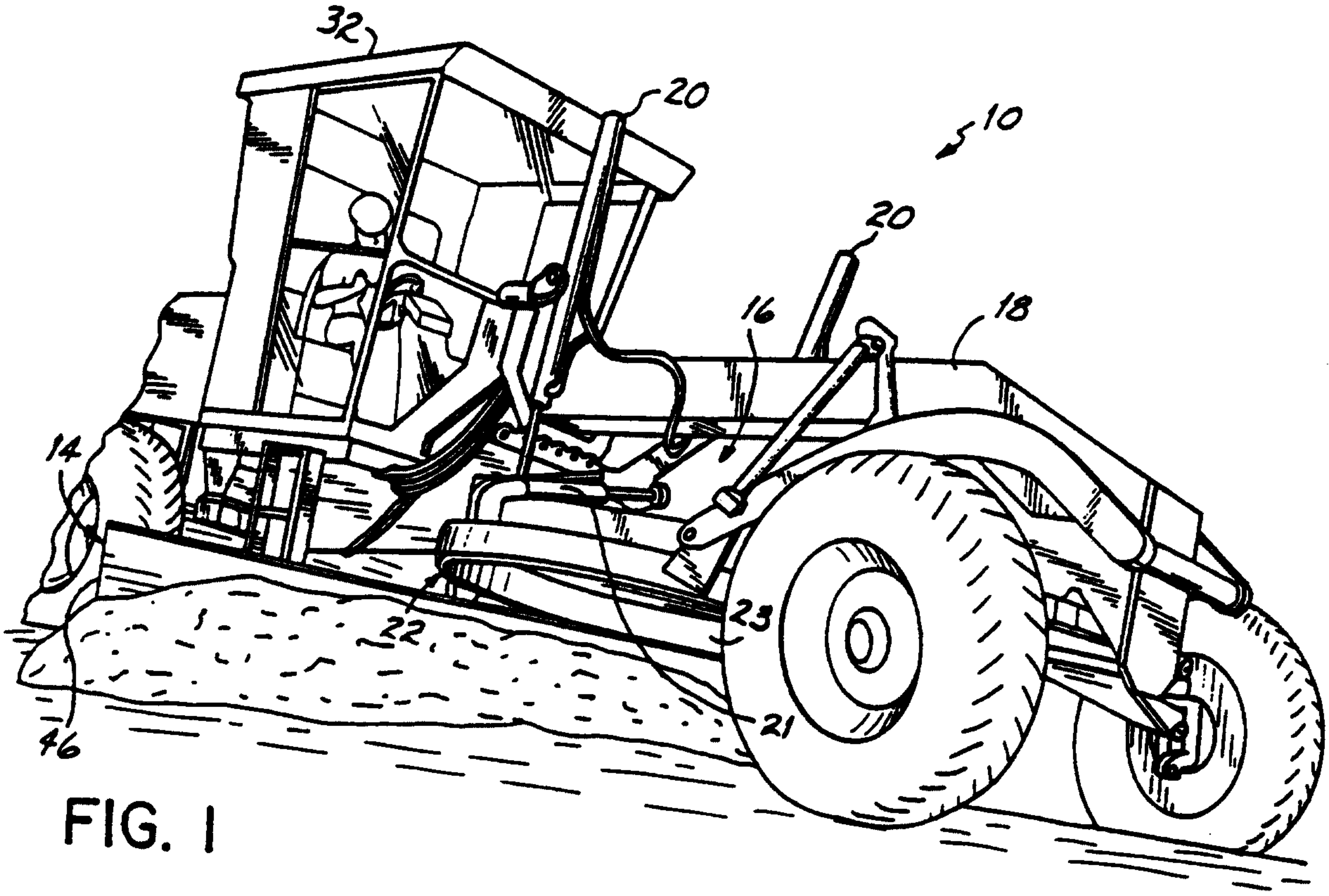


FIG. 1

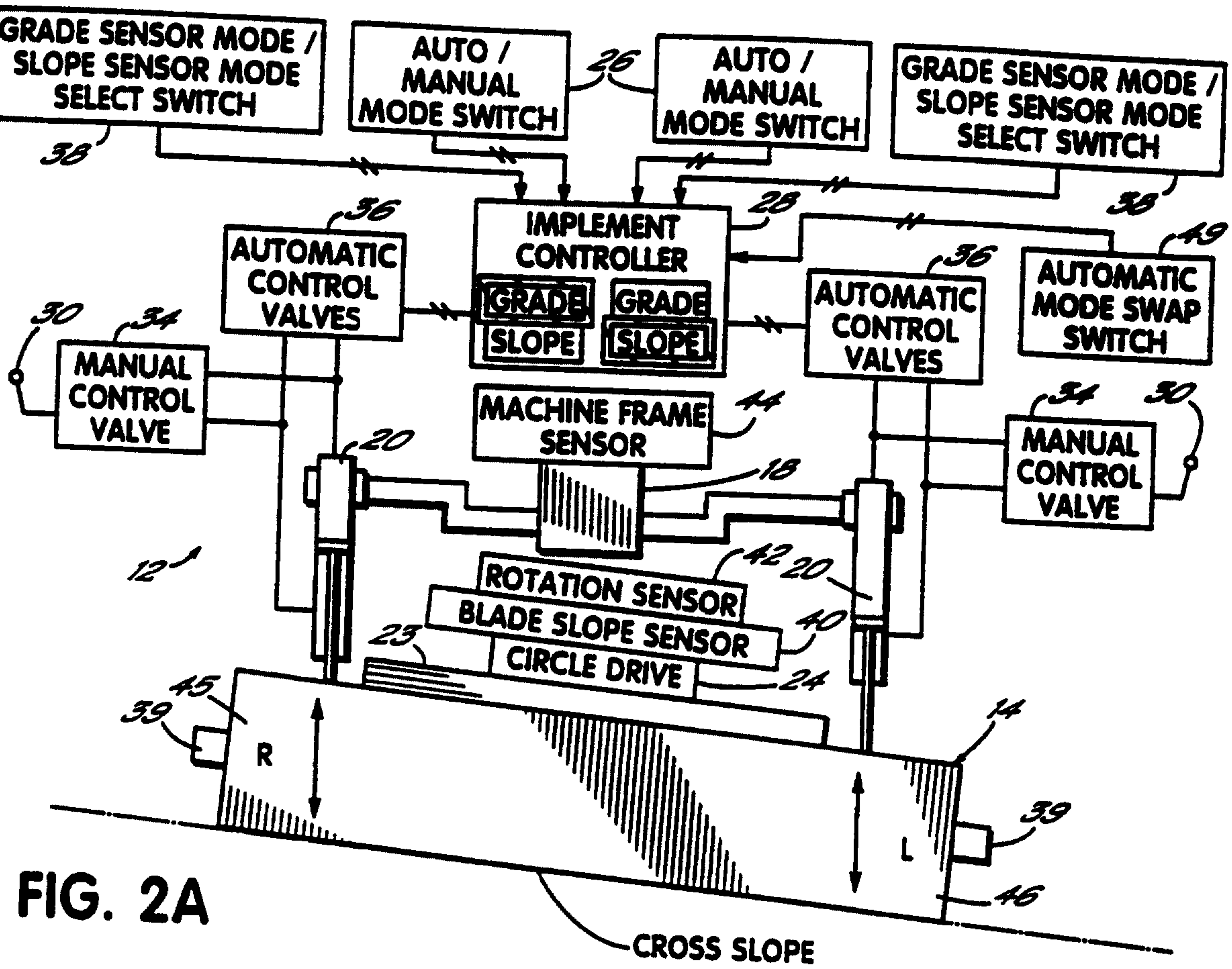
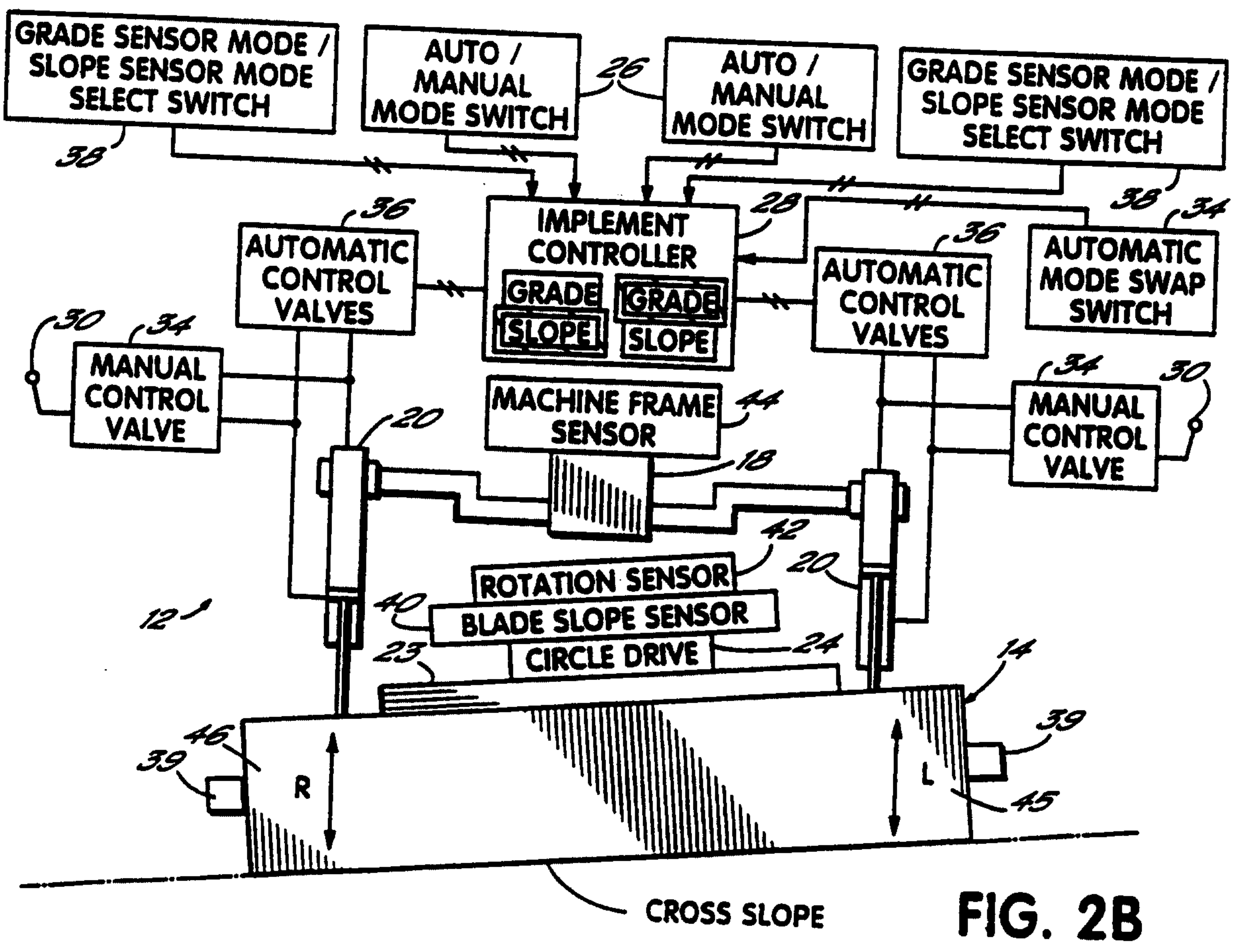

GRADE SENSOR MODE / SLOPE SENSOR MODE SELECT SWITCH
AUTO / MANUAL MODE SWITCH
AUTO / MANUAL MODE SWITCH
GRADE SENSOR MODE / SLOPE SENSOR MODE SELECT SWITCH
IMPLEMENT CONTROLLER
GRADE
SLOPE
GRADE
SLOPE
AUTOMATIC CONTROL VALVES
AUTOMATIC CONTROL VALVES
AUTOMATIC MODE SWAP SWITCH
MANUAL CONTROL VALVE
MANUAL CONTROL VALVE
MACHINE FRAME SENSOR
ROTATION SENSOR
BLADE SLOPE SENSOR
CIRCLE DRIVE
R
L
CROSS SLOPE

FIG. 2A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AUTO / MANUAL MODE SWITCH
AUTO / MANUAL MODE SWITCH
GRADE SENSOR MODE / SLOPE SENSOR MODE SELECT SWITCH
IMPLEMENT CONTROLLER
GRADE
SLOPE
GRADE
SLOPE
AUTOMATIC CONTROL VALVES
AUTOMATIC CONTROL VALVES
AUTOMATIC MODE SWAP SWITCH
MANUAL CONTROL VALVE
MANUAL CONTROL VALVE
MACHINE FRAME SENSOR
ROTATION SENSOR
BLADE SLOPE SENSOR
CIRCLE DRIVE
R
L
CROSS SLOPE

FIG. 2B

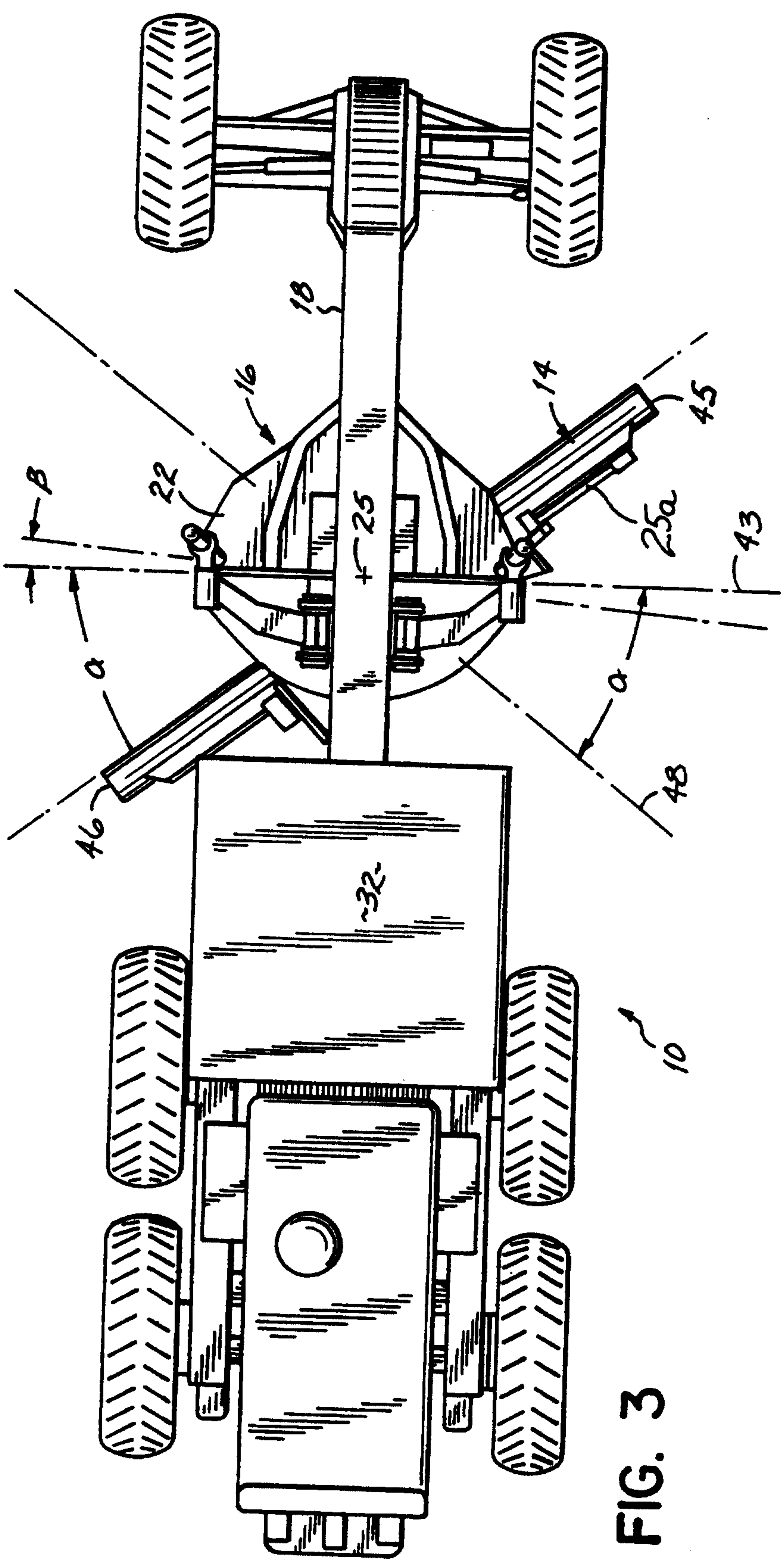


FIG. 3

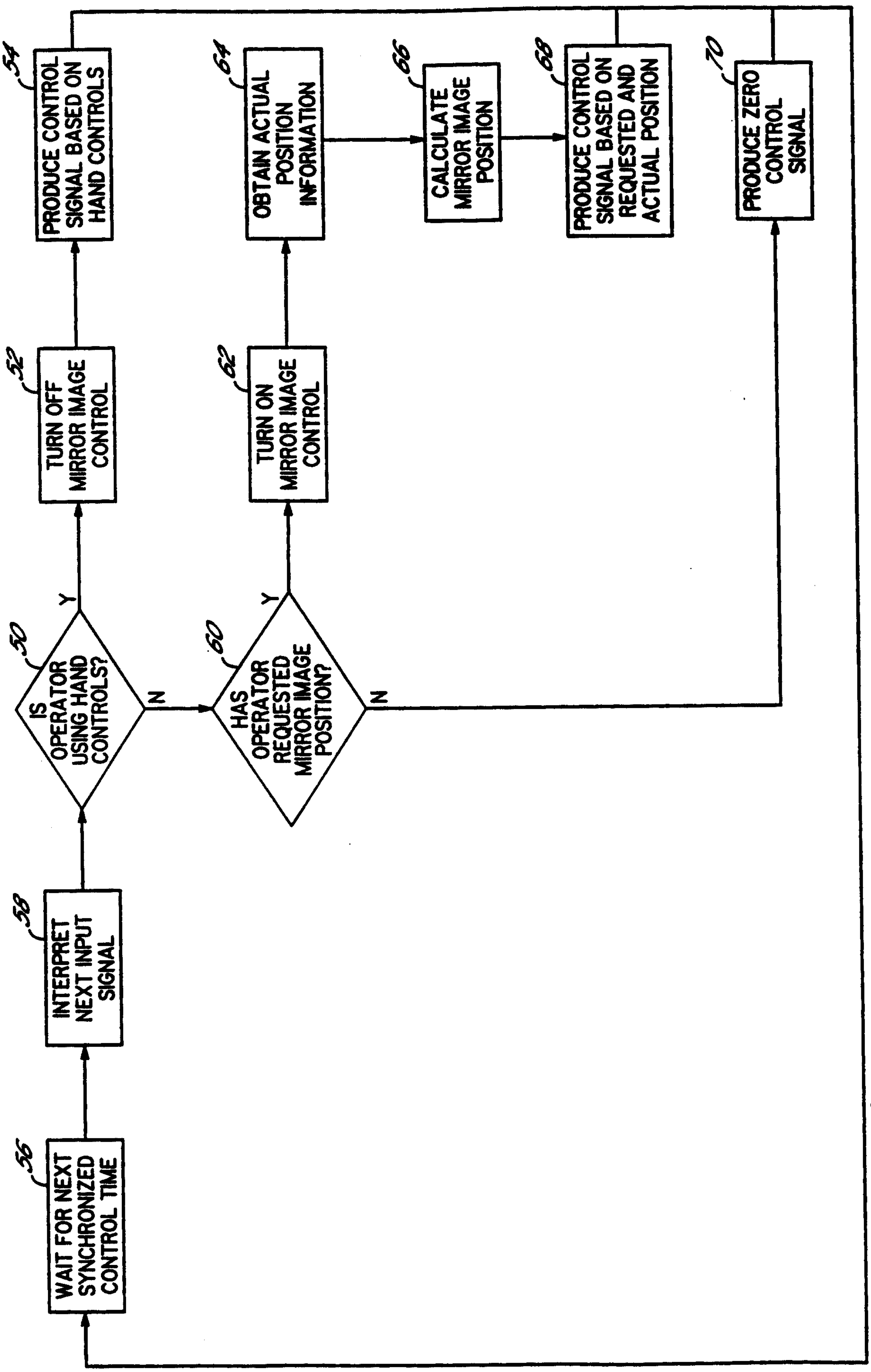
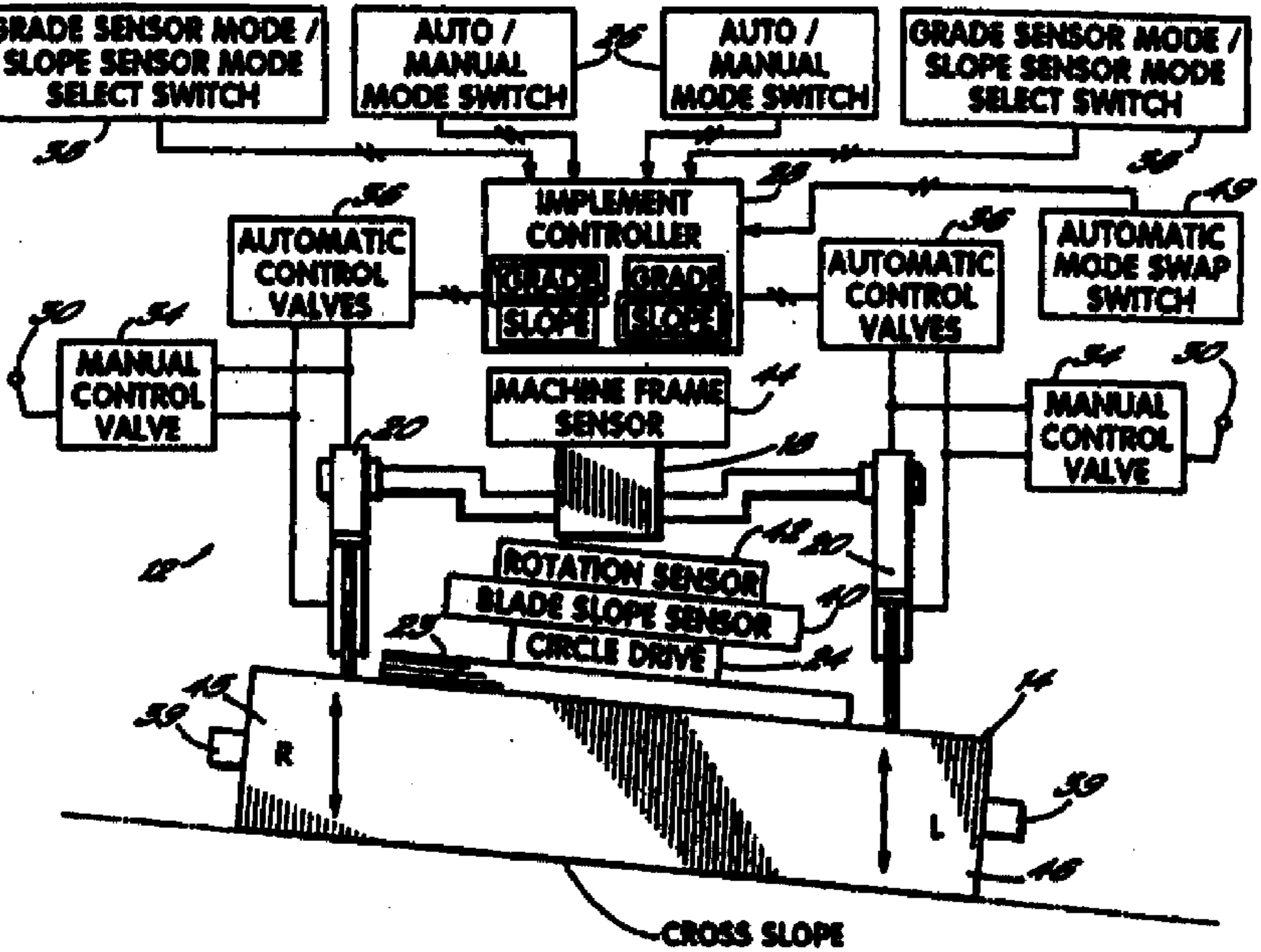

56
WAIT FOR NEXT SYNCHRONIZED CONTROL TIME
58
INTERPRET NEXT INPUT SIGNAL
50
IS OPERATOR USING HAND CONTROLS?
Y
N
52
TURN OFF MIRROR IMAGE CONTROL
54
PRODUCE CONTROL SIGNAL BASED ON HAND CONTROLS
60
HAS OPERATOR REQUESTED MIRROR IMAGE POSITION?
Y
N
62
TURN ON MIRROR IMAGE CONTROL
64
OBTAIN ACTUAL POSITION INFORMATION
66
CALCULATE MIRROR IMAGE POSITION
68
PRODUCE CONTROL SIGNAL BASED ON REQUESTED AND ACTUAL POSITION
70
PRODUCE ZERO CONTROL SIGNAL

FIG. 4



GRADE SENSOR MODE / SLOPE SENSOR MODE SELECT SWITCH
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R
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CROSS SLOPE