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Kelley et al.

[54] **MOTOR GRADER HAVING DUAL STEERING MECHANISMS**

[75] Inventors: **Craig B. Kelley**, Dunlap; **Matthew A. Hartman**, Bloomington; **Mark D. Shane**, Princeville; **Daniel E. Shearer**, Metamora; **Bernie D. Lunsford**, Lowpoint, all of Ill.

[73] Assignee: **Caterpillar Inc.**, Peoria, Ill.

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[52] **U.S. Cl.** ..... **180/333**; 74/471 XY

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Primary Examiner—Harold J. Tudor
Attorney, Agent, or Firm—Kevin M. Kercher

[57] **ABSTRACT**

A dual steering system for controlling the steering of a motor grader is disclosed. The first portion of the steering system comprises a steering wheel connected through a hydraulic steering valve to hydraulic right and left steering cylinders, which are connected to the right front tire and left front tire, respectively. Rotation of the steering wheel causes rotation of the front tires. A second portion of the steering system comprises a first button and a second button that are mounted to a control lever. Actuation of the first button sends a first electrical input signal and actuation of the second button sends a second electrical input signal to an electronic control computer. The electronic control computer generates control signals in response to the electrical input signals and transmits these control signals to a plurality of electro-hydraulic actuators. Actuation of an electro-hydraulic actuator by one of the control signals leads to actuation of the right steering cylinder and the left steering cylinder thereby causing rotation of the front wheels of the grader in one of two directions. Thus, the direction of travel of a motor grader can be controlled by one of two steering systems, one of which permits an operator to maintain contact with a control lever while adjusting the steering of the motor grader.

5 Claims, 4 Drawing Sheets

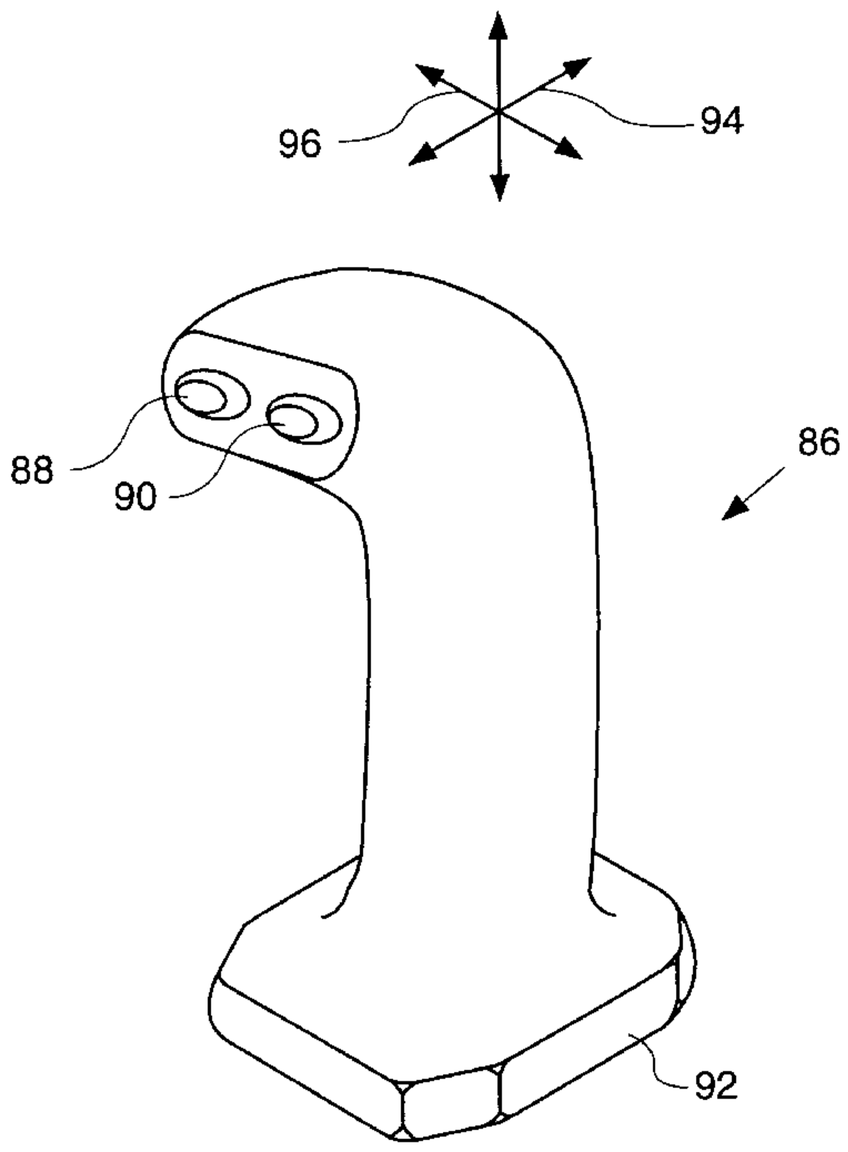
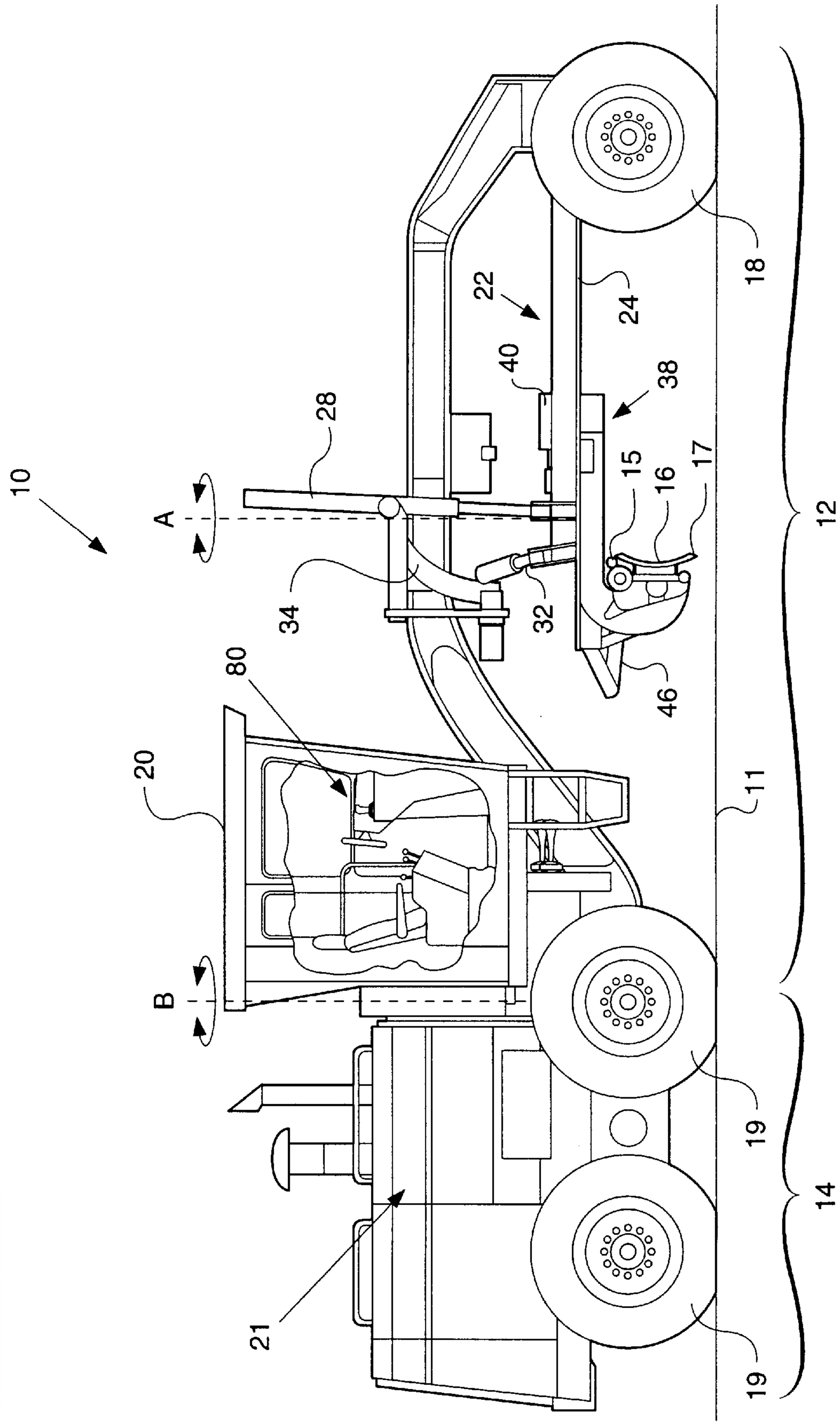


FIG - 1



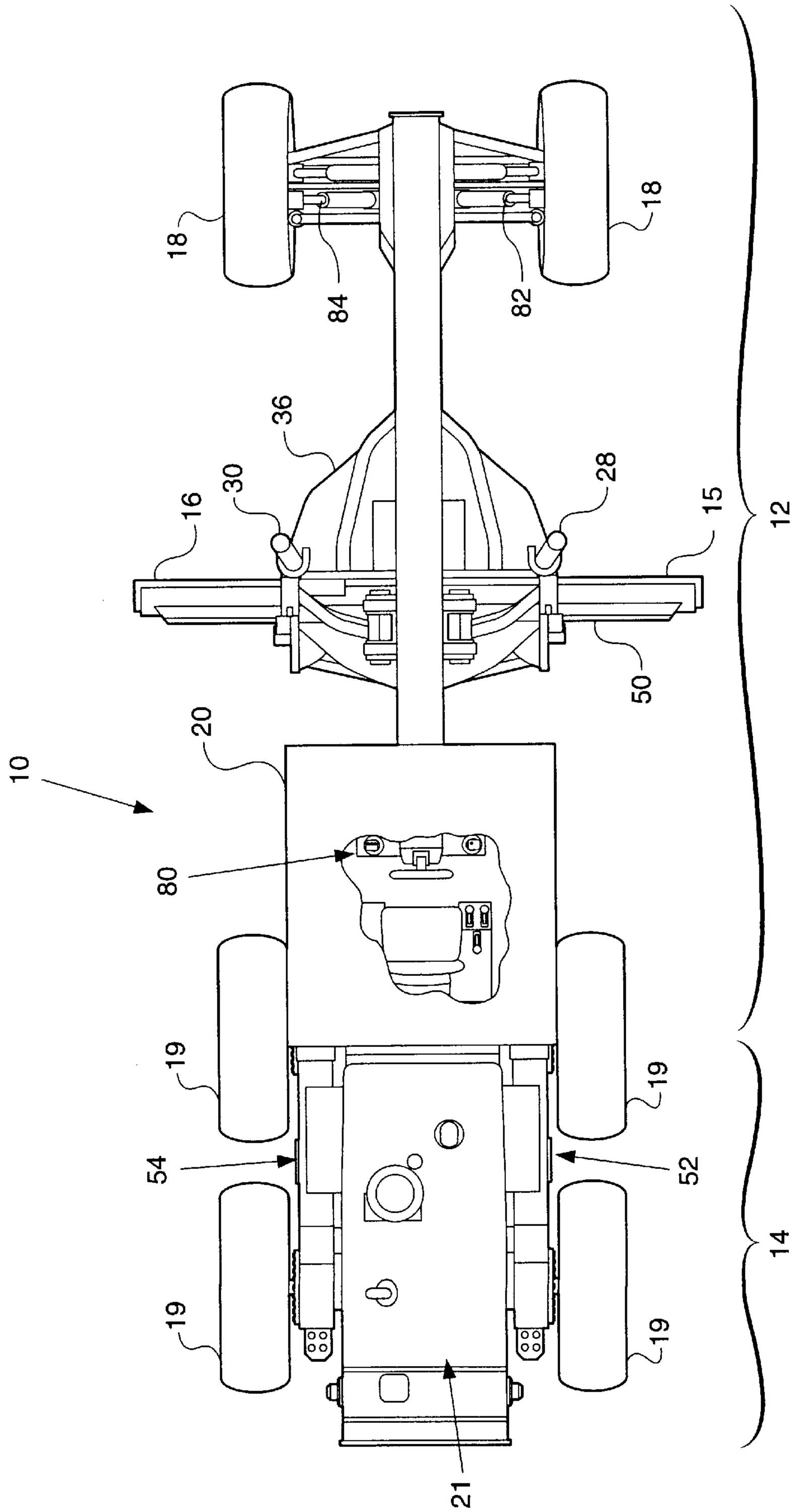


FIG-2-

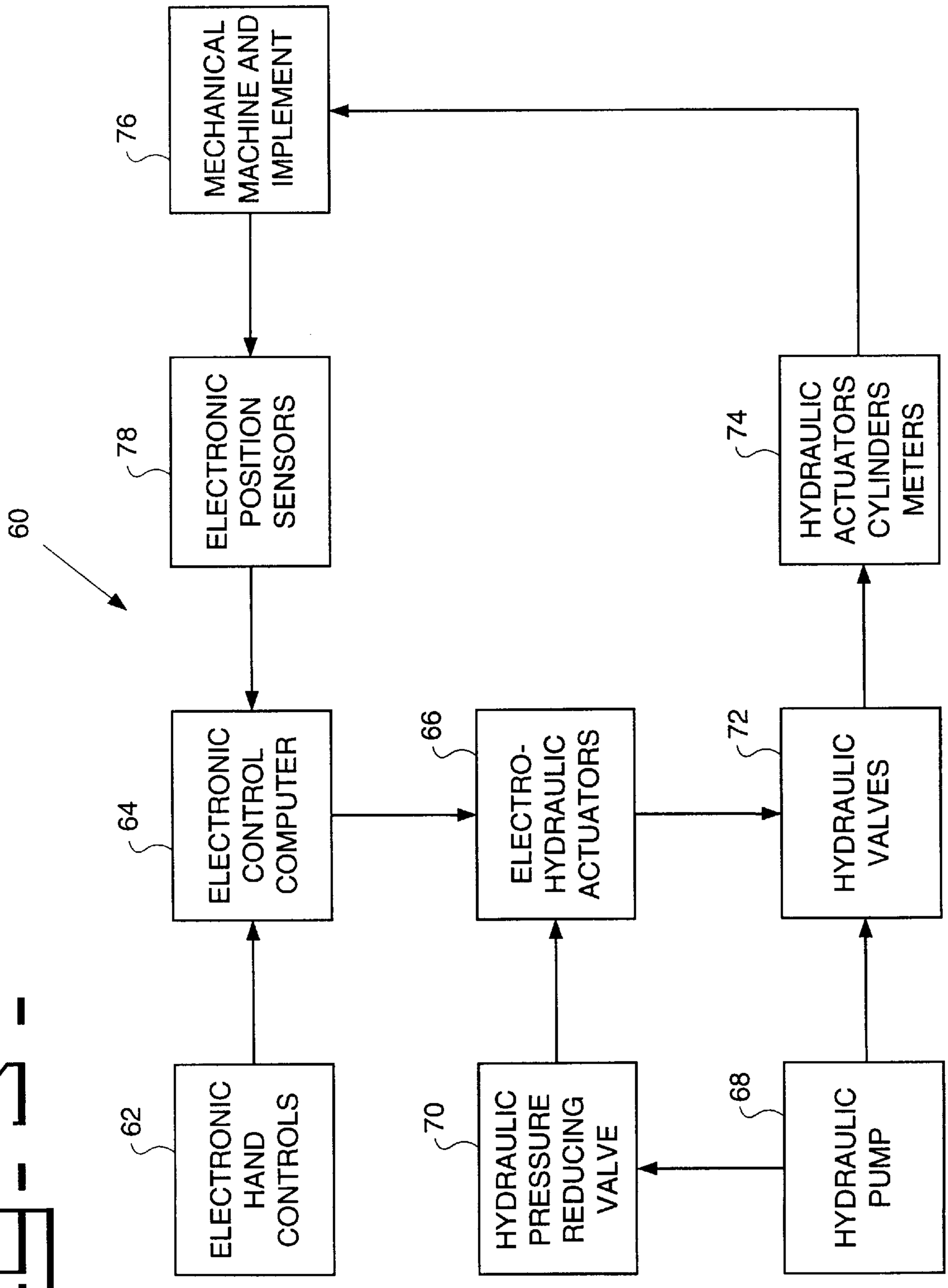
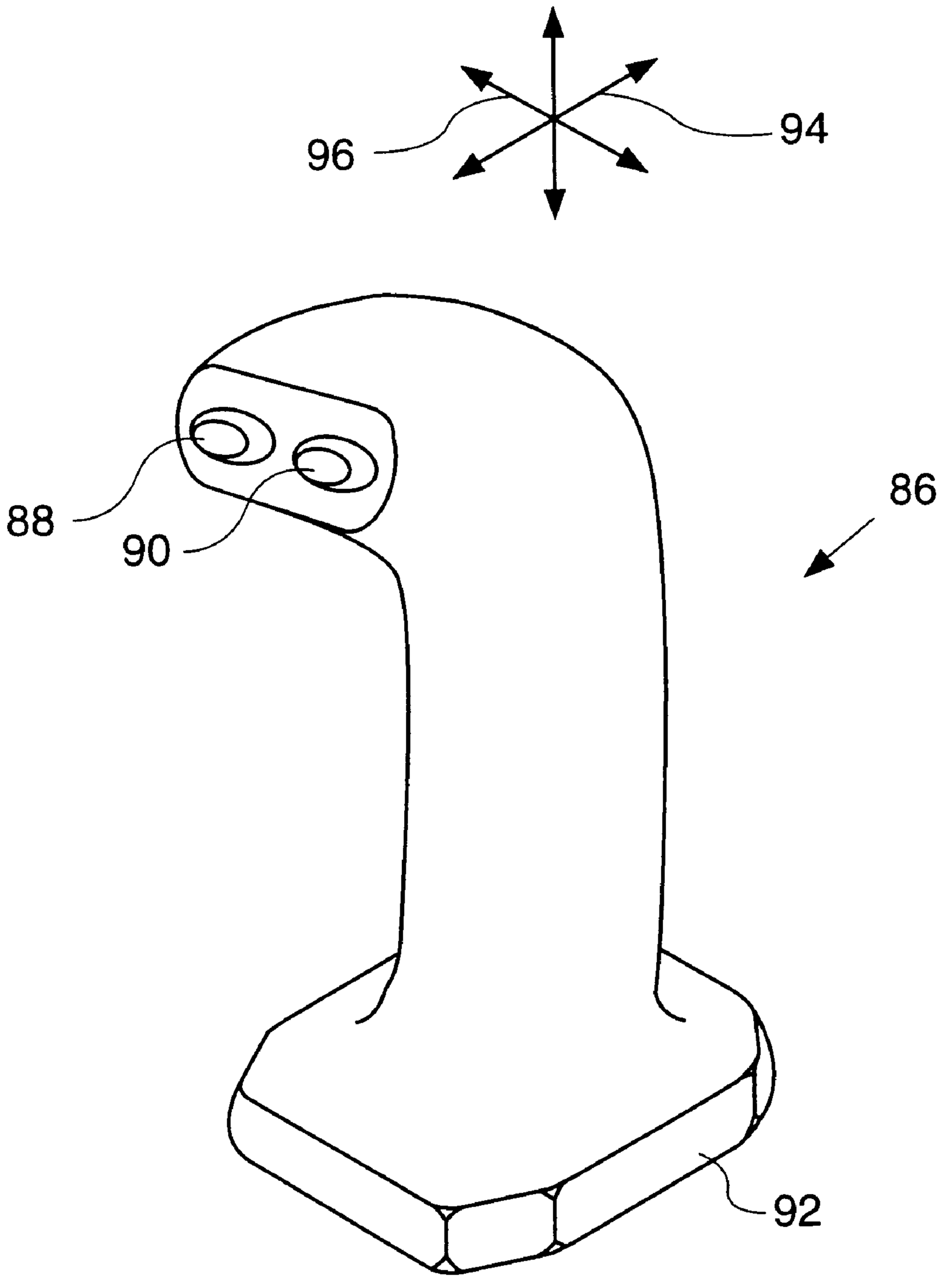

60
62
ELECTRONIC HAND CONTROLS
64
ELECTRONIC CONTROL COMPUTER
66
ELECTRO-HYDRAULIC ACTUATORS
68
HYDRAULIC PUMP
70
HYDRAULIC PRESSURE REDUCING VALVE
72
HYDRAULIC VALVES
74
HYDRAULIC ACTUATORS CYLINDERS METERS
76
MECHANICAL MACHINE AND IMPLEMENT
78
ELECTRONIC POSITION SENSORS

FIG-3

FIG. 4



MOTOR GRADER HAVING DUAL STEERING MECHANISMS

DESCRIPTION

1. Technical Field

This invention relates generally to a motor grader and specifically to a motor grader that includes dual steering controls.

2. Background Art

This invention relates generally to a motor grader that includes two mechanisms for controlling the steering of the motor grader.

Motor graders include many hand-operated controls to perform functions such as positioning an implement or a blade in several orientations, articulating the frame of the grader, and adjusting other grader settings. In most graders steering is accomplished by means of a steering wheel that acts through the hydraulic system of the motor grader.

Current motor graders require numerous hand-operated controls because typically each hand-operated control is used to control only one or two functions. Often, the operator of the motor grader must steer the grader while performing many other functions, such as adjusting the blade tip, adjusting the blade angle relative to the frame, and adjusting the articulation of the grader frame. Because the typical hand-operated controls are spaced apart, performing all of these functions while steering the vehicle is difficult, inefficient, and fatiguing for the operator. The operator must frequently remove one or both hands from the steering wheel to operate the other controls. To reduce difficulty, increase efficiency, and reduce operator fatigue, it is desirable to provide an apparatus that permits an operator to steer a motor grader without requiring the operator to release controls that control motor grader implements. Also it is desirable to provide an apparatus that is ergonomically advantageous for controlling both steering and these other functions.

3. Disclosure of the Invention

The present invention provides an efficient and ergonomic steering control system for a motor grader. The system permits the motor grader to be steered by one of two mechanisms that can be selected by the operator.

In a preferred embodiment, the steering mechanism comprises an electro-hydraulic control system and a control lever having a first button and a second button. The electro-hydraulic control system comprises an electronic control computer, a plurality of electro-hydraulic actuators, a hydraulic right steering cylinder associated with one of the plurality of electro-hydraulic actuators and a hydraulic left steering cylinder associated with another of the plurality of electro-hydraulic actuators. The hydraulic right steering cylinder and the hydraulic left steering cylinder are each connected to one of a pair of front tires of the motor grader. The first button transmits a first electronic input signal to the electronic control computer and the electronic control computer transmits a first control signal to the electro-hydraulic actuators associated with the hydraulic right steering cylinder and the hydraulic left steering cylinder in response to the first electronic input signal. The first control signal actuates the electro-hydraulic actuators associated with the hydraulic right steering cylinder and the hydraulic left steering cylinder, and the hydraulic right steering cylinder and the hydraulic left steering cylinder rotate the pair of front tires a first direction in response to actuation of the associated electro-hydraulic actuators by the first control signal. The

second button transmits a second electronic input signal to the electronic control computer and the electronic control computer transmits a second control signal to the electro-hydraulic actuators associated with the hydraulic right steering cylinder and the hydraulic left steering cylinder in response to the second electronic input signal. The second control signal actuates the electro-hydraulic actuators associated with the hydraulic right steering cylinder and the hydraulic left steering cylinder and the hydraulic right steering cylinder and the hydraulic left steering cylinder rotate the pair of front tires a second direction in response to actuation of the associated electro-hydraulic actuators by the second control signal. The second direction is opposite to the first direction.

In a most preferred embodiment, the steering control system further includes a steering wheel hydraulically connected to the hydraulic right steering cylinder and the hydraulic left steering cylinder. Rotation of the steering wheel a first direction actuates the right steering cylinder and the left steering cylinder to rotate the pair of front tires the first direction. Rotation of the steering wheel a second direction actuates the right steering cylinder and the left steering cylinder to rotate the pair of front tires the second direction.

Thus, the present invention permits an operator to steer a motor grader while maintaining control of a control lever that is used to control other motor grader functions. In addition, the present invention permits the operator to utilize the steering wheel, as is typically done, when it is advantageous.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a motor grader;

FIG. **2** is a top view of the motor grader;

FIG. **3** is a schematic block diagram of an electro-hydraulic control system for the motor grader; and

FIG. **4** is a side perspective of a control lever and steering mechanism designed in accordance with the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a motor grader is shown generally at **10** in FIGS. **1** and **2**. The motor grader **10** is used primarily as a finishing tool to sculpt a surface of earth **11** to a final arrangement. Rather than moving large quantities of earth in the direction of travel like other machines, such as a bulldozer, the motor grader **10** moves relatively small quantities of earth from side to side.

The motor grader **10** includes a front frame **12**, a rear frame **14**, and a blade **16** having a top **15** and a cutting edge **17**. The front and rear frames **12** and **14** are supported by front tires **18** and rear tires **19**. An operator cab **20** containing the many controls including a steering wheel **80** necessary to operate the motor grader **10** is mounted on the front frame **12**. An engine, shown generally at **21**, is used to drive or power the motor grader **10**. The engine **21** is mounted on the rear frame **14**. The blade **16**, sometimes referred to as a moldboard, is used to move earth. The blade **16** is mounted on a linkage assembly shown generally at **22**. The linkage assembly **22** allows the blade **16** to be moved to a variety of different positions with respect to the motor grader **10**. Starting at the front of the motor grader **10** and working rearward toward the blade **16**, the linkage assembly **22** includes a drawbar **24**.

The drawbar **24** is mounted to the front frame **12** with a ball joint. The position of the drawbar **24** is controlled by three hydraulic cylinders, commonly referred to as a right lift cylinder **28**, a left lift cylinder **30**, and a center shift cylinder **32**. A coupling, shown generally at **34**, connects the three cylinders **28**, **30**, and **32** to the front frame **12**. The coupling **34** can be moved during blade repositioning but is fixed stationary during earthmoving operations. The height of the blade **16** with respect to the surface of earth **11** below the motor grader **10**, commonly referred to as the blade height, is controlled primarily with the right lift cylinder **28** and the left lift cylinder **30**. Each lift cylinder, **28** and **30**, functions to raise and lower the associated end of the blade **16**. Thus, the right lift cylinder **28** raises and lowers the right end of blade **16**. The center shift cylinder **32** moves the drawbar **24** from side to side relative to the front frame **12**.

The drawbar **24** includes a large, flat plate commonly referred to as a yoke plate **36**, as shown in FIG. **2**. Beneath the yoke plate **36** is a large gear, commonly referred to as a circle **38**. The circle **38** is rotated by a hydraulic motor commonly referred to as a circle drive **40**, as shown in FIG. **1**. Rotation of the circle **38** by the circle drive **40** pivots the blade **16** about an axis A fixed to the drawbar **24**. The blade **16** is mounted to a hinge (not shown) on the circle **38** with a bracket (not shown). A hydraulic blade tip cylinder **46** is used to pitch the bracket forward or rearward and thus pitch the top **15** of the blade **16** forward and rearward relative to the cutting edge **17**. The blade **16** is mounted to a sliding joint in the bracket allowing the blade **16** to be slid or shifted from side to side with respect to the bracket. A hydraulic side shift cylinder **50**, shown in FIG. **2**, is used to control the side to side shift of the blade **16**.

Referring now to FIG. **2**, a right articulation cylinder, shown generally at **52**, is mounted to the right side of the rear frame **14** and a left articulation cylinder, shown generally at **54**, is mounted to the left side of the rear frame **14**. The right and left articulation cylinders **52** and **54** are hydraulic and used to rotate the front frame **12** about an axis B shown in FIG. **1**. The axis B is commonly referred to as the articulation axis. In FIG. **2**, the motor grader **10** is positioned in a neutral or zero articulation angle. The rear tires **19** are driven by a differential (not shown) as is well known in the art. Adjacent the front tires is a hydraulic right steering cylinder **82** and a hydraulic left steering cylinder **84**. The right steering cylinder **82** and the left steering cylinder **84** are used to control the position of front tires **18** and thus steer motor grader **10**. In a conventional motor grader **10** rotation of the steering wheel **80** is used to actuate the right steering cylinder **82** and the left steering cylinder **84**. As would be understood by one of ordinary skill in the art, the front tires **18** could be rotated using only a single steering cylinder mounted to either the left or the right front tire **18**.

FIG. **3** is a schematic block diagram of an electro-hydraulic control system **60** for the motor grader **10**. The control system **60** is designed to operate the various hydraulic controls of the motor grader **10** described above. The system **60** includes a plurality of electronic hand controls represented by block **62**, which transform the actions of an operator□s hands on controls such as a control lever **86** (see FIG. **4**) into a plurality of electrical input signals. These input signals carry operational information to an electronic control computer, represented by block **64**.

The control computer **64** receives the electrical input signals produced by the hand controls **62**, processes the operational information carried by the input signals, and transmits control signals to a plurality of drive solenoids, each of which is located in an electro-hydraulic actuator, represented by block **66**.

The hydraulic portion of the control system **60** requires both high hydraulic pressure and low pilot pressure. High hydraulic pressure is provided by a hydraulic pump, represented by block **68**. The hydraulic pump **68** receives a rotary motion, typically from the engine **21** of the motor grader **10**, and produces high hydraulic pressure. Low pilot pressure is provided by a hydraulic pressure reducing valve, represented by block **70**. The hydraulic pressure reducing valve **70** receives high hydraulic pressure from the hydraulic pump **68** and supplies low pilot pressure to the electro-hydraulic actuators **66**.

Each electro-hydraulic actuator **66** includes an electrical drive solenoid and a hydraulic valve. The solenoid receives control signals from the electronic control computer **64** and produces a controlled mechanical movement of a core stem of the actuator **66**. The hydraulic valve receives both the controlled mechanical movement of the core stem of the actuator **66** and low pilot pressure from the hydraulic pressure reducing valve **70** and produces controlled pilot hydraulic pressure for hydraulic valves, represented by block **72**.

The hydraulic valves **72** receive both controlled pilot hydraulic pressure from the electro-hydraulic actuators **66** and high hydraulic pressure from the hydraulic pump **68** and produce controlled high hydraulic pressure for hydraulic actuators, cylinders, and motors, represented by block **74**.

The hydraulic actuators, cylinders, and motors **74** receive controlled high hydraulic pressure from the hydraulic valves **72** and produce mechanical force to move the front frame **12** of the grader **10** and several mechanical linkages, represented by block **76**. As described above, movement of the front frame **12** of the grader **10** with respect to the rear frame **14** of the grader **10** establishes the articulation angle. Movement of the mechanical linkages establishes the position of the blade **16** or other implements.

Each hydraulic actuator, cylinder, and motor **74**, such as the lift cylinders **28** and **30** and the circle drive motor **40**, includes an electronic position sensor, represented by block **78**. The electronic position sensors **78** transmit information regarding the position of its respective hydraulic actuator, cylinder, or motor **76** to the electronic control computer **64**. In this manner, the control computer **64** can, for example, determine the articulation angle of the grader **10** and position the blade **16**. With such information, the control computer **64** can perform additional operations.

In FIG. **4** a control lever is generally shown at **86**. Control lever **86** includes a first button **88** and a second button **90**. Control lever **86** extends from a mounting base **92**. Control lever **86** is movable along a first axis **94** and a second axis **96**, which is generally perpendicular to the first axis **94**. Control lever **86** is also rotatable about a third axis **98** that is perpendicular to the first axis **94** and the second axis **96**. Control lever **86** can also be moved along axes that are intermediate between first axis **94** and second axis **96**.

The hydraulic right steering cylinder **82** and the hydraulic left steering cylinder **84** are controlled through the electro-hydraulic control system **60** and the first button **88** and the second button **90** on the control lever **86**. Both the hydraulic right steering cylinder **82** and the hydraulic left steering cylinder **84** are each associated with one of the electro-hydraulic actuators **66**.

Pressing the first button **88** transmits a first electronic input signal to the electronic control computer **64**. The electronic control computer **64** then transmits a first control signal to the electro-hydraulic actuators **66** associated with the hydraulic right steering cylinder **82** and the hydraulic left

steering cylinder **84** in response to the first electronic input signal. The first control signal actuates the electro-hydraulic actuators **66** associated with the hydraulic right steering cylinder **82** and the hydraulic left steering cylinder **84**. Actuation of these electro-hydraulic actuators **66** causes hydraulic right steering cylinder **82** and hydraulic left steering cylinder **84** to rotate the pair of front tires **18** a first direction. As long as the first button **89** is held down the hydraulic right steering cylinder **82** and hydraulic left steering cylinder **84** continue to rotate the pair of front tires **18** in the first direction. The front tires **18** maintain their rotated orientation until moved by either rotating the steering wheel **80** or pressing the first button **89** or second button **90**.

Pressing the second button **90** transmits a second electronic input signal to the electronic control computer **64**, which then transmits a second control signal to the electro-hydraulic actuators **66** associated with the hydraulic right steering cylinder **82** and the hydraulic left steering cylinder **84**. The second control signal actuates the electro-hydraulic actuators **66** associated with the hydraulic right steering cylinder **82** and the hydraulic left steering cylinder **84** to cause them to rotate the pair of front tires **18** a second direction opposite to the first direction. As long as the first button **90** is held down the hydraulic right steering cylinder **82** and hydraulic left steering cylinder **84** continue to rotate the pair of front tires **18** in the second direction. The front tires **18** maintain their rotated orientation until moved by either rotating the steering wheel **80** or pressing the first button **89** or second button **90**. Thus, an operator can steer the motor grader **10** with out needing to remove a hand from an implement control lever to rotate the steering wheel **80**. The steering wheel **80** can still be used as described below.

As described above, the control lever **86** is movable along the first axis **94**, the second axis **96**, and the third axis **98**. Movement of control lever **86** along the first axis **94**, the second axis **96**, the third axis **98** transmits an electrical input signal to the electronic control computer **64**. Movement of control lever **86** along an axis intermediate to the first axis **94** and the second axis **96** produces a combination electrical input signal that reflects proportionally the angle of movement of the control lever **86** between the first axis **94** and the second axis **96**. The electronic control computer **64** then transmits a control signal to at least one of the electro-hydraulic actuators **66**. As described above, actuating one of the electro-hydraulic actuators **66** actuates either a hydraulic cylinder, a hydraulic motor, or a hydraulic actuator **74** such as the blade tip cylinder **46**.

Industrial Applicability

The present invention relates generally to a steering system for a motor grader **10**. The steering system comprises a dual steering system wherein the direction of travel of the motor grader **10** can be controlled by either of two separate mechanisms. The first mechanism comprises a typical steering wheel **80** that is connected to the right steering cylinder **82** and the left steering cylinder **84** through a hydraulic steering valve. Rotation of the steering wheel **80** in a first direction causes right steering cylinder **82** and left steering cylinder **84** to rotate the front tires **18** of motor grader **10** a first direction. Rotation of steering wheel **80** in a second direction opposite the first direction causes right steering cylinder **82** and left steering cylinder **84** to rotate front tires **18** in a second direction opposite the first direction. The second means of controlling steering of the motor grader **10** comprises a control lever **86** having a first button **88** and a second button **90**. The first button **88** and second button **90** are connected to an electro-hydraulic control system **60**. Activation of either first button **88** or second button **90** transmits a first electrical input signal or a second electrical input signal respectively. The electrical input signals are received by an electronic control computer **64**. The electronic control computer **64** generates a first control signal and a second control signal in response to the first input signal and the second input signal respectively. The control signals are sent to electro-hydraulic actuators **66** that are associated with the right steering cylinder **82** and the left steering cylinder **84**. The control signals cause actuation of the electro-hydraulic actuators **66** which in turn actuates the right steering cylinder **82** and the left steering cylinder **84** to rotate the front tires **18** in a first direction or a second direction. Preferably, control lever **86** is also used to control a plurality of functions of motor grader **10**. Thus, the present invention provides a steering control system for a motor grader **10** that permits the motor grader **10** to be steered without requiring an operator to remove a hand from an implement control lever.

The present invention has been described in accordance with the relevant legal standards, thus the foregoing description is exemplary rather than limiting in nature. Variations and modifications to the disclosed embodiment may become apparent to those skilled in the art and do come within the scope of this invention. Accordingly, the scope of legal protection afforded this invention can only be determined by studying the following claims.

What is claimed is:

1. A steering mechanism for a motor grader comprising:

an electro-hydraulic control system and a control lever having a first button and a second button;

said electro-hydraulic control system comprising an electronic control computer, a plurality of electro-hydraulic actuators, a hydraulic right steering cylinder associated with one of said plurality of electro-hydraulic actuators and a hydraulic left steering cylinder associated with another of said plurality of electro-hydraulic actuators, said hydraulic right steering cylinder and said hydraulic left steering cylinder each connected to one of a pair of front tires of a motor grader;

said first button transmitting a first electronic input signal to said electronic control computer, said electronic control computer transmitting a first control signal to said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder in response to said first electronic input signal;

said first control signal actuating said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder, and said hydraulic right steering cylinder and said hydraulic left steering cylinder rotating said pair of front tires a first direction in response to actuation of said associated electro-hydraulic actuators by said first control signal;

said second button transmitting a second electronic input signal to said electronic control computer, said electronic control computer transmitting a second control signal to said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder in response to said second electronic input signal; and

said second control signal actuating said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder, and said hydraulic right steering cylinder and said hydraulic left steering cylinder rotating said pair of front tires a second direction in response to actuation of said asso-

ciated electro-hydraulic actuators by said second control signal, said second direction opposite said first direction.

2. A steering mechanism for a motor grader as recited in claim **1** wherein said control lever is movable along at least one axis;

movement of said control lever along said at least one axis transmitting a third electrical input signal to said electronic control computer;

said electronic control computer transmitting a third control signal to at least one of said plurality of electro-hydraulic actuators in response to said third electrical input signal; and

said third control signal actuating said at least one of said electro-hydraulic actuators, said actuated electro-hydraulic actuator actuating one of a hydraulic cylinder, a hydraulic motor, or a hydraulic actuator.

3. A steering mechanism for a motor grader as recited in claim **1** further including a steering wheel hydraulically connected to said hydraulic right steering cylinder and said hydraulic left steering cylinder;

rotation of said steering wheel a first direction actuating said right steering cylinder and said left steering cylinder to rotate said pair of front tires said first direction; and

rotation of said steering wheel a second direction actuating said right steering cylinder and said left steering cylinder to rotate said pair of front tires said second direction.

4. A steering mechanism for a motor grader comprising:

an electro-hydraulic control system and a control lever having a first button and a second button;

said electro-hydraulic control system comprising an electronic control computer, a plurality of electro-hydraulic actuators, a hydraulic right steering cylinder associated with one of said plurality of electro-hydraulic actuators and a hydraulic left steering cylinder associated with another of said plurality of electro-hydraulic actuators, said hydraulic right steering cylinder and said hydraulic left steering cylinder each connected to one of a pair of front tires of a motor grader;

said first button transmitting a first electronic input signal to said electronic control computer, said electronic control computer transmitting a first control signal to said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder in response to said first electronic input signal;

said first control signal actuating said electro-hydraulic actuators associated with said hydraulic right steering

cylinder and said hydraulic left steering cylinder, and said hydraulic right steering cylinder and said hydraulic left steering cylinder rotating said pair of front tires a first direction in response to actuation of said associated electro-hydraulic actuators by said first control signal;

said second button transmitting a second electronic input signal to said electronic control computer, said electronic control computer transmitting a second control signal to said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder in response to said second electronic input signal;

said second control signal actuating said electro-hydraulic actuators associated with said hydraulic right steering cylinder and said hydraulic left steering cylinder, and said hydraulic right steering cylinder and said hydraulic left steering cylinder rotating said pair of front tires a second direction in response to actuation of said associated electro-hydraulic actuators by said second control signal, said second direction opposite said first direction;

a steering wheel hydraulically connected to said hydraulic right steering cylinder and said hydraulic left steering cylinder;

rotation of said steering wheel a first direction actuating said right steering cylinder and said left steering cylinder to rotate said pair of front tires said first direction; and

rotation of said steering wheel a second direction actuating said right steering cylinder and said left steering cylinder to rotate said pair of front tires said second direction.

5. A steering mechanism for a motor grader as recited in claim **4** wherein said control lever is movable along at least one axis;

movement of said control lever along said at least one axis transmitting a third electrical input signal to said electronic control computer;

said electronic control computer transmitting a third control signal to at least one of said plurality of electro-hydraulic actuators in response to said third electrical input signal; and

said third control signal actuating said at least one of said electro-hydraulic actuators, said actuated electro-hydraulic actuator actuating one of a hydraulic cylinder, a hydraulic motor, or a hydraulic actuator.

* * * * *