United States Patent [19]
Ikeda et al.

[11] **3,831,683**
[45] **Aug. 27, 1974**

[54] **SYSTEM FOR CONTROLLING THE LEVEL OF AN EARTH-REMOVING BLADE OF A BULLDOZER**

[75] Inventors: **Toshimichi Ikeda**, Ibaraki-Ken; **Masataka Kawauchi; Atsushi Matsuzaki**, both of Tokyo; **Masayuki Suzuki**, Kashiwa, all of Japan

[73] Assignee: **Hitachi Construction Machinery Co., Ltd.**, Tokyo, Japan

[22] Filed: **Sept. 1, 1972**

[21] Appl. No.: **285,645**

[30] **Foreign Application Priority Data**

Sept. 6, 1971 Japan 46-68049

[52] **U.S. Cl.** **172/4.5**, 37/DIG. 20
[51] **Int. Cl.** **E02f 3/76**
[58] **Field of Search** 172/4.5, 2; 37/DIG. 20

[56] **References Cited**

UNITED STATES PATENTS

2,902,979	9/1959	Gurries et al.	172/4.5
3,026,638	3/1962	Hayner et al.	172/4.5
3,058,242	10/1962	Ocnaschek	172/4.5
3,497,014	2/1970	Ask	172/4.5
3,556,225	1/1971	Matsuzaki	172/4.5
3,674,094	7/1972	Kuntz	172/4.5

Primary Examiner—Stephen C. Pellegrino
Attorney, Agent, or Firm—Craig & Antonelli

[57] **ABSTRACT**

A system for controlling the level of an earth-removing blade of a bulldozer. The system comprises a first circuit means adapted for manual control of the level of the earth-removing blade and a second circuit means automatically operative to keep the earth-removing blade at a predetermined level. The first circuit means is usable in usual earth excavating and removing operation of the bulldozer while the second circuit means is usable to produce a flatly bulldozed earth surface. The second circuit means includes electric and hydraulic circuits. The electric circuit includes an input setting unit, a gyro-means to measure the actual level of the blade, and a circuit for comparing the signals from the input setting unit and gyro-means to emit an instruction signal. The hydraulic circuit includes valves operative in response to the instruction signal to control the amount and direction of the fluid to be fed from a fluid source to a cylinder for the actuation of blade supporting arms of the bulldozer for thereby automatically controlling the blade level.

3 Claims, 4 Drawing Figures

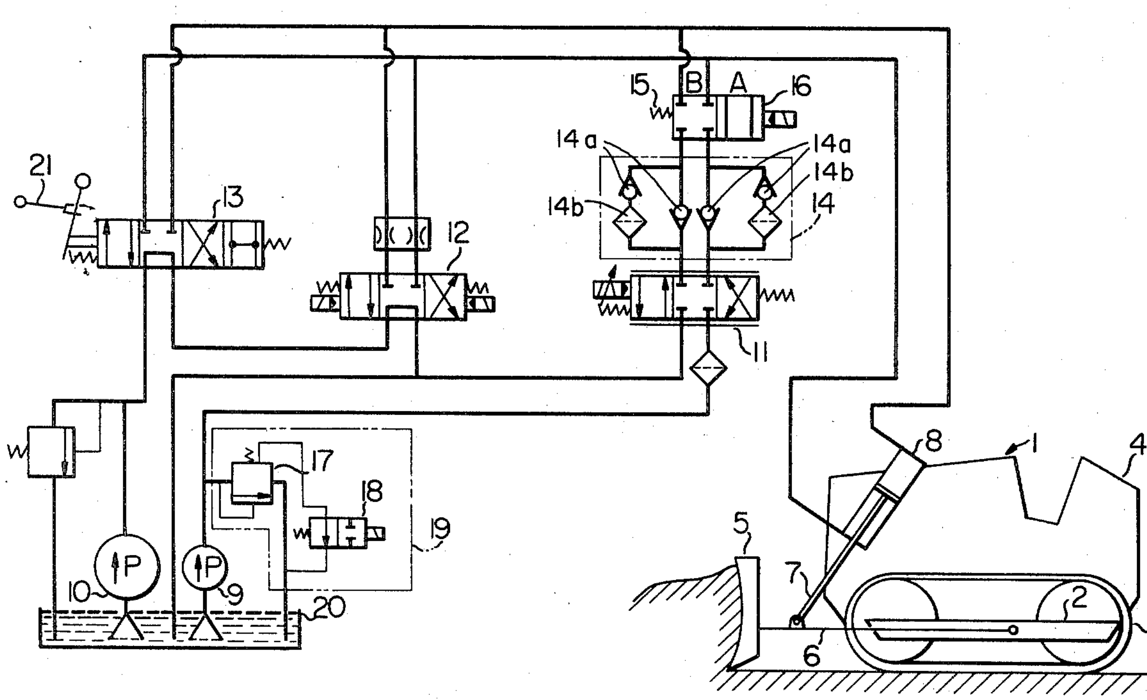
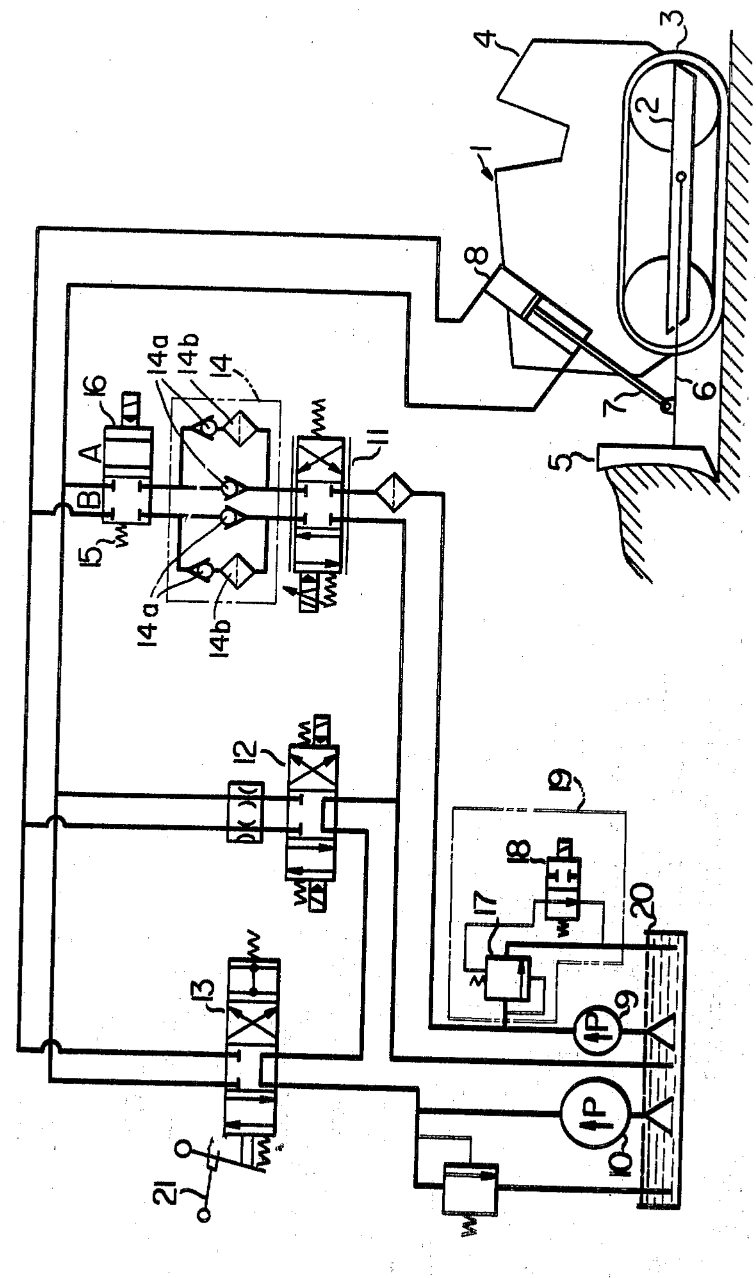


FIG. 1



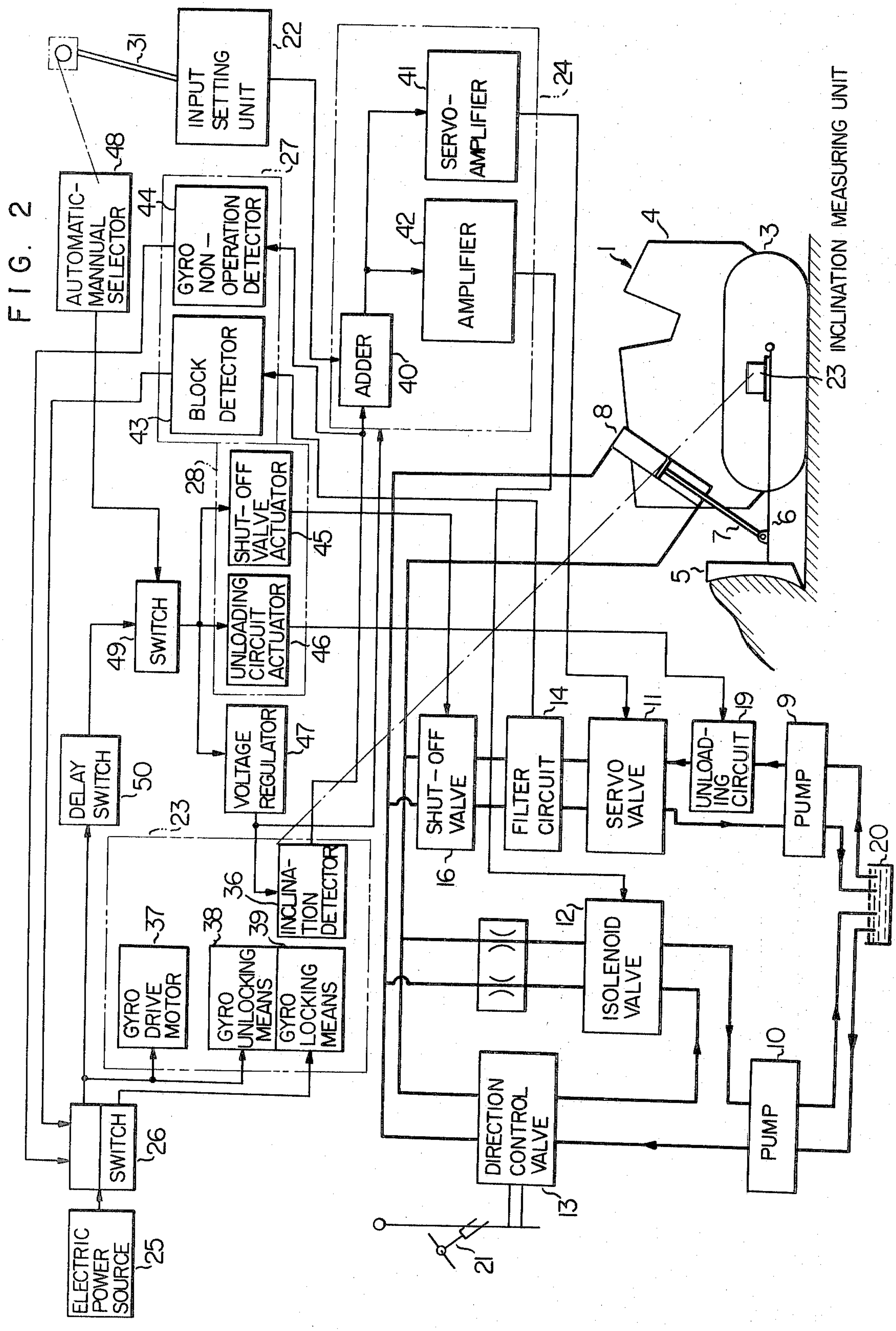

INPUT SETTING UNIT
22
31
AUTOMATIC-MANNUAL SELECTOR
48
27
GYRO NON-OPERATION DETECTOR
44
BLOCK DETECTOR
43
28
SHUT-OFF VALVE ACTUATOR
45
UNLOADING CIRCUIT ACTUATOR
46
SWITCH
49
DELAY SWITCH
50
VOLTAGE REGULATOR
47
ADDER
40
AMPLIFIER
42
SERVO-AMPLIFIER
41
24
23
INCLINATION DETECTOR
36
GYRO DRIVE MOTOR
37
GYRO UNLOCKING MEANS
38
GYRO LOCKING MEANS
39
SWITCH
26
ELECTRIC POWER SOURCE
25
SHUT-OFF VALVE
16
FILTER CIRCUIT
14
SERVO VALVE
11
UNLOADING CIRCUIT
19
PUMP
9
20
ISOLENOID VALVE
12
PUMP
10
DIRECTION CONTROL VALVE
13
21
1
3
4
5
6
7
8
23 INCLINATION MEASURING UNIT

FIG. 2

FIG. 3

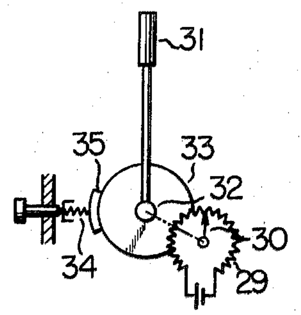
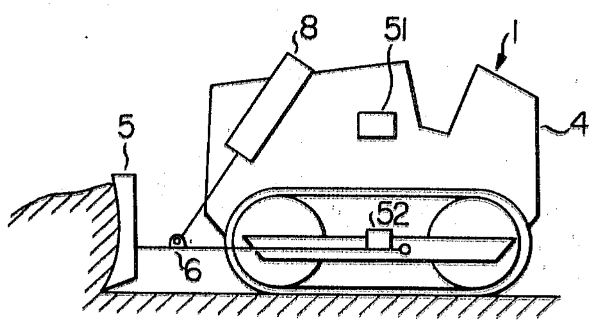


FIG. 4



SYSTEM FOR CONTROLLING THE LEVEL OF AN EARTH-REMOVING BLADE OF A BULLDOZER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a bulldozer and, more particularly, to a system for controlling the level of an earth-removing blade pivotally mounted on the forward end of a bulldozer.

2. Description of Prior Art

In general, a bulldozer is designed to perform not only a heavy operation in which the bulldozer is operated to scrape raised portions of the ground and forcibly push, transfer or heap up the scraped earth and sand, but also a light operation, such as ground conditioning or production of building lots, in which the bulldozer is operated to produce substantially flatly bulldozed or levelled ground surfaces.

There is an increasing demand for the application of bulldozers to light operations, such as ground conditioning, production of building lots, or road reparing and improvement, in which bulldozers are required to produce accurately finished substantially flat ground surfaces.

In bulldozer operation to produce a generally flatly levelled ground surface, it is very difficult and requires skilled technique to manually keep the blade of the bulldozer at a controlled substantially fixed level because the bulldozer body is subjected to pitching due to rugged ground surface. More specifically, if a ground surface produced by removal of the earth by means of an earth-removing blade of a bulldozer is once rugged for some reasons, the caterpillars of the bulldozer moving across the rugged ground surface are caused to alternately ride on raised portions of the ground and fall down in recessed portions thereof for thereby causing pitching of the bulldozer body, with a result that the ground surface becomes more and more rugged. In order that the rugged ground surface may be flatly bulldozed, an operator is required to operate an operating lever of the bulldozer to control the earth-removing blade thereof while the operator carefully investigates the state of the portion of the ground surface which is located forwardly of the earth-removing blade and which is included in the dead angle of view sight as viewed from normal operating position and while the operator watches the movement of the earth-removing blade relative to the rugged ground surface. It takes a great amount of time for a man to become skilled in such complicated control operation. Particularly, the blade control operation is very difficult and needs highly skilled technique when the bulldozer moves at a higher speed.

For the reasons, there has been proposed a system for automatically keeping the earth-removing blade of a bulldozer at a predetermined substantially fixed level even if the operator of the bulldozer frees the blade control lever out of control by his hand. For example, U.S. Pat. No. 3,556,225 issued on Jan. 19, 1971 discloses a system for automatically keeping the earth-removing blade of a bulldozer at a predetermined controlled level. The system utilizes an optical level reference device disposed outside the bulldozer body, i.e., placed for example on the ground so that the level reference is followed to control the blade level. The automatic blade level control system of this type, however, fails to provide a satisfactory blade level control and an improved working efficiency.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a system for controlling the level of an earth-removing blade of a bulldozer which enables the blade to produce a substantially flat bulldozed ground surface.

It is another object of the present invention to provide a system of the kind specified and which is operable not only to automatically keep the earth-removing blade of the bulldozer at a predetermined substantially fixed level but also to manually control the blade level.

It is a further object of the present invention to provide a system of the kind specified and which is operative to control the bulldozer blade level with good response and controllability.

A still further object of the present invention is to provide a system of the kind specified and in which a selected one of automatic and manual controls of the blade level can be performed by the use of a selected hydraulic power source for economical and efficient operation of the system.

In order to achieve the above objects, the present invention provides a system for use with a bulldozer which has an earth-removing blade, arms supporting said blade and a hydraulically operated means such as a cylinder for actuating said blade supporting arms to control the level of said blade. The system includes an automatic control means comprising an input setting unit for setting a desired level for the blade and emitting a first signal representing the desired blade level set, a measuring unit detecting the angle of inclination of the blade supporting arms relative to a reference plane to measure the actual level of the blade and emit a second signal representing the actual blade level measured, and a controlling circuit operative to detect a deviation of the second signal from the first signal and actuate the hydraulic cylinder in such a manner that the deviation is made "zero." The input setting unit of the automatic control means is installed within a body of the bulldozer rather than being disposed outside the bulldozer body as is the level reference device of the prior art. The automatic control means is operative to compare the first and second signals from the input setting and measuring units, respectively, and automatically control the blade substantially at the desired or predetermined level in such a manner as to compensate for the deviation of the second signal from the first signal. The system of the invention also includes a manual controlling means which is manually operable by an operator independently of the automatic control means to control the blade level, i.e., upwardly and downwardly adjust the blade level.

As discussed above, the system of the present invention comprises independent controlling means which are operative not only to automatically control the level of an earth-removing blade of a bulldozer substantially at a desired or predetermined level but also to manually control the blade level. A selected one of the independent controlling means can be used for a most suited particular application of the bulldozer operation. In other words, the system of the present invention enables a bulldozer to be highly efficiently and accurately controlled not only in a usual earth-pushing operation but in another kind of operation, such as production of building lots and roads, in which the bulldozer is required to produce substantially precisely, flatly levelled or bulldozed ground surface.

The above and other objects, features and advantages of the present invention will be made apparent by the following description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagrammatical illustration of the hydraulic circuit of a preferred embodiment of the system according to the present invention;

FIG. **2** is a block diagram mainly showing the electric circuit of the preferred embodiment of the system according to the invention;

FIG. **3** illustrates in side elevation the details of an input setting unit employed in the system of the invention; and

FIG. **4** shows a modification of the measuring unit employed in the system of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIG. **1**, there is shown a preferred embodiment of the system for controlling the level of an earth-removing blade of a bulldozer according to the present invention. The bulldozer is generally indicated at **1** and generally shown as having track frames **2** (only one of which is shown), caterpillars **3** (only one of which is shown) operatively mounted on the track frames **2**, a tractor body **4** mounted on the track frames **2**, a blade **5** for removing the earth, arms **6** (only one of which is shown) pivotally mounted at their one ends on the track frames **2** for supporting the blade **5** on the other ends, and hydraulic cylinders **8** (only one of which is shown) each having a piston rod **7** secured at one end to a piston in the cylinder **8** and pivotally connected at the other end to the associated blade supporting arm **6** for controlling the level of the earth-removing blade **5**.

The illustrated embodiment of the system of the invention includes a first pump **9** and a second pump **10** having a greater capacity than that of the first pump **9**. The pumps **9** and **10** form hydraulic pressure sources for the system of the invention. In a pipe line extending between the first pump **9** and the cylinder **8** is provided a control valve **11** of continuous control action type. In the illustrated embodiment of the invention, the control valve **11** is preferably a serovovalve. In a pipe line extending between the second pump **10** and the cylinder **8** is provided an on-off type control valve **12**, which forms a part of an automatic control means of the system of the invention, and a manually operated direction control valve **13** forming a part of a manual control means of the system of the invention. The valves **12** and **13** are in parallel with the servovalve **11**. In the illustrated embodiment of the invention, the on-off action type valve **12** is preferably a solenoid operated valve.

The servovalve **11** and the solenoid valve **12** are operative to automatically maintain the earth-removing blade **5** at a controlled, substantially predetermined level. This will be called "automatic control" hereunder. The direction control valve **13** is manually operable by an operator to vary the level of the earth-removing blade **5**. This will be called "manual control" hereunder. The valve **13** is operable by means of an operating lever which can be held in a locked position by a locking lever **21** during automatic control of the blade level. The hydraulic circuit in which the servovalve **11** is provided includes a filter circuit **14** provided in the circuit on the outlet side of the servo-valve **11** for filtering and removing foreign materials such as dust particles contained in the fluid returned through the circuit from the cylinder **8**. The circuit also includes a shut-off valve **16** provided between the filter circuit **14** and the cylinder **8**. The shut-off valve **16** is changed over, when the system of the invention is manually operated, by a return spring **15** from a position indicated at A in which the servovalve **11** has been communicated through the shut-off valve **16** with the cylinder **8** to a position indicated at B in which the communication between the servovalve **11** and the cylinder **8** is blocked by the shut-off valve **16**. On the outlet side of the first pump **9** in the hydraulic circuit including the servovalve **11** is provided an unloading circuit **19** which is operative to unload and return the hydraulic fluid from the pump **9** to a reservoir **20** during manual control of the system of the invention. The unloading circuit **19** includes a pressure control valve **17** and a solenoid operated valve **18** which serves as a pilot valve for the pressure control valve **17**. As shown in FIG. **1**, the filter circuit **14** comprises a combination of conventional check valves **14***a* and filters **14***b*.

When the afore-described hydraulic circuit of the system of the present invention is operated to level the surface of the earth, i.e., when the hydraulic circuit is operated to automatically control the level of the earth-removing blade **5** so that the cutting edge of the blade **5** is positioned in a reference plane which, for example, may be the plane in which the treads of the caterpillars of the bulldozer are included, the servovalve **11** and the solenoid valve **12** are automatically operative to make "zero" the deviation of a value representing the actual level of the blade **5** relative to another value representing a predetermined level of the blade **5** with respect to the reference plane.

The above-described automatic control can be performed by an electric circuit shown in FIG. **2** in which reference numerals the same as those used in FIG. **1** represent the same parts as those shown in FIG. **1**. The electric circuit for the automatic control includes an input setting unit **22** for setting a desired level of the blade **5** and emitting an electrical signal representing the desired blade level set, a measuring unit **23** operative to detect the actual angle of inclination of the blade supporting arms **6** with respect to the horizontal and measure the actual level of the blade **5** on the basis of a value representing the actual inclination of the arms for emitting a second signal representing the actual blade level measured, a comparator or comparing circuit **24** operative to compare the signal from the input setting unit **22** with the signal from the measuring unit **23** for determining the deviation of the latter signal from the former one and for emitting operating instructions to the servovalve **11** or to the solenoid valve **12** in accordance with the amplitude of the deviation, an electric power source **25**, a switch **26** for the electric power source, means **27** for detecting a trouble in the automatic control circuit used in the course of an automatic control of the system of the invention and means **28** for changing the hydraulic circuits when an automatic control is changed to a manual control or vice versa.

In the embodiment of the invention shown in FIGS. 1 and 2, the measuring unit 23 is preferably mounted on a blade supporting arm 6 to measure the angle of inclination of the arm 6 with respect to a reference plane so that the level of the blade 5 is directly measured on the basis of the angle of inclination of the arm 6.

A description will be made with respect to the details of the elements of the above-described electric circuit. As will be seen in FIG. 3, the input setting unit 22 comprises a potentiometer 29 which is a displacement-voltage transducer, a lever 31 operative to move a contact 30 of the potentiometer 29, a friction disc 33 mounted on a pivot 32 of the lever 31, a breaking member 35 urged by a spring 34 against the friction disc 33. The input setting unit 22 is arranged such that the angular movement of the lever 31 for an angle about an axis of the pivot 32 is operative to rotate the contact 30 for causing the potentiometer 29 to emit an electric signal corresponding to the angle of desired inclination of the blade supporting arms 6. When the angular movement of the lever 31 is discontinued at an angular position, the lever 31 will be held in that position by the cooperation of the friction disc 33 and the breaking member 35.

The measuring unit 23 is mounted on a blade supporting arm 6 in such a manner that the unit 23 is guarded against exterior shock and foreign material such as dirt and sand particles. The measuring unit 23 preferably include several attachments such as a detector 36 comprising a gyroscope, means 37 for driving the gyroscope, means 38 for unlocking the gyroscope in stationary position, and means 39 for holding or locking the gyroscope. The measuring unit 23 is arranged such that, when the switch 26 is switched on, the gyro unlocking means 38 is operated and the detector 36 is driven by the gyro drive motor 37 to measure the angle of inclination of the arms 6 and, when the switch 26 is switched off, the operation of the motor 37 is discontinued and the gyro locking means 39 is operated to lock the gyroscope. The measuring unit 23 may be formed of gyro units of the type disclosed in Japanese Pat. Publication No. 3699/1962 published on June 6, 1962 and relating to "A Method of Starting Operation of a Gyrocompass," Japanese Utility Model Publication No. 22601/1970 published on Sept. 7, 1970 and relating to "A Gyro Clamping Mechanism," and Japanese Pat. Publication No. 298/1962 published on Jan. 25, 1962 and relating to "An Apparatus for Centering and Holding a Gyroscope," while the detector 36 may be of the type disclosed in "Electric Measurement Handbook" by Jiro Yamauchi, 3rd print published on May 30, 1970, paragraph 2.2.1 "Orientation and Position Measuring Devices," pages 984 to 987. Alternatively, the measuring unit 23 may comprise a pendulum or a manometer.

The comparing circuit 24 includes an adder 40 which detects the deviation of the signal from the gyro-means 23 with respect to the signal from the input setting unit 22 and emits a signal either to instruct the servovalve 11 to operate when the deviation is lesser than a predetermined value, or to instruct both servovalve 11 and solenoid valve 12 to operate when the deviation is greater than the predetermined value. The comparing circuit 24 also includes a servo amplifier 41 of the type disclosed in U.S. Pat. No. 3,000,121 issued Sept. 19, 1961 which is operative to amplify the servovalve operation instruction signal from the adder 40 and send the amplified signal to the servovalve 11, and an amplifier 42 of the type disclosed in U.S. Pat. No. 3,556,225 issued Jan. 19, 1971 which is operative to amplify the solenoid valve operation instruction signal from the adder 40 and supply the amplified signal to valve 12.

The trouble detecting means 27 includes a block detector 43 operative in response to an accidental block of the filter circuit 14 on the outlet side of the servovalve 11 to switch-off the electric power source switch 26.

The block detector 43 detects blockage of the filter circuit 14 on the basis of the pressure differential between the inlet and outlet sides thereof and operates a relay to control switch 26 and may be of the type disclosed in Japanese Utility Model Publication No. 32050/1968 published on Dec. 26, 1968 and relating to "A Device for Indicating Block in a Filter." The detector means 27 also includes a gyro nonoperation detector 44 operative in response to the inclination of the blade support arms 6 beyond the measuring capacity of the gyroscope to switch off the switch 26 and, at the same time, cause the gyro locking means 39 to operate to lock the gyroscope.

The hydraulic circuit changing means 28 includes a shut-off valve actuator 45 which is operative, during automatic ocntrol of the earth-removing blade 6, to retain the shut-off valve 16 in a position A against the return spring 15 so that the servo valve 11 is in communication with the blade operation cylinder 8. The changing means 28 also includes an unloading circuit actuator 46 by which the unloading circuit 19 is maintained in a position in which the hydraulic fluid from the first pump 9 is not unloaded. The actuators 45 and 46 may be amplifier arrangements which provide an amplified signal necessary for the control of the valve 16 and circuit 19 and may be of the type desclosed in "An Electric-Hydraulic System for Controlling the Turning-up Depth of a Plow Mounted on a Tractor" which is an introduction by Japanese Magazine "Hydraulics and Pneumatics", Vol. 8, No. 3, published in March, 1970. The detector 36 of the gyro-means 23 detects the voltage of electric current from a voltage regulator 47 and apply the detected voltage to the adder 40 of the comparing circuit 24. The actuators 45 and 46 and the voltage regulator 47 are electrically connected through a switch 49 and a delay switch 50 to the power source switch 26. The switch 49 is connected to an automatic-manual selector 48 provided for the operating lever 31 of the input setting unit 22. The switch 49 has contacts which are opened when the automatic-manual selector 48 is changed-over to a manual control position to thereby open the circuit for the supply of an operation signal to the actuators 45 and 46 and the voltage regulator 47. In response to the opening of the contacts of the switch 49, the shut-off valve 16 is moved by the return spring 15 to its B position in which the communication between the servovalve 11 and the cylinder 8 is shut-off while the unloading circuit 19 discharges the hydraulic fluid from the first pump 9 into the reservoir 20 to minimize the power loss of the first pump 9.

In the course of the automatic control of the level of the earth-removing blade 5, since the hydraulic pipe line for the control of the blade level is so arranged as to appropriately adjust the blade to a desired level by the manual operation of the direction control valve 13, the closing of the power source switch 26 energizes the gyro-drive motor 37 of the gyro-means 23 so that the gyro-detector **36** is driven by the gyro-drive motor **37.** When the gyro-detector **36** attains a state sufficiently stable to detect the angle of inclination of the blade supporting arms **6,** the contacts of the delay switch **50** are closed. When the automatic-manual selector **48** is set in the automatic control position and the switch **49** is actuated to close its contacts, the electric current from the power source **25** is fed to the actuators **45** and **46** and the voltage regulator **47.** The actuator **45** will then emit an instruction signal whereby the shut-off valve **16** is changed-over from the B position to the A position in which the servovalve **11** is in communication with the cylinder **8** for the operation of the blade **5.** Similarly, the actuator **46** will emit an instruction signal by which the unloading circuit **19** is made inoperative to unload the hydraulic fluid from the first pump **9** into the reservoir **20,** whereby the fluid is fed from the pump **9** to the servovalve **11** so that the system attains a state in which it is prepared for the automatic control of the level of the earth-removing blade **5** of the bulldozer. In this state of the system, the bulldozer may be laid on a substantially horizontal surface of the ground. Assuming that the substantially horizontal surface mentioned above is selected as the reference plane, the blade **5** is so adjusted that the cutting edge of the blade is positioned substantially at the same level as the treads of the caterpillars **3.** If the input setting unit **22** is so set that the deviation of the signal from the gyro-means **23** relative to the signal from the input setting unit **22** is "zero," the forward movement of the bulldozer causes the blade **5** to produce an earth surface which is substantially co-plannar or flash with the reference plane. In a case where the level of the blade **5** is varied with respect to the reference plane during forward movement of the bulldozer due, for example, to rugged ground surface, the variation is detected by the comparing circuit **24** in the form of a deviation of the signal from the gyro-means **23** with respect to the signal from the input setting unit **22.** The adder **40** of the comparing circuit **24** operates to emit and feed through the servo amplifier **41** to the servovalve **11** an instruction signal for causing the servovalve **11** to operate to compensate for the deviation, i.e., to make the deviation "zero," with a result that the servovalve **11** is moved from its neutral position to one of its operative positions so that the hydraulic fluid from the first pump **9** is introduced into the cylinder **8** through one of the inlets thereof until the level of the cutting edge of the blade **5** is adjusted to be the same as the reference plane. When the blade **5** has attained this position, the adder **40** discontinues emitting the change-over instruction signal to the servovalve **11** so that the latter is restored to its neutral position. As is apparent to those in the art, the servovalve **11** has an inherent characteristic that, even if it is in its neutral position, the servovalve **11** is inoperative to block or shutoff the hydraulic fluid being supplied to the blade operating cylinder **8.** Thus, the cylinder is operable by the hydraulic fluid from the first pump **9** to keep the blade in the adjusted level.

The automatic control above described may be performed in a case where the variation of the level of the earth-removing blade **5** relative to the reference plane is lesser than a predetermined value. In a case where the variation is greater than the predetermined value, the adder **40** of the comparing circuit **24** will emit and feed through the servoamplifier **41** and the solenoid energization circuit **42** to both of the servovalve **11** and the solenoid valve **12** a signal for instructing the servovalve **11** and the solenoid valve **12** to operate to make "zero" the variation. Thus, the servovalve **11** is operated in a manner as described above and, in addition, the solenoid valve **12** is also operated to feed a greater amount of hydraulic fluid from the second pump **10** into the cylinder **8** through one of the inlets thereof in accordance with the direction in which the variation of the blade level has taken place, to thereby adjust the varied level of the blade **5.** The greater amount of the hydraulic fluid from the second pump **10** in combination with the smaller amount of that from the first pump **9** are effective to quickly compensate for the greater variation of the level of the earth-removing blade **5** from the reference plane. The system is operative to repeat the described controlling operation to enable the blade **5** to produce a substantially levelled or flatly bulldozed earth surface.

If the filter circuit **14** is blocked in the course of an automatic control of the blade level, the block detector **43** detects the block of the circuit **14** and operates to open the contacts of the power source switch **26.** In addition, if the angle of inclination of the blade supporting arms **6** relative to the reference plane exceeds the range within which the gyro-means **23** is operative to measure the inclination, the gyro-non-operation detector **44** detects the non-operation of the gyroscope and operates to open the contacts of the power source switch **26** to interrupt the automatic control of the blade level, by which the operator can be advised of the trouble in the circuit for the automatic control.

The control of the level of the earth-removing blade **5** by means of the afore-described automatic control circuit can be performed in the following manner: The operating lever **31** for the input setting unit **22** may be operated to move the contact **30** of the potentiometer **29** of the unit **22** to a position which corresponds to a desired set value on the input setting unit **22.** The servovalve **11** and the solenoid valve **12** are operative to control the amount and direction of the hydraulic fluid to be fed into the cylinder **8** in such a manner that the deviation of the angle of inclination of the blade supporting arms **6,** as measured by the gyro-means **23,** relative to the set value is made substantially "zero," with a result that the blade **5** is moved to a level corresponding to the value set on the input setting unit **22.** In such manner, any desired value may be set in the input setting unit **22** for a desired angle of inclination of the arms **6** relative to the reference plane to enable the bulldozer to be operative to excavate and remove the earth as a conventional bulldozer is.

Selective operation of the automatic-manual selector **48** makes it possible to obtain repeated and alternate performance of automatic and manual controls of the earth-removing blade **5.** More specifically, if the automatic-manual selector **48** is moved to its manual control position, since the contacts of the switch **49** are open and the contacts of the switch **26** are closed, the gyro means **23** is driven by the gyro drive motor **37** and is maintained in its measuring position. However, as the operation instructing signal to the voltage regulator **47** is shut off, the gyro-means **23** does not feed to the adder **40** of the comparing circuit **24** a signal obtained from the detection of the angle of inclination of the blade supporting arms **6.** Since the operation instructing signal to the shut-off valve actuator **45** is shut off, the shut-off valve **16** is moved by the return spring **15** to the B position to shut-off the communication between the servovalve **11** and the cylinder **8.** As the operation instructing signal to the unloading circuit actuator **46** is shut off, the unloading circuit **19** is in a position in which the fluid from the first pump **9** is not passed to the servovalve **11** but returned to the reservoir **20.** Thus, the circuit for the automatic control of the blade level is inoperative. On the other hand, the manually operated direction control valve **13** is operative to actuate the cylinder **8.** The operating lever for the direction control valve **13** may be unlocked to move the valve **13** to a desired position so that the operator can manually control the level of the earth-removing blade **5.** If the automatic-manual selector **48** is then moved to an automatic control position, the contacts of the switch **49** are closed to allow the electric current from the power source **25** to be fed to the actuators **45** and **46** and the voltage regulator **47** so that the gyro means **23** is maintained in its measuring position and the shut-off valve **16** is moved to its A position in which the servo valve **11** is communicated with the blade operation cylinder **8** and the unloading circuit **19** does not unload the hydraulic fluid from the first pump **9** to the reservoir **20** but is operative to feed the fluid to the servo valve **11** for the automatic operation of the system of the invention.

The manually operated direction control valve **13** alone may be used to manually control the level of the blade **5.** In this case, the contacts of the power source switch **26** are opened to make inoperative the gyro-means **23,** the comparing circuit **24,** the servovalve **11** and the solenoid valve **12.** The gyro-locking means **39** are operative in response to the opening of the power source switch **26** to lock or hold the gyro-means **23.**

As described above, the system of the present invention has a blade level control circuit which is automatically operative, regardless of the inclination of the bulldozer body substantially in a vertical plane including the longitudinal axis of the body, to control the angle of inclination of the blade supporting arms relative to a reference plane for thereby maintaining the blade substantially at a predetermined, desired level. The automatic control circuit has incorporated therein an input setting unit by means of which a set value may be appropriately varied to lift or lower the blade in a manner substantially similar to that in which the blade of a conventional bulldozer is operated. Moreover, the system of the invention includes a manually operated direction control valve which is manually operable to control the blade as in conventional bulldozer. Thus, it will be appreciated that the bulldozer which employs the system of the invention can have a widened range of application and operation.

Furthermore, the system of the invention can make use of selected one of hydraulic power souurces in the course of automatic or manual control of the blade level. This not only minimizes the power loss but also provides an improved controllability of the earth-removing blade of a bulldozer.

The system of the invention may be modified within the spirit of the invention. FIG. **4** shows a modification of the invention which comprises an inclination detector **51** mounted on the body **4** of the bulldozer **1** to detect the inclination of the bulldozer body **4** relative to a reference plane and a position detector **52** mounted on a blade supporting arm **6** to detect the inclination of the arm **6** relative to the bulldozer body so that the level of the earth-removing blade **5** is indirectly measured on the basis of the signals from the detectors **51** and **52.**

In the illustrated embodiment of the invention, the input setting unit is of proportional action type while the control valves in the control circuits are of on-off type and continuous control action type, respectively. However, the input setting unit may alternatively be of integral control type and the control valves both may alternatively be of either on-off action type or continuous control type.

What is claimed is:

1. A system for controlling the level of an earth-removing blade of a bulldozer, comprising:

a. a hydraulic fluid source for feeding a hydraulic fluid under pressure to a cylinder operative to upwardly and downwardly actuate arms supporting said blade,

b. a manual controlling means including a manually operated direction control valve located between said hydraulic source and said cylinder to change over the direction of feed of said hydraulic fluid from said hydraulic source to said cylinder for controlling the level of said blade, and

c. an automatic controlling means including a controlling circuit which comprises means for setting a desired level for said blade including an input setting unit emitting a first signal representing the desired blade level set, a measuring unit on said bulldozer detecting the angle of inclination of said blade supporting arms to measure the actual level of said blade and emitting a second signal representing the measured actual blade level, a comparing circuit responsive to said first and second signals and operative to detect a deviation of said second signal from said first signal and emitting a third signal representing the deviation, on-off action type and continuous control action type control valve means located between said hydraulic source and said cylinder and operative in response to said third signal to control the amount and direction of said hydraulic fluid to be fed into said cylinder in such a manner as to compensate for said deviation to thereby automatically control the level of said blade.

2. A system as claimed in claim **1,** in which said hydraulic fluid source comprises:

a. A first pump located between said hydraulic source and said continuous action type control valve means and in fluid communication therewith for feeding an amount of said hydraulic fluid to said continuous control action type control valve means, and

b. a second pump located between said hydraulic source and said on-off action type valve means and direction control valve and in fluid communication therewith for feeding a larger amount of said hydraulic fluid than that by said first pump to said on-off action type valve means and said manually operated direction control valve.

3. A system as claimed in claim **1,** in which said measuring unit on said bulldozer included in said automatic controlling means comprises a detector mounted on a blade supporting arm of said bulldozer to detect the angle of inclination of said arm for measuring the level of said blade.

* * * * *