

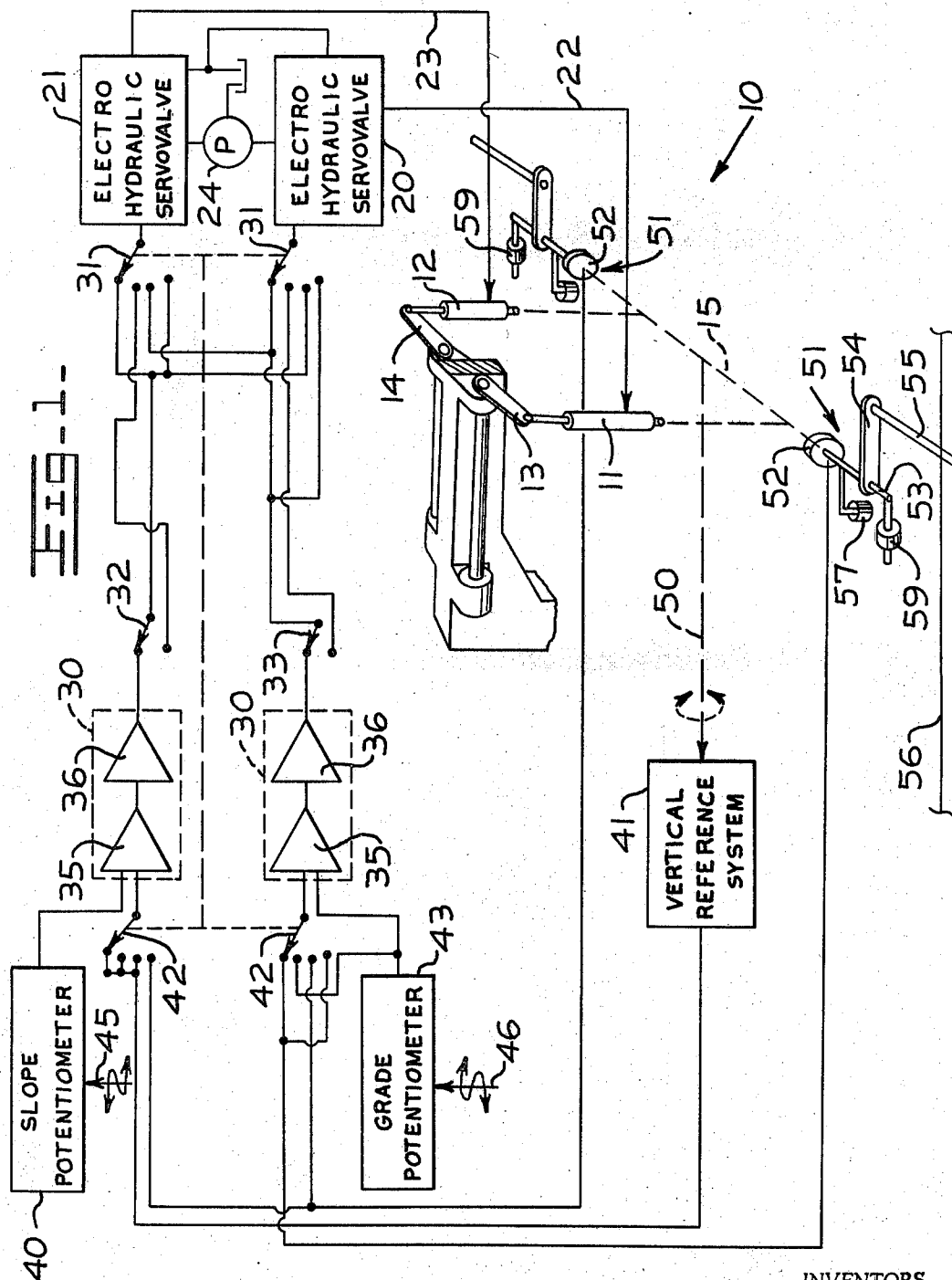
Feb. 17, 1970

R. D. SCHOLL ET AL
 INTEGRATED AUTOMATIC SLOPE-GRADE CONTROL
 SYSTEM FOR MOTOR GRADERS

3,495,663

Filed June 26, 1968

4 Sheets-Sheet 1



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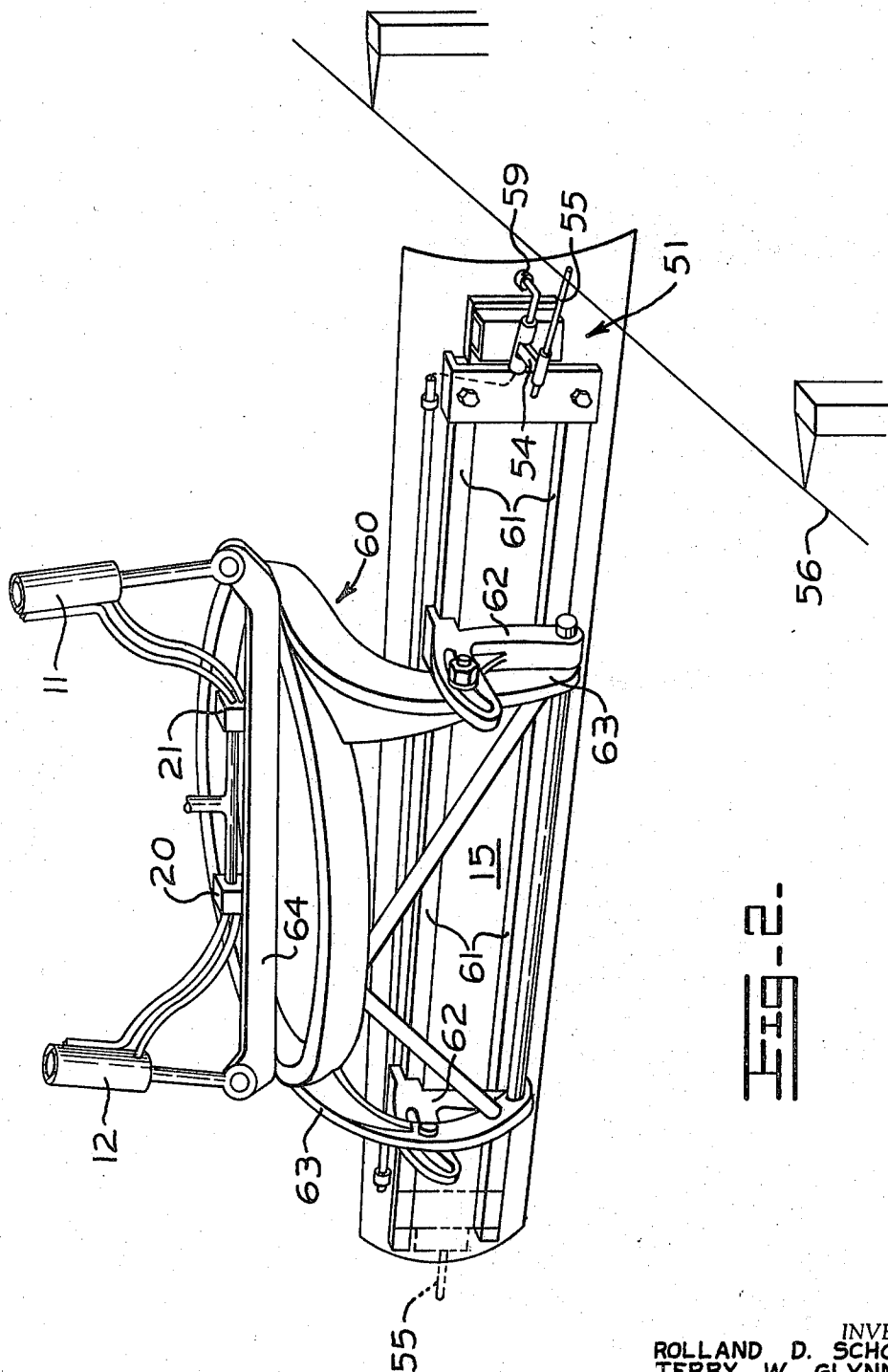


FIG. 2-

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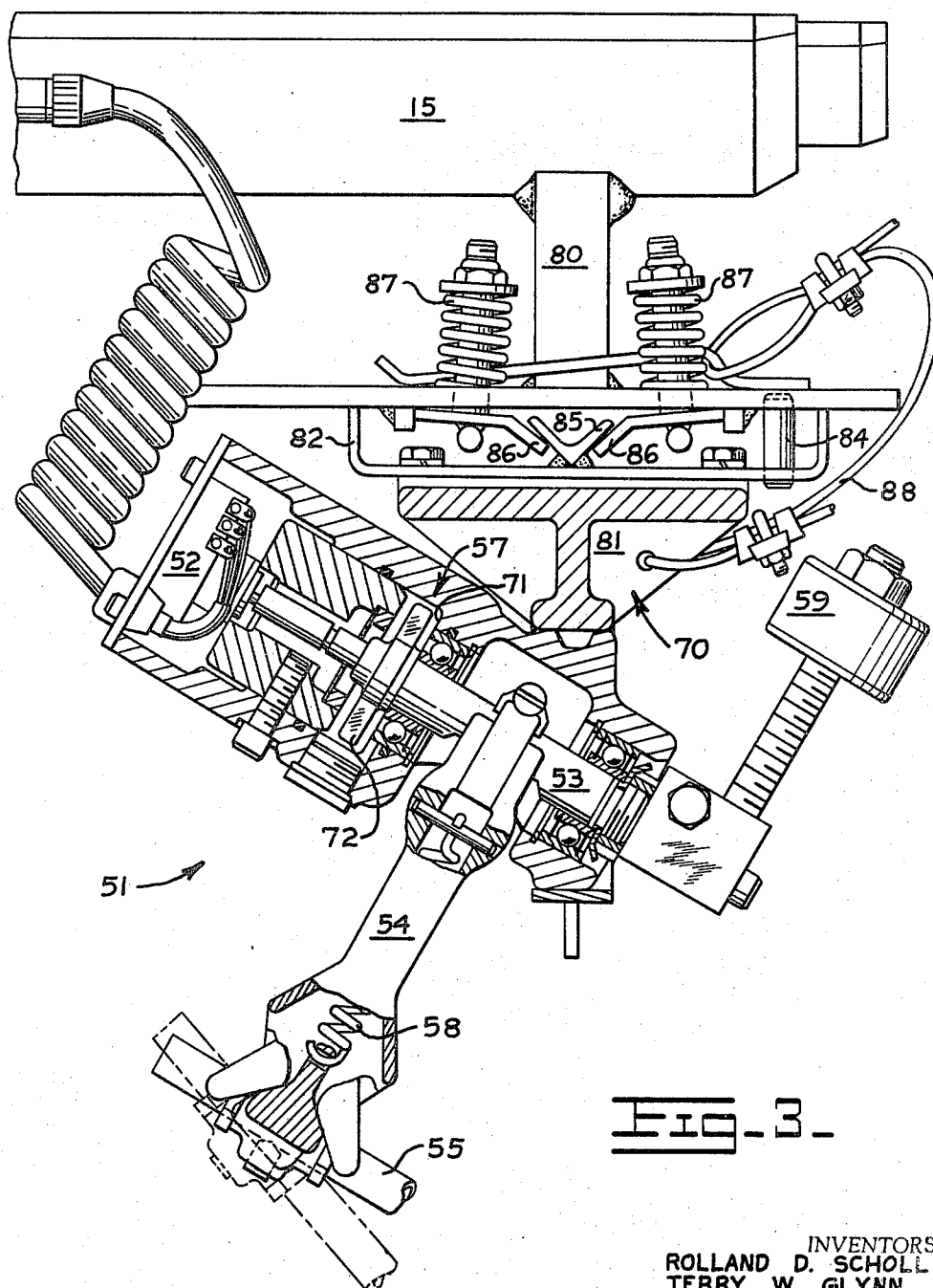


Fig. 3.

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Fig. 4.

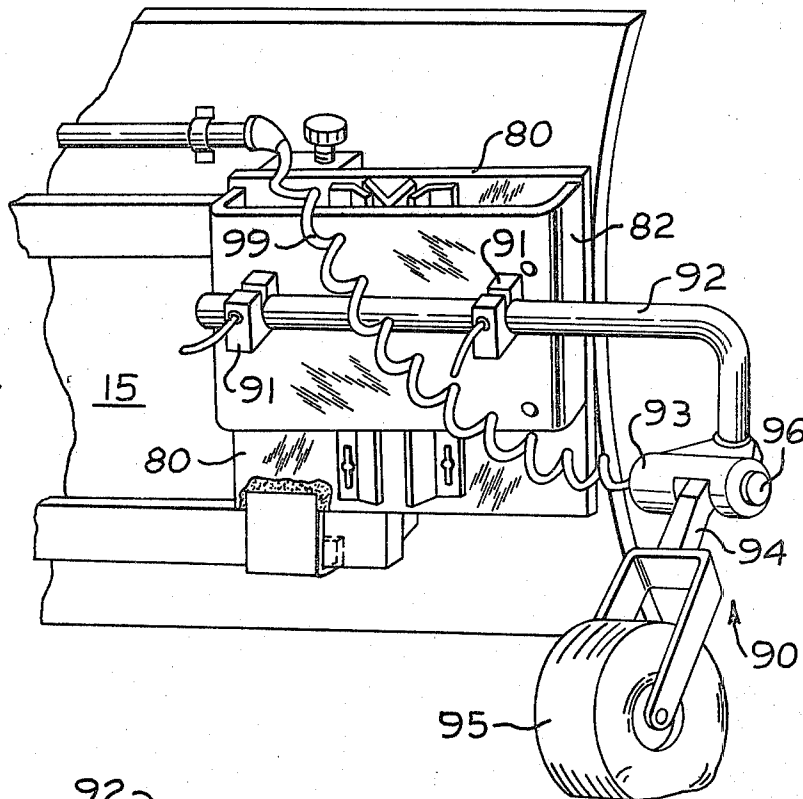
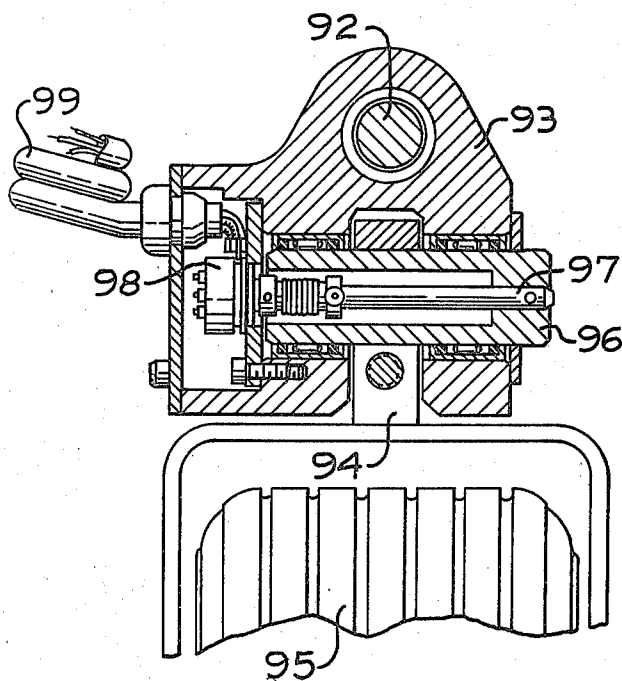


Fig. 5.

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3,495,663

INTEGRATED AUTOMATIC SLOPE-GRADE CONTROL SYSTEM FOR MOTOR GRADERS

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Filed June 26, 1968, Ser. No. 740,128

Int. Cl. E02f 3/76

U.S. Cl. 172—4.5

4 Claims

ABSTRACT OF THE DISCLOSURE

A fully integrated blade control system is provided in a motor grader by connecting the circle to the lift arms with two hydraulic jacks, operating these jacks through separate electro-hydraulic valves, controlling the operation of each valve by a separate control circuit, and using as inputs to the control circuits signals from sensing means on opposite ends of the blade for determining the position of its associated end relative to an external reference and a signal from vertical reference means connected to determine the blade position with reference to the vertical so the three signals can be connected to the control circuits through a switching means whereby any one or two of said output signals can be employed to automatically control blade position.

Cross reference to related application

In U.S. patent application Ser. No. 541,715 filed by Page et al., Apr. 11, 1966 now abandoned in favor of continuing application Ser. No. 804,358, a vertical reference system is described. Reference is made to this application for the description of a typical vertical reference system which could be employed with the instant invention.

Background of the invention

A vertical reference system as described in the above-mentioned application provides an output that can be used to control the slope of the motor grader blade. Other prior art shows various devices to provide control of grade or elevation of the blade, but none of the prior art shows a fully integrated system for both slope and grade control, operating from several different signal sources.

Grade and slope in the instant invention can be simultaneously controlled by a signal from a vertical reference system and another signal from a sensor at one of the ends of the blade through the sensor's cooperation with an external reference. Alternatively, grade and slope control can be effected by using the two separate signals from the sensors at opposite ends of the blade by switch selection. Also, grade or slope can be independently selected for controlling either end of the blade, with control for the other end supplied through the normal manual controls of the motor grader.

Summary of the invention

In a motor grader having a controllable blade and the links between the lift arms and the circle replaced with hydraulic jacks, an automatic control system including a separate electro-hydraulic valve means for controlling each jack, two parallel control circuits each connected to an electro-hydraulic valve means, switch means connected to both control circuits, external sensor means connected to opposite ends of the blade, each sensor means having its output connected to said switch means, and a vertical reference system connected to said blade and having its output connected to said switch means

whereby any one or two of said three outputs can be used to control the blade position automatically through the control circuits.

Brief description of the drawings

FIG. 1 is a simplified schematic view showing the control system associated with a blade of a motor grader; FIG. 2 is a perspective of the blade circle and supporting jacks with external sensor units illustrated on the outboard ends of the blade;

FIG. 3 shows one of the sensor units in section mounted on a blade fixture with a break-away attaching plate;

FIG. 4 is a broken away perspective of one end of the blade with wheel actuating the external sensor unit; and

FIG. 5 is an enlarged section of the wheel actuated sensor unit shown in FIG. 4.

Description of a preferred embodiment

In FIG. 1, schematically illustrating the novel blade control 10, jacks 11 and 12 have been employed to replace the normal links between lift arms 13 and 14 and the blade assembly, illustrated as broken line 15, which normally includes an intermediate circle mounted on a draw-bar.

Jacks 11 and 12 are controlled by electro-hydraulic valves, 20 and 21 respectively, through a hydraulic piping represented by lines 22 and 23. Pump 24 supplies pressurized fluid to the valve units for jack actuation.

Each valve unit is controlled by one or the other identical, parallel control circuits 30 depending on the position of ganged switch 31 which can switch valve units 20 or 21 to one or the other of the control circuits or to a manual position to deactivate both valve units. Switch 31 allows an operator to place a particular automatic control function on either side of the machine, which increases flexibility. Switches 32 and 33 allow either of the control circuits to be disconnected independently.

Each control circuit is composed of identical amplifier units or modules so that only one type of these units need be stocked. Also, if in the field one control circuit fails on slope control when that function is needed, the amplifier modules may be switched to provide automatic slope control. In each control circuit a differential operational input amplifier 35, whose output is connected to a current booster amplifier 36, forms each of the control amplifier circuits, with the latter providing the power necessary to actuate the electro-hydraulic valve to which its output is connected.

Each differential amplifier has two inputs, in the case of one control circuit, slope potentiometer 40 provides one of the inputs and an external sensor unit or a vertical reference system 41 provides the other, depending on the position of ganged switch 42 that is ganged with switch 31 illustrated by a broken line in the drawings so these switch are selectively moved in unison. Likewise, the other control circuit has an input from grade potentiometer 43 and an input from one or the other external sensor unit, depending on the position of switch 42. The slope potentiometer is manually set through shaft 45 while the grade potentiometer is manually set through shaft 46. The slope dial is calibrated in percent of slope and bank slope ratio and a digital calibration is employed on the grade dial with 100 units or more per foot indicated thereon.

Operation of the control circuits is identical. Each differential amplifier's output drives to balance its two inputs which causes the downstream operational amplifier to send a signal to its associated electrohydraulic valve

unit, operating its associated jack 11 or 12 in a direction to reduce the difference between the two input signals to zero or null.

Basically, the system employs three signal generating means besides the two manually operated potentiometers 40 and 43. One of these signal generating means is a vertical reference system 41 which is driven by a linkage 50 connecting it to the blade, such as the ball resolver unit described in the above-referenced application. This system continuously provides a signal indicative of the transverse slope position of the blade with reference to vertical. The other two signals generating means include identical external sensor units 51 located at opposite ends of the blade 15.

Each sensor unit 51 includes a potentiometer 52 whose wiper is driven through shaft 53 journaled on appropriate bearings on its associated end of the blade. The outboard end of each shaft is connected to an arm 54 oriented perpendicular to the shaft and a wand 55 is connected to the free end of the arm to extend outwardly beyond the end of the blade where its end can engage an external reference, such as a grade wire 56, curb, ground, etc. Each arm or shaft includes a dash pot assembly 57 to reduce bounce. When a wheel follower unit is used, damping is accomplished through a low pressure tire and increased mass.

In FIG. 2, the blade 15 is shown connected to a circle 60 through its associated rails 61 slidable in shoes 62 connected to arms 63 of the circle. The circle is in turn connected to the drawbar 64 in a conventional manner and jacks 11 and 12 are connected to the outboard ends of the rear of the drawbar.

The sensor unit 51 employed at the outboard ends of the blade, in FIGS. 2 and 3 is cylindrical with an internal damping system and the wand 55 is attached to arm 54 by means of a spring 58 which will allow the wand to snap out of the slot in the end of the arm if the wand catches on an immovable object so the sensor unit will not be damaged. An adjustable counter weight 59 is included so that the wand can be adjusted to ride on the underside of the wire 56 reducing its sag between stakes if desired.

FIG. 3 illustrates in detail the operational sensor unit 51 with wand 55 carried by arm 54 through which shaft 53 is rotatably operable. A release spring 58 is used to attach the wand to the arm and potentiometer 52 is located on the end opposite the arm. The shaft passes through a circular dash pot unit 57 in the housing.

As can be seen in FIG. 3, the sensor unit 51 includes a circular housing having two spaced walls which support shaft 53 at spaced locations on bearings. A bracket 70 is welded to the housing for attaching it to the back of the blade. Counter weight 59 is adjustably mounted on the arm on a threaded extension so the weight may be adjusted to achieve sufficient vertical load on the wand for best tracking depending on whether the wand is to ride on top or bottom of the external grade wire.

A chamber 71 is located where the shaft 53 passes the housing and a vane wheel with radially projecting vanes is keyed to the shaft so it will rotate in the chamber as the shaft turns. The chamber is partially filled with a viscous fluid to provide necessary damping.

The damper 57 includes a circular chamber 71 centrally located in the housing through which shaft 53 extends. Keyed to the shaft in the chamber is a vane wheel 72 which has a small clearance with the sides of the chamber which is partially filled with viscous damping fluid. Through this arrangement, rotational oscillations of the shaft are dampened so that the electrical gain of the sensor may be increased without introducing additional instability into the automatic control.

Each of the brackets 70 for the wand sensor units 51 mount parallel to the rear edge of blade 15, adjacent to its outboard ends, and clamp the housing in a position

so the axis of shaft 53 and wand 55 are in all planes parallel with the cutting edge of blade 15. Thus the wand 55 is representative of the blade cutting edge when in contact with grade wire 56, curb, ground, etc. However, to minimize the "hang-up" of the wand on wire supporting stakes, the wand sensor units 51 are preferably clamped to the housing in a position so that the axis of shaft 53 and wand 55 trail behind the longitudinal axis of the blade, making an angle of about 30° therewith.

Actually, each bracket 70 is composed of two principal parts comprising a stationary bracket fixture 80 which is clamped or otherwise fixedly attached to the blade and a detachable mounting fixture 81 which fixedly retains the sensor unit 51.

The mounting fixture 81 includes a U-shaped member 82 which is accurately positioned on stationary bracket fixture 80 by dowels 84 when assembled thereon. Retention of the mounting fixture on the plate is accomplished by release means, which in FIG. 3, is composed of an angle bar 85 welded to the U-shaped member and two toggle plates 86 which through associated springs 87 engage the flanges of the angle bar and urge the member against the plate where it is aligned by the dowels.

With this mounting arrangement, the mounting fixture will "pop" free of the plate if the wand or other parts of the sensor unit catch or become entangled with objects likely to damage them because of the relative movement between them if rigidly mounted to the blade. A lanyard 88 attached between the plate and the mounting fixture will prevent loss of the sensor unit when it becomes detached under operating conditions.

In FIG. 4, the wand sensor unit 51 is replaced with a wheel sensor unit 90, which mounts on bracket 82 in place of the wand sensor unit. A pair of clamps 91 secured to the bracket maintains a downward oriented swivel shaft 92 on which the housing 93 of the wheel unit is casted so the wheel unit will track along side blade 15. A strut 94 having a low pressure tire 95 mounted therein is swingably mounted in the housing on a pin 96 having its axis oriented horizontally. The strut is keyed to the pin so that it will rotate when the wheel moves up and down.

As can be seen in FIG. 5, the pin is supported on bearings in the housing and drives a concentric shaft 97 which is connected to potentiometer 98. A coiled electrical cable 99 connects the potentiometer to the control system and the shaft will change the resistance value of the potentiometer as the tire moves up and down.

A very low pressure tire is used so small rocks and pebbles will not cause the wheel position to vary unless there is a change in the average area over which the wheel tracks. Since the wheel casters and tracks along side the blade, it provides a reference relative to the cut previously made by the blade.

What is claimed is:

1. In combination with a motor grader having a frame, a blade and jack means mounted on opposite sides of its frame and connected to the blade for controlling the blade, a fully integrated slope and grade automatic blade control comprising:

two electro-hydraulic valve means connected with a fluid pressure source, each of said valve means connected to a separate jack means whereby one valve means controls the jack means on one side of the frame and the other valve means controls the jack means on the opposite side;

two parallel control circuit means;

cross switch means coupled to receive the output of said two control circuit means and connected with said two electro-hydraulic valve means, and operable to selectively connect one control circuit means to one electro-hydraulic valve means and the other control circuit means to the other electro-hydraulic valve means;

two manually controlled potentiometer means, one con-

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ected to each control circuit to provide a manually selected input;

three signal producing transducer means, two of said transducer means being external sensor units connected adjacent to opposite ends of said blade and operable to produce a signal representing the position of its end of said blade relative to an external reference, the other transducer means being a vertical reference means connected to said blade and operable to produce a signal representing the position of the blade with reference to vertical; and

mode switch means coupled to receive the signals from said three transducer means and connected to said two control circuits, said mode switch means operable to connect any two of said signals to said control circuit means whereby slope and grade of the blade can be automatically controlled by any two of said signals from said three transducer means in combination with the inputs from said potentiometer means.

2. The combination in claim 1 wherein each control circuit means include a differential operational amplifier and a current booster amplifier whereby differences in its input from its manually adjusted potentiometer means and the signal from the transducer means coupled to it

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causes the amplifier circuit to produce a signal proportional to said differences which is capable of actuating the electro-hydraulic valve means in a direction to reduce said differences.

3. The combination described in claim 2 wherein the external sensor units include a potentiometer driven by a journaled shaft connected to it, an arm connected to said arm and wand means connected to said arm, said wand means operable to track on external reference means as the motor grader moves.

4. The combination described in claim 3 wherein the bracket includes a spring release means allowing it to release from the blade if the wand means catches on a stationary object.

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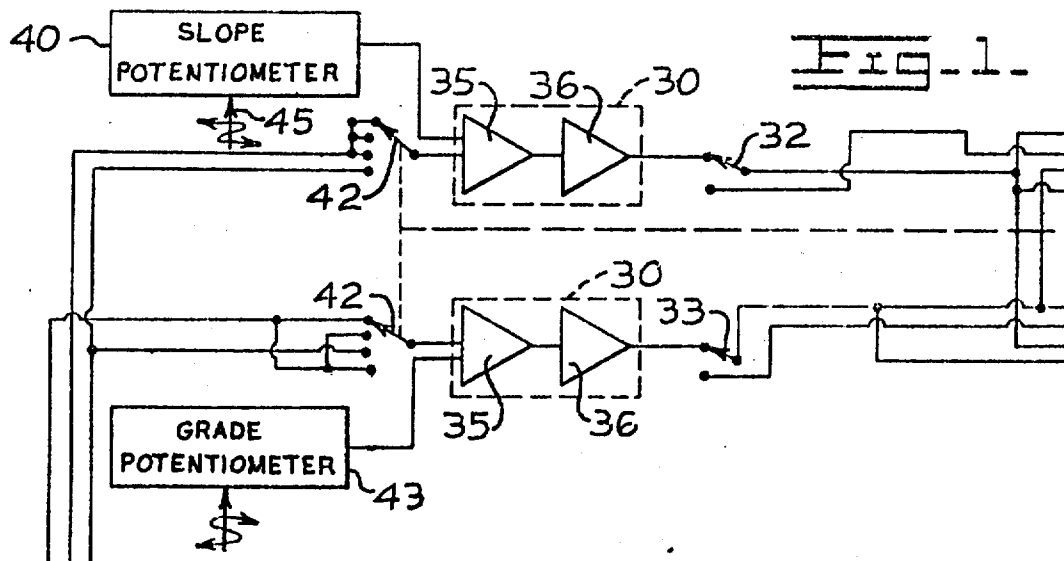
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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,495,663 Dated February 17, 1970

Inventor(s) R. D. Scholl et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:



In reference to Figure 1, the lower switch 42 should show that its second contact is connected to a potentiometer 52 rather than to potentiometer 43.

Signed and sealed this 28th day of January 1975.

(SEAL)
Attest:

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Commissioner of Patents