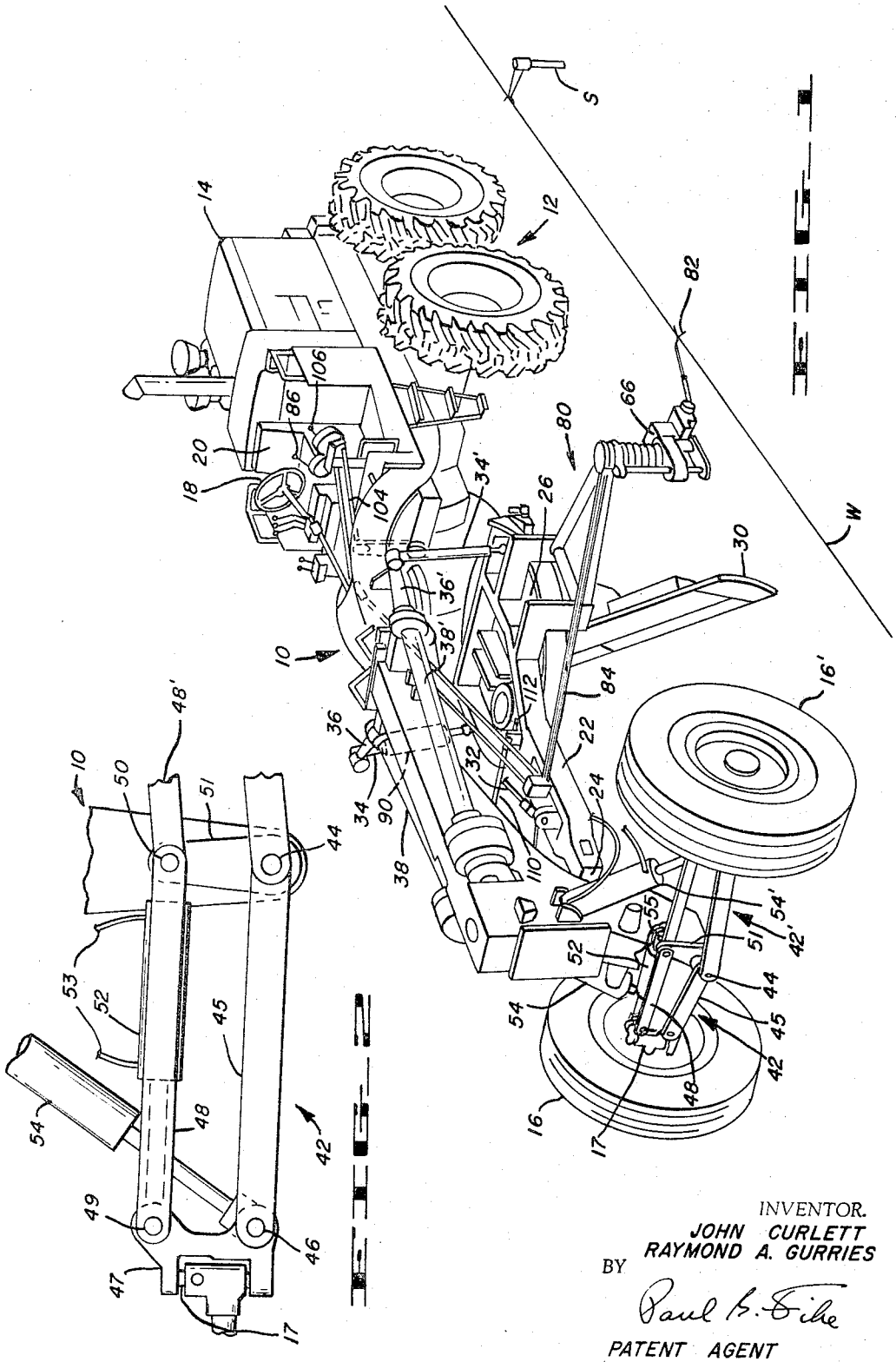
Oct. 17, 1967 J. CURLETT ETAL 3,346,976

LEVEL CONTROL MECHANISM FOR ROAD BUILDING MACHINES

Filed Sept. 16, 1964 2 Sheets-Sheet 1



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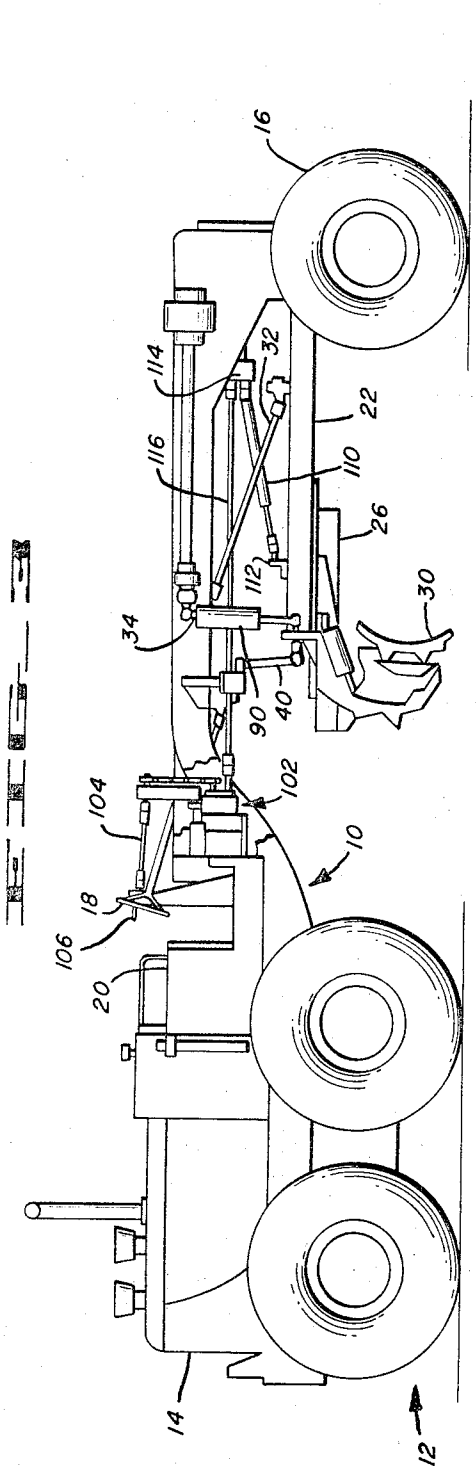
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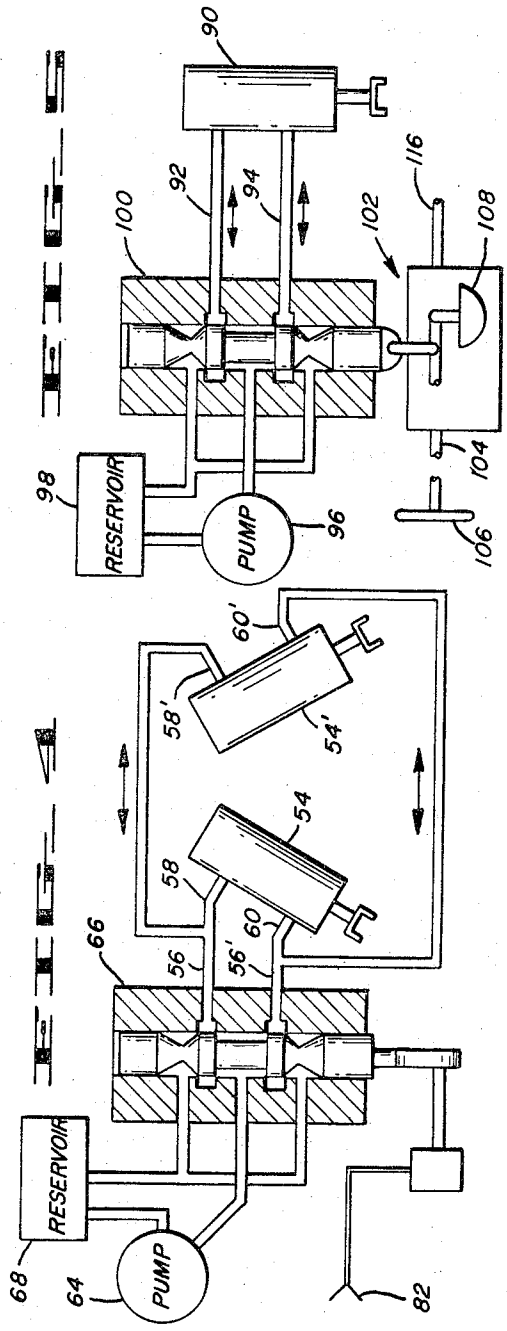
PATENT AGENT

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LEVEL CONTROL MECHANISM FOR ROAD BUILDING MACHINES

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ABSTRACT OF THE DISCLOSURE

A level control mechanism for the blade or moldboard of a road grader or the working implement of similar machines which controls automatically the longitudinal disposition of the main blade-suspending frame of the machine relative to an external grade reference to maintain a predetermined relative disposition therebetween and thus maintain the entire blade at its desired operational level regardless of its shear angle and the existent ground level encountered by the machine.

The present invention relates generally to road building machines, and more particularly, to a level control mechanism for the working implement of a road building machine, such as, for example, the earth-moving blade of a road grader.

The level control mechanism of the present invention can be advantageously applied, by way of example, to a conventional road grader which generally includes an elongated, arched frame that is supported fore and aft by suitable wheels and adjustably suspends at an intermediate position a generally transversely-extending earth-moving blade. More particularly, the blade is suspended for vertical adjustment, lateral adjustment, and angular adjustment, as required and as controlled by the machine operator. However, severe problems in maintaining a requisite longitudinal grade and cross-slope are encountered. By way of example, if earth is being moved by a blade positioned at a shear angle of 45° relative to the direction of machine motion (a typical operation), if the ground level rises in front of the machine, the front wheels of the grader will rise so that blade height will increase. However, the longitudinal slope of the angularly-disposed blade will also change. Under operator control, the blade can be lowered so that its central portion may be reset at the desired grade level, but because of the change in the longitudinal blade slope, the forwardly projecting end of the angularly-disposed blade will be higher than the rearwardly projecting end thereof and additional correction is required. The multiplicity of requisite corrections is difficult for even the most experienced operator.

In view of this and other operational defects in existent road graders and other road building machines wherein longitudinal grade and cross-slope must be accurately maintained, it is a general object of the present invention to provide a level control mechanism which automatically maintains the blade or other working implement of a road building machine at a desired level both longitudinally and transversely relative to the direction of machine motion.

More particularly, it is a significant feature of the present invention to provide a level control mechanism that can be applied to existent road graders or other road building machines with minimal modification thereof.

Additionally, it is a feature of the invention to provide a level control mechanism which automatically functions to maintain the blade or other working implement at a desired height relative to a grade wire, existent surface, or any other pre-established external grade reference.

Yet more particularly, it is a feature to provide a level control mechanism including adjustment means connected between the front supporting wheels of a road grader and the forward portion of the frame whereby such frame and the blade suspended therefrom are raised or lowered in response to vertical deviations relative to the aforementioned external grade reference so as to automatically maintain the frame and supported blade in a predetermined longitudinal disposition relative to such grade reference.

Such adjustment means, in accordance with another feature of the invention, preferably takes the form of a pair of hydraulic cylinders connected respectively to two transversely spaced wheels at the front end of the road building machine, such cylinders being hydraulically associated to automatically accommodate differences in elevation of the surface encountered by such wheels.

A related feature of the invention is the arrangement for mounting a grade reference sensor in transverse alignment with the blade to assure accurate control of blade height.

In accordance with another aspect of the invention, it is a feature to provide a level control mechanism for a road building machine including means for automatically adjusting the transverse slope of the blade or other working implement so as to maintain the requisite pre-established cross-slope of the graded surface.

Preferably, it is a feature of the invention to control the transverse slope of the blade or other working implement in response to a gravity sensing device such as a pendulum.

Yet more particularly, it is a feature to provide means including a gravity responsive device for controlling the transverse slope of the working implement which device is mounted on the main frame of the unit and is operatively interconnected with the adjustably-mounted working implement by feedback linkage whereby further change in disposition of the working implement is stopped upon attainment of a pre-established cross-slope setting.

It is an additional feature of the invention to provide a level control mechanism including a cross-slope control for the working implement involving the simple addition of a hydraulic ram or other extensible member to the existent vertical control linkage for the working implement.

These as well as other objects and features of the invention will become more apparent from a perusal of the following description of an exemplary embodiment of the present invention depicted in the accompanying drawings wherein:

FIG. 1 is a perspective view of a generally conventional road grader having a level control mechanism applied thereto in accordance with the present invention, the road grader being viewed from the left front thereof,

FIG. 2 is an enlarged fragmentary elevational view of the front portion of the road grader,

FIG. 3 is a somewhat diagrammatic elevation of the right side of the road grader with the control mechanism incorporated therein,

FIG. 4 is a diagrammatic representation of the grade control system of the mechanism, and

FIG. 5 is a diagrammatic view of the cross-slope control mechanism.

As shown in FIGS. 1 and 3, the road grader to which the level control mechanism of the present invention is applied, is of generally conventional design including a rigid frame **10** mounted at its rearward end on dual wheel units **12** that are driven from a conventional diesel engine **14** mounted thereabove. The frame **10** extends forwardly in a somewhat arched configuration for support at its forward extremity on transversely spaced wheels **16**, **16'**, which can be steered about vertical spindles, one of which is shown at **17** in FIG. 1, through suitable interconnecting linkage to a steering wheel **18** mounted above the rear portion of the frame in front of the operator's seat **20**.

An auxiliary blade-mounting frame **22** is pivotally secured as indicated at **24** to the underside of the forward end of the main machine frame **10** and extends rearwardly to rotatably support a quadrant **26** to the underside of which the earth-moving blade **30** is rigidly attached.

Conventional drive linkage **32** is connected between the quadrant **26** and a control handle adjacent the operator's seat **20** to provide rotative adjustment of the quadrant and consequent angular adjustment of the blade **30** about a substantially vertical axis. To raise or lower the blade **30**, links **34**, **34'** are pivotally secured to opposte sides of the auxiliary frame **22** at their lower ends and are pivotally connected to the extremities of crank arms **36**, **36'** at their upper ends. The crank arms **36**, **36'** are rotated, either indviidually or simultaneously, from suitable actuating linkage **38**, **38'** controlled by the operator so that the auxiliary frame **22** may be raised or lowered to, in turn, effect vertical adjustment of the blade **30** or a variation in the transverse slope thereof, the pivotal mounting **24** of the auxiliary frame **22** permitting such adjustments. To effect lateral motion of the blade **30**, additional linkage, indicated at **40**, and also under the control of the operator, effects lateral shifting of the auxiliary frame **22** and the blade **30** therewith. No further details of the road grader will be explicated since the described construction is conventional and in and of itself forms no part of the present invention. As a corollary, it will be apparent from the following description of the invention that application thereof to road graders or other road building machines differing in details from the illustrated structure is within the contemplated scope of the invention.

In accordance with the present invention, the conventional axle joining the front wheels **16**, **16'** is replaced by two centrally conjoined parallelogram units which are pivoted in mirror like symmetry from a horizontal pin **44** fixed to the front of the frame **10**, thus to allow each wheel individually to be raised or lowered relative to the supported frame and also enable the front wheels **16**, **16'** to be leaned laterally.

With added reference to FIG. 2, each parallelogram unit **42** includes a main axle section **45** pivotally mounted at its ends on the fixed pin **44** and another pin **46** at the lower end of a support bracket **47** for the wheel spindle **17**. A rod **48** is pivotally connected at its opposite ends to a pin **49** at the upper end of the bracket **47** and a movable pin **50** on the upper end of a link **51** pivoted at its lower end on the fixed frame pin **44**, thus completing the parallelogram unit **42**. Consequently, each of the parallelogram units is joined to the frame **10** at the common pin **44** but can be shifted laterally in a conjoint fashion to provide lateral leaning of the wheels **16**, **16'** while maintaining parallelism thereof or can be individually raised or lowered to provide vertical adjustment of the wheels **16**, **16'** relative to the frame **10**, again while maintaining wheel parallelism.

To actuate lateral leaning of the wheels **16**, **16'**, a double-acting hydraulic ram **52** is connected pivotally between the upper bracket pin **49** and a horizontal pin **55** fixed on the frame, this pin being aligned with the movable pin **50** when the wheels **16**, **16'** are in their upright dispositions, as best shown in FIG. 2. Suitable hydraulic lines indicated at **53** effect, under operator control, extension or retraction of the ram **52** to thus shift the rods **48**, **48'** thereby changing the disposition of both parallelogram units **42**, **42'** and the amount of wheel lean.

For raising or lowering of the wheels **16**, **16'**, a double-acting hydraulic ram **54**, **54'** is pivotally connected in an angular disposition between each side of the forward portion of the frame **10** and the bracket pin **46**. Accordingly, if both rams **54**, **54'** are simultaneously extended, the front end of the frame **10** will be raised relative to the supporting wheels **16**, **16'**. On the other hand, if the rams are retracted, the front end of the frame **10** will be lowered relative to the wheels **16**, **16'**. Since the wheels **16**, **16'** are connected to the frame **10** by the parallelogram units **42**, **42'**, the planes defined by the wheels will remain in parallelism regardless of their elevation relative to the supported frame.

The two height-control rams **54**, **54'** are simultaneously actuated through common feed and return conduits **56**, **56'** which divide into branch conduits **58**, **58'** and **60**, **60'** for connection to the upper and lower ends of the rams **54**, **54'** respectively, as shown in FIGS. 1 and 2 and diagrammatically represented in FIG. 4. Hydraulic fluid is supplied to one or another of the common conduits **56**, **56'** under pressure from a suitable pump **64** under the control of a four-way hydraulic valve **66** which is actuated to connect one conduit to the pump and the other as a return line connected to a hydraulic reservoir **68** in a conventional fashion.

The hydraulic control valve **66** is actuated by a control member that is operatively associated with an external grade reference in a manner such that the earth-moving blade **30** is maintained at a predetermined height relative to such reference. More particularly, as shown most clearly in FIG. 1, a bracket **80** is rigidly secured to one side of the auxiliary blade-mounting frame **22** to project laterally therefrom in tratnsverse alignment with the blade **30** and mount at its outer end the aforementioned control valve **66** in mechanically cooperative relationship with a sensor member in the form of an outwardly projecting feeler fork **82** that is arranged to engage a grade wire W strung in parallelism to the path of machine motion at a desired level, suitable supporting stakes S for the wire W being disposed at spaced intervals along such path. Preferably, the valve **66** and the associated feeler fork **82** are constructed in a manner described in detail in U.S. Patent No. 3,142,915, so as to perform the functions already indicated and also provide for manual adjustment of the level of the feeler fork **82** through rotatable mechanical rods **84** whose extremity is connected to a rotary handle **86** adjacent the operator's seat **20**.

Once the operator has set the blade **30** at a predetermined level by the appropriate manipulation of the vertical blade control linkage **34**, **36**, **38** and has also adjusted the feeler fork **82** in encompassing relationship with the external grade wire W, the blade height will be automatically maintained at such predetermined level throughout the grading operation. More particularly, as the road grader advances and if, for example, the front wheels **16**, **16'** encounter a rise in the surface being graded, the resultant raising of the wheels effects a raising of the main frame **10** and also the auxiliary frame **22** together with the feeler fork **82** mounted therefrom. The feeler fork movement is transmitted to the described control valve **66** in a fashion to deliver fluid through conduits **56**, **58**, **58'** to the lower ends of the hydraulic rams **54**, **54'** to effect retraction thereof and thus lower the frame **10**. Such lowering of the main frame **10** continues until it, the auxiliary frame **22**, blade **30** suspended therefrom, and the feeler fork **82** regain the pre-established level, whereupon the valve **66** closes and further vertical motion of the frame **10** and the blade **30** mounted therefrom ceases. If, on the other hand, the front wheels encounter a depression, the feeler fork **82** moves in a fashion so as to open the control valve **66** to supply fluid under pressure through conduits **56'**, **60**, **60'** to extend the rams **54**, **54'** and, in turn, raise the frame **10**, the blade **30** supported therefrom, and the feeler fork **82** until the latter has regained its original level, whereupon the vertical lifting ceases. Since the feeler fork **82** is disposed immediately transversely of the blade **30**, the accuracy of the blade height is maintained precisely. Furthermore, since the front wheels **16**, **16'** encounter either rises or depressions in the surface to be graded in advance of the blade **30**, the changes are anticipated and corrections are made before the blade encounters such rise or depression. In short, the longitudinal disposition of the frame **10** is maintained in constant preset relation to the grade wire W regardless of the ground level encountered by the advancing ma-

chine. Consequently, the blade **30** is also maintained at the desired level regardless of its shear angle.

If but one of the front wheels **16, 16'** encounters a rise or depression, a pressure imbalance is established between the two hydraulic rams **54, 54'**, and since they are connected through the branch conduits **58, 58'** and **60, 60'**, such pressure imbalance is automatically accommodated so that no variation in transverse angular disposition of the frame or the blade supported therefrom is experienced. If such lifting (or lowering) of one wheel **16** or **16'** changes the general height of blade disposition, the feeler fork **82** will, of course, actuate the control valve **66** in the manner described hereinabove to automatically readjust the blade height to the requisite grade level.

Generally, since the rear wheel units **12** of the grader pass over surfaces which have already been encountered by the blade **30** and are accordingly graded to the desired finished surface, no lifting nor lowering of the rear end of the machine frame will be experienced. However, if, for any reason, such lifting or lowering of the rear end of the frame were experienced, the feeler fork **82** would again be shifted to actuate the valve **66** and adjust the blade to the requisite pre-established height.

It is to be particularly noted that minimal modification of a conventional road grader is necessary to provide the described grade control. A simple modification of the mounting of the front wheels **16, 16'** to enable individual vertical adjustment thereof is the only change required. The remaining elements of the grade control mechanism constitute simple additions of hydraulic and mechanical elements which in no way interfere with the ordinary operation of the grader. While the described double-acting rams **54, 54'** are preferred to give positive height control, it will be obvious that single acting cylinders can be substituted therefor, pressure being applied to raise the frame and relieved to permit frame lowering under its own weight.

In accordance with another aspect of the invention, an additional, simple modification of a conventional road grader of the general type illustrated together with the addition of a gravity responsive control means enables automatic control of the transverse slope of the earth-moving blade **30** and the cross slope of the graded surface. More particularly, for this purpose, one of the vertical adjustment links **34** connected to the auxiliary frame **22** for raising or lowering that side portion of the blade **30** is modified to incorporate a hydraulic ram **90** which normally will function after the fashion of the replaced rigid link when not actuated, but when actuated in a manner to be described hereinafter, will raise or lower that side of the auxiliary blade-mounting frame **22** and the blade **30** mounted therefrom to provide for an adjustment of the transverse slope of the blade to re-establish a desired transverse disposition thereof, as set by the operator.

With reference to FIGS. 1 and 3, and additional reference to the schematic diagram of FIG. 5, such hydraulic ram **90** constitutes a double-acting ram connected in a hydraulic circuit including feed and return conduits **92, 94** which are placed in communication with a hydraulic pump **96** and reservoir **98** through a four way valve **100** which is controlled by a gravity responsive mechanism. Preferably, the valve **100** and the gravity-responsive mechanism take the form of the pendulum controlled, valve actuating mechanism **102** shown in our Patent No. 3,296,722 to which reference is made for details of construction and operation. Preferably such pendulum controlled, valve actuating mechanism **102** constitutes a unit that is secured rigidly to the frame **10** adjacent the operator's seat **20** and which by means of a rotatable control rod **104** having a handle **106** accessible to the operator can be preset to a deenergized position at a predetermined cross-slope. When the angular transverse disposition of the road grader changes from the pre-established value, the pendulum indicated diagrammatically at **108** in FIG. 5 swings to one side or the other under gravitational force to, in turn, open the control valve **100** in a fashion to supply hydraulic fluid under pressure through conduits **92** or **94** to the lower or upper end of the double-acting hydraulic ram **90** which will, in turn, lower or raise the lateral portion of the blade **30** thereunder.

In order to de-energize further ram actuation when the requisite cross-slope of the blade **30** has been attained, feedback means from the blade **30** to the pendulum-controlled, valve-actuating mechanism **102** is provided. More particularly, a telescopic rod **110** is operatively connected at one end to a member **112** mounted on the auxiliary blade-mounting frame **22** so as to be rotated in one direction or the other in response to any variation in transverse blade disposition. The rod **110** projects forwardly and upwardly and at its remote end is connected to a step-up gear box **114** mounted on the main frame and the amplified output from such gear box is transmitted by the rotation of another rod **116** extending rearwardly under the main frame for connection to the pendulum-controlled, valve actuating mechanism **102** to provide a feedback input in the manner described in detail in U.S. Patent No. 3,296,722. In order to accommodate relative motions between the main frame **10** of the grader and the auxiliary frame **22** which mounts the blade **30**, suitable universal, pivotal connections are provided at each end of the feedback rod **110** extending therebetween and the rod is of the described telescopic construction to enable variation in its length.

The operation of the cross-slope control can be briefly stated. If, for example, the left side of the machine is raised by the surface encountered, the left side of the blade **30** will also rise, but the disposition of the pendulum **108** will change at the same time to instigate movement of the valve **100** to supply hydraulic fluid under pressure through conduit **94** to the lower end of the hydraulic ram **90** effecting retraction thereof and a consequent raising of the right side of the blade **30**. When the original transverse slope of the blade **30** has been re-established, such information is transmitted by rotation of the feedback rods **110, 116** to the pendulum control unit and effect closure of the valve **100** so that no further change in the transverse slope of the blade will be experienced. Obviously, at the same time that such change in cross-slope is being accommodated, the rise on the left side of the machine will effect movement of the feeler fork **82** to accordingly exert fluid pressure at the lower ends of the hydraulic rams **54, 54'** mounting the front wheels **16, 16'** so that the frame **10** will be lowered until the original level is re-established. In short, through the cooperation of the described grade control operative from a pre-established external reference and the gravity-responsive cross-slope control, the earth moving blade **30** will always be maintained in the originally established plane of travel.

Obviously, various modifications and/or alterations can be made in the described structure without departing from the spirit of the invention, and the foregoing description of an exemplary embodiment is provided only for illustrative purposes and is not to be constructed in a limiting sense. The actual scope of the invention is to be indicated only by reference to the appended claims.

What is claimed is:

1. Level control mechanism for the working implement of a road building machine including a frame, mobile support means therefor, and separate means for suspending laterally-spaced portions of the working implement from the frame, said control mechanism comprising means connected between the mobile support means and the frame for vertically adjusting the disposition of the frame, means including a member adapted for operative association with an external grade reference for controlling vertical adjustment of the frame on the mobile support means, means connected between the frame and at least one laterally-spaced portion of the working implement for vertically adjusting that portion of such working implement, and means responsive to a lateral deviation in

the transverse slope of the working implement for controlling vertical adjustment of the laterally-spaced portion of the working implement.

2. Level control mechanism according to claim 1 wherein said implement-adjusting means includes a hydraulic ram.

3. Level control mechanism according to claim 2 wherein said adjustment-control means includes a pendulum-actuated hydraulic control valve connected to control the supply of hydraulic fluid to said hydraulic ram.

4. Level control mechanism according to claim 3 wherein said pendulum-actuated hydraulic control valve is mounted on said frame and which comprises feedback means connected between the working implement and said pendulum-actuated hydraulic control valve to close said valve upon attainment of a pre-established transverse slope of the working implement.

5. Level control mechanism for the working implement of a road building machine including a frame having transversely-spaced supporting wheels, and separate means for suspending laterally-spaced portions of the working implement from the frames, said control mechanism comprising means connecting the transversely-spaced supporting wheels to the frame for individual relative vertical adjustment, means for actuating relative vertical adjustment of the wheels simultaneously, means including a member adapted for operative association with an external grade reference for controlling the vertical adjustment of the wheels relative to the supported frame, means connected between the frame and at least one laterally-spaced portion of the working implement for vertically adjusting that portion of such working implement, and means responsive to a lateral deviation in the transverse slope of the working implement from a pre-established value for controlling vertical adjustment of the laterally-spaced portion of the working implement.

6. Level control mechanism according to claim 5 wherein said wheel-adjustment actuating means includes hydraulic rams extending downwardly from opposite sides of the frame for connection to the supporting wheels.

7. Level control mechanism according to claim 6 wherein said wheel adjustment actuating means includes a source of hydraulic pressure connected to said hydraulic rams through a common conduit.

8. Level control mechanism according to claim 6 wherein said wheel connecting means includes a shiftable parallelogram unit connected between the frame and each of the transversely-spaced wheels so that vertical motion and lateral leaning of the wheels is accommodated.

9. Level control mechanism according to claim 8 which comprises an additional hydraulic ram connected in substantially a horizontal disposition between said frame and one of said parallelogram units to effect, upon actuation, lateral leaning of the wheels.

10. Level control mechanism for the blade of a road grader including a frame having transversely-spaced supporting wheels at one end, additional mobile supporting means at the remote end, and separate means for suspending laterally-spaced portions of the blade therefrom, said control mechanism comprising means connected between said transversely-spaced supporting wheels and the frame for vertically adjusting the end of the frame supported thereby, means including a member adapted for operative association with an external grade reference for controlling vertical adjustment of the frame on the supporting wheels, means connected between the frame and at least one laterally-spaced portion of the blade for vertically adjusting that portion of the blade, and means responsive to a lateral deviation in blade slope for controlling vertical adjustment of that portion of the blade.

11. Level control mechanism for the working implement of a road building machine including a frame having transversely-spaced front and rear supporting wheels and means for suspending the working implement from the frame, which control mechanism comprises separate frame adjusting means connected between said frame and the front supporting wheels for varying the vertical distance therebetween, and means including a control member adapted for operative association with an external longitudinally-extending grade reference for simultaneously actuating said separate frame adjusting means in response to a deviation of working implement height from a pre-established relationship to the external grade reference so as to reestablish said frame longitudinally in its original relation to the external grade reference.

12. Level control mechanism according to claim 11 wherein said frame adjusting means includes a hydraulic ram connected between the frame and each front supporting wheel.

13. Level control mechanism according to claim 12 wherein said actuating means for said hydraulic rams includes a source of hydraulic fluid under pressure, said hydraulic rams being connected to said pressure source through a common hydraulic conduit.

14. Level control mechanism for the working implement of a road building machine including a frame having transversely-spaced supporting wheels, which control mechanism comprises a shiftable parallelogram unit connected between the frame and each of the transversely-spaced wheels so that vertical motion and lateral leaning of the wheels is accommodated, means operatively connected between the frame and said parallelogram unit to laterally shift the same and effect lateral leaning of the wheels, and means connected between the frame and each of said parallelogram units to effect vertical pivotal motion thereof to raise or lower the wheels relative to the frame.

15. Level control mechanism for the working implement of a road building machine including a frame having mobile support means and carrying the working implement which level control mechanism comprises frame-adjusting means connected between said frame and said mobile support means for varying the vertical angular relation therebetween in the direction of machine travel and means operatively associated with an external grade reference defining a rectilinear path extending generally along the path of machine travel for actuating said frame adjusting means to maintain the longitudinal disposition of said frame in substantially constant vertical angular relation to such rectilinear path.

16. Level control mechanism according to claim 15 which comprises means adjustably supporting laterally-spaced portions of the working implement from said frame, and means operative in response to cross-slope deviation of the working implement from a predetermined disposition for actuating said adjustable support means to return the working implement to the original predetermined disposition.

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