June 21, 1960 P. K. BEEMER ET AL 2,941,319

GRADING MACHINE BLADE SUPPORT

Filed May 17, 1957

FIG. 1.

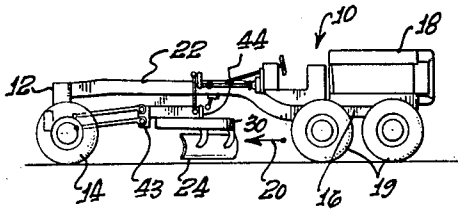


FIG. 5.

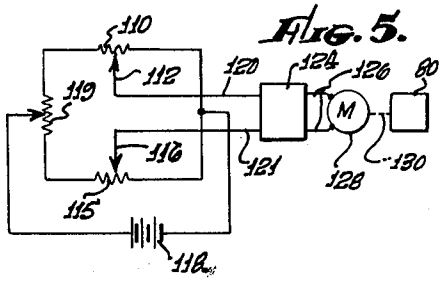


FIG. 2.

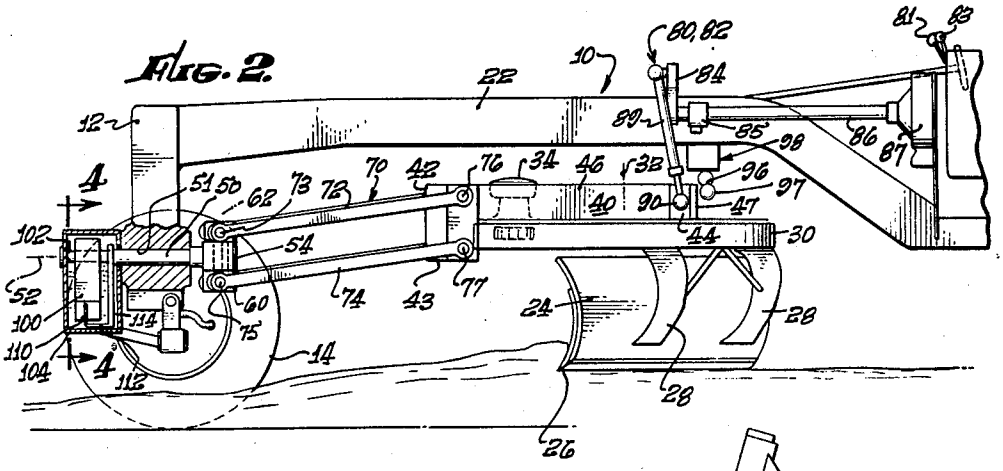


FIG. 3.

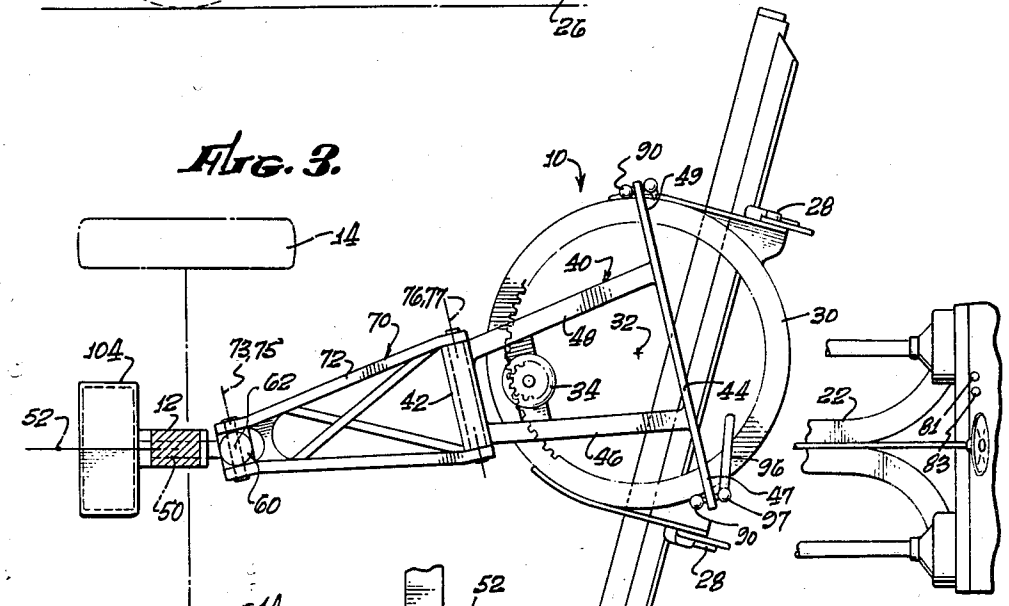
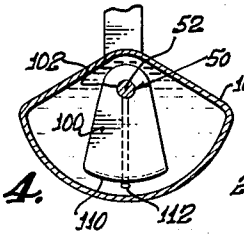


FIG. 4.



INVENTORS.
PAUL K. BEEMER,
REEFORD P. SHEA,
BY
By Barkalow + Lewis

United States Patent Office 2,941,319 Patented June 21, 1960

2,941,319

GRADING MACHINE BLADE SUPPORT

Paul K. Beemer, Laguna Beach, and Reeford P. Shea, Riverside, Calif., assignors to Preco Incorporated, Los Angeles, Calif., a corporation of California

Filed May 17, 1957, Ser. No. 659,985

4 Claims. (Cl. 37—156)

This invention has to do with earth working machines of the type in which an elongated blade extends generally transversely of the direction of travel of the machine and is movable relative to the machine frame to vary the transverse slope of the earth surface produced.

The invention is concerned more particularly with improved means for supporting the blade of such machines with respect to the machine frame.

One advantage provided by the improved supporting structure of the present invention is that the angle at which the working face of the blade engages the earth adjacent the blade edge does not vary as the vertical position of the blade is changed to alter the depth of cut or fill being produced.

A further advantage of the novel blade supporting structure, with which the invention is especially concerned, is that the transverse grade angle of the finished earth surface bears a definite and relatively simple relation to the orientation of certain of the blade supporting members. That feature of the novel blade supporting structure is utilized, in accordance with a further aspect of the invention, to provide a particularly simple, economical and effective control system, whereby the blade may be automatically controlled in such a way as to produce a finished earth surface having a desired transverse grade angle.

In many conventional grading machines, the blade is mounted in fixed relation on a circle frame which is carried by a drawbar, the circle frame being rotatable with respect to the drawbar about a circle axis perpendicular to the working edge of the blade. The drawbar is ordinarily of elongated, generally trianguler or T shape and has its forward corner mounted with respect to the machine frame by means of a ball and socket joint or its equivalent. The drawbar is thus capable of limited universal rotational movement about its forward end with respect to the machine frame. That movement is ordinarily controlled by power drive means which act through linkage mechanisms engaging the rearward corners of the drawbar. In particular, one rearward corner of the drawbar may be raised and the other lowered to vary the grade angle produced by the blade; and both rearward corners of the drawbar may be raised or lowered together to vary the depth of cut. Rotation of the circle frame with respect to the drawbar varies the shear angle with which the blade edge engages the earth.

A disadvantage of that type of blade mounting, which is particularly disturbing when it is desired to control the grade angle automatically, is that the relationship between the grade angle and the orientation of the blade-supporting structure is quite complex. In general, any change in the angular relation of the drawbar with respect to the machine frame, and also any change in the angular relation of the circle frame with respect to the drawbar, causes a change in the grade angle. And the existing grade angle, even assuming horizontal position of the machine frame, bears no simple relation to the angular positions of the structural components.

In accordance with the present invention, the previous type of drawbar construction is replaced by a subframe which is movably mounted with respect to the machine frame in a distinctive manner. That mounting is such that the circle axis is maintained at all times perpendicular to the direction of travel of the machine. At the same time, the subframe is rotatable about an axis parallel to the direction of travel to vary the grade angle. In preferred form of the invention, the subframe is also rotatable with respect to the machine frame about a generally vertical axis to provide transverse blade movement in substantially the usual manner; and is movable in translation along a generally vertical path to vary the depth of cut. Furthermore it is preferred that a primary member of the supporting structure, by which the rest of the blade supporting structure is directly mounted on the machine frame, is so mounted on that frame as to be rotatable about an axis parallel to the direction of travel of the machine. That rotation then corresponds directly to the actual transverse grade angle for which the blade is set, regardless of the angular adjustment of the circle frame and regardless of the detailed adjustment of other degrees of freedom of the mechanism.

With that type of blade support, the face of the blade adjacent the cutting edge engages the earth at an angle which does not vary with the depth of cut. In addition, with the described support structure the axis of rotation of the circle frame is always perpendicular to the finished earth surface left by the blade; and the transverse slope of that earth surface corresponds directly to the angular position of the primary member just described. It is therefore relatively simple and economical to provide control means for the blade drive mechanism for automatically maintaining a desired grade angle under control of rotation of the described primary member of the blade supporting structure.

A full understanding of the invention and of its further objects and advantages will be had from the following description of an illustrative embodiment, of which description the accompanying drawings form a part. The particulars of that description are solely for illustration, and are not intended as a limitation upon the scope of the invention, which is defined in the appended claims.

In the drawings:

Fig. 1 is a side elevation, somewhat schematic, of an illustrative embodiment of the invention in a grading machine;

Fig. 2 is a fragmentary side elevation, corresponding to a portion of Fig. 1 at enlarged scale;

Fig. 3 is a plan corresponding to Fig. 2, with portions cut away;

Fig. 4 is a transverse section on line 4—4 of Fig. 2; and

Fig. 5 is a schematic diagram representing an illustrative servo control system in accordance with the invention.

In the illustrative grading machine shown in the drawings, the machine frame is denoted generally by the numeral 10. Machine frame 10 includes a forward generally vertical post 12 which supports the front wheels 14 with their usual steering and adjustment mechanism. The rearward portion 16 of frame 10 supports engine 18 and is carried by the rear wheels 19 by which the machine is driven in a normal direction of travel indicated by the arrow 20. The intermediate portion 22 of machine frame 10 is elevated to provide clearance for the earth-working tool and its supporting and control structure. An illustrative elongated blade is indicated at 24 with straight working edge 26. Blade 24 is typically

mounted in fixed relation, as by brackets indicated at 28, on a circle frame 30, which may be of conventional construction.

In accordance with the present invention, circle frame 30 is rotatably mounted on a subframe, represented in illustrative and somewhat schematic form at 40. The axis of rotation of circle frame 30 with respect to subframe 40 is indicated schematically at 32 and will be referred to as the circle axis. The mounting structure by which the circle frame is rotatably mounted on subframe 40 may be substantially identical with known structures by which the circle frame is mounted on the drawbar of existing grading machines. Means for driving the circle frame rotation are indicated schematically at 34, and may be of conventional construction, utilizing either hydraulic or mechanical power.

Subframe 40, as shown, is a substantially plane rigid frame of trapezoidal plan, comprising front and rear transverse members 42 and 44, respectively, and left and right side members 46 and 48. Rear member 44 extends transversely beyond its junctions with side members 46 and 48 to provide transversely spaced arm portions 47 and 49 which support circle frame 30 and carry fittings for connection of the drive mechanism to be described. Forward transverse member 42 of subframe 40 extends out of the plane of the frame, downwardly as illustratively shown, forming a generally vertical post portion 43.

In accordance with the broader aspects of the invention, subframe 40 may be mounted with respect to machine frame 10 by any suitable type of support structure which maintains circle axis 32 perpendicular to direction of travel 20, while permitting relative movement of the subframe and machine frame in any combination of further degrees of freedom which provide the required types of blade movement. A particular feature of the invention in preferred form is the fact that the primary member of that support structure, by which the remainder of the structure is directly related to machine frame 10, is mounted with respect to the machine frame for relative rotation about an axis parallel to the direction of travel 20. That primary member, in the present illustrative embodiment, is indicated at 50, and is journaled at 51, in frame post 12 on a member axis 52. Member axis 52 is parallel to the normal direction of travel of the machine, indicated by arrow 20.

It is preferred that subframe 40 be mounted with respect to primary member 50 by structure which permits their relative rotation about a generally vertical axis which is perpendicular to member axis 52 and parallel to circle axis 32. That relative rotation permits normal transverse shifting of the grader blade toward one side or the other of the machine. Such movement is permitted in the present embodiment about the axis indicated at 62, which is defined by the journal sleeve 54. That sleeve forms the rearward portion of primary member 50 and extends perpendicularly to member axis 52. A bracket member 60 is journaled in that bearing sleeve, and is thus rotatable with respect to member 50 about bracket axis 62 perpendicular to member axis 52. Subframe 40 is mounted on bracket 60 by any suitable structure that maintains circle axis 32 parallel to bracket axis 62.

It is further preferred that the last described structure permits relative translational movement of the subframe and bracket in a direction generally parallel to the circle axis. In the present embodiment such translational movement is permitted by a parallelogram linkage, indicated generally by the numeral 70, which comprises the upper and lower linkage frames 72 and 74. Each of those frames is essentially plane and trapezoidal in form (Fig. 3). The forward ends of the respective linkage frames are pivotally mounted on bracket 60 on the pivot axes 73 and 75, which are mutually parallel, perpendicular to bracket axis 62, and spaced longitudinally of the latter axis. The rearward ends of linkage frames 72 and 74 are pivotally mounted on post portion 42 of subframe 40 on the pivot axes 76 and 77, which are mutually parallel, perpendicular to circle axis 32 and spaced longitudinally of that axis by a distance equal to the separation of pivot axes 73 and 75. With that connecting structure between the subframe and bracket 60, the subframe and blade can be raised or lowered freely, moving in translation along an arcuate path which is generally parallel to circle axis 32. During that movement, and also during bodily rotation of bracket 60 and subframe 40 about bracket axis 62, circle axis 32 is maintained always parallel to bracket axis 62, and hence perpendicular to member axis 52 and to direction of travel 20 of the entire machine.

When the blade is mounted with respect to the machine frame in accordance with the present invention, for example by the illustrative structure just described, the blade movements may be driven, if desired, by mechanism of conventional type. For example, left and right blade lift mechanisms 80 and 82 may be provided which are power driven from engine 18 under control of manual handles 81 and 83, respectively. As shown schematically, left blade lift mechanism 80, for example, comprises a crank arm 84 journaled on machine frame 10 on a bracket 85 and driven from engine 18 via a shaft 86 and suitable gear and clutch mechanism in housing 87. Crank arm 84 is connected by the link 89 to a ball joint 90 fixedly mounted near the end of left frame arm 47 of subframe cross member 44. The mechanism in clutch housing 87 is controllable in known manner by handle 81 to drive crank arm 84 in upward and downward directions in response to handle movement in two opposite directions. Right lift mechanism 82 may be of similar construction, similarly controlled by handle 83.

Simultaneous drive of both blade lift mechanisms in the same direction raises or lowers both ends of subframe member 44 by approximately equal amounts. Due to the constraint imposed by parallel linkage 70, the subframe and its carried blade then moves upward or downward substantially without rotation; and, in any case, without rotation about a transverse axis such as occurs with a conventionally mounted drawbar.

Drive of one lift mechanism only, or of both in opposite directions, causes transverse tilting of the subframe and the blade. Such action changes the grade angle setting of the blade, and circle axis 32 swings out of the vertical. However, parallel linkage 70 causes bracket member 60 and primary member 50 to rotate about member axis 52 in response to the described subframe rotation in such a way that bracket axis 62 remains parallel to circle axis 32. And since bracket axis 62 is constrained to remain in a plane perpendicular to the direction of travel, circle axis 32 remains parallel to such a plane. Hence the rotational movement of subframe 40 takes place about member axis 52, and circle axis 32 lies always in a plane perpendicular to the member axis.

A transverse blade drive of conventional type may also be provided, typically comprising the transverse oblique link 96. The lower end of link 96 is connected to subframe 40 as by a ball joint 97. The upper end of link 96 is shiftable transversely of machine frame 10, as by mechanism which is indicated schematically at 98 and controlled by a manual handle, not explicitly shown. Transverse blade drive via mechanism 98 causes the entire assembly of subframe 40, blade 24, parallel linkage 70 and bracket 60 to swing through a limited angle about bracket axis 62. That movement is broadly similar to the corresponding transverse blade movement in a conventional motor grader, but with the distinctive difference that in structure of the present type circle axis 32 is maintained parallel to bracket axis 62 and hence perpendicular to direction of travel 20.

An important advantage in mounting the blade on the machine frame in accordance with the present invention is that the grade angle for which the blade is set cor-

responds directly to the angular position of primary member 50 about member axis 52. Thus, the angular position of member 50 relative to machine frame 10 provides a measure of the transverse slope of the finished earth surface, measured relative to the machine frame; and the angular position of member 50 relative to the direction of gravity provides a measure of the absolute transverse slope of the finished earth surface. It is therefore possible to provide automatic control mechanism of servo type for controlling the blade position in terms of an error signal derived from primary member 50.

The direction of gravity may be provided as a reference variable in any convenient manner, utilizing, for example, such known devices as a suitably damped pendulum, a gravity responsive mercury switch or a gyroscope. Such a device may be mounted directly on member 50, for example at its forward end ahead of journal bearing 51. Between such a vertical indicating device and member 50 may be connected any suitable type of transducer for producing a signal, preferably of electrical nature, which represents the existing angular relation between member 50 and the direction of gravity. That signal may then be employed as an input control signal for a servo control system for controlling the blade lift mechanism 80 or 82. For example, the described angle signal may be compared to a signal representing the desired value of the transverse grade angle, to derive a servo error signal.

As an illustrative example, a pendulum is indicated somewhat schematically at 100, journaled on a shaft 102 which is mounted coaxially with member axis 52 within a housing 104. Shaft 102 may comprise an integral portion of primary member 50. Housing 104 is typically mounted in fixed relation on the forward face of frame post 12, but may be carried alternatively on member 50. Suitable damping means for the pendulum may be provided, for example, by a viscous fluid within housing 104. An illustrative transducer for developing an electrical signal comprises a potentiometer driven by the relative movement of member 50 and pendulum 100. For example, an arcuate potentiometer winding 110 may be mounted on the pendulum mass concentric with its axis 52 and may be engaged by a potentiometer brush 112 which is rotatively fixed with respect to member 50 by a brush arm 114.

Potentiometer winding 110 may be connected as shown in Fig. 5 in parallel with the winding 115 of a second potentiometer across a source of power, shown as the battery 118. The potentiometer indicated at 119 facilitates zero adjustment of the bridge network. The brush 116 is manually adjustable on winding 115 in accordance with the desired value of grade angle. An output signal is taken on lines 120, 121 from the two potentiometer brushes 112 and 116, respectively, and is supplied to a servo amplifier, represented schematically at 124. The output from amplifier 124 on lines 126 is utilized, as via a motor 128, to control the action of blade lift mechanism 80. The dashed line 130 in Fig. 5 between motor 128 and mechanism 80 may, for example, represent a linkage mechanism by which manual control handle 81 is displaced in one direction or the other in accordance with the direction of drive of motor 128.

When the actual grade angle to which blade 24 is set corresponds to the desired angle set at potentiometer 115, 116 the position of brush 112 on winding 110 corresponds electrically to that of brush 116 on winding 115. The resulting signal on lines 120, 121 is then zero and lift

mechanism 80 remains idle. If that correspondence of brush positions is disturbed, whether by manual operation of the uncontrolled blade lift mechanism 82, by tilting of the entire machine frame, by manual change of the setting of brush 116, or by some other cause, the resulting error signal on lines 120, 121 causes motor 128 to actuate lift mechanism 80 in a direction to restore balance of the bridge circuit. That action automatically restores the grade angle setting of the blade to the desired value.

It will be understood that the invention, although described with relation to a particular grading machine having mechanically driven blade lift drive, may readily be adapted to other types of earth working machine, including those having hydraulic type of blade lift drive. Many other particulars of the described illustrative embodiment may be greatly modified without departing from the proper scope of the invention, which is defined in the appended claims.

We claim:

1. In a grading machine, the combination of a machine frame movable over the ground in a normal direction of travel, a subframe, a circle frame mounted on the subframe and rotatable with respect thereto about a circle axis, a blade mounted on the circle frame with its working edge in a plane perpendicular to the circle axis, a support member journaled on the machine frame on a member axis that is parallel to the direction of travel, structure interconnecting the subframe and the support member for limited relative movement, said structure maintaining the circle axis always perpendicular to the member axis and permitting translational movement of the subframe relative to the support member transversely of the member axis, the subframe being rotatable with the support member about the member axis, drive means actuable to drive the subframe movement, and means acting in response to rotation of the support member about the member axis to develop a control signal representing the transverse grade angle of the blade.

2. The combination defined in claim 1, and wherein said structure comprises a bracket member journaled on the support member for rotation relative thereto about a bracket axis that is perpendicular to the member axis, and means interconnecting the bracket member and the subframe for relative translational movement, the last said means acting to maintain the circle axis always parallel to the bracket axis.

3. The combination defined in claim 1, and wherein said structure comprises a bracket member journaled on the support member for rotation relative thereto about a bracket axis that is perpendicular to the member axis, and a plurality of mutually parallel links pivotally connected to the subframe and to the bracket member on parallel pivot axes which are perpendicular to the bracket axis and to the circle axis.

4. The combination defined in claim 1, and including also means for actuating said drive means under control of said control signal.

References Cited in the file of this patent

UNITED STATES PATENTS

544,320	Pennock et al.	Aug. 13, 1895
1,864,639	Crezee	June 28, 1932
1,936,518	McColm	Nov. 21, 1933
2,189,286	Gustafson	Feb. 6, 1940
2,472,944	Furer et al.	June 14, 1949
2,846,635	Shea	Aug. 5, 1958