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[54] **SKID SUPPORTED CUTTING BLADE**

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[52] **U.S. Cl.** **172/4.5,** 172/783

[51] **Int. Cl.** **E02f 3/76,** E02f 3/12

[58] **Field of Search** 172/781, 783, 4.5, 172/4, 484, 387, 392, 393

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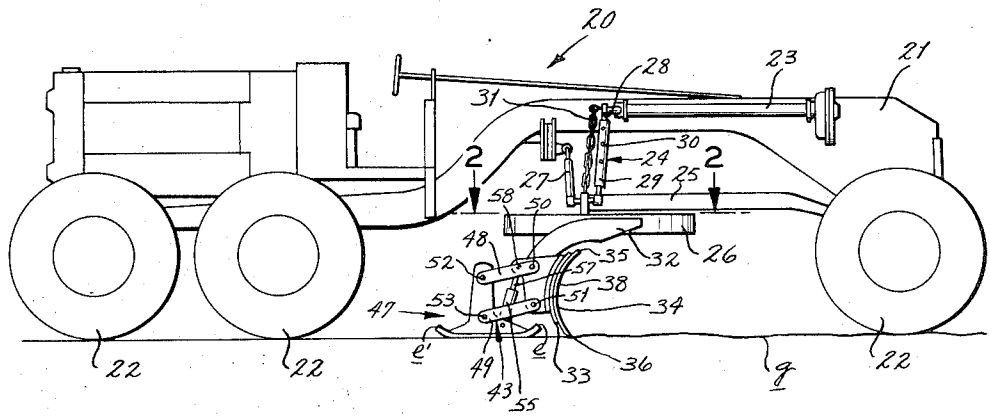
[57] **ABSTRACT**

A surface finishing vehicle having a skid supported cutting blade, the height of which is automatically controlled by a position sensing apparatus disposed in engagement with a reference string preset at a predetermined grade; the skid being connected to the cutting blade through a parallel linkage assembly and a double-acting cylinder which latter is in circuit with the position sensing apparatus whereby extension and retraction of said cylinder is effected responsive to the movement of said apparatus along said reference string.

11 Claims, 6 Drawing Figures



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SHEET 1 OF 2

FIG. 1

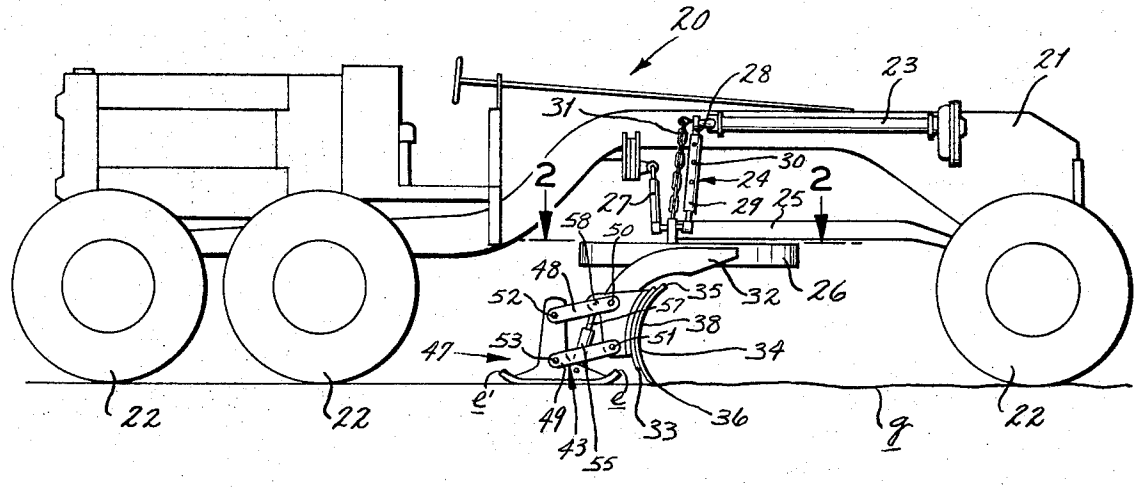

FIG. 2

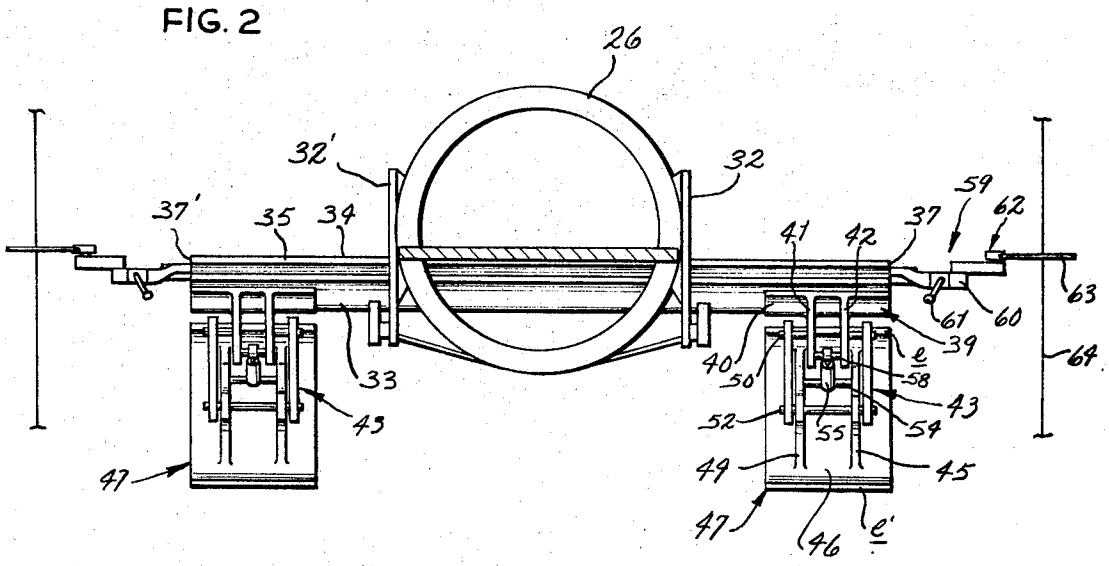

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FIG. 3

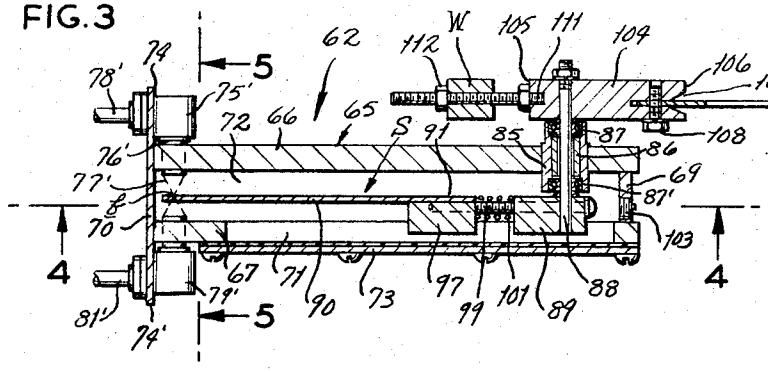


FIG. 5

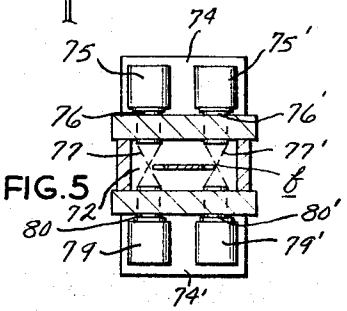


FIG. 4

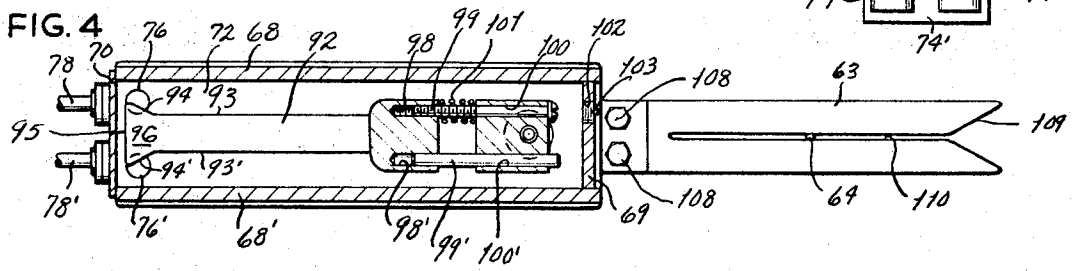
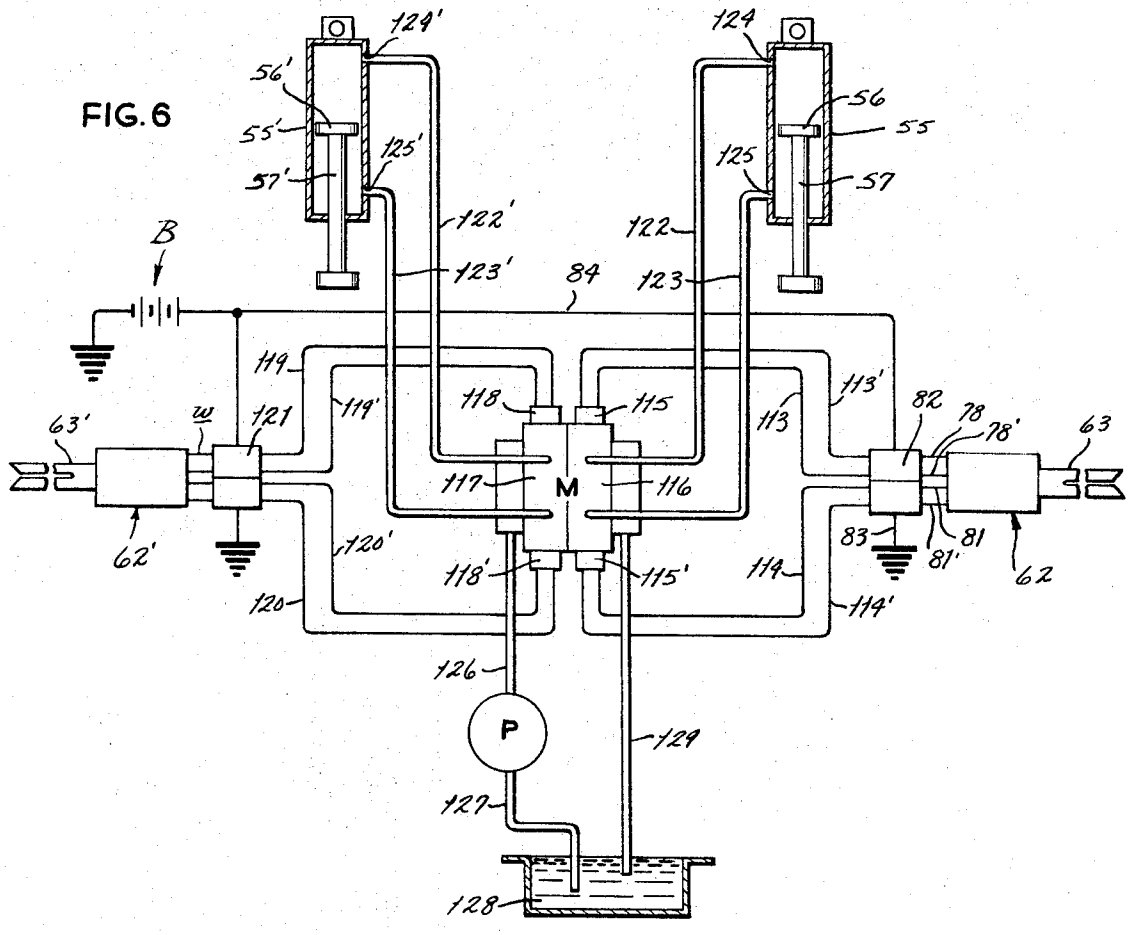


FIG. 6



SKID SUPPORTED CUTTING BLADE

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates in general to surface finishing equipment and, more particularly, a skid supported, automatically controlled, cutting blade.

Surface finishing equipment, such as graders or the like, commonly use string line references to automatically guide and control the height of the cutting tool above ground. The reference string is preset to the desired profile of cut as well as to the path of cut so that the cutting blade will spread or trim the material to the same profile as the reference string.

As most surface finishing equipment are supported above ground by rubber, resilient tires, the tilt factor of the equipment as it moves along rough or soft terrain is a problem in the industry. For example, if the front wheels of the vehicle suddenly enter into a dip, or sink into a soft region, the cutting blade would penetrate more deeply than desired. Since the cutting edge in surface finishing equipment of the prior art is normally supported on the frame of the vehicle, the blade will move upwardly and downwardly relative to the movement of the frame. Therefore, the depth penetration of the blade cutting edge could not be accurately controlled as it advanced over ground.

The present invention contemplates utilizing a pair of ground engaging skids mounted in trailing relationship to the end edges of the cutting blade. Since the skids are located rearwardly of the blade, they are traveling on a relatively smooth surface, as the rough terrain will have been flattened forwardly of the blade, thereby resulting in a relatively smooth travel over the ground. The skids are connected to the blade through a linkage assembly and a hydraulic-operated ram for supporting the cutting blade independently of the frame. Therefore, the rockable movement of the vehicle frame as it travels over rough terrain will not affect the performance of the cutting blade. The hydraulically operated ram of each skid is in circuit with a position sensing apparatus which is mounted on opposed end edges of the cutting blade for engaging a reference string located on either side of the path of cut so that the hydraulic ram will be actuated in accordance with the reference string as the vehicle travels along the ground.

Therefore, by the utilization of the skids the cutting blade is supported relatively freely above ground, as opposed to being rigidly fixed to the frame of the vehicle, so that the depth penetration of the cutting edge is automatically controlled by the position sensing apparatus as the skids advance over ground. Accordingly, the cutting edge of the blade moves the earth for developing an even surface and an accurate cut relative to the specified grade. The number of corrective control actions and the extent of error requiring such correction are reduced, as the problems caused by the rocking of the vehicle frame have been eliminated, thereby simplifying the operation, maintenance, and reducing the cost of the heretofore necessary control components.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a surface finishing vehicle having a skid supported, automatically controlled, cutting blade constructed in accordance with and embodying the present invention.

FIG. 2 is a horizontal section taken on the line 2—2 of FIG. 1.

FIG. 3 is a horizontal section taken through the position sensing apparatus of the present invention.

FIG. 4 is a vertical section taken on the line 4—4 of FIG. 3.

FIG. 5 is a vertical transverse section taken on the line 5—5 of FIG. 3.

FIG. 6 is an electro-hydraulic schematic diagram.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference characters designate like corresponding parts, there is shown in FIG. 1 a surface finishing vehicle **20**, such as a grader or the like, comprising a mobile frame **21** which is supported above ground by wheels **22**. Provided on each side of frame **21** is the customary lift mechanism **23** having one end portion connected to the upper end of a draft link **24**, the lower end of which is connected to the draw bar **25**, which in turn is fixed to the conventional circle **26**. The draw bar **25** is also connected to frame **21** through a cross link **27** in the usual manner.

In conventional graders, the draft link **24** normally comprises an extensible member **28** and a sleeve member **29** for telescopically receiving the extensible member **28**, both members **28** and **29** incorporating a plurality of apertures, as at **30**, which are adapted to be placed in alignment for accommodating a locking pin (not shown), whereby vertical adjustment of the draft link **24** may be effected to regulate the distance between the circle **26** and the frame **21**, as is well-known in the art. By the present invention, the locking pin (not shown) is removed so that the draft link **24** is free for telescopical movement and the draw bar **25** is connected to the frame **21** by a flexible member **31**, such as a chain or the like. Thus, it will be observed that the draw bar **25** and the associated circle **26** are free to move relative to the frame **21** for purposes to be presently described.

Formed integrally with the circle **26** on diametrically opposed portions thereof are arcuate support members **32,32'** which curve downwardly and rearwardly for connection to a mold board **33** having an elongate cutting blade **34** attached thereto. Said cutting blade **34** is provided with an upper edge **35**, a lower cutting edge **36**, and end edges **37,37'**, which edges cooperate to define an intervening face **38** being forwardly concave in a customary manner.

Referring to FIG. 2 it will be observed that the structure carried by the mold board **33** and the cutting blade **34** is identical in every respect on the opposed sides of the transverse axis thereof. Therefore, only one side will be described, it being understood that like elements on the other side will be designated by like reference characters in order to facilitate understanding and to avoid unnecessary repetitive explanation.

Mounted to the rearward face of mold board **33** immediately adjacent said end edge **37** is a support bracket **39** comprising an arcuate plate **40** being formed on the same radius of curvature as mold board **33** and being connected thereto in a suitable fashion. Projecting rearwardly of plate **40** are a pair of flanges **41,42** which are interconnected by a linkage assembly **43** to a pair of spaced-apart uprights **44,45** formed integral with the shoe **46** of a ground engaging skid **47**. Said

shoe 46 is formed with upturned end portions *e,e'* for facilitating the slideable movement of skid 47 freely over the ground *g*.

The linkage assembly 43 comprises an upper set of parallel links 48 and a lower set of parallel links 49, each set of links 48,49 being presented in vertically spaced, planar parallel relationship. The forward end portion of each set of links 48,49 are pivotally connected by upper and lower stub pins 50,51, respectively, to the outer face of the related flange 41,42. The rearward end portion of each set of links 48,49 are pivotally connected to upper and lower shafts 52,53, respectively, to the uprights 44 and 45. It will be observed that the upper and lower shafts 52,53 extend transversely through the uprights 44 and 45 whereas the upper and lower stub pins 50,51 terminate in the outer face of the flanges 41 and 42. Thus, the flanges 41,42 of support bracket 39, the linkage assembly 43, and the uprights 44,45 of skid 47, together with the respective stub pins 50,51 and shafts 52,53 cooperate for permitting the skids 47 to move in parallelism with the cutting blade 34.

Interposed between uprights 44 and 45, spacedly upwardly from shoe 46 there is provided a rod 54 having fixed thereto one end portion of a hydraulic cylinder 55 within which is received a piston 56 (FIG. 6) and a piston rod 57, the latter projecting outwardly endwise of cylinder 55. The outer end portion of piston rod 57 is pivotally connected to a pin 58 having end portions fixed to the inner faces of the respective flanges 41,42. The hydraulic cylinder 55 is adapted to extend and retract piston rod 57, as will be described, thereby constituting elevator means for raising and lowering the end edge portion of cutting blade 34 relative to the shoe 46 of skid 47.

Mounted on the end edge 37 of cutting blade 34 is a conventional adjustment mechanism 59 being of the guide screw type having a carriage 60 which is threadedly engaged to a screw (not shown) for manipulating the carriage 60 upwardly and downwardly responsive to the rotation of the screw by a hand crank 61, as is well-known in the art. Fixed to the carriage 60 is a position sensing apparatus 62 having a feeler arm 63 rockably mounted thereto for engaging a reference line or string 64 which is supported above ground *g* at the desired grade as is customarily accomplished in grading procedures.

As will be described in the operation hereinbelow, the position sensing apparatus 62 is in circuit with said hydraulic cylinder 55 so that the cutting edge 36 of blade 37 will be raised and lowered responsive to the movement of feeler arm 63 on the reference string 64 for maintaining the cutting edge 36 at the desired height and angle.

Referring to FIGS. 3–5 of the drawings, position sensing apparatus 62 comprises a housing 65 having a top wall 66, a bottom wall 67, side walls 68,68', a front end wall 69, and a rear end wall 70; said bottom wall 67 having an aperture 71 opening into a compartment 72 defined by the walls of housing 65. Said aperture 71 is closed by a cover plate 73 for maintaining housing 65 in a dust proof condition. Although the aperture 71 is illustrated as being relatively large, it will be understood that same may be considerably smaller and closed with a plug or the like instead of the cover plate 73, if so desired. Said rear wall 70 is of greater height than housing 65 having upper and lower end portions projecting beyond the related top and bottom walls 66,67 for developing upper and lower flanges 74,74', respectively. Suitably mounted to said upper flange 74 are a pair of axially spaced-apart light source heads 75,75' each having a cylindrical body 76,76' which is snuggly received within appropriate openings (not shown) within said top wall 66. Each light source head 75,75' projects a beam of light 77,77' indicated in phantom lines in FIG. 3, into said compartment 72; said heads 75,75' being adjustably mounted on upper flange 74 so that the focal point *f* of light beams 77,77' is positioned in planar alignment with the longitudinal axis of housing 65. Said light source heads 75,75' are in circuit through leads 78,78' to a convenient source of power, such as vehicle battery B (FIG. 6), for supplying a continuous source of power so that a light beam 77,77' is projected at all times during operation.

Mounted to the lower flange 74' are a pair of sensing receivers 79,79' each having a cylindrical body 80,80' positioned within a suitable opening in bottom wall 67 in axial alignment with the opposed cylindrical bodies 76,76' of the light source heads 75,75'. Each of said sensing receivers 79,79' are adapted to receive said light beams 77,77', respectively, for closing a circuit, as will be seen; each sensing receiver 79,79' being connected by leads 81,81' to an amplifier 82 (FIG. 6), one side of which is connected to ground by lead 83; the other side to the battery B by lead 84.

Spacedly rearwardly from front wall 69, said top wall 66 is provided with an opening (not shown) for receiving a sleeve 85 which houses a bushing 86 interposed between upper and lower bearing assemblies 87,87', respectively, for accommodating a couple pin 88.

The lower end portion of couple pin 88 projects within compartment 72 where same is fixed within a mounting block 89 which constitutes the forward end portion of a sensor control member S presented longitudinally within housing 65. Said sensor control member S comprises a flag arm 90 having a forward end portion 91 which is disposed spacedly rearwardly of the mounting block 89 and merges into a relatively narrow, elongate shank 92 having side edges 93,93' diverging outwardly endwise into flared margins 94,94' in the region adjacent said light beams 77,77', respectively. Said flared margins 94,94' terminate into a rearward end edge 95 for developing a triangular-shaped tongue 96.

Secured to the under face of the forward end portion 91 of flage arm 90 there is a block 97 having a pair of spaced-apart bores 98,98'; the bore 98 being internally threaded for threadedly receiving the end portion of an adjustment screw 99, and the bore 98' being smooth for slidably accommodating the end portion of a dowel pin 99'. Both the adjustment screw 99 and the dowel pin 99' project forwardly and outwardly of said block 97 into axially aligned bores 100,100' formed within said mounting block 89. Interposed between said blocks 89 and 97 surroundingly of adjustment screw 99, there is a spring 101 for normally biasing said blocks 89 and 97 away from each other. Access is provided to adjustment screw 99 through a threaded opening 102 tapped within said front end wall 69, which opening 102 is adapted to threadedly receive a removable plug 103. Thus, by removing the plug 103 and turning adjustment screw 99, the flag arm 90 may be moved longitudinally forwardly and rearwardly within said housing compartment 72 for altering the relative

position of the flared margins 94,94' of tongue 96 in relation to the light beams 77,77'. For purposes to be presently seen, the flared margins 94,94' normally overlie the sensing receivers 79,79' so that the light beams 77,77' are blocked from being transmitted thereto.

The upper end portion of couple pin 88 projects outwardly of the sleeve 85 for threaded engagement within a mounting block 104 having a rearward end wall 105 and a forward end wall 106, the latter having a transverse slot 107 provided therein. Received within the slot 107 is the rearward end portion of said feeler arm 63 which is maintained therein as by conventional screws 108. The feeler arm 63 is fabricated from a highly resilient strong material, such as fiberglass, and projects forwardly of the mounting block 104 with its forward end portion being formed with a V-shaped cutout 109 which tapers inwardly and rearwardly into an elongate slot 110 for receiving reference string 64. It will be observed that mounting blocks 104 and 89 are fixed to couple pin 88 so that both blocks 104 and 89 will move through the same angle upon being turned. Therefore, through the positive connection between said blocks 104 and 89, the flag arm 90 will pivot about the axis of couple pin 88 through the same angle as feeler arm 63. Accordingly, when the feeler arm 63 is moved by its engagement with reference string 64 said flag arm 90 will be moved through the same angle.

Fixed within said rearward end wall 105 of mounting block 104 is a threaded shank 111 upon which is received a balance weight W adapted for axial movement thereon. Said balance weight W is maintained at a preselected position by a lock nut 112. Because of the positive connection between feeler arm 63 and flag arm 90 the balance between feeler arm 63 and flag arm 90 may be readily adjusted by moving balance weight W forwardly and rearwardly on the threaded shank 111. It will be understood that balance weight W may be conveniently provided on the shank 92 of flag arm 90 if so desired with access being provided through the removable cover plate 73.

Depending on which direction the flag arm 90 is pivoted responsive to the movement of feeler arm 63, one of said flared margins 94,94' of tongue 96 will swing out of blocking engagement with the related light beam 77,77' for permitting transmittal of same to the immediately underlying sensing receiver 79 or 79' for closing the circuit. The signals emitted by the sensing receivers 79,79' are transmitted to the amplifier 82 through the leads 81,81' for enhancing the emitted signal. Said amplifier 82 is connected through leads 113,113', and leads 114,114' to electric solenoids 115,115', respectively, which solenoids 115,115' are positioned on the opposed ends of a spool valve 116 incorporated within a master valve M. Also incorporated in master valve M is another spool valve 117 disposed immediately adjacent to and in parallel relationship with said spool valve 116; said spool valve 117 being controlled by solenoids 118,118' which are connected by leads 119,119' and leads 120,120', respectively, to an amplifier 121 being in circuit through leads collectively designated *w*, to the other position sensing apparatus 62'.

Said spool valves 116,117 of master valve M are in paired relationship, said spool valve 116 being in communication with hydraulic ram 55 by conduits 122,123 which are connected to ports 124,125, respectively, located adjacent the opposed end portions of said hydraulic ram 55; and spool valve 117 being in communication with the hydraulic ram 55' by conduits 122,123' which are connected to ports 124',125', respectively, located adjacent the opposed end portions of said hydraulic ram 55'.

Said master valve M is connected by conduit 126 to the discharge side of a pump P, the intake side of which is connected by conduit 127 to a reservoir 128 of hydraulic fluid, said reservoir 128 also being connected to master valve M by return line 129. Therefore, by selective energization of solenoids 115,115' and 118,118', through signals emitted by either position sensing apparatus 62 or 62', respectively, said hydraulic rams 55,55', respectively, will effect the raising and lowering of said cutting blade 34.

In operation, with the reference string 64 being received within the slot 110 of feeler arm 63, the flag arm 90 will be pivoted about the axis of couple pin 88 through a like angle as feeler arm 63. In the event that a deeper cut is dictated by a lowering of the reference string 64, relative to the ground surface *g*, said feeler arm 63 will be moved correspondingly downwardly and flag arm 90 will be moved through a like angle, thereby permitting the light beam 77' of sensor head 75' to be received within sensing receiver 79' for closing a circuit. The amplifier 82 directs the signal from sensing receiver 79' through leads 114,114' for energizing solenoid 115' which establishes communication between conduits 126 and 122 for supplying hydraulic fluid to ram 55. Upon entering ram 55 the fluid will push piston 56 downwardly for lowering the cutting blade 34 until the tongue 96 of flag arm 90 again blocks the light beam 77' through the return of feeler arm 63 to the proper straddling relationship with reference string 64. The fluid within ram 55 on the downwardly side of piston 56 will pass through port 125 for return through conduit 123 and master valve M through return line 129 to the reservoir 128. Similarly, when the feeler arm 63 is moved upwardly as it follows the reference string 64, the circuit is completed through sensor receiver 79 for emitting a signal through leads 113,113' to energize solenoid 115 wherein fluid from reservoir 128 will be pumped through conduit 126 and 123 for raising the piston 56 and hence the cutting blade 34. The fluid within ram 55 on its upward side will be returned through conduit 122 and return line 129 to the reservoir 128.

Thus, it will be observed that as the feeler arm 63 moves upwardly and downwardly as it travels along the reference string 64, the flag arm 90 will move through a like angle for opening and closing circuits through the sensing receivers 79 and 79' for alternatively energizing solenoids 115 and 115', respectively, which effect supply of fluid to the hydraulic ram 55 which in turn retracts and extends the piston 56 for elevating and lowering the cutting blade 34. Accordingly, the proper height of the cutting blade 34 may be achieved at all times throughout the operation of the surface finishing equipment 20.

Through the adjustment screw 99, the flag arm 90 may be adjusted longitudinally within housing compartment 72 so that the flared margins 94 and 94' may be positioned at the focal point *f* of both light beams 77,77'. With the tongue 96 so centered, accuracy to 0.005 inch of travel of the wire feeler arm 63 may result in the adjustment of the cutting blade 34. Since the work accomplished by the flag arm 90 passing through

light beam 77 or 77' is a frictionless operation, apparatus 62 offers a more reliable sensing instrument than heretofore thought possible. The accuracy of the flag arm 90 may be increased or decreased depending upon the job conditions by merely turning adjustment screw 99 to move the flared margins 94 and 94' of tongue 96, either closer to the focal point *f* of the light beams 77,77' or further away.

In the same manner, the position sensing apparatus 62' effects the extension and retraction of piston 56' of hydraulic ram 55' for raising and lowering the other end edge 37' to adjust the angle of the cutting blade 34. Since the apparatus 62' operates in the identical manner as apparatus 62, the detailed description of the same is unnecessary.

Although the surface finishing vehicle 20 of the present invention has been defined as having a pair of position sensing apparatuses 62 and 62', it will be understood that a conventional horizon sensor, commonly referred to as a pendulum, may be mounted on the mold board 33 in place of apparatus 62' for adjusting the slope angle of the cutting blade 34.

Having thus described our invention what we claim and desire to obtain by Letters Patent is:

1. A device for automatically controlling the depth penetration of a cutting tool in accordance with a reference string comprising:
- support means for said cutting tool adapted for slideable travel over ground, said support means comprising a ground engaging skid having a shoe and an upstanding portion;
- linkage means connecting the upstanding portion with said cutting tool;
- elevator means interconnecting said support means and said cutting tool for vertical adjustment of the latter relative to the former;
- position sensing means having a housing attached to said cutting tool, said position sensing means including a rockably mounted feeler member engagable with said reference string and disposed exteriorly of said housing;
- sensor means within said housing, said sensor means including light projecting means and a light responsive switch;
- means operatively connecting said light responsive switch and said elevator means for actuating said elevator means upon closing of said light responsive switch;
- sensor control means comprising an arm disposed within said housing;
- said arm being normally presented between said light projecting means and said light responsive switch for maintaining the latter in a circuit-opened condition;
- means coupling said arm to said feeler member for effecting simultaneous movement therewith to close said light responsive switch responsive to the movement of said feeler member.

2. The invention as defined in claim 1 and further characterized by:
- a second light responsive switch provided within said housing and located adjacent said first light responsive means;
- second means operatively connecting said second light responsive switch and said elevator means for actuating said elevator means upon closing of said second light responsive switch;
- said first light responsive switch being closed by said arm when said feeler member is swung upwardly by said reference string, and second light responsive switch being closed by said arm when said feeler member is swung downwardly by said reference string.

3. The invention as defined in claim 2 and further characterized by:
- said arm having a rearward end portion having outwardly flared margins, said rearward end portion being normally positioned in overlying relationship with said first and second light responsive switches;
- said rearward end portion having a width in its narrowest portion greater than the distance between the centers of said light responsive switches.

4. The invention as defined in claim 3 and further characterized by:
- adjustment means on said arm for moving same longitudinally within said housing relative to said light responsive switches.

5. The invention as defined in claim 3 and further characterized by:
- balance means mounted on said feeler member maintaining said arm in substantially planar normal relationship to said light responsive switches.

6. A surface finishing vehicle of the type used for moving earth in accordance with a reference string preset at a predetermined grade comprising:
- a mobile frame adapted for travel substantially parallel to said reference string;
- a cutting blade;
- at least one ground engaging member supporting said cutting blade independently of said frame;
- means freely connecting the cutting blade and said frame for permitting raising and lowering of said cutting blade independently of said frame;
- elevator means interconnecting said ground engaging member and said cutting blade for effecting raising and lowering of same relative to the ground engaging member;
- position sensing means having a housing supported on said blade and extending laterally outwardly thereof;
- said position sensing means including a rockably mounted feeler arm disposed exteriorly of said housing and engageable with said reference string for travel therealong;
- sensor means including light projecting means and at least one light responsive switch within said housing;
- means operatively connecting said light responsive switch and said elevator means;
- sensor control means comprising an arm disposed within said housing;
- said arm being normally presented between said light projecting means and said light responsive switch for maintaining the latter in a circuit-opened condition;
- means coupling said arm to said feeler arm for effecting simultaneous movement therewith to close said light responsive switch responsive to the movement of said feeler arm.

7. A surface finishing vehicle as defined in claim 6 and further characterized by a second ground engaging member supporting said cutting blade, said ground engaging members being disposed transversely at the sides of said mobile frame;

said cutting blade extending between said ground engaging members and adjustably supported thereon independently of said frame;

second elevator means connecting said second ground engaging member to said cutting blade for selectedly raising and lowering same.

8. A surface finishing vehicle as defined in claim **6** and further characterized by:

a second light responsive switch provided within said housing and located adjacent said first light responsive means;

second means operatively connecting said second light responsive switch and said elevator means;

said first light responsive switch being closed by said arm when said feeler arm is swung upwardly by said reference string, and second light responsive switch being closed by said arm when said feeler arm is swung downwardly by said reference string.

9. A surface finishing vehicle as defined in claim **8** and further characterized by:

said arm having a rearward end portion having outwardly flared margins, said rearward end portion being normally positioned in overlying relationship with said first and second light responsive switches;

said rearward end portion having a width in its narrowest portion greater than the distance between the centers of said light responsive switches.

10. A surface finishing vehicle as defined in claim **9** and further characterized by:

adjustment means on said arm for moving same longitudinally within said housing relative to said light responsive switches.

11. A surface finishing vehicle as defined in claim **9** and further characterized by:

balance means mounted on said feeler arm maintaining said arm in substantially planar normal relationship to said light responsive switches.

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