This invention relates to automatically controlling the depth of operation of an earth working machine in response to changes in forward travel speed thereof.

In the operation of conventional earth working machines, the operator tries to maintain forward motion of the vehicle and minimize drive wheel slippage by manipulating the depth controls of the earth penetrating element. As is understood by those engaged in excavation work, the time required for loading an earthmover or scraper depends on forward travel speed and depth of cut. Too deep a cut stalls the machine and too shallow a cut does not properly use the machine's capabilities.

During the loading operation, the operator is not only observing forward travel speed, but also wheel slippage and the loading resistance of the material being excavated. Thus, the operator must exercise considerable skill in order to make the most efficient use of the earthmover.

It is an object of this invention to provide improved means for automatically raising and lowering an earth working tool in response to decreases and increases in its forward travel speed.

It is a further object of this invention to provide means for automatically regulating the depth of operation of an earth working machine to cause the machine travel speed to fall within an efficient earth working speed range.

It is a further object of this invention to provide an automatic control for an earth working machine which obviates the need for the operator to personally observe the depth of cut to properly and efficiently operate the machine.

It is a further object of this invention to provide an automatic control system for an earth working tool of the hereinbefore outlined character wherein the system is made inoperative when the tool is raised above a predetermined height.

It is a further object of this invention to provide an automatic depth control system for an earth working machine which is responsive to increases and decreases in the forward travel speed and having a retractable ground engaging means, for measuring the forward travel speed of the machine, which is automatically raised and lowered when the machine is placed in transport or earth working positions, respectively.

It is a further object of this invention to provide an automatic depth control system of the hereinbefore outlined character wherein a manually adjustable control is provided to adjust the depth of cut-speed relationship in the control system.

These and other objects and advantages of this invention will be apparent to those familiar with the art when the following description is read in conjunction with the drawings in which FIGS. 1 and 2 schematically illustrate two embodiments of my invention applied to a motor scraper.

Referring to FIG. 1, I illustrate my invention incorporated in an earth working machine in the form of a motor scraper having a two wheel tractor 11 and a two wheel scraper 12. The two wheel scraper includes a draft yoke 13 articulatively connected to the tractor 11 and a bowl 14 which is connected to the rear ends of the draft yoke arms on a transverse axis 16. The general construction of the bowl is along conventional lines, a blade element 17 being provided at the forward, lower end of the bowl and the bowl being raised and lowered by a double acting hydraulic ram 18 pivotally connected at its opposite ends to the bowl 14 and draft yoke 13.

The lift ram 18 is controlled by an electrically operated open center control valve 21 which preferably is mounted on the draft frame 13 near the lift ram. The valve 21 is shown in its neutral or hold position in which the fluid is locked in opposite ends of the ram 18 by virtue of the supply ports 22, 23 being blocked by lands 24, 25 of the valve spool 26. In this position, fluid supplied by an engine driven pump, not shown, is delivered through supply passage 27 to the valve 21 and is returned to reservoir, not shown, through return passage 28. An electrical control system 31 is provided for selectively operating the control valve 21 from the operator's station 20 where a two terminal switch 34 is located. The switch is provided to selectively energize solenoids 32, 33 through leads 40, 45.

Before describing the automatic depth control, it should be understood that the vertical position of the cutting edge within its range of cutting depth determines the resistance to forward travel of the earth working machine. In other words, deep penetration of the cutting edge of element 17 requires greater tractive effort of the propelling means than a lesser penetration. The travel speed of the earth mover varies in direct proportion to the depth of penetration of the earth working element 17 limited by the capability of the vehicle and the rolling resistance of the wheels when the cutting edge has no penetration.

In order to maintain forward travel within a relatively narrow range of speeds, I provide means for automatically causing the power means 18 to raise or lower the cutting element 17 in response to predetermined decreases and increases in the forward travel speed of the earthmover. The automatic means I provide measures forward travel speed of the earthmover. Since the front wheels may spin and the rear wheels may be raised off the ground by a pusher, I prefer to provide separate ground engaging means in the form of a wheel 41. Wheel 41 is pivotally mounted on an arm 42 having its forward end pivotally connected to the frame of the scraper 12. A flyweight speed indicator 43 is driven by the wheel 41 and moves a pivotally mounted signal indicator or switch 44 in response to changes in forward travel speed. The movable contactor 44 contacts terminal 60 or 46 of double terminal, single pole switch 45 in response to decreases or increases in travel speed. Leads 47, 48 connect the solenoid valve 21 in parallel with the manually operated control for the solenoid valve. The shiftable control member 44 is connected by a suitable lead 49 to a terminal 51 flexibly mounted on the draft yoke 13 of the earthmover. A mating terminal 52 is flexibly mounted by the bowl 14 and is connected by a lead 53 to the main electric control system intermediate the battery 35 and manual control switch 34. A suitable manual off-on switch 56 is provided in the automatic control circuit to permit the activation thereof at the operator's discretion. The forward travel speed sensing wheel 41 is biased to a raised position by a spring 61 and is forcibly lowered.
to a ground engaging position by a single acting air ram 62 controlled by a normally closed electrically operated air valve 63 controlling the air flow through supply passage 64 from the air reservoir 66. The solenoid operated air valve 63 is connected to the automatic control system electrical circuit by branch lead 67.

**Operation**

In operation, the operator drives the earthmover to the loading area with the scraper bowl in carry or raised position and the switch 56 is closed as the earthmover approaches the cut. A pushing tractor, if used, is then brought into position to push against the rear bumper 71. With the earth mover at approximate excavating speed, the operator lowers the bowl by operating manual control switch 34, to a point below a predetermined elevation to cause the cooperative control components 51, 52 of switch 50 to engage. Upon closing switch 56 and assuming the blade element 17 being lowered sufficiently to close switch 50, the ground engaging wheel 41 will be lowered through the opening of valve 63 which causes the air ram 62 to expand, thus forcing the arm 42 downward. After switches 56 and 50 are closed and the earthmover traveling at approximately the expected or desired excavating speed, the speed controlled switch will take over control of lift ram 18 and control the depth of earth working element 17.

Assuming that the ground becomes increasingly difficult to penetrate, the forward travel speed of the earthmover will slow down and the flyweight mechanism 43 will cause the shaft member 44 to actuate or energize lead 48. When this occurs the solenoid 33 will be energized and the valve spool 26 will be moved to the left. When the valve spool 26 is moved to the left, fluid under pressure is supplied to port 22 and supply hose 72, which will cause compression of ram 18, to cause the solenoid 32 to move the valve spool 26 to the right thereby supplying fluid to conduit 73 and connecting 72 to the reservoir passage 28. This will cause the ram 18 to be expanded to lower the blade element 17 to an increased depth of penetration. As the vehicle slows down under the increased draft load, the contactor 44 will return to its neutral or disengaged position in which illustrated and the fluid in ram 18 will again be locked by virtue of the valve spool 26 returning to its illustrated hold position. When the earthmover bowl has been filled, the operator may open switch 56 and thus cause the solenoid air valve 63 to close and exhaust air from the air ram 62. The ground engaging wheel 41 will then be raised by spring 61 to an inoperative position, and the automatic control system will be inactivated so as to not interfere in any way with the operation of the valve 21 by the manually activated control system thereafter.

Other mechanical and electrical components may be found satisfactory. For instance, as shown in FIG. 2, the flyweight device 43 might be replaced by an electric generator 81 whose speed variable electrical output would be passed by lead 82 to a switch acting electrical device 83 by way of a manually adjustable signal modifier 84. By using a manually adjustable means 84 with the automatic control system the range of travel speed automatically maintained by the system can be changed at the will of the operator. The switch actuating device 83 may take the form of a high-low voltage sensor with switch means 85 to connect lead 49' to lead 68' to raise the blade 17 when the signal from generator 81 is below a predetermined voltage and to connect lead 49' to 47' to lower the blade 17 when the generator output is above a predetermined voltage. Manually adjustable voltage control means 84 is operable to vary the relationship between the speed of generator 81 and the voltage delivered to sensor switch means 83. This adjustable control permits the operator to conveniently select the most efficient range of travel speed (excavating speed) for each particular ground condition and each pusher tractor capability.

Although the invention is illustrated in an earthmover, this automatic control system could be adapted to other earth working machines.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination with an earth working machine movable forwardly over the ground and having an earth penetrating element adjustable vertically within a range of depths of earth working operation, power means for vertically adjusting said element, control means automatically causing said power means to raise and lower said element in response to predetermined decreases and increases, respectively, in a forward travel speed of said machine, and means rendering said control means inoperative when said element is above a predetermined elevation and automatically rendering said control means operative when said element is lowered below said predetermined elevation including cooperative control components carried on said machine and earth penetrating element.

2. The structure set forth in claim 1 wherein said control means includes ground engaging means for measuring the speed of forward travel of said machine.

3. The structure set forth in claim 2 wherein said ground engaging means are vertically adjustable between ground engaging and nonground engaging positions and further comprising means for automatically placing said ground engaging means in its ground engaging positions when said element is below said predetermined elevation and for raising said ground engaging means when said element is raised above said predetermined elevation.

4. The structure set forth in claim 1 and further comprising a manual control, and means for causing operation of said power means in response to operation of said manual control.

5. The structure set forth in claim 1 and further comprising manually adjustable means associated with said control means for changing the range of travel speed automatically maintained by said control means.

6. In combination with an earth working machine movable forwardly over the ground and having an earth penetrating element adjustable vertically within a range of depths of earth working operation, power means for vertically adjusting said element, and control means automatically causing said power means to raise and lower said element in response to predetermined decreases and increases, respectively, in a forward travel speed of said machine including ground engaging means for measuring the speed of forward travel of said machine, said ground engaging means being vertically adjustable between ground engaging and nonground engaging positions and means for automatically placing said ground engaging means in its ground engaging position when said element is below a predetermined elevation and for raising said ground engaging means when said element is raised above said predetermined elevation.

7. The structure set forth in claim 6 and further comprising a manual control, and means for causing operation of said power means in response to operation of said manual control.
8. The structure set forth in claim 6 and further comprising manually adjustable means associated with said control means for changing the range of travel speed automatically maintained by said control means.

9. The structure set forth in claim 8 and further comprising a manual control, and means for causing operation of said power means in response to operation of said manual control.

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